CICER L., A MONOGRAPH OF THE GENUS, WITH SPECIAL REFERENCE TO THE CHICKPEA (*CICER ARIETINUM* L.), ITS ECOLOGY AND CULTIVATION

L. J. G. VAN DER MAESEN

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Dit proefschrift met stellingen van

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De Rector Magnificus van de Landbouwhogeschool,
H. A. Leniger

Wageningen, 4 september 1972

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PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD
VAN DOCTOR IN DE LANDBOUWWETENSCHAPPEN,
OP GEZAG VAN DE RECTOR MAGNIFICUS, PROF. DR. IR. H. A. LENIGER,
HOOGLERAAR IN DE TECHNOLOGIE,
IN HET OPENBAAR TE VERDEDIGEN
OP WOENSDAG 11 OKTOBER 1972 TE 16.00 UUR
IN DE AULA
VAN DE LANDBOUWHOGESCHOOL TE WAGENINGEN

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Aan mijn ouders

CONTENTS

... Even as from a broad shovel in a great threshing floor, fly the blackskinned beans and chickpeas, before the whistling wind, and the stress of the winnower's shovel, even so from the breastplate of renowned Menelaos bounced far away the bitter arrow of Helenus...

(after LANG, LEAF and MEYERS: The complete Works of Homer)

STELLINGEN

I

De bloei van de meeste cultivars van *Cicer arietinum* wordt versneld door Lange Dag.

II

Het begrip cleistogamie voor de afwijkingen in bloei en vruchtzetting van *Cicer arietinum* wordt door CHANDRASEKHARAN en PARTHASARATHY onjuist gehanteerd.

CHANDRASEKHARAN, S. N. and PARTHASARATHY, S. V., Cytogenetics and Plant Breeding. Madras: 349 (1948); 339 (1960)

III

De kritieke daglengte van *Cicer arietinum* heeft voor de praktijk van de teelt geen betekenis.

SANDHU, S. S. and HODGES, H. F., Agron. J. 63-6: 913-914 (1971)

IV

Experimenteel taxonomisch onderzoek is geboden om de vormenrijkdom in het genus *Cicer* ten volle praktisch te kunnen benutten.

V

Ecologie als autonome wetenschap is toch onverbrekelijk gekoppeld aan taxonomie.

WILSON, E. O., Ecology 52-5: 741 (1971)

VI

Internationale regelingen behoren wetenschappelijk botanisch onderzoek in grensgebieden of politiek omstreden gebieden mogelijk te maken voor gekwalificeerde onderzoekers van elke nationaliteit.

VII

De chemische en anatomische eigenschappen van *Cadia* (*Caes.*) bevestigen de reeds bestaande morfologisch-taxonomische visie, dat het genus een uitzonderlijke plaats in het systeem toekomt.

VAN EYK, J. L. en RADEMA, M. H., Pharm. Weekbl. 107: 13-20 (1972);
CORNER, E. J. H., Phytomorphology 1: 117 (1951) en pers. commun. (1972)

VIII

De veredeling op resistentie tegen insecten is ten onrechte achtergebleven bij de veredeling op resistentie tegen schimmels.

IX

Bij het opsporen van de oorzaken van verwelking bij *Cicer arietinum* moet behalve aan de structuur van de grond en de aanwezigheid van bodemschimmels ook aan nematoden aandacht worden geschonken.

OOSTENBRINK, M., Tijdschr. Plantenziekten 57: 52–64 (1951);
SHARMA, R. D., Proefschr. Wageningen, 140–146 (1971)

X

De keker (*Cicer arietinum*) leent zich ook in de geïndustrialiseerde wereld goed voor verwerking tot een vet- en suikerarme versnapering.

XI

De prijzen van synthetische vezels en verpakkingsmaterialen dienen zo te worden gereguleerd, dat de kosten van milieubeheer worden gedragen en de positie van de natuurlijke vezels wordt vergemakkelijkt.

UNCTAD Symposium, Intern. Samenwerking 4–2: 4 (1972); 5–4: 86 (1972)

XII

De Angolakoffie-actie, hoe goed ook bedoeld, treft in eerste instantie de kleine Angolese boer en heeft op Portugal hoogstens een moreel effect.

XIII

Het toenemend gebruik van kruiden en specerijen in al dan niet natuurlijke vorm is een voorbeeld van verzet tegen de „vervlakking van deze tijd".

VAN DE POL, P. A., Proefschr. Wageningen, stelling 10 (1972)

PREFACE

Cicer arietinum L., the chickpea, is the world's third pulse crop. Yet its products play a very small part in world trade. They are, however, very important for local consumption. *Cicer arietinum* has been cultivated since antiquity, mainly in the semi-arid, temperate to warm regions of the Old World. Because of its insignificance to world trade, little fundamental research has been carried out on this crop. Until recently, breeding has only been of local importance.

This thesis is a monograph on *Cicer*. It includes original work on taxonomy and geography of the genus and on the physiology and ecology of the crop species, carried out in the Laboratory of Plant Taxonomy and Plant Geography and the Department of Tropical Crops of the Agricultural University, Wageningen. I began to study chickpeas in 1967 as a part of my 'ingenieur' studies, and the work continued in October, 1968, as the subject for my thesis.

The taxonomy was revised because many new species have been described in the genus since the last monograph was published in 1929. The experimental work contributes to the more fundamental ecological problems of the chickpea. The other subjects are described from data collected during study-tours to the main producing areas in India, Turkey, Spain and northern Africa, and from literature. The literature has been compiled as a bibliography.

1. ORIGIN AND HISTORY OF THE CHICKPEA

1.1. INTRODUCTION

One of the oldest and most widely used grain leguminosae in the Middle and Far East is the chickpea, *Cicer arietinum* L. Only in rare cases are wild forms or relatives of cultivated plants known, but in the genus *Cicer* this may be so. In the immediate vicinity of cultivated chickpea, especially in Turkey and Syria, wild relatives occur, although not in abundance. In Iran and Afghanistan the wild relatives are distinguished from the cultivated species by greater differences in characteristics and altitude.

As we can see with a little imagination, early man collected the most palatable and remunerative plants for his needs. Later these were chosen for cultivation.

Cicer arietinum is not known in the wild. Is this because the chickpea that is cultivated now represents taxa selected from wild-growing populations by man, and has survived due to this selection? Mutation will have occurred certainly in these selected taxa. Was hybridization another cause for the origin of new cultivars? Has there been a continuous contact (crossing, additional selections) with wild-growing species? Some references, however, claim that the species has been found in the wild in Greece (PLINY), on Crete (LENZ, 1859) and in Palestine (MEIR cf. DUSCHAK, 1871). How far these assumptions are correct, is difficult to say, because in these areas the plant could have easily escaped from cultivation.

The long history of this pulse is very interesting; so a survey of chickpea's progress during the past centuries is given in this chapter. Prehistoric data on the chickpea are not very abundant so that its earliest distribution is only sketchy. There have been written reports about the characteristics and the uses of this ancient pulse crop since the dawn of the Greek civilization. Dietic and medicinal uses were the main interest of the early authors.

1.2. PREHISTORIC DATA

The seeds of *Cicer arietinum* often occur in archeological finds, but rarely as undamaged specimens. HELBAEK (1959) mentioned Palestinian finds of the fourth millenium BC as among the earliest, and stated that the seeds suffered rather more in the carbonized stage than those from other species because of the protruding hilum and beak. Although the occurrence has been established many times, the archeological data up till now are clearly insufficient to justify a particular study of the actual early cultivation and domestication of *Cicer arietinum* (HELBAEK, 1970, pers. commun.). It seems to have been grown indiscriminately among other legumes, such as lentil, grass pea, and bitter vetch, which are found together in solid deposits.

The earliest known occurrence of the chickpea and a specimen probably belonging to a wild species of *Cicer* were reported from the Hacilar site near Burdur in Turkey. The deposits in these layers were detated by the C^{14} method to about 5450 years BC (HELBAEK, 1970).

For later millenia (ca. 3300 BC onwards during the Bronze Age) proof of cultivation was found in Iraq and adjacent countries (HOPF, 1969), for instance at Jericho. The late Bronze Age left us chickpeas stored in large vessels on Crete. Excavations in India (RAMANUJAM, 1970) indicate a later introduction, as also mentioned in 1.7.

1.3. WRITTEN SOURCES

The first quotation about the chickpea is found in the Iliad by HOMER (about 1000–800 BC), where the arrows of Helenus, son of Priam, bouncing away from the breastplate of Menelaos are compared with beans and 'erebinthos' (chickpeas), being thrown by the winnower.

A recent linguistic study proved the presence of the chickpea in the Nile valley, at least as far back as the New Kingdom (1580–1100 BC). DIXON (1969) came across the chickpea as 'falcon-face' (Hrw-b'k) among a number of plant names on a papyrus school text.

Some of the work of ancient and mediaeval writers has been compiled and rewritten many times by the seventeenth Century herbalists, who included many details based on belief and ancient interpretations. Modern knowledge about origin of plants starts with 'l'Origine des plantes cultivées' by ALPHONSE DE CANDOLLE (1882) who considered floristic, linguistic and etymological data.

The pre-linnaean literature on *Cicer* is relatively abundant, the chickpea being mentioned in most herbals. Illustrations, sometimes coloured by hand, are often fine examples of etching and aquarelling. The comments are invariably about botanical characteristics, the uses as food and in medicine.

The name *Cicer* is of Latin origin (HORATIUS). Cicero, the well-known Roman senator, adopted his name from the common crop of that time. Actually, it was a nickname before. DON (1882) supposed that *Cicer* was derived from the Greek 'kikus', force or strength. DUSCHAK (1871) derived the name from the Hebrew 'kirkes'. In Hebrew, 'kikar' means round. The epithet *arietinum* was first used by COLUMELLA, perhaps as translation of 'krios' (L. aries; E. ram). HEHN (1874) gave many details on the relationships of the names of *Cicer* and related pulses. In Egypt, no records were found on paintings and inscriptions of monuments. As the name for chickpea in Arabic ('hommes') is completely different from the supposed old Hebrew name ('ketsech', in fact probably *Vicia sativa* or *Nigella sativa*), DE CANDOLLE concluded that no cultivation took place in Egypt nor in Palestine before the beginning of our era. Nevertheless it was reported that Jews took roasted chickpeas as food to the fields (DUSCHAK, 1871). The names 'purkedan' and 'kirkes' occur in the Talmud and were translated into *Cicer*. LÖW (1924) compiled Aramaic and Hebrew names for chickpea. THEOPHRASTUS stated that chickpeas were not present in India. ATHENAEUS referred to phrases in Greek literature, where 'erebinthos' were mentioned.

The chickpea had a many-sided reputation. Facts and general assumptions were mingled with legends. After 1800, the medicinal uses of chickpea seeds were rarely referred to, so that its medicinal properties, if any, did not seem important to more modern medicine.

The 'doctrine of signatures' proposed by PARACELSUS (1493–1541) and rejected by DODONAEUS (1583) developed from a way of considering the appearance of plants (and animals) which was very common in ancient history: one could see 'signs', pointers to the beneficial effects a plant had. And so morphology suggested the second meaning of the Greek 'erebinthos': the testis. This indicated that pulses could have an aphrodisiac effect. Priests and scholars should not eat them, to avoid 'an inhibition of high spiritual principles and the process of thinking'. Only the poorer classes used pulses, such as chickpea (MURR, 1890). HORATIUS classified the pulse as a food for the poor (*Cicer frictum*) and this image still remains.

PLINY mentioned the role of a certain kind of *Cicer* as a 'venerium' at feasts in honour of goddesses. At flower festivals chickpeas were thrown over the heads of the people and caught with much hilarity. Pulses were very seldom used as a subject for ornament on tombs and other monuments. However, several other crop plants were known in pharaonic Egypt, where so much detailed information on agriculture is displayed on frescoes. DIOSCORIDES (first Century AD) stated in his Greek herbal that *Cicer* is generally assumed to be agreeable to the stomach. It is a healthy food with a not unappealing taste. ATHENAEUS referred to the use of boiled and roasted chickpeas. Tender young seeds were used as a dessert. PLINY recommended the use of pulses, such as chickpeas. In early Rome, they were sold in the streets. APICIUS, in his Roman cookery book, described many recipes, among them a barley broth containing lentils, peas and chickpeas. The seeds were used as a diuretic, and to encourage menstruation and stimulate birth and lactation. It was eaten to produce a good skin colour and to prevent skin diseases. These effects could be ascribed to the healthiness of the food.

Cicer was thought to heal inflammations of the stones, scabs and ulcers of the head and cancrous ulcers. Touching warts (with fresh plants?) at new moon and binding them in linen cloths would make them disappear. Presumably the acids in the glandular hairs all over the plant had some effect on the warts. DIOSCORIDES mentioned that the pulse caused flatulence, a property *Cicer* shares with every pulse if eaten irregularly or in large quantities.

DODONAEUS (1583, 1608) who compiled one of the most complete herbals of his time, described many ways of utilization. He distinguished five species of *Cicer*: the tame or round *Cicer*, the hooked *Cicer* and three wild *Cicers*. Only the hooked species is really *Cicer*, subdivided into *C. nigrum*, the red or black seeded form (also called *C. rubrum* by the old apothecaries) and the white-seeded form *C. album* or *C. candidum*. His illustration is drawn rather accurately. The tame or round *Cicer*, which was not illustrated, is applicable to

Vicia ervilia Willd. (*Ervum ervilia* L.) as GAMS (1924) pointed out. The vernacular, mocho, is the same as the modern Italian vernacular, moco, for *V. ervilia*. This species was sometimes erroneously listed as *Cicer ervillum*.

Ervum, *Ervilia* and *Orobus* have been used in confusion throughout history for *Cicer* and related genera.

The three wild species of *Cicer* do not belong to our concept of *Cicer*, judging from the short description given by DODONAEUS and his illustrations. The first species is not recognizable from the description, but the other two could be *Hedysarum* sp. and *Ononis rotundifolia* L., respectively. DODONAEUS (16th Century) reported that the chickpea was believed to be a sexual stimulant. In any case the pulse has a high nutritive value. Curiously enough, lentils were considered to have the opposite effect and this was probably the reason why the lentil was included in the diet in monasteries on meatless days.

Some people added chickpeas to the diet of stallions before they had to do their duty.

DODONAEUS advised patients with kidney and bladder stones to drink the water in which chickpea seeds were cooked rather than eat the seeds themselves. To eat the seeds was bad for ulcers of the kidney and the bladder. The same water with rosemary added was supposed to cure dropsy and jaundice. *Cicer* might be successful for those with small voices. To cure tumours, chickpea flour was mixed with endive (this use must be classified under the wide range of salve materials used by quacks). Snakebites could be cured with the flour, boiled with *Hypericum*. It was advised that the unpleasant after-effects of this pulse could be avoided if the seeds were eaten with poleye (= *Pulegium* (mint) and cinnamon or with poppy-seeds. WEIMANN (1739) mentioned roasted chickpea as the best substitute for coffee in Europe.

In India, the acid secretion of chickpea leaves has been used medicinally (WATT, 1890). Cloths are spread over the plants during the night and then wrung out when soaked with the acids and dew. Old Sanskrit writers mentioned this 'vinegar' as an astringent, sometimes it was used against dyspepsia, indigestion and constipation when mixed with carbonate of potash. The liquid replaced vinegar, and diluted with water it gave a pleasant beverage. Snakebites were treated with the acids too, although this treatment is denied by a reference in KIRTIKAR and BASU (1933). In the Deccan, the steam of plants in boiling water is inhaled to cure dysmenorrhoea. The acid secretion is also said to reduce fever, to check vomiting and so on. Plasters of the boiled leaves are applied to sprains. The roasted seeds serve as a substitute for coffee in India. They also have the effect of an aphrodisiac, of healing flatulency and as a diuretic. So, in case of flatulency, roasted chickpeas seem to have an opposite effect to boiled ones. KIRTIKAR and BASU (1933) gave the uses from the Ayurveda and the Yunani. It is thought that the ripe seeds are anthelmintic. JAIN and TAREFDAR (1970) reported that the Santal tribe in Bihar used chickpea against dysentery, not specifying which part of the plant was used.

In some Christian communities in the Middle East, it is customary to eat chickpeas on Palm Sunday because Jesus Christ is said to have walked through a chickpea field on his way to Jerusalem on Palm Sunday. The other reason is the belief that it will protect the people throughout the year from bloody tumours (boils). Löw (1924) listed this use from Montpellier, UPHOF (1968) gave no specification. When the Holy Family fled to Egypt, according to a legend genst (broom, *Cytisus scoparius* (L.) Link) and chickpea fields crackled and thus their presence was audible. These plants therefore were doomed to crackle, the chickpea plant remained prickly by its secretion (Löw, l.c.; TEIRLINCK, 1930). However, this could not have happened if the flight to Egypt was in January, because no crops are ripening and brittle at that time.

1.5. CULTIVATION IN ANCIENT TIMES

There have been several ancient customs and ideas on how chickpea should be cultivated. In India (WATT, 1890) since ancient times, *Cicer arietinum* has been considered as a soil improving crop, especially as the soil did not become very impoverished if this pulse was grown in rotation or in mixture with cereals. It was generally believed that lightning could be injurious to flowering. In some regions, the peasants grew a line of linseed around the fields to protect the crop against this evil. The chickpea has always been grown on ploughed but only coarsely tilled fields. Topping or grazing young plants to stimulate tillering is an old practice.

THEOPHRASTUS stated (cf. DODONAEUS) that the pulse could be grown successfully on 'saltish' soils, because the plants caused salinity themselves. He mentioned the deep roots. Further (cf. HORT, 1961) the need of black and fat soils, the exhaustive character (apparently with regard to water!), the presence of a white, a red and a black form, the presence of a rot disease and some morphological characteristics. The crop could be sown both early and late. PLINY likewise described the treatment of soaking the seeds for one day previous to sowing, to overcome the 'poisoning' of the soil. On this treatment opinions differed in India, where after-effects were both good and bad when the crop was worked into the soil after threshing. Besides grazing the young crop, the hay was gathered for cattle-fodder in some areas, while in other regions the acids were said to injure the mouths of the cattle.

DODONAEUS remarked that no pests were harmful to the crop, as was stated in the Talmud too. THEOPHRASTUS mentioned that caterpillars were present on the crop under warm and humid conditions, although in the same work he stated that chickpeas produced no 'worms' in decaying seeds.

1.6. GEOGRAPHY

Old sources never give for most crop plants, well defined and complete indications of centres of origin. When floras became available more could be said of the geography of, amongst many taxa, *Cicer arietinum*. DE CANDOLLE

(1882) restricted the region of origin of the chickpea vaguely to the East, between Greece and the Himalayas, laterally limited by the Krim and Ethiopia. The ancient cultivation can clearly be seen from the philology of the names, and the botanical and historical data. Together they indicate an origin south of the Caucasus and northern Persia.

VAVILOV (1926) indicated several areas of origin, i.e. centres of diversity. These are the SW. Asian and the Mediterranean centres; Ethiopia was considered as another (secondary) centre of diversity. HARLAN (1969) considered the chickpea as an early introduction into the East African highlands. Black-seeded chickpeas are mainly confined to Ethiopia, while in Turkestan, Afghanistan and the Caucasus these forms are absent; in Turkey, Iran and India they are not uncommon (POPOVA, 1937). Large-seeded chickpeas occur in the Mediterranean, small-seeded ones are characteristic for the eastern part of the area, as is the case with several other pulses. The stature of the plant is tall in the western part, but small in the Orient and especially in Ethiopia, where chickpeas have a very short vegetation period.

POPOV (1929) developed the theory that *Cicer arietinum* was a species that was 'artificially made by man' and never existed in the wild. Ancient breeding methods now lost would have led to a whole series of cultivated plants. Although *Cicer arietinum* has never been found in the wild, recently more and more closely related taxa have been found. These facts make his remarkable point of view less probable for *Cicer*. Selection of conspicuous types, mutations and so on are, in reality, ways of conserving crop plants which, if unobserved by man, would not have survived in this form without cultivation as protection.

The ancestors of *Cicer arietinum* could be *C. pinnatifidum* Jaub. et Spach and one of the Anatolian species. The recently described *C. echinospermum* P. H. Davis and *C. bijugum* K. H. Rech. give rise to more speculation about the origin of the chickpea (DAVIS, 1969). POPOV suggested to cross these species with the larger group of perennial ones. This will cause many more difficulties than crosses between annuals as interspecific crosses between annuals and perennials are usually difficult. A re-synthesis of some properties of the cultivated *C. arietinum* may reveal more about the possible evolutionary steps. The question is not purely academic, but also of importance to *Cicer* research and breeding.

1.7. DISTRIBUTION

The spreading of the chickpea to different areas is fairly well known from the available literature, but the most ancient roads over which *Cicer* travelled can only be surmised. Evidently its history is closely related to that of man. Before records were written, the chickpea was spread westwards by the Western Aryans (the Pelasgians and the Hellenes) to the Mediterranean and eastwards to India (DE CANDOLLE, 1882). It is also probable that the plant was indigenous to SE. Europe. The Greeks, Phoenicians and the Romans spread the cultivation in the Mediterranean area. In Spain, however, the cultivation may antedate these civilizations, because of the unrelated Spanish, Baskian and French names. Löw (1924) remarked that the Phoenicians must have known *Cicer* in their homeland, if they brought the crop to the Iberian Peninsula. They exported known indigenous plants. The presence in Talmudic and Rabbinic literature, possibly not yet accessible to De Candolle, of the name 'chimtza' and its derivatives point to an old traditional cultivation in Palestine. From Egypt recently new data on ancient cultivation have become available (Dixon, 1969) (1.2).

More detailed information about the importation to the Indian subcontinent was compiled by Ramanujam (1970). After the first prehistoric findings in India (2000 BC), the first data about non-domesticated chickpeas go back to 600 BC. Allchin (1969) was of opinion that chickpeas were introduced relatively recently in India. In Nevasa (near Aurangabad, Maharashtra) chickpeas were found in a layer dating from 300–100 BC according to Sankalia et al. (1960 cf. Allchin l.c.). In the literature of the Aryans, the Purana (books), the crop was mentioned in the 4th Century AD, but not in the 1st Century. Besides the northern Continental trails the chickpea could also have been introduced via south Indian harbours.

The Dravidians have the words 'but', 'buta', 'kadalai', for chickpea, names that are completely different from the Sanskrit 'chennuka' which became 'chana'. Trade was rather extensive with King Solomon and the Pharaohs. In Memphis even an Indian colony existed. The Greek may also have reached South India.

The 'kabuli' forms of *Cicer arietinum* are most probably of recent introduction to India (about 1700). No reports have been made prior to this date. This name logically points to Kabul on the ancient 'Silk Road' from Europe via Samarkand to India. Most probably these types, so alike the Mediterranean ones, were brought to the East and so had to adapt themselves to a different environment. Their fitness to Indian conditions is still moderate.

Watt (1908) stated that the name 'gram' comes from the Portuguese 'grâo' (grain) and is a special appropriation made in India. The name 'Bengal gram' does not indicate a Bengali origin of the chickpea, but must merely be attributed to the earliest British influence in India, where Bengal was conquered first. Several things new to the British were called Bengal, for instance the Bengal tiger which is also not typically Bengali.

In the western part of northern Africa only the big white-seeded forms are known, which must have been imported by the Greeks, the Phoenicians or the Romans. Occasionally chickpea occurs in the drier parts of the more equatorial African countries. The use of chickpeas in the Oriental and particularly the Syrian-Lebanese kitchen caused incidental trials to grow the plant near trade centres.

In Kenya, the pulse has probably been imported by the Indians during the past century (Mann, 1947). Father Francisco Alvares mentioned (1520) the use of chickpeas in the Ethiopian Empire. Since there was an ancient cultivation here as well as ancient trade roads to Egypt, it is logical to suppose

Cicer was known in Egypt. However, since the same types of chickpea are not found in Egypt and Ethiopia, it is unlikely that there was any distribution between these countries. The lack of distribution may be ascribed to both mutual unsuitability for particular types and the low image of these crops. The bulk of articles traded was of a precious nature.

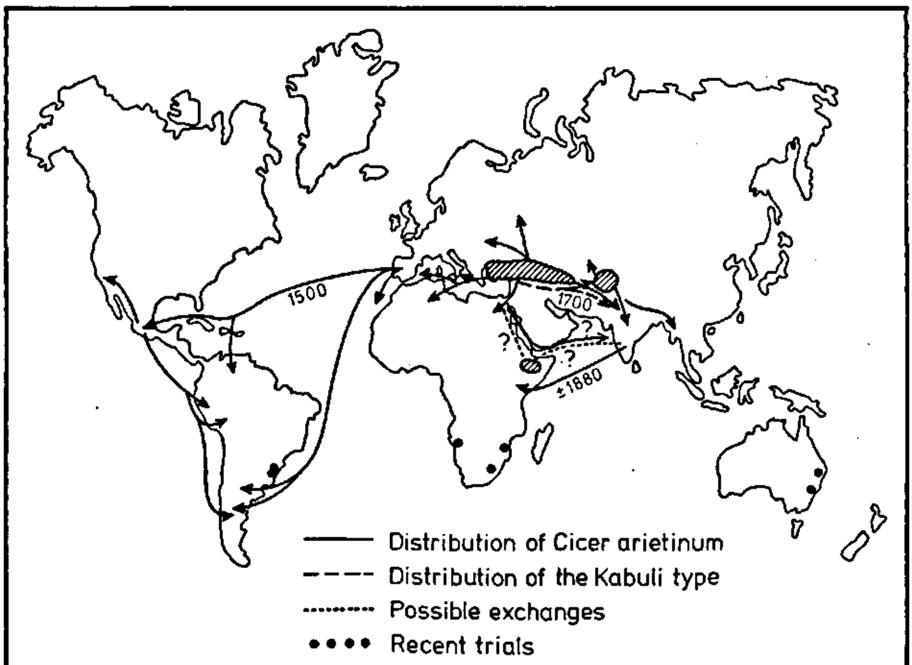
The Spaniards and Portuguese introduced *Cicer* to the New World, where Mexico now is the most important grower of this crop. Argentina and Chile also have significant areas under chickpea; in Brazil effort has been made recently to increase cultivation.

Asian Indian communities, settled in the West Indies, are importing the seeds for food and grow it in small quantities when technically and economically possible.

In Australia the cultivation is not yet of importance. The Agricultural Extension Services in New South Wales and Queensland proved recently that cultivation is possible in these regions.

Although there is little international trade in chickpeas, small quantities are exported for human consumption to countries unsuited for growing this pulse. Indian immigrants in Britain and in tropical countries, Spanish and N. African labourers in Western Europe and Latin-Americans in the USA induce trade in chickpeas.

The distribution of the chickpea from its original centres to other parts of the world is summarized in Map 1.



MAP 1. Areas of origin and distribution routes of chickpea

2. TAXONOMY OF THE GENUS CICER L.

2.1. INTRODUCTION

Within the context of this monograph the taxonomy of the genus *Cicer* has been revised. Although *Cicer* has been in a relatively advantageous situation since it was last revised in 1929, so many new species have been described that the genus could no longer be surveyed. This revision is based on the material of about 25 herbaria and on studies of living plants. I collected seeds and specimens on various trips or obtained them by correspondence with several scientists, both agriculturalists and botanists. From the following herbaria the material was studied, either while visiting the institutes, or from sheets sent on loan:

ANK	Ankara, Turkey: Ankara Universitesi Fen Fakültesi, Botanik Enstitüsü.
BM	London, Great Britain: British Museum (Natural History).
BR	Bruxelles, Belgium: Jardin Botanique National.
C	København, Denmark: Botanical Museum and Herbarium.
E	Edinburgh, Great Britain: Royal Botanic Garden.
G	Genève, Switzerland: Conservatoire et Jardin botaniques.
GOET	Göttingen, Germany: Systematisch-Geobotanisches Institut, Universität Göttingen.
ISTE	Istanbul, Turkey: Farmakognozi Enstitüsü, Istanbul Üniversitesi.
ISTF	Istanbul, Turkey: Farmakobotanik ve Genetik Enstitüsü, Istanbul Üniversitesi.
IZM	Izmir-Bornova, Turkey: Botanik Kürsüsü, Ege Üniversitesi.
JE	Jena, Germany: Institut für Spezielle Botanik und Herbarium Haussknecht.
K	Kew, Great Britain: The Herbarium and Library.
L	Leiden, Netherlands: Rijksherbarium.
LE	Leningrad, U.S.S.R.: Herbarium of the Komarov Botanical Institute.
LINN	London, Great Britain: The Linnean Society of London.
M	München, Germany: Botanische Staatssammlung.
MPU	Montpellier, France: Institut de Botanique, Université de Montpellier.
MW	Moscow, U.S.S.R.: Department of Botany of the Lomonosov State University of Moscow.
OXF	Oxford, Great Britain: Fielding Herbarium, Druce Herbarium, Department of Botany.
P	Paris, France: Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie.
RAB	Rabat, Morocco: Institut Scientifique Chérifien, Laboratoire de Phanérogamie et Laboratoire de Cryptogamie.

S Stockholm, Sweden: Botanical Department, Naturhistoriska Riksmuseum.
U Utrecht, Netherlands: Botanical Museum and Herbarium.
W Wien, Austria: Naturhistorisches Museum.
WAG Wageningen, Netherlands: Laboratory of Plant Taxonomy and Plant Geography.
WU Wien, Austria: Botanisches Institut und Botanischer Garten der Universität Wien.

I have seen all the specimens cited, except when stated otherwise. Many thanks are due to the directors or curators and staff members of the above mentioned institutes. Because of their kind co-operation it was possible to see all the material.

After the description of the generic characteristics, nomenclature and other notes, the species have been dealt with in alphabetical order. A subchapter treats the subdivision of the genus, to depict the supposed infrageneric relationships.

When no material of newly described or rare species could be obtained, these were described according to the protologues. At present their entry in the key is not possible since no critical comparison with other species has been possible. They were classified in the sections according to the designations of the original authors.

Illustrations have been drawn from most of the approved species.

2.2. Description of the genus Cicer L.

Cicer L., Sp. Pl. ed. 1: 738. 1753; DC., Prodr. 2: 354. 1825; Jaubert and Spach, Ann. Sci. Nat. Bot. Sér. 2-18: 223–235. 1842; Walpers, Repert. Bot. Syst. 2: 883. 1842; Walpers, Ann. Bot. Syst. 1: 242. 1848–49; ibid. 2: 397. 1851–52; Alefeld, Oest. Bot. Zeitschr. 9: 352. 1859; Alefeld, Bonpl. 9: 66, 348. 1861; Benth. and Hook., Gen. Pl. 1: 524. 1867; Baillon, Hist. Pl. 2: 202, 239. 1870; Baker, Fl. Trop. Afr. 2: 172. 1871; Baker, Fl. Brit. India 2: 176. 1879; Boissier, Fl. Orient. 2: 560–65. 1872 and Suppl.: 194. 1888; Taubert in Engl.; Nat. Pflz. Fam. 3–3: 349, t. 129. 1894; Engler, Veg. Erde 9: Pflanzenw. Afr. 3–1: 645. 1915; Gams in Hegi, Ill. Fl. Mittel-Europa 4–3: 1496. 1924; Popov, Bull. Appl. Bot. Gen. Pl. Br. 21–1: 1–254. 1928–29; Popova, Kult. F. SSSR 4: 25–71. 1937; Parsa, Fl. Iran 2: 22, 28, 434–439. 1943; Linczevski, in Fl. USSR 13: 386–406. 1948; Kitamura, Fl. Afghan.: 223–227. 1960; Kitamura, Pl. W. Pakistan and Afghan.: 90–91. 1964; Fürnkranz, Oest. Bot. Zeitschr. 115: 400–410. 1968; Gum, Taxon 18–6: 727. 1969; Davies, Fl. Turkey 3: 267–274. 1970.

Type species: *Cicer arietinum* L.

Synonyms: *Nochotta* S.G. Gmelin, Reise Russland 3: 23, t. 3. 1774, descriptio generico-specifica, type species *N. oleracea* S.G. Gmelin (= *Cicer arietinum* L.); *Spiroceras* (Jaub. et Spach) Hutch., Gen. Fl. Pl. 1: 452. 1964, nomen invalidum, in synonymity (see also GUM, 1969).

Annuals or *perennials* with annual stems, arising each growth season from the woody roots or rootstocks, conspicuously glandular or eglandular pubescent. *Stems* flexuous or straight, flat or faintly ribbed, erect, semi-erect or prostrate, 10 up to 80 cm long. *Leaves* 3–36 leaflets, paripinnate or imparipinnate; rachis ending in a tendril, a spine or a leaflet. *Leaflets* with partly or nearly entirely toothed margin, tooth of midrib often recurved. *Stipules* very small up to slightly larger as the lower leaflets, toothed or spiny. *Flowers* solitary or in 2–5–flowered axillary racemes; calyx subregular or dorsally gibbous at the base, teeth equal or unequal; *corolla* veined, white, pink, purple or blue, 5–29 mm long; vexillum mostly obovate, sometimes with pubescent exterior; alae free from the carina, obovate-oblong, pedicellate, auricle ½–1 × the pedicel; carina rhomboid, pedicellate, ventral margin partly adnate, dorsal margins partly adherent; *stamens* diadelphous; free part upturned; style filiform, glabrous, except near the ovary, upturned in the staminal tube; stigma hardly or not broader than the style, slightly broader after pollination; *ovary* ovate or elongate. *Pods* inflated, elliptic, obovate or elongate-rhomboid, acuminate, persistent stamens sometimes present, up to 3 cm, with 1–10 seeds. *Seeds* bilobular to subglobular, conspiciously beaked, hilum rather deep, chalazal tubercle present; surface smooth, wrinkled, tuberculate or with smooth or echinate spinelets; in various shades of brown, grey, black, white, yellowish-orange or green.

Distribution: 35 wild species in Central and Western Asia, one species endemic in Greece, one in Ethiopia and one in Morocco, the one crop species widely cultivated in the Indian subcontinent, Iran, Central Asia, the Mediterranean countries, Ethiopia, Mexico, Peru and Chile (see Map 2, Table 1; Section 3.1.).

2.3. NOTES

2.3.1. *Nomenclatural history of the genus*

The genus *Cicer* was described by LINNAEUS and based on *C. arietinum*, the type species. LINNAEUS used the names from TOURNEFORT, who took the classical names existing since antiquity. Curiously enough LINNAEUS did not describe *C. judaicum*, of which a specimen has been and is still present in the Linnaean Herbarium. The similarity to *C. arietinum* has been noticed, since the specimen is stored under the same number without further specification.

The genus was erroneously united with *Lens* in HORTUS CLIFFORTIANUS (1737) and different editions of GENERA PLANTARUM. The first edition of SPECIES PLANTARUM (1753) does not contain this concept. Most editions of GENERA PLANTARUM (e.g. 1754, 1778) quote *Lens* in the TOURNEFORT concept as a synonym to Cicer.

Important revisions in the genus were made by JAUBERT and SPACH (1842) and POPOV (1929) who added several new species. POPOV also reviewed the relationships with other genera in *Leguminosae* and its role in evolution. This publication is not easily accessible being mainly in Russian.

Floral treatments were made for the Asia Minor-Iranian area by BOISSIER (1872), for Soviet Central Asia (LINCZEVSKI, 1948) and for Turkey (DAVIS, 1970). A first compilation for the flora of Afghanistan appeared after the Japanese expeditions in this area (KITAMURA, 1960). Most floras of the Soviet republics in the Caucasus and Central Asia contain descriptions of the *Cicer* species occurring in their area.

2.3.2. *Relationship to other genera*

The genus *Cicer* belongs in the tribe *Vicieae* Brown and is one of the smaller genera. The related genera with their number of species are

Vicia	± 120 species
Cicer	39 species
Lens	9 species
Pisum	6 species
Lathyrus	102 species

Abrus (4 species), previously mostly included in *Vicieae*, is placed in a separate tribe: *Abreae* Hutchinson, because of the absence of the tenth stamen. *Cicer* differs from the other genera in *Vicieae* by its glabrous style, the inflated pods and the glandular pubescence. A key for the *Vicieae*, adapted from TAUBERT (1894) and HUTCHINSON (1964) is the following:

1. Style glabrous, fruits inflated . . . . **Cicer**
   Style hairy, fruits compressed 2
2. Staminal tube oblique at the top, alae adnate to the carina 3
   Staminal tube straight at the top, alae hardly adnate to the carina or free 4
3. Ovules and seeds usually more than two, flowers often rather big, brightly coloured (mostly blue) . . . . **Vicia**
   Ovules two, seeds one to two, flowers small, white or light blue . . **Lens**
4. Style dilated in the upper part . . . . **Lathyrus**
   Style dilated in the upper part, margins reflexed, forming a laterally compressed body . . . . **Pisum**

Possible links between *Cicer* and taxa outside the *Vicieae* were considered. The concept of *Cicer* as a reticulate combination of the characters of *Vicia* and *Ononis* (tribe *Trifolioleae* Benth. et Hook., *Genistae* cf. Popov, or *Ononidae* Hutch.) was proposed by POPOV. In the Miocene (25–15 million years ago), he suggested *Cicer* would have been formed in a complex of taxa after hybridizations between *Vicia* (from the North) and *Ononis* (from the South) in – probably – the Western part of the ancient Mediterranean. In the Pliocene (up to 1 million years ago) the more xerophytic forms shifted to the East (Central Asia) and the more mesophilous forms moved to the West (present Mediterranean) with a more humid climate. Here the genus was reduced considerably. Greece, Morocco, and Ethiopia each have one solitary endemic species.

DAVIS (1970) gave the genus a 'somewhat intermediate position' between the *Vicieae* and the *Ononidae*. *C. incisum* and *C. chorassanicum* were previously described in *Ononis*, *C. incisum* originally in *Anthyllis*. Miss KUPICHA (Edinburgh) will publish a study on the relationship in *Vicieae* in the near future.

Ononis differs from *Cicer* mainly by its monadelphous stamens, while in *Cicer* the topmost stamen is free and the staminal tube is not closed. Per inflorescence never more than 5 flowers are found, in *Ononis* this may be 1, 2 or 3. The germination of *Ononis* is epigaeal, of *Cicer* hypogaeal. *C. chorassanicum* has trifoliolate leaves, as is usual for *Ononis*. *C. incisum* has 3–5 folioles. Other characteristics in common are the glandular pubescence, the toothed leaflets, the few-flowered axillary racemes. In some *Ononis* species, pods are also inflated.

2.3.3. *Habit and growth*

The species of *Cicer* are annual and perennial herbs (Sections *Monocicer* and *Chamaecicer*) or small perennial shrublets, which have woody tap roots (Sections *Polycicer* and *Acanthocicer*). These woody tap roots, as well as the perennial rootstocks of the alpine species, produce new stems and branches every growing season. The aerial part of annuals and perennials dry and/or disappear at the end of the hot summers and in cold winters, as is normal in mountanous regions. Most *Cicer* species belong to the xerophytic vegetations, which do not cover the soil and grow slowly if humidity conditions are above a certain minimum. The number of stems and the volume of the shrub depend on the amount of rainfall in a particular year. Of the more resistant species (*C. pungens*, *C. macracanthum*) dried stems of the previous year remain attached to the plant. A 'xerophytic' character present in all species is the glandular pubescence of stems, leaves, calyx and pods. Some species even have puberulous vexillae, e.g. *C. nuristanicum*, *C. grande*, *C. paucijugum*; others have only a pubescent pedicel, calyx and pod (*C. subaphyllum*, *C. stapfianum*). Typical is the deep tap root, which is woody in the perennial species and can be up to 2 cm or more in diameter, and the sturdy spines.

In two species, *C. subaphyllum* and *C. stapfianum*, the leaflets are transformed into spines.

The height of the species ranges from 10 cm (e.g. *C. atlanticum*, *C. incisum*) to 40–50 cm or sometimes 75–100 cm (*C. arietinum*, *C. montbretii*). Branching is extensive in C. *tragacanthoides*, *C. pungens*, and rather variable within *C. arietinum*.

Apart from the bushy growth of many species, *C. atlanticum* and *C. incisum* have a more prostrate growth, and *C. graecum* is reported to climb in shrubs, using the tendrils at the end of the leaf rachis. *C. cuneatum* is a bushy plant but also uses its tendrils for support. Nevertheless not all species possessing tendrils will grow as climbers. The previously mentioned species belong to a more humid climate and grow in open bush type or steppe vegetations. *C.*

microphyllum e.g. only uses the tendrils to fix the branches more or less vertically. The tendrils are attached to other plants or both recent and old branches from the same plant without showing a true climbing habit.

The number of leaflets, although of great taxonomical importance, may vary within the specimen. This number ranges from 3 to about 36. Most species are not very consistent in the placement of the leaflets, which may be both nearly opposite or entirely alternate. The leaf rachis may end in a leaflet (Sections *Monocicer* and *Chamaecicer*), a tendril (*Polycicer*) or a spine (*Acanthocicer*). The stipules, also of great taxonomical importance, range from simple or incised perules (e.g. *C. pinnatifidum, C. arietinum, C. incisum*) to more leafy incised perules (*C. montbretii, C. songaricum, C. fedtschenkoi*) which can be as big or bigger than the largest leaflets (*C. fedtschenkoi, C. songaricum*). Further the stipules can be more rigid perules (*C. pungens, C. rechingeri*) or even spiny (*C. macracanthum, C. acanthophyllum*).

In perennial species (e.g. *C. songaricum, C. nuristanicum, C. anatolicum*) several perules or scale leaves are present at the base of the stems. *C. arietinum* has two scale leaves, other annuals bear also two or sometimes three scale leaves. Apart from this, the first leaves often have less leaflets than leaves appearing later on the fullgrown plant.

The hairy pods are inflated and contain one up to eight or ten pea-like seeds, with a wide variation in form and colour from one species to another, and especially within *C. arietinum*. The form ranges from globular to hooked, with a more or less pronounced beak. The colour is mostly greyish brown, brown or black, but can also be white, green, yellowish, and red. The seed coat is often tuberculated. The cotyledons remain in the soil during germination.

The corolla of *C. arietinum* is white, blue or pinkish in various shades. When pinkish or purplish, the colour changes to bluish after 1–2 days, when fading. *C. pinnatifidum, C. judaicum* and *C. bijugum* similarly change the colour of their corolla, as can be expected from the other purple-flowered species. This change in colour also explains the sometimes widely different descriptions of the shade within one species. *C. montbretii* and *C. isauricum* have white flowers, *C. oxyodon* has yellowish flowers and *C. chorassanicum* has white or yellow flowers with violet or greenish stripes. The corolla is veined and sometimes striped.

A very detailed comparative study on the morphology within the genus *Cicer* was given by POPOV (1929).

2.3.4. *Flowering seasons*

C. arietinum, being cultivated on elevations up to 2400 m, grows in the winter periods on the Indian subcontinent, Egypt, and Mexico and flowers from January to March. In the Mediterranean it flowers in spring (May-June). The majority of wild species are later in flowering. After the cold season a rapid regrowth, whether from seeds or rootstocks, is initiated. Flowering then takes place 1–2 months after emergence. The pods are inflated fairly rapidly (in *C. arietinum* often within 3 days, in *C. pinnatifidum* and *C. bijugum* within a week) and it takes two to four weeks to fill the pods and slightly longer to complete ripening. The complete period of flowering extends generally to one month. The last flowers may fail to set. At higher altitudes flowering is retarded, the alpine species *C. atlanticum* and *C. incisum* flower at the end of July and August.

Flowering specimens of *C. cuneatum* are found in September up to the end of November before and after the end of the rainy season in Tigre, Ethiopia. In the extreme southeast of Egypt, flowering plants were collected in January. More detailed data are given under the respective species.

2.3.5. *The geographical distribution of the genus* Cicer L.

The areas delimited by POPOV (1929) are generally correct today. The distribution of the old species is now known in more detail and new species added to the knowledge of sectional spreading.

As the map (Map 2) shows, the areas distinguished by POPOV need not be changed:

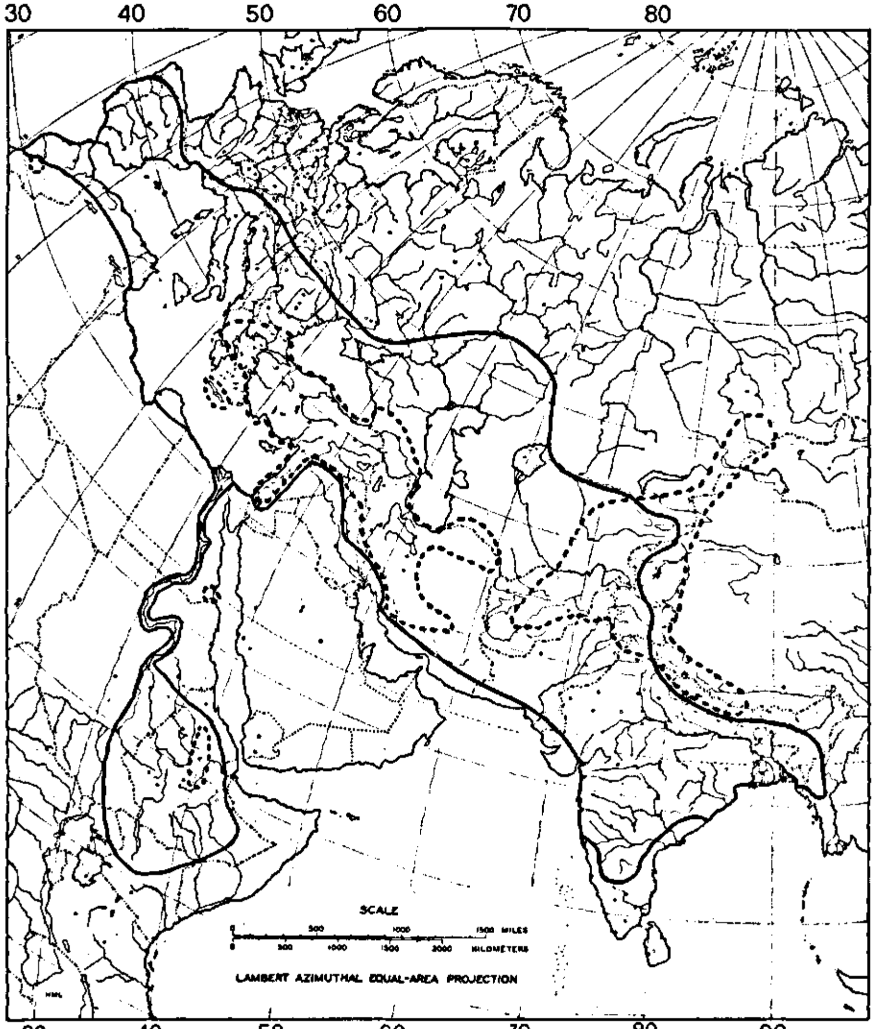
1. The Western area in patches (Morocco, Ethiopia, Crete, Greece).
2. The Asia Minor-Persian continuous area (Turkey, Iran, Irak, Syria, Israel, Caucasus).
3. The Eastern continuous area (Central Asia, Himalaya, Afghanistan).

The cultivated chickpea, being transported to and introduced in many new regions, occupies a much larger area, as shown in Chapter 3. The original area of *Cicer* is delimited by the longitudes of 22° and 85° E and the latitudes of 30° and 52° N and the patches of Morocco (about 8° W Long., 32° N Lat.) and Ethiopia-Egypt (37°–40° E Long., 10°–23° N Lat.). The Eastern part of the area nowadays is known to be nearly as rich in number of species as is the Western part, although knowledge on the diversity of the Western wing has also increased considerably since POPOV's monograph.

The ecology and altitudinal distribution of the species are dealt with under the respective descriptions. *Cicer* species occur from sea level up to an altitude of 5600 m. Some annual species do not grow above 1000 m. The section *Polycicer* has many representatives on medium altitudes (1000–2000 m) while the sections *Chamaecicer* and *Acanthocicer* mainly occur on high altitudes (2000–5600 m). Some species of the section *Polycicer* are also found at the higher altitudes.

2.3.6. *Availability of material*

To the areas where the genus *Cicer* is best represented: Minor Asia, South Western and Central Asia, there were several expeditions. AUCHER ELOY (1830–35) collected in Minor Asia and Persia, as did BORNMÜLLER (1892–1929). COQUEBERT DE MONTBRET visited Asia Minor (1832–35), and STRAUSS (1898–1905) collected in Persia. Additional material was scarce. Recently RECHINGER, PODLECH, FREITAG, DAVIS, and others, secured a fair number of specimens. The preparation of the now published FLORA OF TURKEY and FLORA OF IRAQ



MAP 2. Distribution of the genus *Cicer* (- - - - -) and the main areas of cultivation of *C. arietinum* in the Old World (———)

as well as the work on the FLORA IRANICA were very valuable because they included an intensified search of these regions, which also yielded several new *Cicer* species. In the Russian herbaria more material must now be available, although LINCZEVSKI (1948) still complained about the low number of specimens. Here FEDTSCHENKO, POPOV, REGEL and others collected the *Cicer* material from the Russian parts of Asia.

Even nowadays material is rather scarce, suggesting that (wild) species occur nowhere over large areas. Sometimes a species is reported to be frequent. Living seeds are very difficult to obtain. I could frequently study *C. arietinum* on the fields on my trips to India, Turkey, Spain and Morocco.

A collection of about 140 numbers of *Cicer arietinum* and some wild species was grown from many sources and has been preserved in Herbarium Vadense (WAG). During the last stage of my study I found additional material of *C. montbretii*, *C. pinnatifidum*, *C. isauricum* and *C. echinospermum* in Turkey. Co-operating botanists have been very helpful and added *C. anatolicum*, *C. cuneatum*, *C. montbretii*, *C. pinnatifidum*, *C. judaicum*, *C. bijugum* and *C. incisum* seeds to the collections, often after much personal effort.

Perennial species are especially difficult to cultivate outside their original habitat. This is a severe handicap to botanists and in particular to plant breeders.

2.3.7. *Uses*

The various uses of the chickpea, *C. arietinum* L., are described in Chapter 10.

All other species are not directly used by man, but several data reveal that some non-spiny species are eaten by cattle. DUTHIE (cf. WATT, 1890) mentioned that *Cicer microphyllum* (taken for *C. songaricum*) was an annual (in fact the species is perennial) believed to fatten cattle well. Therefore it comes under Himalayan fodder plants. I collected *C. echinospermum* which had been partially bitten off by goats. I was told that *C. isauricum* was relished also by goats. Also a cooperating botanist found it difficult to collect seeds of *C. incisum* on the Libanon mountains, because goats had eaten a great many plants since flowering. BALLS (1932, on herbarium label) said that peasants ate the slightly acid leaves of *C. anatolicum* to slake thirst when they crossed the mountains.

Acid secretion is present in most *Cicer* species, although it is unknown to what extent. In *C. pinnatifidum* and *C. judaicum* the leaflets taste less acid than in *C. arietinum*, which is also eaten by cattle. Therefore the assumption that at least the non-spiny annuals and perennials in the genus *Cicer* can be eaten by cattle seems to be justified.

The deep-rooting species play a role in the natural struggle against erosion. The drought resistance of most species is well suited for their occurrence in semi-arid and alpine vegetations. However, *Cicer* specimens appear to grow scattered and widely spaced in a plant-cover and so no special role can be ascribed to any *Cicer* species in combating erosion.

2.4. SUBDIVISION OF THE GENUS

The first infrageneric taxa, which are still used by some authors, were described by JAUBERT and SPACH (1842). Four sections were distinguishable: 1. Sect. *Arietaria* (stems herbaceous, leaves without a tendril), 2. Sect. *Vicioides* (stems herbaceous, leaves ending in a curled tendril), 3. Sect. *Spiroceras* (base woody, leaves ending in a spiny type of tendril), 4. Sect. *Tragacanthoides* (base woody, leaves ending in a straight spine). Only some important characters have been described here. BOISSIER (1872) adapted this division but merged Sect. *Vicioides* and Sect. *Spiroceras* into Sect. *Vicioides.* ALEFELD (1859) distinguished three groups: 1. *Imparipinnata,* 2. *Cirrhifera,* 3. *Apiculata.* The only characteristic included is the leaf rachis. The names speak for themselves and the then known species are almost classified as by JAUBERT and SPACH. Remarkably enough ALEFELD omitted *C. montbretii, C. pinnatifidum* and *C. spiroceras.*

POPOV (1929) proposed a new system, with the comment that his division is also coarsely empirical. The basis for a theoretical system is absent and he supposed that his division was as liable to change as the older ones. POPOV classified the genus into two subgenera, four sections and, when necessary, subsections, series and subseries. LINCZEVSKI (1948) streamlined the divisions within the sections to some extent on a more morphologic and less phylogenetic base. In both systems the newly described species can be placed without too great difficulties. I have based my classification on the LINCZEVSKI concept of POPOV's system. Some characteristics had to be adjusted.

Originally POPOV combined his Subseries *Orientalia* and Subseries *Anatolo-Persica* into the Series *Anatolo-Perso-Orientalia* which points to a more interrelated status of these groups. This statement remains entirely correct. Apparently for practical reasons LINCZEVSKI made the division which I also used.

Genus **Cicer** L.

SUBGENUS *Pseudononis* M. Pop.

Flowers small, 5–10 mm, seldom (in some varieties of *C. arietinum*) up to 15 mm. Calyx subregular, base hardly gibbous at the base or not, teeth nearly equal, sublinear.

Section 1. *Monocicer* M. Pop. Species annual, stems firm, erect or horizontal, branched from the base or at medium height.

Series *Arietina* Lincz. Leaves imparipinnate, arista small or absent.

C. arietinum L.
C. bijugum K. H. Rech.
C. echinospermum P. H. Davis
C. judaicum Boiss.
C. pinnatifidum Jaub. et Spach

Series *Cirrhifera* m. – Leaves ending in a tendril, arista 4–12 mm (*Rachis fere cirrho terminatus, arista mediocre*).

C. cuneatum Hochst.

Series *Macro-aristae* m. – Leaves imparipinnate, arista long, 5–20 mm (*Foliolae imparipinnatae, arista longiora*).

C. yamashitae Kitam.

Section 2. *Chamaecicer* M. Pop. Species annual or perennial. Stems thin, creeping, branched, with a leafless part in the soil.

Flowers small, 5–10 mm.

Series *Annua* m. – Species annual (*Species annua*)

C. chorassanicum (Bge) M. Pop.

Series *Perennia* Lincz. – Species perennial (*Species perennis*)

C. incisum (Willd.) K. Maly

SUBGENUS *Viciastrum* M. Pop.

Flowers medium large (12–15 mm) or large (17–27 mm). Calyx strongly gibbous at the base, teeth unequal. Perennial species.

Section 3. *Polycicer* M. Pop. – Leaf rachis ending in a tendril or a leaflet, rather weak, never spiny.

Subsection 1. *Nano-polycicer* M. Pop. Rhizome creeping. Stems short. Leaflets imparipinnate, broadly cuneate, top toothed. Peduncle ending in a short weak arista, longer than or equal to the pedicel.
Flowers 13–17 mm long. Related to Section *Chamaecicer* of Subgenus *Pseudononis.*

C. atlanticum Coss. ex Maire

Subsection 2. *Macro-polycicer* M. Pop. Rhizome short, not creeping. Stems ascendent, 10–75 cm. Peduncle ending in a firm arista, pedicels shorter.

– Flowers medium large, 14–15 mm. Calyx teeth lanceolate, 2–4 × as long as the tube.

1. Series *Persica* M. Pop. Inflorescences 1–2–flowered, bracts minute. Stipules about half as large as the leaflets, simple or toothed. Leaflets in 2–12 pairs.

C. kermanense Bornm.
C. oxyodon Boiss. et Hoh.
C. spiroceras Jaub. et Spach
C. subaphyllum Boiss.

– Flowers large, 17–27 mm. Calyx teeth triangular-lanceolate, 1–2 × as long as the tube.

2. Series *Anatolo-Persica* (M. Pop.) Lincz. (= Subseries *Anatolo-Persica* M. Pop.). Inflorescences 1–2–flowered.
Flowers large, 20–27 mm. Calyx teeth short, bracts minute. Stipules mostly smaller than the largest foliolae. Leaflets in 4–9 pairs.

C. anatolicum Alef.
C. balcaricum Galushko

3. Series *Europaeo-Anatolica* M. Pop. Inflorescences 2–5–flowered, bracts more or less foliolate. Stipules small or about half as large as the leaflets. Leaflets toothed except near the base, in 4–8 pairs.

C. floribundum Fenzl
C. graecum Orph.
C. isauricum P. H. Davis
C. montbretii Jaub. et Sp.

4. Series *Flexuosa* Lincz. (= Subseries *Orientalia* M. Pop. p.p.).

Inflorescences 1–2–flowered, bracts minute. Stipules much smaller than the largest foliolae. Leaflets in 4–13 pairs.
Xerophytic mountanous group.

C. baldshuanicum (M. Pop.) Lincz.
C. flexuosum Lipsky
C. grande (M. Pop.) Korotk.
C. incanum Korotk. (?)
C. korshinskyi Lincz.
C. mogoltavicum (M. Pop.) Koroleva
C. nuristanicum Kitamura

5. Series *Songorica* Lincz. (= Subseries *Orientalia* M. Pop. p.p.). Inflorescences 1–2–flowered, bracts minute. Stipules almost equal to the largest foliolae. Leaflets in 2–18 pairs.
Mountanous group, high altitudes.

C. fedtschenkoi Lincz.
C. multijugum van der Maesen
C. paucijugum Nevski
C. songaricum Steph. ex DC.

6. Series *Microphylla* Lincz. (= Subseries *Orientalia* M. Pop. p.p.). Inflorescences 1–2–flowered, bracts minute. Stipules smaller than or equal to the largest foliolae.
Leaflets in 7–10 pairs. Medium and high altitudes.

C. microphyllum Benth. in Royle

Section 4. *Acanthocicer* M. Pop. Leaf rachis persistent, straight, ending in a spine. Arista spiny. Stems branched, base woody. Spiny shrublets, subpulvinus.

Series *Pungentia* Lincz. Stipules foliolate or small spines.

C. pungens Boiss.
C. rechingeri Podlech
C. stapfianum K. H. Rech.

Series *Macracantha* Lincz. Stipules spiny.

C. macracanthum M. Pop.
C. acanthophyllum Boriss.
C. garanicum Boriss. (?)

Series *Tragacanthoidea* Lincz. Stipules small, foliolate triangular incised perules.

C. tragacanthoides Jaub. et Spach

2.5. Key to the species of Cicer

1. Annual. Leaves imparipinnate, rarely ending in a tendril. Flowers small, up to 10–12 mm, usually smaller (Sect. *Monocicer, Chamaecicer*) . . 2
– Perennial. Leaves paripinnate or imparipinnate. Flowers usually bigger than 12 mm, up to 30 mm 9

2. Leaves imparipinnate, plant prostrate or erect 3
– Leaves ending in a tendril, plant climbing . . . . **9. C. cuneatum**
3. Folioles 3, cuneate-flabellate, stipules small, 1 mm, flowers 5–6 mm, plant up to 15 cm . . . . **8. C. chorassanicum**
– Folioles more than 3 4
4. Leaflets in 2(3) pairs, oblong-obovate, stipules ovate-lanceolate, 2–5 mm, flowers c. 9 mm, arista 0–3 mm, plant up to 30 cm . . . **7. C. bijugum**
– Leaflets more numerous 5
5. Folioles in 2–3 pairs, cuneate-elliptic or lanceolate, stipules bidentate, c. 2 mm long, flowers c. 7 mm, arista very long, 5–20 mm, plant up to 30 cm . . . . **39. C. yamashitae**
– Arista short or absent 6
6. Folioles in 3–4 pairs, simply incised, 4–10 mm, leaf petiole short, stipules ovate to flabellate, 5(7) mm, 2–3 teeth, flowers 6–8 mm, plant 10–30(40) cm, seeds 4–6 mm . . . . **31. C. pinnatifidum**
– Otherwise 7
7. Folioles in 3–6 pairs, often doubly incised at the top, 4–7 mm, leaf petiole long, stipules 2–3 mm, 2–5 teeth, flowers 5–6 mm, plant 15–40 cm, seeds 3–4 mm . . . . **20. C. judaicum**
– Otherwise, leaflets larger 8
8. Folioles in 3–7 pairs, elliptical, serrate, seeds large, smooth or tuberculate, 5–12 mm, plant cultivated . . . . **3. C. arietinum**
– Folioles in 3–5 pairs, elliptical to elongate, serrate, seeds with echinate hairs, 7 mm, plant not cultivated . . . . **10. C. echinospermum**
9. Leaf rachis ending in a tendril or a leaflet 10
– Leaf rachis ending in a sturdy spine (Sect. *Acanthocicer*) 31
10. Flowers small, 8–10 mm, leaves imparipinnate, 5–7 leaflets, rootstocks slender, habit creeping, 5–15 cm . . . . **18. C. incisum**
– Flowers larger 11
11. Flowers medium large, c. 15 mm, leaves imparipinnate, 5–16 leaflets, rootstocks slender, habit sturdy, erect, 4–10 cm . . . **4. C. atlanticum**
– Flowers medium large or large, plants larger, rootstocks woody (Sect. *Polycicer*) 12
12. Flowers medium large, c. 15 mm 13
– Flowers large, c. 20–27 mm 16
13. Folioles spine-shaped, plant glabrous . . . . **37. C. subaphyllum**
– Folioles normal, flat, plant pubescent 14
14. Folioles rounded, 5–15 mm long, 5–17 mm wide, tendril often ramified . . . . **29. C. oxyodon**
– Folioles fanshaped, base cuneate, very remote, tendril sturdy, curled . 15
15. Folioles 3–7 mm long, 3–9 mm wide, in 3–8 pairs . **35. C. spiroceras**
– Folioles 5–9 mm long, 5–15 mm wide, in (3)6–12 pairs . . . . **21. C. kermanense**
16. Inflorescences 1–2-flowered, rarely more, bracts minute perules . . 17
– Inflorescences (1)2–5-flowered, bracts more or less foliolate 24

17. Stipules flabellate-rounded, about as large as or larger than the leaflets, toothed 18
– Stipules obliquely ovate or triangular, small or half as large as the leaflets, sometimes nearly as large, incised 19
18. Plant 18–35 cm, sticky, intensily glandular-pubescent, leaves imparipinnate, with 4–7 pairs of leaflets, obovate, 5–13 mm long, 4–7 mm wide, arista ending in a small foliole, 1–5 mm . . . . . . **11. C. fedtschenkoi**
– Plant 25–40 cm, less densily pubescent, leaves ending in a tendril or tendrillous leaflet, leaflets in 5–7 pairs, flabellate, 4–12 mm long, 2–8 mm wide, arista rarely ending in a small foliole . . . . . **34. C. songaricum**
19. Folioles small, up to 10(17) mm 20
– Folioles larger, up to 25(27) mm, in some specimens up to 10 mm only 27
20. Folioles in 2–4(5) pairs, leaves imparipinnate or ending in a slender spine . . . . **30. C. paucijugum**
– Folioles more numerous 21
21. Plant densily pubescent, 10–30 cm, leaves imparipinnate, leaflets in 9–18 pairs, obovate to oblong-lanceolate, top toothed, inflorescences 1-flowered . . . . **27. C. multijugum**
– Plant less pubescent, 20–70 cm, leaves with less leaflets, ending in a tendril or an endleaflet at the lower leaves, inflorescences 1–2flowered . 22
22. Plant more or less glandular pubescent, tendril always simple, leaflets narrowly cuneate to cuneate-obovate, upper half of margin toothed, stipules triangular-incised, up to nearly as large as the leaflets, 2–12 mm . . . . **24. C. microphyllum**
– Plant thinly pubescent 23
23. Leaflets not very close, obovate or obovate-elliptic, 5–15 mm, in 8–13 pairs, margin toothed except near the base, tendril simple, stipules small, triangular-incised, 2–4(7) mm . . . . **28. C. nuristanicum**
– Leaflets very remote, broadly cuneate-flabellate, 3–7 mm, in 8–11 pairs, top truncate-incised, tendril often ramified, stipules small, triangular-incised, 2–4 mm . . . . **25. C. mogoltavicum**
24. Hairs very long, 1–2 mm 25
– Hairs shorter, up to 1 mm 26
25. Leaves ending in a leaflet. Leaflets elliptical, flowers white . . . . **26. C. montbretii**
– Leaves ending in a tendril, ramified or not, at lower leaves a topleaflet, flowers blue or purple, plant climbing . . . . **15. C. graecum**
26. Leaflets oblong-obovate, spiny toothed, 7–24 mm long, 5–15 mm wide, bracts 1–2 mm, flowers white . . . . **19. C. isauricum**
– Leaflets oblong-elliptical, finely toothed, 8–15 mm long, 3–8 mm wide, bracts 2–3 mm, flowers bluish violet . . . . **13. C. floribundum**
27. Leaflets in 4–7 pairs, rather close, cuneate-obovate, elliptic or subrotundate, 7–15(18) mm long, stipules generally half as long as the leaflets. Minor Asia, Iran, Caucasus . . . . **2. C. anatolicum**
– Leaflets in 4–8 pairs, rather close or more rem te, ovate, obovate, cuneate-

elliptic or subrotundate, 5–22 mm long. Central Asia 28

28. Plant densily glandular pubescent, 30–40 cm, stems flexuous, leaflets in 5–8 pairs, cuneate-obovate, up to 15 mm long, 12 mm wide, rachis ending in a ramified (or simple) tendril . . . . **12. C. flexuosum**
- Plant less glandular pubescent, stems straight or slightly flexuous . 29

29. Plant sparsely mainly eglandular pubescent, 30–40 cm, leaflets in 4–8 pairs, rounded to cuneate-truncate, 5–18 mm long, 4–15 mm wide, rachis ending in a simple tendril . . . . **6. C. baldshuanicum**
- Plant glandular pubescent, 20–80 cm 30

30. Plant 20–50 cm, leaves ending in a simple or ramified tendril with 4–6 pairs of leaflets, elliptic, 10–25 mm long, 6–12 mm wide, teeth simple, triangular-acuminate . . . . **16. C. grande**
- Plant 50–80 cm, leaves ending in a spiny curl or a tendril, with 5–6 pairs of leaflets, broadly cuneate or obovate, 10–17(20) mm long, 6–10 mm wide, teeth broadly acuminate, bipartite . . . . **22. C. korshinskyi**

31. Leaflets small, 1–5 mm long, in 5–11 pairs, 1–2–flowered inflorescences . 32
- Leaflets larger, 5–10(13) mm long, 1–flowered inflorescences **32. C. pungens**

32. Stipules consisting of 1 long horizontal spine, 10–25 mm, and a vertical short secondary spine, 1–10 mm, leaflets obovate or obovate-elongate, 3–5(8) mm long, 1–, seldom 2(3)–flowered inflorescences . . . . **23. C. macracanthum**
- Stipules shorter vertical spinelets, up to 8 mm or foliolate 33

33. Leaflets foliolate 34
- Leaflets mostly spine-shaped . . . . **36. C. stapfianum**

34. Stipules horizontal lanceolate perules, 2–5 mm long. Leaflets in 3–7 pairs . . . . **1. C. acanthophyllum**
- Stipules minute foliolate perules, adjacent to the stem, triangular-lanceolate, leaflets very small, 1–5 mm 35

35. Plant rather straight, c. 40 cm, leaf rachis ending in a sturdy spine, leaflets in 5–10 pairs, rotundate-ovate, 2–5 mm long, top with 3–7 teeth . . . . **33. C. rechingeri**
- Plant low, sturdy or more slender, ascendent, leaf rachis ending in a sturdy spine or a slightly incurved spiny tendril, leaflets in 2–8 pairs, ovate to subrotundate, 1–5(6) mm long, top with 1–3(5) teeth . . . . **38. C. tragacanthoides**
- ad *C. tragacanthoides*: larger, slender forms from Kopet-dagh . . . . var. **turcomanicum**

Note

C. garanicum and *C. incanum* (near *C. macracanthum* in Sect. *Acanthocicer*), *C. balcaricum* (Sect. *Polycicer*) have not been included in this key because these species are imperfectly known.

1. C. acanthophyllum Boriss. **Fig. 1, p. 25; Map 3, p. 26**

Borissova in Novit. Syst. Pl. Vasc., Leningrad 6: 167. 1970.

Type: C. Asia, Pamir, Schach-Darja riv., Korshinsky s.n. (LE, holotype, not seen).

Perennial. Roots woody, shrublet branched from the base, glandular and eglandular pubescent.

Stems rather straight, sometimes flexuous, faintly ribbed, 20–35 cm long.

Leaves 10–16(18) leaflets, paripinnate; rachis 2–4.5 cm, grooved above, ending in a spine.

Leaflets rather remote, obovate-truncate, base rounded, top truncate-acuminate, sometimes incised, toothed, 2–5 mm long, 1–3 mm wide, both sides prominently veined, teeth 5–7(9), triangular, an often recurved spinelet prolonging the midrib.

Stipules spine-shaped, 2–6(15) mm, at the base regularly with a second spinelet, elsewhere only occasionally, 1–2 mm, or consisting of a more or less foliolate incised perule, 2–6 mm at the base of the plant.

Flowers in 1–, seldom 2–flowered axillary racemes; peduncle (15)20–40(60) mm long, with a spiny arista, (4)8–20 mm; bracts minute triangular-lanceolate simple perules; pedicels 7–15 mm, recurved when bearing fruits.

Calyx strongly dorsally gibbous at the base, tube 3–4 mm; teeth triangular-lanceolate, acuminate, 4–6 mm long.

Corolla veined, purplish blue; vexillum obovate, top emarginate-mucronulate, base spoonshaped, 16–22 mm long, 10–14 mm wide; alae oblong-obovate, base shortly auriculate, ca. 15 mm long, 6–7 mm wide; carina rhomboid, ca. 14 mm, frontal side of ventral margin adnate.

Stamens 9 + 1, persistent, filaments ca. 15 mm long (fused part 12 mm, free part 3 mm), anthers basi-dorsifix.

Ovary ovate-elongate, 4 mm long, 2 mm wide, 10 ovules; style ca. 11 mm, upturned, stigma broadened.

Pods elliptic-rhomboid, elongated, 18–26 mm long, 7–8 mm wide.

Seeds obovate, beaked, 5 mm long, 2.5 mm wide (not fully mature), seed coat brown, irregularly greyish tuberculated, chalazal tubercle not very prominent.

Note

In the section *Acanthocicer* the species with spiny stipules are: *C. macracanthum, C. acanthopyllum, C. rechingeri,* and *C. garanicum.* The first two possess real spines, up to 25 mm, the last two have spiny perules appressed to the stem, up to 6 mm. *C. macracanthum* has paired secondary stipules, sometimes up to 3 pairs, the largest up to 4 mm. *C. acanthopyllum* has simple stipules, mostly not exceeding 8 mm and sometimes up to 15 mm long. Sometimes minute secondary stipules occur, so that even this important characteristic may cause doubt. Material seen by Borissova also showed several bispinulate stipules. The arista of *C. macracanthum* is mostly longer than the pedicel, as also in

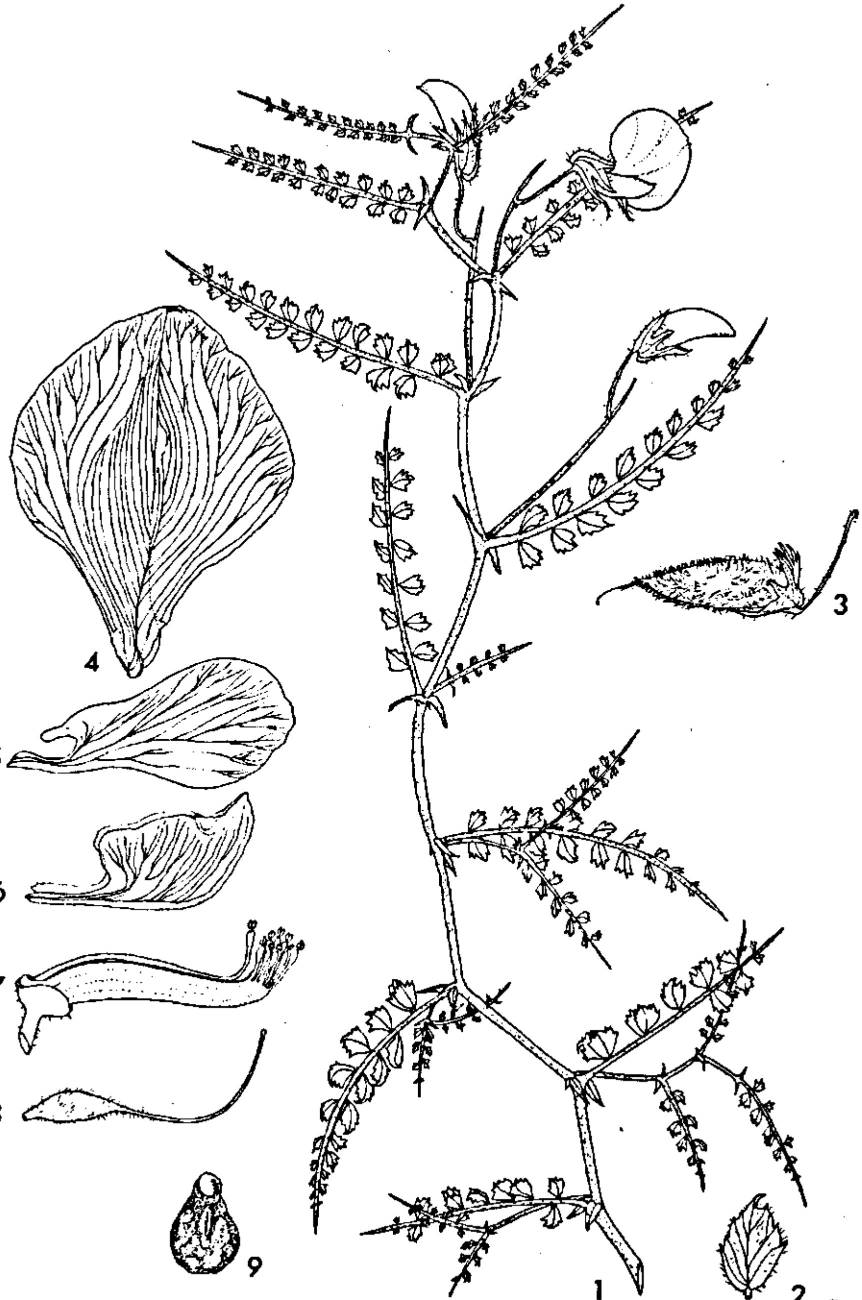


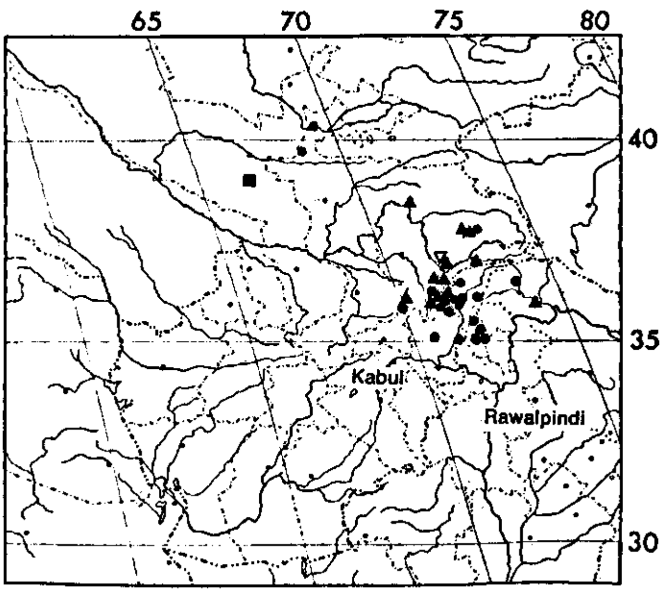
FIG. 1. *C. acanthophyllum* Boriss. – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. young pod, $^5/_6$ ×; 4. flag, $2^1/_2$ ×; 5. wing, $2^1/_2$ ×; 6. keel, $2^1/_2$ ×; 7. anthers, $2^1/_2$ ×; 8. pistil, $2^1/_2$ ×; 9. seed, $2^1/_2$ × (ROEMER 54, W)

C. rechingeri. Though BORISSOVA described the arista of *C. acanthopyllum* as shorter than, or seldom longer than, the pedicel, in the material identified by her (OVCZINNIKOV and AFANASSJEV 1362) the arista was often longer than the pedicel and measured up to 20 mm. *C. acanthophyllum* appears to be more closely branched than *C. macracanthum* and *C. rechingeri*. *C. macracanthum* is somewhat larger, has more and relatively larger leaflets, the flowers may be larger and have broader calyx-teeth. Specimens now referred to *C. acanthophyllum* were formerly often called *C. macracanthum*.

Geographical note

C. macracanthum and *C. acanthophyllum* do not have separate geographical areas, as was stated in the protologue of *C. acanthophyllum*. In north-western Afghanistan and Pakistan the areas appear to overlap. On the other hand, both species are very closely related and sometimes intermediate specimens prove to be difficult to classify.

Distribution: Afghanistan, Kashmir, Pamir, Badakhshan.
Altitudes: 2500–4000 m
Ecology: Rubble slopes, dry valleys, near lakes, with *Artemisia persica* and *Polygonum coriarium*. Flowering: July-August.



MAP 3. ▲ *C. acanthophyllum*, ● *C. macracanthum*, ▽ *C. garanicum*, ■ *C. incanum*

Specimens examined: Afghanistan, Badakhshan: Edelberg 2166, Minjan, Miyan Deh (C, W); Frey 192, Tilli, Munjan (W); Podlech 12394, upper Anjuman Valley (E, M); Afghanistan-Wakhan: Renz 72, Sarchant Valley S of Qala Panja (W); Roemer 54, Quazideh (W); Wojtusiak s.n., Quazideh Valley (W).

Kashmir: Giles A 82, Glusar Valley, Gilgit (CAL); Wendelbo 45, Barum Gol below Zapobili, Chitral (BM, K, OXF).

USSR, Tadzhikistan: Ladmipa 13736, Badakshan, near Vanch (LE); Ovczinnikov and Afanassjev 1362, Wakhan, Ishkashim (LE); Paulsen 890 and 1057, mts near Lake Yashilkul (C).

2. C. anatolicum Alef. Fig. 2, p. 28; Map 4, p. 30

Bonplandia 9: 349. 1861; JAUB. et SP., Ann. Sci. Nat. Sér. 2: 230–31. 1842 and Ill. Or. 1: 83, t. 43B (as *C. songaricum* Steph.); BOISS., Fl. Orient. 2: 562. 1872; ZEDERBAUER, Ann. K. K. Natürhist. Hofmus. Wien 20: 404, 452. 1905; POPOV, op. cit. 206. 1929; POPOVA, Kult. Fl. SSSR 4: 67. 1937; PARSA, Fl. Iran 2: 436–9. 1948; LINCZEVSKI, in Fl. USSR 13: 391. 1948; GROSSGEIM, Fl. Kavkaza ed. 2, 5: 379. 1952; KARJAGIN in Fl. Azerb. 5: 475. 1954; MAKHADZHJANA, Fl. Armen. 4: 271–277. 1962; DAVIS, Fl. Turkey 3: 270. 1970.

Type: Turkey, in dumosis Tmoli (Boz dağ) BOISSIER, (G, holotype; isotypes in BM, C, K, P, WU).

Synonyms: *C. glutinosum* Alef., l.c.; *C. songaricum* Jaub. et Sp. non Steph., l.c.

Perennial. Woody rootstocks, branched from the base and at lower nodes, pubescent, mainly glandular hairs.

Stems straight or ascending, sometimes slightly flexuous, faintly ribbed, 20–40 (60) cm long.

Leaves (3)8–14(16) leaflets, (3)4–8(11) cm long, ending in a simple or (seldom) ramified tendril, sometimes in an endleaflet (lower leaves).

Leaflets opposite or nearly so, more or less close, cuneate-obovate, elliptic or subrotundate, 7–15(18) mm long, 4–10(13) mm wide, base rounded-cuneate or cuneate, top acuminate or rounded, margin dentate except near the base, teeth linear-triangular, acuminate, spinulate, tooth of midrib longer than the lateral ones, often inflexed, sometimes tendrillous, lower side more intensely pubescent than the upper side.

Stipules oblique, triangular-incised, small (upper leaves) or nearly as big as the leaflets, generally half as big as the leaflets, broad at lower leaves, (1)3–11 mm long, (1)3–8(10) mm wide, 4–6 unequal teeth, triangular or obtuse, acuminate.

Flowers in 1–2-flowered axillary racemes; peduncles 20–45 mm long, ending in a pointed arista, 3–4 mm long; bracts minute triangular perules, faintly dentate or not; pedicels 5–10(12) mm long, recurved when bearing pods.

Calyx dorsally gibbous at the base; tube 3–5 mm; teeth broad or lanceolate, acuminate, 5–8 mm long.

Corolla veined, lilac, dark blue, violet purple or lavender, exterior of flag green; vexillum obovate, 19–23 mm long, 15–16 mm wide, top emarginate-mucronate, base spoonshaped; alae oblong-obovate, ca. 16 mm long, 7–8 mm wide, base (5 mm) longly auriculate (3 mm); carina rhomboid, ventral margin curved, not angular, adnate for ⅔ from the top, ca. 14 mm, base ca. 5 mm.

FIG. 2. *C. anatolicum* Alef. – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. pod, $^5/_6$ ×; 4. flag, $2^1/_2$ ×; 5. wing, $2^1/_2$ ×; 6. keel, $2^1/_2$ ×; 7. anthers, $2^1/_2$ ×; 8. pistil, $2^1/_2$ ×; 9. seed, $2^1/_2$ × (ARCHIBALD 2187, E)

Stamens 9 + 1, persistent, 12 mm long (fused part ca. 9 mm, free part ca. 3 mm).

Ovary oblong-ovate, 7 mm long, 3 mm wide, 6–7 ovules, style ca. 8 mm, upturned.

Pods elliptical-oblong, 20–30 mm long, ca. 10 mm wide.

Seeds subglobular to nearly rounded-triangular, beaked, 5–7 mm long, seed coat dark brown to black with greyish ridges, chalazal tubercle small, flat.

Note

The differences from the related species in the section *Polycicer* are rather difficult to describe. In fact hardly any characteristic of *C. anatolicum*, that would never occur in any of the related species, is difficult to find. The leaves have less pairs of leaflets than in *C. microphyllum* and *C. nuristanicum*. The first pair of leaflets tends to be placed very near to the stem, like in *C. nuristanicum* but unlike in *C. songaricum* and *C. microphyllum*. The leaflets are as large as in *C. nuristanicum*, but more often cuneate-obovate, distinctly thicker and with coarser veins. The leaflets mostly are more elliptical and oblong than in *C. songaricum*, and usually not so small and narrow as in *C. microphyllum*. The leaflets are toothed up to near the base, as in *C. nuristanicum*, but not as in *C. songaricum*, *C. microphyllum* and *C. flexuosum*. The stipules are less toothed than in *C. songaricum*, as in *C. microphyllum*, and very small in the upper leaves. The inflorescences are mostly 2-flowered, unlike *C. songaricum* and unlike the majority of inflorescences in *C. microphyllum* and *C. nuristanicum*. The seeds are larger than in *C. microphyllum*, and often slightly larger than in *C. songaricum*. The most direct way to distinguish *C. anatolicum* is by its geographical distribution: Asia Minor and the Elburz mountains of Iran. The other species occur in Central Asia, the Himalayas, and Afghanistan.

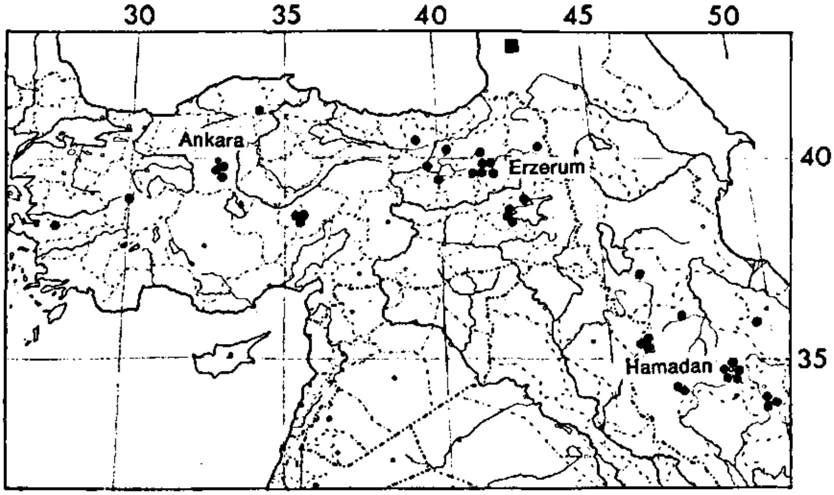
Distribution: Turkey (Anatolian part), N.W. and W. Iran, N. Iraq, Soviet Armenia.

Altitudes: 1150–3300 m

Ecology: Sandy, rocky and rubble sloped, calcareous or not, sometimes igneous, schistous, metamorphic, in scrub or *Pinus nigra* forest, *Juniperus*, dry places near water. Flowering: May-August (September).

Specimens examined: Iran: Archibald 2187, Kurdistan, 3 km N of Zarineh (E, K); Aucher-Eloy 1127, Kuh-e-Alvand (BM, G, K, MPU, OXF, P, WU); Balls 106, Kuh-e-Alvand (E); Haussknecht s.n., Pir Omar Gudrun (P); Haussknecht s.n., Avroman Dagh Mts, Schahu (BM, JE, K, P, WU); Haussknecht 303, Schahu Mt (JE); Iranshah 13300, Kurdistan, Devan-Danch, Sharifabad (W); Koelz 17867, Bakhtiari prov., Gahar (W); Knapp s.n. (WU); de Lerfest s.n. (C); Michaux s.n. (P); Olivier s.n., Kermanshah to Amadan (P); Pichler s.n., Kuh-e-Alvand near Haidare (K, W, WU); Pichler s.n., Kuh-e-Alvand, Malaier Pass near Hamadan (G, JE, WU); Pichler s.n., foothills of Kuh-e-Alvand (W); Strauss 87, Kuh-e-Alvand (G, K); Strauss s.n., Tshehar-Khatun Mt, Kuh-i-Raswend (G, JE); Strauss s.n., mts near Nehavand (JE); Strauss s.n., Arak (Sultanabad), Kuh-i-Raswend (JE, K, W); Strauss s.n., Arak (Sultanabad) (JE); Strauss s.n., Kuh-e-Alvand, near Hamadan (JE); Strauss s.n., Saweh, Arak (Sultanabad) (JE); Velliard s.n., Kuh-e-Alvand (C).

Iraq: Gillett 11894, Jebel Avroman above Darimar (K).



MAP 4. • *C. anatolicum*, ■ *C. balcaricum*

Turkey: Akman s.n., Ankara, Beyman forest (June) (ANK); Akman s.n., ibid. (Sept.) (ANK); Attila s.n., Palandöken Dag (ISTF); Aucher-Eloy s.n., ad Araxem (Aras river) (P); Bağda, Hacikadin Kiraş, Ankara (ISTF 1429); Baki 274, Ankara, Beynam forest (K); Balansa 920, Argaeus Mt (Erciyas Dağ) (BM, G, JE, K, MPU, P, W, WU); Balls 1767, Vavuk Dağ, Bayburt (K); Başarman s.n., Ankara (ISTF); Boissier, in dumosis Tmoli (Boz Dağ) (BM, C, G, K, P, WU); Calvert and Zohrab 237, Erzurum (JE, K, OXF); Davis and Polunin 23549, Nemrut Dağ, prov. Bitlis (BM, E, K); id. 24751, Suphan Dağ, prov. Bitlis (ANK, E, K); Davis and Hedge 29276, Pülümür, prov. Tunceli (K); id. 29492, Pasinler-Horasam, prov. Erzurum (ANK, BM, E, K); id. 31766, Keşiş Dağ above Cimin, prov. Erzincan (BM, E, K); Davis en Coode 36852, Murat Dağ above Gediz below Hamann, prov. Kütahya (K); Davis 46010, Pelli Dağ W side, prov. Bitlis (E, K); id. 47623, 30–32 km from Oltu to Tortum, prov. Erzerum (E, K); Heilbronn s.n., Kayseri (Erciyas Dağ?) (ISTF); id. s.n., Kop Dağ (ISTF); Huet du Pavillon 15, stream near Erzurum (BM, G, JE, K, L, W, WU); Kotschy 208, above Tshomakli near Kayseri (G, JE, K, P, WU); McNeill 592, Nemrut Dağ, prov. Bitlis (E, K); Siehe 198, steam near Assendjik (?), Cappadocia (BM, G, JE, K, W, WU); Sintenis 4181, Tosya, Giaur Dağ, Vilajet Kastambuli, prov. Kastamonu (BM, G, JE, K, P, W, WU); Sintenis 5745, Gümüşane, Aegyri Dağ (BM, BR, C, E, G, JE, K, L, M, P, W, WU); de Tchikatchef 549, W Asia Minor (P); Walther s.n., Palandöken Dağ, S of Erzurum (WAG); Watson et al. 3215, Gavur Dağ N of Erzurum (E); Wiedemann s.n., Elma Dağ near Ankara (K); Zederbauer s.n., Ercyas Dağ (near Kayseri) (WU); Zorab 544, Erzurum (K).

USSR, Caucasus: Sosnovsky 129, near Salačur, prov. Kars, distr. Olty (K, W).

3. C. arietinum L. **Fig. 3, p. 33; Map 1, 2, 22; p. 8, 16, 146**

Sp. Pl. ed. 1–2: 738. 1753; QUER, Fl. Espan. 4: 243. 1764; GAERNTNER• Fruct. Sem. Pl. 2: 151, 326. 1791; HOUTTUYN, Artsenygewassen 2: 74. 1796; DC et DE LA MARCK, Fl. Franc. éd. 3, 4: 600. 1805; SIMS, Curtis's Bot. Mag. 49: t. 2274. 1822; DC., Prodr. 2: 354. 1825; ROXBURGH, Fl. Indica 3: 324. 1832; JAUBERT and SPACH, Ann. Sci. Nat. Bot. Sér. 2–18: 326. 1842 and Ill. Pl. Orient. 1: 83. 1842; LEDEBOUR, Fl. Ross. 1: 660. 1842; ALEFELD, Oest. Bot. Zeitschr. 9–11: 355. 1859; BOISSIER, Fl. Orient. 2: 560. 1872; ROXBURGH, Fl. Indica 3: 567. 1874; TRAUTVETTER, Acta Hort. Petrop. 3: 33. 1875; BAKER in

HOOKER, Fl. Brit. India 2: 176. 1879; NYMAN, Comp. Fl. Europ.: 200. 1878–1882; AITCHISON, Transact. Linn. Soc. London 2nd ser. Bot. 3-1: 59. 1888; POST, Fl. Syria, Palest. Sinai: 284. 1896; PRAIN, Bengal Pl. 1: 259. 1903 (repr. 1963); HOWARD, HOWARD and KHAN, Mem. Dept. Agric. India 7–6: 213. 1915; GAMS in Hegi, Ill. Fl. Mittel-Eur. 4–3: 1499. 1924; HAINES, Bot. of Bihar and Orissa: 248. 1925; PROSOROVA, Nut (Cicer) Leningrad: 5–18. 1927; POPOV, op. cit. 177. 1929; VAVILOV, Agricult. in Afghan.: 341–345, 1929; KHAN et al., Mem. Dept. Agric. India. 19–2: 27–47. 1933; KRILOVA, Fl. Zapadn. Sibirj. 7: 1782. 1933; POPOVA, Kult. Fl. SSSR 4: 25–71. 1937; CABALLERO, Fl. Anal. España: 557. 1940; RECHINGER, Fl. Aegaea: 322. 1943; PARSA, Fl. Iran. 2: 435. 1943; LINCZEVSKI, Fl. USSR 13: 388. 1948; GROSSGEIM, Fl. Kavkaza ed. 2–5: 378. 1952; KARJAGIN, Fl. Azerbaidzh. 5: 475. 1954; CUFODONTIS, Bull. Jard. Bot. Brux. 25–3, suppl.: 306. 1955; Fl. Romanica. 5: 348. 1957; RECHINGER, Biol. Skrift. Kong. Dansk. Vidensk. Selsk. 9: 200. 1957; KITAMURA, Fl. Afghan. 223. 1960; MAKHADZHJANA, Fl. Armen. 4: 271. 1962; ZHUKOVSKY, Cult. Plants and Wild Relatives: 26. 1962; KOMAROV, Opr. Rast. Severn. Tadzhikistan, Dushan: 283. 1967; FÜRNKRANZ, Oest. Bot. Zeitschr. 115: 403. 1968; DAVIS, Fl. Turk. 3: 272. 1970.

Type: Spain, Italy, Hort. Cliff. 370 (BM, holotype).

Synonyms: *C. grossum*, Salisb., Prodr.: 340. 1796; *C. sativum* Schkuhr, Handb. 2: 367, t. 202. 1808; *C. physodes* Reichb., Fl. Germ. Excurs.: 532. 1830; *C. rotundum* Jord. ex Alef., Oest. Bot. Zeitschr. 9–11: 356. 1859.

Annual. Widely cultivated for the seeds, deep rooting (1–2 m), more or less branched from the base, and secondary branched at various places. Plant type semi-erect, sometimes erect or prostrate. All parts except the corolla glandular and eglandular pubescent.

Stems straight or flexuous, ribbed, (20)25–60(75) cm long.

Leaves imparipinnate, 11–13(15–17) leaflets, first leaves sometimes with fewer leaflets; rachis 25–60(75) mm long, grooved above, ending in a topleaflet, middle green, somewhat olive, or dark green, with or without anthocyane, in extreme cases purple, sometimes light yellowish green.

Leaflets opposite or not, more or less crowded, subsessile, obovate-oblong to elliptic, (6)10–15(20) mm long, (3)4–12(14) mm wide, base narrowly to broadly cuneate or rounded, top rounded-acuminate, margin serrate, often irregularly, up to about doubly serrate, except at the base, teeth rectangular or triangular-acuminate, tooth at the top of the leaflet pronounced, up to 1.5(2) mm, sometimes incurved, lower surface more prominently ribbed and glandular pubescent than the upper surface.

Stipules ovate to oblique-triangular incised perules, 2–4(6) teeth, 3–5(11) mm long, (1)2–4(6) mm wide, in some cases up to 14 mm long (seedlings).

Flowers in 1(rarely 2)-flowered axillary racemes, peduncles (6–8)13–17(30) mm, ending in a small perule or arista, 0.2–4 mm; bracts small triangular or tripartite perules, up to 1.5 mm; pedicels 6–13 mm, straight when flowering, recurved when bearing fruits.

Calyx faintly dorsally gibbous at the base; tube 3–4 mm; teeth lanceolate, 5–6 mm long, midrib prominent.

Corolla veined, pinkish, purplish or red (fading into blue) or white, rarely greenish white or blue.

Vexillum obovate, 8–10(11) mm long, 7–10 mm wide, exterior glabrous or loosely pubescent with eglandular hairs; alae obovate, 6–9 mm long, ca. 4 mm, wide, at the base (1–2 mm) auriculate (1 mm); carina rhomboid, 6–8 mm, pedicel 2–3 mm, ⅔ of frontal side of ventral margin adnate.

Stamens 9 + 1, sometimes persistent, filaments 6–8 mm long (fused part 4–5 mm, free part 2–3 mm, upturned), anthers basi-dorsifix.

Ovary ovate, 2–3 mm long, 1–1.5 mm wide, 2(–4) ovules, style 3–4 mm, glabrous or hairy except for last mm, upturned, stigma hardly broadened when pollinated.

Pods rhomboid-ellipsoid (ovate-oblong), densily mainly glandular pubescent, 14–25 (29) mm long, 8–15 (20) mm wide.

Seeds ovate-globular or angular, beaked, (4)7–10(11) mm long, (4)5–8 mm wide, seed coat colourless, white or creamy, yellowish with an orange tinge, most often brown in various shades, further black or dull green; surface smooth, wrinkled or tuberculate. Sometimes minute black dots are present or a mosaic pattern. Chalazal tubercle (spermotylium) prominent, hilum deep, greyish, with a conspicuously coloured margin.

Distribution, altitudes and ecology: see chapters 3, 5 and 6.

Vernacular names:

Afghanistan: nakhut

Albania: kikere (Pelasgian)

Arabian countries: hommes, homms, homos, omnos, hammes, hammous, hamiça, hamos, alhamos, chemps, jumez, beiqa (the seeds and the crop); melaneh, hommos-melana (the plant); blabi, lablabi, leblebi (roasted seeds)

Bulgaria: nakhut, slanutok

Burma: kalapai, kulapia ('western, exotic beans')

Denmark: fugleørt, musørt, kikeraert

Ethiopia: chimbera, scembira, shimbrah (Amharic, Galla p.p.); seberé (Adi-Quala); atir, atir saho, atir cajeh ('pea, red pea' Tigre and Tigrina); adungaré (also beans in general, Galla)

Finland: kahviherne

France: pois chiche (mostly used); pois bécu, pois blanc, pois de brebis, pois breton, pois café, pois chabot, pois ciche, pois citron, pois cornu, pois gris, pois pointu, pois tête de bélier; becudo (Languedoc); café français, césé (Montpellier); céséron, cézé (S.E.); cézérons, ciche, cicérole, ciserole, ciserolle, garance, gairoutte, garvanche, garvance, garvane, garvanna; seses (Marseille)

Germany: Kichererbse (mostly used), Chicher, Chichina, Chichuria, Cicererbis, Cisa, Cyfer, Czycke, Deutsche Kaffeebohne, Deutscher Kaffee, Echte Kicher, Fontanellerbse, Garabanzen, Graue Erbsen, Kaffeeerbsen, Kecher, Kicher, Keicheren, Kekeren, Keyker, Kicher Erbsen, Kicher(n) Kraut, Kicherling, Kicher(e)n, Malagaerbsen, Römische Kicher, Spärber-

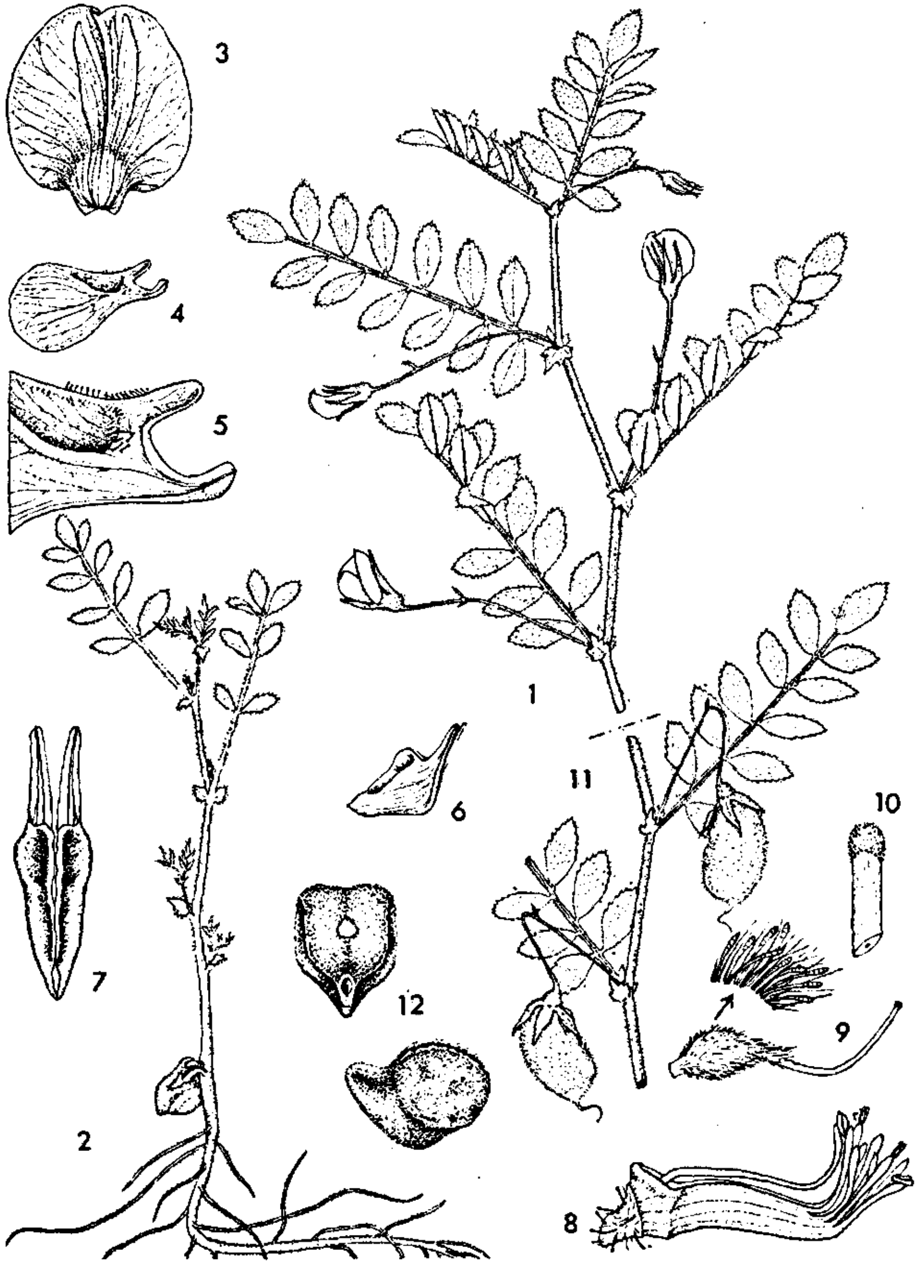


FIG. 3. *C. arietinum* L. – 1. branch, $^5/_6$ ×; 2. seedling, $^5/_6$ ×; 3. flag, $2^1/_2$ ×; 4. wing, $2^1/_2$ ×; 5. detail of wing, $7^1/_2$ ×; 6. keel, side view, $2^1/_2$ ×; 7. keel, dorsal view, 5 ×; 8. anthers, 5 ×; 9. ovary, 5 ×; 10. style, stigma, 20 ×; 11. fruiting branch, $^5/_6$ ×; 12. seed, $2^1/_2$ × (WESTPHAL 4049 B, 7696–8, Ethiopia, WAG)

kopfel, Sisern, Sekeren, Venuskicher, Ziesererbsen, Zisererwedsen, Ziser (2), Ziserbohne

Great Britain and anglophone countries: chickpea (mostly used), arich pea, barnchiches, chiches, Egyptian pea, garavance, garbanzo bean (USA) hamoos pea (from the Arabic) (chickpea is a corruption of chich-pea, from Index Kewensis cf. Sims in Curtis's Bot. Mag. 1822).

Greece: erebinthos, krios (ancient); rebinthia, revithia (modern); stragaliais (roasted seeds)

Hungary: hagoly-borsó, hagolsa, bagoly borsó, bagolych-borsó ('owl's pea'); csicseri borsó

Indian subcontinent: gram, common gram, Bengal gram (English); chana (mostly used, Hindi); adas, but, channa, chunna, chela, hurbari, rohala (Hindi); chole, chana (Punjabi); chana, chola (Rajputana); but, buthalai, boot-kaley, chala, chola, chota but (Bengali); chana, chania (Gujerati), boot (Orya), harbara (Marathi); kadalai, sundal kadalai (Tamil); harimandha-kam, sanagalu (Telugu); kadale (kannada); kadala (Malagalan); mong, moong (Kashmir); butmah (Assamese); karikadale, kempukadade, kudoly (Canarese); kadli (Karnatic); chono (Konkani); but, morujang (Mundari); but (Santali); chahna, chana (Sindhi); korkadala (Sinhalese); balabhaishajya, balabhojya, chanaka, chennuka, harimantha, jivana, kanchuki, Krishnachanchuka, sakalapriya, sugandha, Vajibhakshya, Vajimantha (Sanskrit)

Iran: nakhud, nokhot

Israel: chimtza tarbutit, chimtza, chumtza (Aramese); ketsech?, kiker, chimtza (from chomitz, acid) (Hebrew); karbantos (from the Spanish); hamiz, humus (from the Arabic)

Italy: cece, ceci, cecio, cece bianco, cesari; cesco (Liguria); sisar, scisser (Tessin); spizole, arbia (S. Tirol)

Kenya: mdengu (Swahili)

Netherlands: keker, kekererwt, kicher (also Flemish); cicererwt, citrullen, citsers, sisser, sissererwt, Spaanse erwt

Northern Africa: ikiker, kiker, hamaz (Berber); djelbane (Berber Tamachel)

Norway: bukkeert

Poland: nut, ciciorka, ciecierzyca pospolita

Portugal: grâo, grâo de bico, agrâo de bico, chicaro, ervanços

Rumania: naut, nohot

South Africa: dwerg ertjie

Spain and Latin America: garbanzo (mostly used); gravancos; sigró, ciuro (Catalonia); garbantzua (Basque)

Sudan: hommez, kabkaza

Sweden: kikärt, kaffeärt

Turkey: nohut, nohud, nachius

USSR: nut, nakhut, nokhut, nukhut; nachunt (Armenia); nokhud (Azerbaydzhan); mukhudo; ovetche harokh (sheep's pea); puzirnyj gorokh (glandular pea)

Specimens examined: numerous, from all cited herbaria, except LE, MW, with living and preserved material, grown from collections obtained from Lyallpur, New Delhi, and other institutes as mentioned in Section 6.1.

4. C. atlanticum Coss. ex Maire **Fig. 4, p. 36; Map 5, p. 37**

Coss. ex BATTAND and TRAB., Fl. Alger.: 267. 1889 (nomen); MAIRE, Bull. Soc. Hist. Nat. Afr. Nord 19: 42. 1928; POPOV, op. cit. 188. 1929.

Syntypes: Morocco, Mt Aziouel, Seksaoua and Mt Ouensa and Mt Taboughert, Ait-Adouyouz, IBRAHIM s.n.; and Mt Gourza, Goundafa, HUMBERT and MAIRE (P, holotypes; isotypes in BM, BR, C, G, K, MPU).

Homotypic synonym: *C. maroccanum* M. Pop., op. cit. 188. 1929.

Perennial herb. Long slender rootstocks, creeping between stones, noded. All aerial parts glandular pubescent.

Stems leaved part erect-flexuous, ribbed, 4–10 cm, terrestrial part long, internodes up to 5 cm, sparsely pubescent, with small unifoliolate leaves on the nodes.

Leaves lower ones short, upper ones longer with more leaflets, 3–15 leaflets, imparipinnate, rachis 5–30 mm, ending in a topleaflet or a pair of leaflets.

Leaflets crowded, opposite or nearly so, cuneate-oblong or oblong, base cuneate, top rounded, dentate, 5–9 teeth, triangular or with rounded margins, up to 1 mm long, top obtuse, 5–10 mm long, 3–5 mm wide, lower surface more prominently veined than upper surface.

Stipules ovate, acuminate or with 2–3 irregular dents, up to 3 mm, prominently veined.

Flowers in single-flowered axillary racemes, peduncle 9–15 mm, ending in an arista, 2–5 mm, bracts minute perules, pedicels 3–7 mm, recurved when bearing pods.

Calyx dorsally gibbous at the base, prominently veined; tube ca. 4 mm; teeth lanceolate-acuminate, 3–6 mm.

Corolla veined, rose-purplish, lighter purple stripes, outside less pigmented, vexillum obovate, 13–15 mm long, 10 mm wide, top emarginate-mucronate.

Pods ovate, 15 mm long, 8 mm wide, 1–2 seeded.

Seeds ovoid, sharply beaked; sidely compressed, seed coat brown (black teste Maire), surface finely tuberculated.

Note

Cicer atlanticum is endemic to Morocco and more material is badly needed for a better knowledge of its ecology and geography, and in relation to plant breeding. The isolated position outside of the proper area of the genus *Cicer* has given rise to different theories on its origin.

Distribution: Morocco.

Altitudes: 2700–2900 m

Ecology: alpine vegetation, schistous rubble slopes, mountain tops. Flowering: June-August.

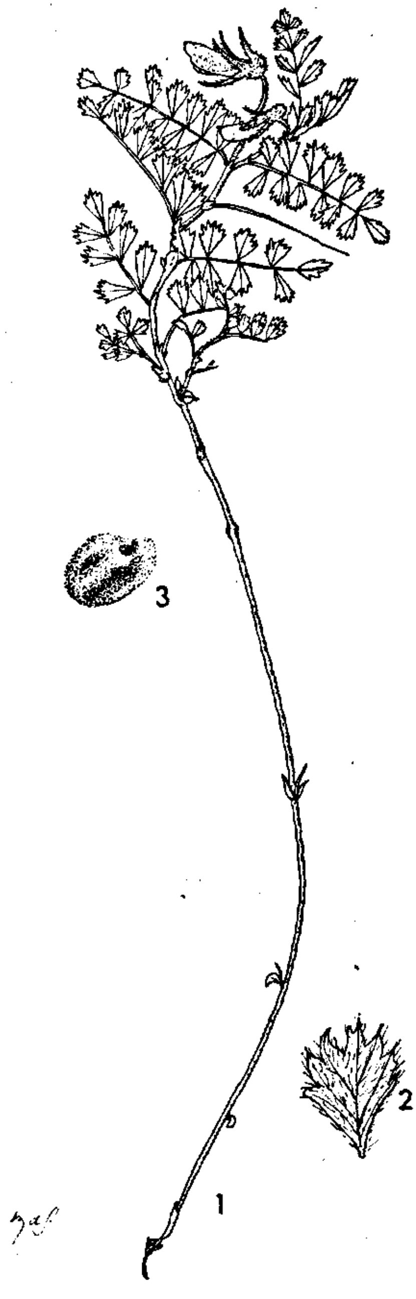
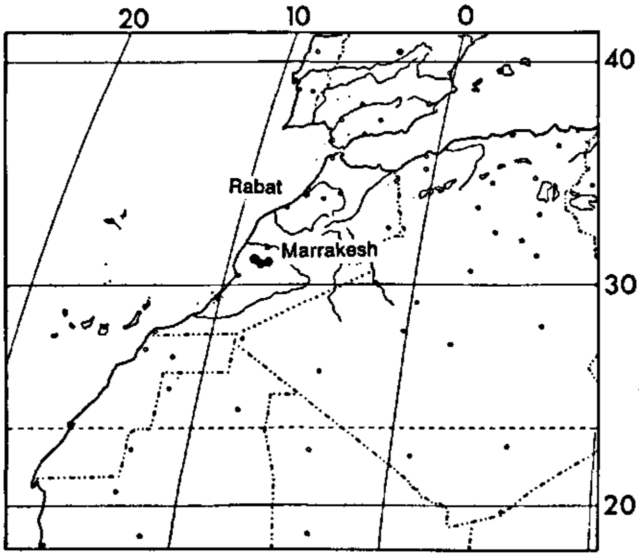


FIG. 4. *C. atlanticum* Coss. ex Maire – 1. plant, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. seed, $2^1/_2$ ×
(IBRAHIM, syntype, P)



MAP 5. *C. atlanticum*

Specimens examined: Morocco: cited syntype specimen; Institut Scientifique Chérifien 26780, Pic de Timerquet (near Dj. Tizirt?), Grand Atlas (RAB).

5. C. balcaricum Galushko **Map 4, p. 30**

Novit. Syst. Plant. Vasc. 6: 174–176. 1970.

Type: Caucasus, Balcaria, source of Baksan R., near Elbrus village, 2000 m, GALUSHKO and KURDJASHOVA 25–8–1964 (LE, holotype, not seen).

Perennial. Branched from the base, more or less glandular pubescent.

Stems erect or subascendent, flexuous, ribbed, 30–60 cm long.

Leaves paripinnate, 12–16(18) leaflets, rachis 6–10 cm long, ending in a simple tendril, or in a leaflet (lower leaves).

Leaflets obovate, oblong-obovate, cuneate-obovate or elliptic, 10–15 mm long, base cuneate, margin serrate except near the base, sometimes doubly serrate, teeth acute with a spinelet, 3–3.5 mm long, the teeth of the midrib reflexed.

Stipules ovate-lanceolate, nerves prominent, 5–7 mm long, teeth acute, up to half as long as the stipules.

Flowers in 2-flowered axillary racemes, peduncles 35–45 mm long, ending in a spiny arista, 5–11 mm long; pedicel 3–10(12) mm long.

Calyx gibbous at the base, glandular pubescent, 11–14 mm long.

Corolla blue-violet, exterior glabrous or hairy; vexillum broadly obovate, 20–25 mm long, top emarginate; carina shortly rostrate.

Pod oblong, 25–36 mm long, glandular pubescent (villose).

Seeds obovate, beaked, 4–5 mm long, seed coat black, rough.

Note

From this species no material or illustration was seen, and so the protologue was taken for the description. The differences with *C. anatolicum*, *C. flexuosum* and *C. songaricum* are the cuneate base of the leaflets and the form of the teeth of the leaflets.

Distrubution: Caucasus.
Altitude: 2000 m
Ecology: Southern exposed rubble slopes.

6. C. baldshuanicum (M. Pop.) Lincz. **Fig. 5, p. 39; Map 6, p. 40**

Not. Syst. Herb. Inst. Bot. Acad. Sci. USSR 9: 112. (1948?) 1949; Linczevski in Fl. USSR 13: 395. 1948.

Type: Tadzhikistan, lower Darvaz Mts between Chovaling and Jach-su rivers, from Zagara to Jach-su river, MICHELSON 1428 (LE, holotype, not seen).

Paratypes: Baldshuan, Regel (LE), Kuljab, near Czargi, DIVNOGORSKAJA 503 (LE), Shuro-abad near Pushalak, LINCZEVSKI and MASLENNIKOVA 901 (LE), Tirjai Mts near Piandsh river, between Chirmandshou and Anshirou-pojen villages (N of Shuro-Abad), LINCZEVSKI 477 (LE).

Basionym: *C. flexuosum* Lipsky subsp. *baldshuanicum* M. Pop., op. cit. 211. 1929.

Perennial. Roots woody, branched from the base, sparsely (mainly eglandular) pubescent.
Stems straight or slightly flexuous, faintly ribbed, 30–40 cm long.
Leaves 8–14 leaflets, rachis 5–10(12) cm long, grooved above, ending in a simple tendril, seldom a tendrillous leaflet.
Leaflets opposite or nearly so, not very close, rounded to cuneate-truncate, 5–18 mm long, 4–15 mm wide; base rounded-cuneate, top incised or truncate, margin dentate except near the base, teeth broadly triangular, acuminate, up to 2 mm, tooth of midrib shorter than the lateral ones and often recurved.
Stipules flabellate, 4–8 mm long, with 5–9 teeth, up to half as long as the stipule.
Flowers in 1–2-flowered axillary racemes; peduncle 3–6 cm long, ending in a sturdy arista, 5–10 mm long; bracts minute single or incised perules; pedicels 6–11 mm, recurved when bearing fruits.
Calyx dorsally gibbous at the base; tube ca. 3 mm; teeth ca. 6 mm, broadly acuminate.
Corolla veined; vexillum obovate, 20 mm long, 14–18 mm wide, base spoon-shaped; alae obovate, ca. 15 mm long, 7 mm wide, base longly auriculate; carina rhomboid.
Stamens 9 + 1, persistent, filaments ca. 12 mm (fused part 8 mm, free part 4 mm, upturned); ovary ovate-elongate, ca. 4 mm, style ca. 7 mm, upturned.
Pods rhomboid-elongate, shortly (mainly eglandular) pubescent.
Seeds not known.

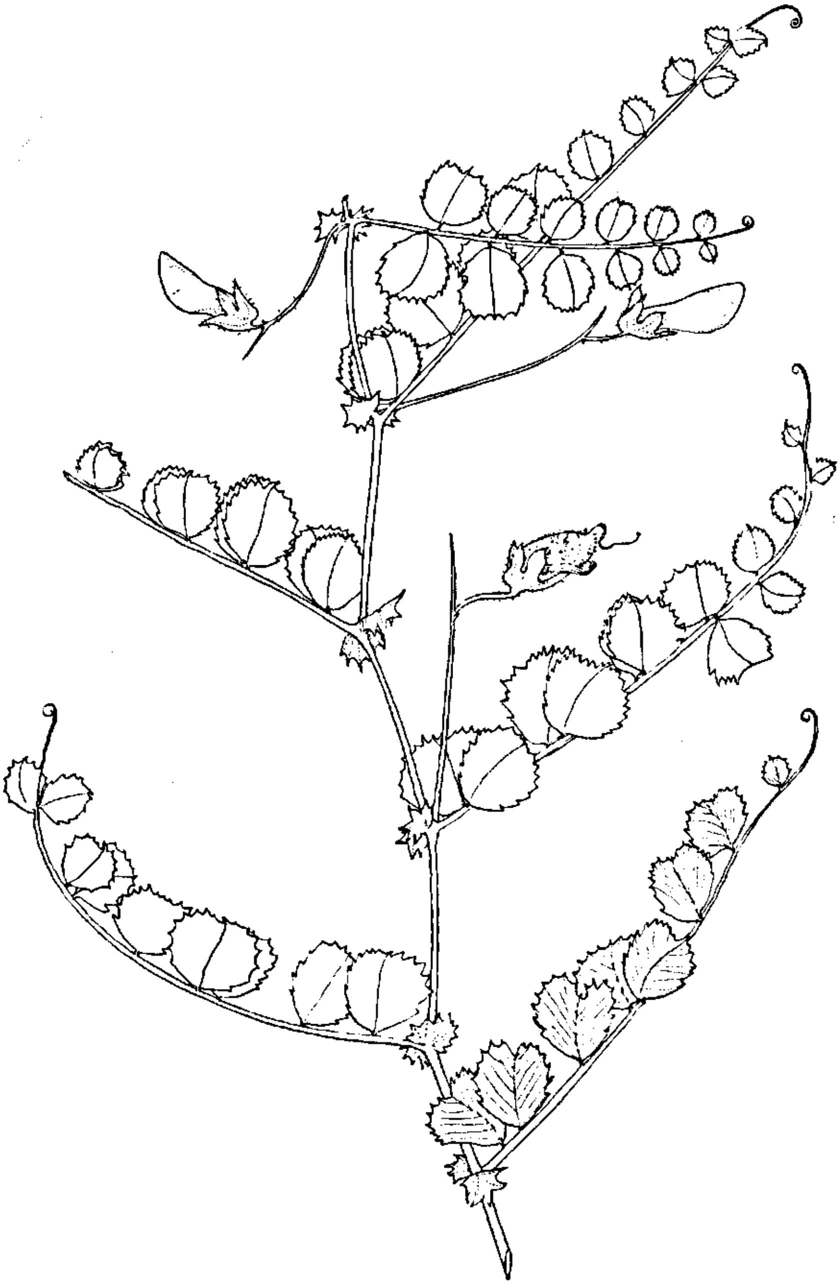
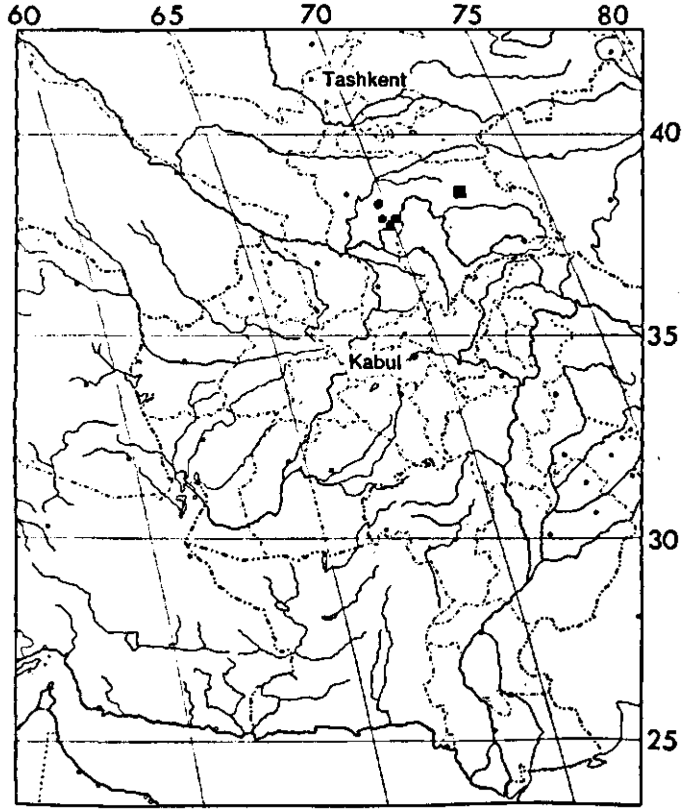


FIG. 5. *C. baldshuanicum* (M. Pop.) Lincz. – branch, $^{5}/_{6}$ × (DIVNOGORSKAJA 503, LE)

Note on publications of LINCZEVSKI: The 5 species new described by LINCZEVSKI or raised by him to the rank of a species were published in Not. Syst. Inst. Bot. Acad. Sci. USSR 9, which was meant to appear in 1948, but appeared in 1949. Other information gave the day of publication as December 23, 1948 and this is later than the Flora of the USSR 13, published in January 24, 1948. The species are entered in the Flora (without latin description) earlier than in the other work, which met apparently with more delay.

Distribution: S. Tadzhikistan, Pamir-Alai.
Altitudes: 1600–2000 m
Ecology: on slopes, near water. Flowering: May-July.



MAP 6. • *C. baldshuanicum*, ■ *C. korshinskyi*

Specimens examined: USSR, Tadzhikistan: Divnogorskaja 503, Kulyab (LE, paratype); Linczevski and Maslennikova 477, N of Shuro-Abad (LE, paratype); id. 901, S of Shuro-Abad, near Pushalak (LE, paratype); Regel s.n., Baldshuan (LE, paratype).

7. C. bijugum K.H. Rech. **Fig. 6, p. 42; Map 7, p. 43**

Arkiv. Bot., Stockh., andra ser. 1: 510. 1952; RECHINGER, Arkiv. Bot., Stockh. 5-1: 257. 1959; DAVIS, Fl. Turkey 3: 272. 1970.

Type: Syria, Azaz, HARADJIAN 4442 (Hb. Del. holotype: in G; isotypes in G, K (photograph) W, WU).

Annual herb, branched mainly at the base, densely glandular-pubescent, on surfaces of leaves also eglandular hairs.

Stems erect or semi-erect, faintly ribbed, 15–30 cm long.

Leaves (3)5–7 leaflets, imparipinnate; rachis 15–25 mm, grooved above, ending in 1(–2) leaflets.

Leaflets fairly close, narrowly oblong-obovate, base cuneate, top rounded, (5)10–15(18) mm long, 3–8 mm wide, lower side more prominently veined than the upper side, margin dentated except near the base, teeth triangular, the top of the leaflets often doubly incised.

Stipules ovate-lanceolate with 1–2 teeth or flabellate with 3–5 teeth (lower part of the plant), 2–5 mm long, nerves prominent.

Flowers in single-flowered axillary racemes, peduncle 3–7 mm, ending in a tiny arista, 0–3 mm, bracts minute perules, pedicels 5–8 mm, recurved when bearing fruits.

Calyx slightly dorsally gibbous at the base, tube 2–3 mm, teeth triangular-lanceolate, 3–5 mm long.

Corolla veined, pink, light bluish-violet when fading, tip of keel violet; vexillum broadly ovate, nearly circular, 9 mm long, 10 mm wide, top emarginate, base broad, purplish; alae broadly obovate, 8 mm long, 5 mm wide, shortly based and auriculate; carina rhomboid, 6 mm long, $\frac{3}{4}$ of frontal side of ventral margin adnate, shortly based.

Stamens 9 + 1, filaments 6 mm (fused part 4 mm, free part 2 mm, upturned), anthers dorsifix.

Ovary ovoid, 3 mm long, 2 ovules; style 4 mm, upturned.

Pods elliptic-globular, 12–15 mm long, 8–9 mm wide, with long glandular hairs.

Seeds subglobular-beaked, 5–8 mm long, 3–6 mm wide, seed coat brownish black, densely echinulate, spines 0.5 mm; hilum and chalazal tubercle surrounded by spinelets.

Note

C. bijugum is different from *C. arietinum* by its smaller stature, the bijugate leaflets, smaller flowers and fruits and the echinulate seeds. Because it grows at medium altitudes, crossing with *C. arietinum*, which is closely allied, is quite possible.

Distribution: S.E. Anatolia, N. Syria, N. Iraq.

Altitudes: 500–1300 m

Ecology: weed in orchards, harvested and abandoned fields. Flowering: (April) May-June.

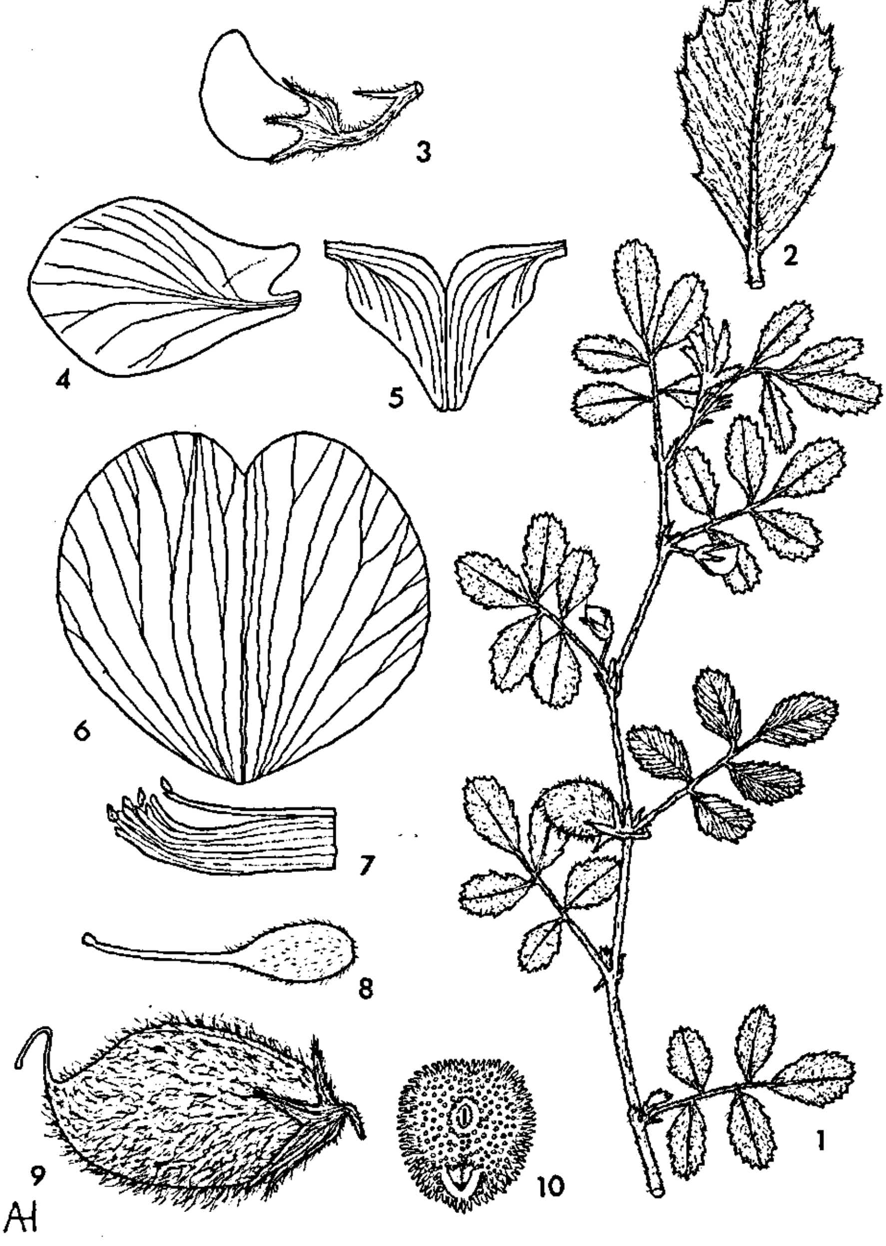
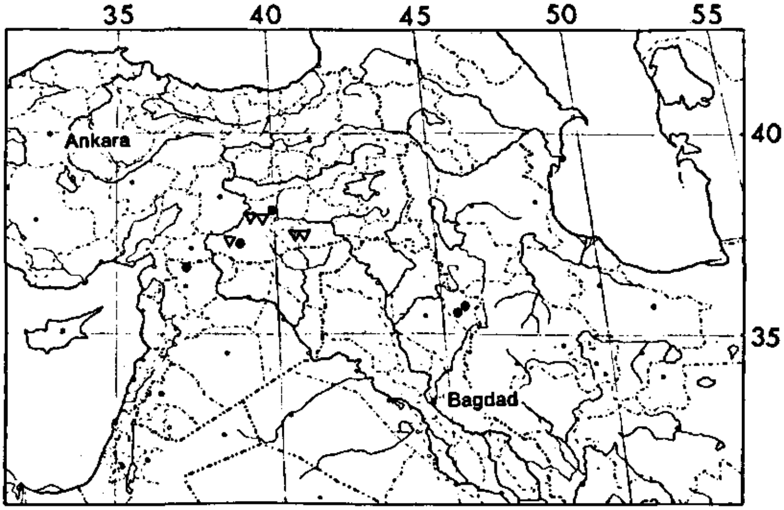


FIG. 6. *C. bijugum* K.H. Rech. – 1. branch, 5/6 ×; 2. leaflet, 2 1/2 ×; (HARADJIAN 4442, W) 3. flower, 2 1/2 ×; 4. wing, 5 ×; 5. keel, 5 ×; 6. flag, 5 ×; 7. anthers, 5 ×; 8. pistil, 5 ×; 9. pod, 2 1/2 ×; 10. seed, 5 × (ANK, s.n.s.d.)



MAP 7. • *C. bijugum*, ▽ *C. echinospermum*

Specimens examined: Iraq: Gillett and Rawi 7669, Bakrajao near Suleimanya (K); Wheeler Haines 1544, Kopi Qaradagh (E, K).

Syria: Frère Louis s.n., Deir et Djemal (N Syria) (P); id. s.n., Gatina (N Syria) (P); Haradjian 4442, near Azaz (G, holotype; K, W, WU).

Turkey: anon. sine loc. (ANK, WAG); Baytop s.n., 33 km from Diyarbakır to Elâzığ (ISTE 20.127 a, WAG); Sintenis 751, Urfa, near Kara-Pinar (K, MPU, W).

8. C. chorassanicum (Bge) M. Pop. **Fig. 7, p. 45; Map 8, p. 46**

op. cit. 180. 1929; PARSA, Fl. Iran 2: 435–436. 1943 (as *C. trifoliolatum* Bornm.); RECHINGER, Biol. Skrift. Kong. Dansk Vidensk. Selsk. 9–3: 200. 1957; KITAMURA, Fl. Afghan.: 223. 1960; PODLECH and DIETERLE, Candollea 24–2: 211–212. 1969.

Type: Iran, Khorassan Mts, BUNGE (ex BOISS.) (G? holotype, not seen).

Paratype (holotype of synonym *C. trifoliolatum* Bornm.): Iran, Elburz Mts, Shimran Mt, Ferasad village near Teheran, BORNMÜLLER 6636 (JE, holotype; WU, isotype).

Basionym: *Ononis chorassanica* Bunge in BOISSIER, Fl. Orient. 2: 62. 1872.

Synonym: *C. trifoliolatum* Bornm., Bull. Herb. Boiss. Sér. 2–5: 849. 1905.

Annual. More or less branched plantlet, all parts glandular pubescent, epicotyl long (up to 10 cm), colourless, ascending between pebbles.

Stems erect or semi-erect, simple or branched on lowest nodes, partly subsurfaceous, epigaeal part 5–15 cm, ribbed.

Leaves trifoliolate; petiole 10–23 mm, grooved above.

Leaflets cuneate-flabellate, 6–10 mm long, 3–9 mm wide, base cuneate, top rounded or truncate and dentated, upper surface clearly ribbed, green, lower surface prominently ribbed, purplish green, teeth triangular or rounded-acuminate, up to 1.5 mm.

Stipules minute, up to 1 mm, purple, major tooth with pronounced midrib, minor tooth if present also ribbed.

Flowers in single-flowered axillary racemes; peduncle 3–6 mm, ending in a purplish arista 2–9 mm; bracts minute; pedicel 3–6 mm, recurved when flower wilts.

Calyx dorsally gibbous at the base; tube 1–2 mm; teeth 2–3 mm, lanceolate, with three riblets.

Corolla veinea, 5–6 mm, pink, greenish, yellowish or creamy white with violet striped centre of flag and violet tipped keel; vexillum obovate, top slightly emarginate, mucronulate; alae obovate, at the base auriculate; carina rhomboid, topmost third of frontal side of ventral margin adnate, 4 mm long.

Stamens 9 + 1, persistent, filaments upturned, anthers basi-dorsifix.

Ovary ovoid, pilose with glandular hairs, one ovule; style upturned, papils of pistil recurved.

Pods ovoid, 8–10 mm long, 5–6 mm wide, one seeded.

Seeds ovate-globular, edged, beaked, 4–6 mm long, seed coat greyish brown, roughly tuberculated, chalazal tubercle round, black, slightly emerged.

Note

The amount of anthocyane pigment is variable, as in *C. arietinum* and *C. pinnatifidum*. Entirely green specimens also occur. This variation seems to be linked to the habitat although genetic factors can also be expected to play a role. Purplish leaves and other parts are not always accompanied by pink flowers, as is usually seen in *C. arietinum*.

Distribution: N. Afghanistan, N., N.E. Iran.

Altitudes: 1400–3300 m

Ecology: rocky and rubble slopes, sometimes calcareous or granitic, gneiss, dry valleys, Flowering: (April) May-July.

Specimens examined: Iran: Bornmüller, J. and A. 6636, Elburz Mts, near Teheran, above Ferasad (JE, WU); Gauba 579, Vessieh, near Karaj (W).

Afghanistan: Akhtar 706/45, Koh-a-Dukhtar-a-Kaffir, near Kabul, and Cult.! Kew (K); Edelberg 1861, Panjao (C, W); id. 1879, Deh Kundi (C); Furse 5692, 64 km N of Ghazni (K); id. 8396, 40 km W of Bamian (K); Gamble 48, Kabul (K); Gilli 1730, Jebel Seradsh (W); id. 1731, Tangi Gharu, near Mai Pass (W); id. 1732, Sher Darwasah (W); id. 1733, Sebroderahan Mt, S of Shewahi, lower Logar Valley (W); Hedge and Wendelbo W 3117, Kabul, Koh-i-Asamai (E); id. W 3575, Doab, prov. Bamian (E); id. W 4122, Ajar Valley, W of Doab, prov. Bamian (E); id. W 4652, Bamian, near hotel (E); Hedge and Ekberg W 7033, 8 km S of Kabul to Logar (E); id. W 7304, 15 km N of Gulestan, prov. Farah (E); Hedge and Wendelbo W 8681, Khash Kul bridge, Helmand R., prov. Vardah (E); Kerstan 508, Tengi-Gharu, Kabul R. (W); Koelz 12020, Nozi (E, W); id. 11873, Pule Alam, S of Kabul (W); Köie 2394, Hauz-i-Mahiha (near Ghazni) (C, E, W); id. 3675, Obeh-Chist (C); Lindberg 780, Tang-Saïdan Steppe (W); Neubauer 109, Kabul, rock near Aliabad (W); id. 569, Gulbahar (W); id. 570, Kabul, Sher Darwasa Mt (W); id. 3075, Panjshir Valley (W); Podlech 10964, Banu Middle Andarab Valley, prov. Baghlan (E, M); Rechinger 16632, Ajar Valley, W of Doab ('King's Valley') (W); ib. 16791, between Bulola and Shibarm, prov. Bamian (W); id. 17500, Arghandeb Valley

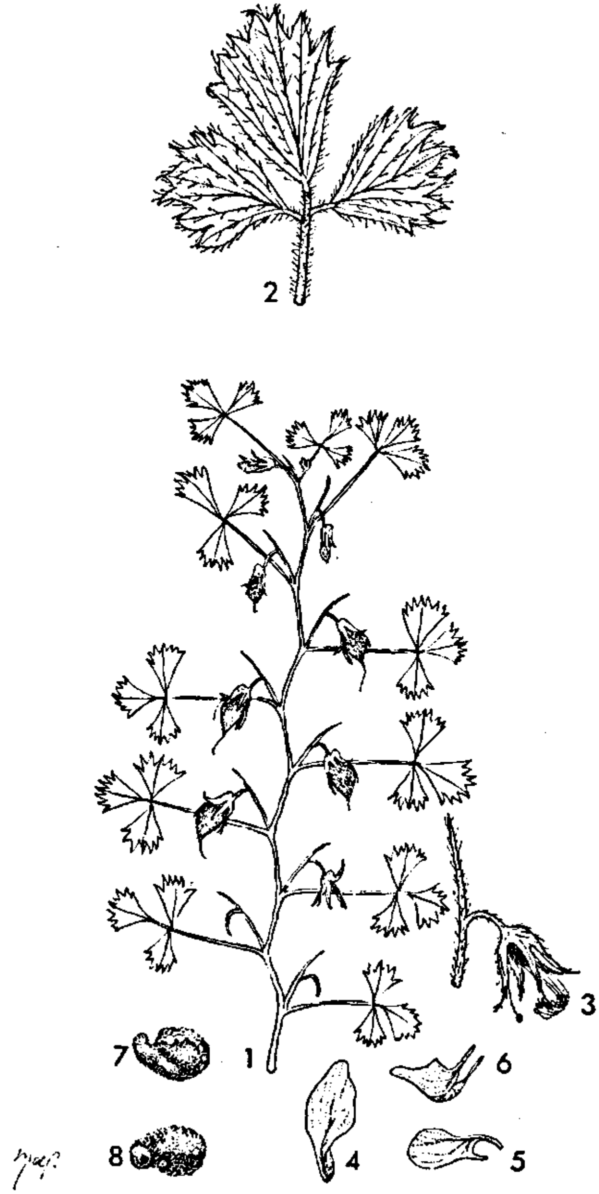
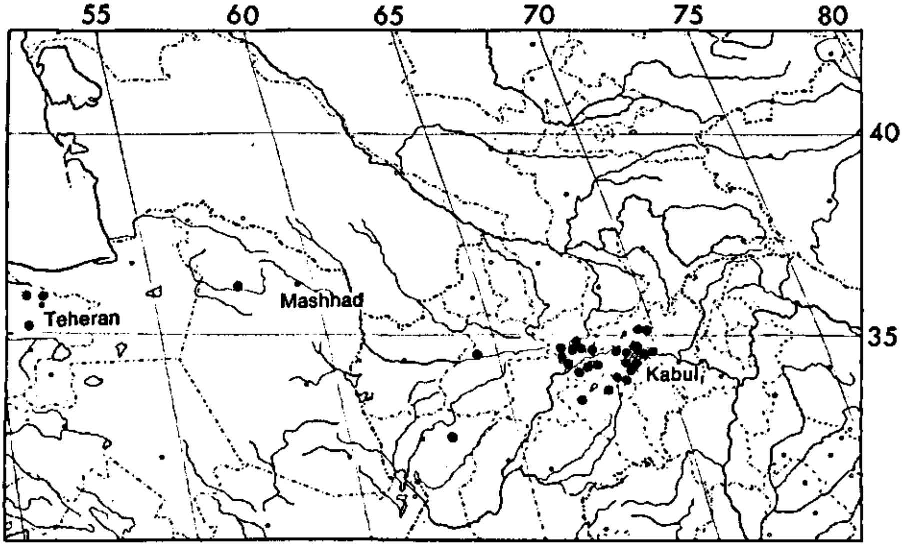


FIG. 7. *C. chorassanicum* (Bge) M. Pop. – 1. branch, $^{5}/_{6}$ ×; 2. leaf, $2^{1}/_{2}$ ×; 3. developing pod, $2^{1}/_{2}$ ×; 4. flag, $2^{1}/_{2}$ ×; 5. wing, $2^{1}/_{2}$ ×; 6. keel, $2^{1}/_{2}$ ×; 7, 8. seed, $2^{1}/_{2}$ × (1, 2, 8: RECHINGER 37414; 3–7: KÖIE 2394, W)



MAP 8. *C. chorassanicum*

near Sang-i-Masha, prov. Ghazni (W); id. 18149, between Bamian and Band-i-Amir (W); id. 18685, between Kotal Deraz Kol Mt and Panjao near Mandigak, prov. Bamian (W); id. 31160, 10 km NW of Kabul to Charikar (W); id. 34344, Tang-i-Gharu between Kabul and Sarobi (W); id. 36142, 38–45 km W of Behzud to Panjao (W); id. 36195, 12 km E of Panjao (W); id. 36392, Koh-i-Hisar, between Sauzak Sumaj and Serdah to Sad Barh Mt (W); id. 37414, between Okah and Ghazni (W); Scheibe 62, Tengi-Gharu, Kabul R. (W); Volk 167, 407, 842, 1805, Kabul and Panjshir Valley (W).

9. C. cuneatum Hochst. ex Rich. **Fig. 8, p. 48; Map 9, p. 49**

RICHARD, Tent. Flor. Abyss. 1: 195, 1847; ALEFELD, Oest. Bot. Zeitschr. 9: 356. 1859; BAKER in Oliver, Fl. Trop. Afr. 2: 172. 1871; ENGLER, Veget. Erde 9, Pflanzenwelt Afr. 3-1: 646. 1915; CUFODONTIS, Bull. Jard. Bot. Brux. 25-3 (suppl.): 306. 1955.

Syntypes: Ethiopia, Maye-Goua-Goua, QUARTIN DILLON (P; isotypes in W) and Axum, SCHIMPER sect. 3 1545 (1842) (P; isotypes in BM, G, K, L, MPU) and Kopsia (Kepsaid), SCHIMPER sect. 799 (1852) (P; isotype at K).

Synonym: *C. arietinum* Baker non Linn. in OLIVER, Fl. Trop. Afr. 2: 172. 1871.

Annual. Erect or semi-erect herb, more or less climbing habit, few branches at the base, glandular pubescent.

Stems flexuous in the upper part, faintly ribbed, 40–60 cm.

Leaves lower ones 8–10 leaflets, upper ones to 22 leaflets, opposite or nearly so, rachis (3)5–7(9) mm long, grooved above, mostly ending in a branched tendril, at the lower leaves also with endleaflet.

Leaflets fairly close, narrow-cuneate, base cuneate, top oval-dentated, 5–10 mm long, 2–5 mm wide, both sides clearly veined, lower side greyish green, upper side green; teeth triangular, pointed, up to 2 mm long, tooth of midrib often recurved.

Stipules incised-fanshaped, up till 7 mm, 2–4(5) teeth, clearly ribbed, longest tooth at the side of the leaf.

Flowers in 1-flowered axillary racemes, peduncle up till 30 mm long, ending in a slender arista, 4–12 mm long; bracts minute perules; petiole about 5 mm, recurved after the bud stage.

Calyx slightly dorsally gibbous at the base; tube 2–3 mm; teeth lanceolate-acuminate, 5–7 mm long.

Corolla veined, pink, vexillum obovate, top mucronulate, about 7 mm long, 4 mm wide; alae elongate-obovate, auriculate, 6 mm long, 2 mm wide; carina rhomboid, half of frontal side of ventral margin adnate, 7 mm long.

Stamens 9 + 1, filaments 6–7 mm, (fused part 5 mm, free part 1–2 mm, slightly upturned), anthers dorsifix.

Ovary ovate, 3 mm long, 4 ovules; style 4 mm, upturned.

Pods elliptic-obtuse, 15–23 mm, 7–10 mm wide, dehiscent, 2–4 seeded.

Seeds globular, diameter 3–4 mm, seed coat brownish to black (when ripe), regularly finely tuberculate, chalazal tubercle black, hilum hardly elevated.

Note

C. cuneatum has been found earlier only in Ethiopia, recent accesses were scarce (Seegeler 157). In the farmost south-east of Egypt some specimens were collected, so undoubtedly in the coastal or inner coastal area from the Sudan this species can be expected.

SEEGELER found a dense cluster of *C. cuneatum* near Aksum, the classical habitat, in a recently harvested sorghum field. The species is known in this region as a typical sorghum-weed. The pods were partly attacked by a fungus, the symptoms (round blackened spots) resemble much those of chickpea blight (*Ascochyta rabiei*). Since no observations on chickpea blight are known from Ethiopia, it remains difficult to suppose that *C. cuneatum* is resistant to some degree against the disease of the cultivated *C. arietinum*. The seeds of the attacked pods appeared to be normal in number and size.

Distribution: Ethiopia, mainly Tigre, S.E. Egypt.

Altitudes: 1000–2200 m

Ecology: harvested fields, open vegetation. Flowering: October-November (Ethiopia), January-February (Egypt).

Vernacular names: ait shembra (rat's chickpea, Amharic); ater quasot (shepherd's pea), anchoa ater (rat's chickpea, Tigrinia).

Specimens examined: Egypt: Drai 231/33, Wadi Akân, Jebel Elba, SE Desert (CAIM); Shabetai 2619, Jebel Ekwal, Jebel Elba (CAIM); id. 2620, Wadi Darawein, Jebel Elba (CAIM).

Ethiopia: Pappi 107, Eritrea-Saraé, Gaza Gobo (GZU); Pappi, Penne and Matteoda 138, Eritrea-Saraé, Gaza Gobo (BM, K, W); Pappi 6532, Eritrea, Adi Ghebnis (BM); Petit 4e envoi 363, Adua and environment (P); Prior s.n., near Gapdiam, Tigre (K); Quartin-Dillon

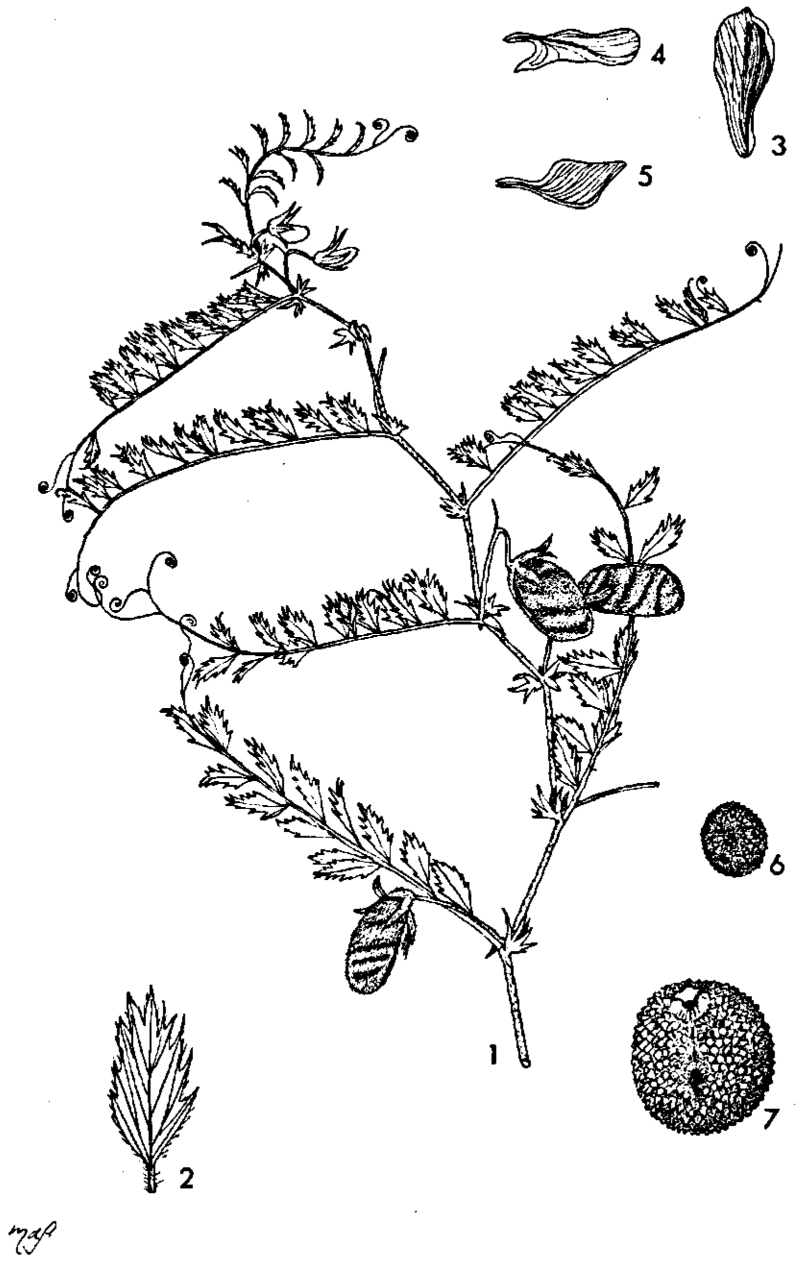
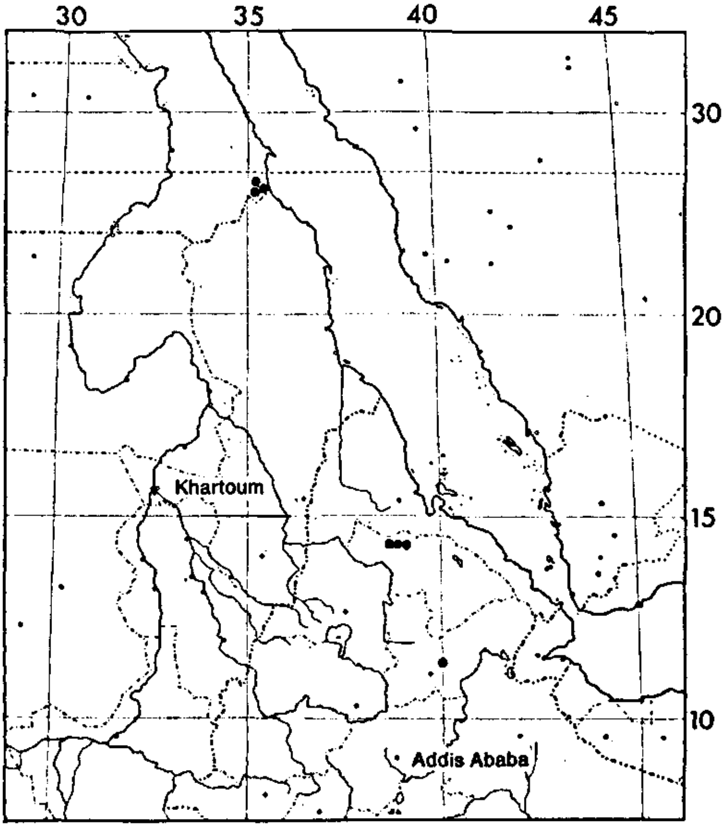


FIG. 8. *C. cuneatum* Richard. – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. flag, $2^1/_2$ ×; 4. wing, $2^1/_2$ ×; 5. keel, $2^1/_2$ × (SCHIMPER 810, L); 6. seed, $2^1/_2$ ×; 7. seed, 5 × (SEEGELER 157, WAG)



MAP 9. *C. cuneatum*

and Petit s.n., road of Mai Goua Goua to Debre Sina (P, W); Schimper 270, Sowwo Soria (Gowwo Doria?), near Mariam Schoide (BM, WU); id. 799, near Kepsaid (K, P); id. 810, near Gapdiam, Tigre (BR, G, K, L, M, OXF, P, W); id. 1545, mts mear Aksum and spread over the whole of Abyssinia (BM, G, K, L, M, MPU, P); Seegeler 157, Aksum, road to Abe Pentaleon Church (WAG).

10. C. echinospermum P. H. Davis **Fig. 9, p. 51; Map 7, p. 43**

Notes Roy. Bot. Gard. Edinb. 29–3: 312. 1969; DAVIS in Fl. Turkey 3: 272. 1970.

Type: Turkey, Urfa, Tel Pinar, SINTENIS 747 (K, holotype; isotype in E (vice-versa on the sheets!) and WU).

Homotypic synonym: *C. edessanum* Stapf ex Bornm. (*nomen nudum*, in herb.) B.B.C. 19–2: 248. 1906.

Annual. Herb, prostrate and procumbent branches mainly at the base, densely pubescent, glandular hairs in minority to eglandular hairs.

Stems straight, faintly ribbed, 20–35 cm long.

Leaves imparipinnate, 7–11 leaflets, rachis 2–4 cm, grooved above, ending in a leaflet.

Leaflets fairly close, opposite or not, shortly petiolulate, obovate-oblong, (4)5–9(11) mm long, 2–5 mm wide, base cuneate, top irregularly rounded, both sides clearly veined, dents 9–15, $\frac{1}{5}$ of the margin entire near the base, dents irregularly triangulate-acuminate, at the upper half doubly incised, dent of midrib often elongated-pointed, 1 mm, straight or slightly recurved.

Stipules 3–5 dentate oblique perules, 2–4 mm long, teeth triangular or lanceolate, at the base of the plants teeth shorter.

Flowers in 1–flowered axillary racemes, peduncle 6–11 mm long, not always ending in an arista, 1–2 mm long, bracts small perules, $\frac{1}{2}$ mm, pedicels 8–11 mm long, sometimes longer than the peduncle, recurved when bearing pods.

Calyx faintly dorsally gibbous at the base, tube 2 mm, teeth lanceolate-acute or acuminate, 4 mm long, purplish green.

Corolla veined, purple or dusky mauve; vexillum obovate, broadly pedicellate, 9–12 mm long, 9–10 mm wide, top acuminate; alae oblong-obovate, base shortly auriculate, 8 mm long, 3 mm wide; carina rhomboid, 7 mm long, 4/5 of frontal side of ventral margin adnate.

Stamens 9 + 1, filaments ca. 7 mm (fused part ca. 5 mm, free part 2 mm, upturned), anthers dorsifix.

Ovary ovoid, 3 mm long, densely glandular and eglandular pubescent, 3 ovules, style 5 mm, upturned.

Pods rounded-ellipsoid, 15–20 mm long, 10–12 mm wide.

Seeds (immature) longly ovoid, faintly beaked, ca. 7 mm long, 5 mm wide, seed coat brown, densely covered with whitish echinate spines.

Note

The recently found specimens of *C. echinospermum*, which are quite similar to the type specimen except for their size (smaller plants and leaflets), bear no ripe seeds with echinate testa. The specimen that I found was collected too early in the season to carry seeds, but the seed coats of the seeds attached to the young plants dug out were tuberculated, not spiny. The spines might have disappeared in the soil where they rested during winter, and during germination, but this is only a guess. The young seeds that developed in the already fully inflated pods of the specimens found had smooth seed coats. This absence of echinate hairs on the testa is also found in young pods of the type material. The development of the spines, therefore, must take place whilst the seeds are filling after fruit-setting. New collections of ripe, echinate seeds should remove any doubts about conspecifity with the type specimen in recent collections and confirm specific segregations from *C. arietinum*, because the echinate seeds are the main characteristic of *C. echinospermum*.

Distribution: E. Anatolia.

Altitudes: 700–1100 m

Ecology: rocky slopes, vineyards, fallow fields, in grass vegetation, *Quercus* scrub. Flowering: May.

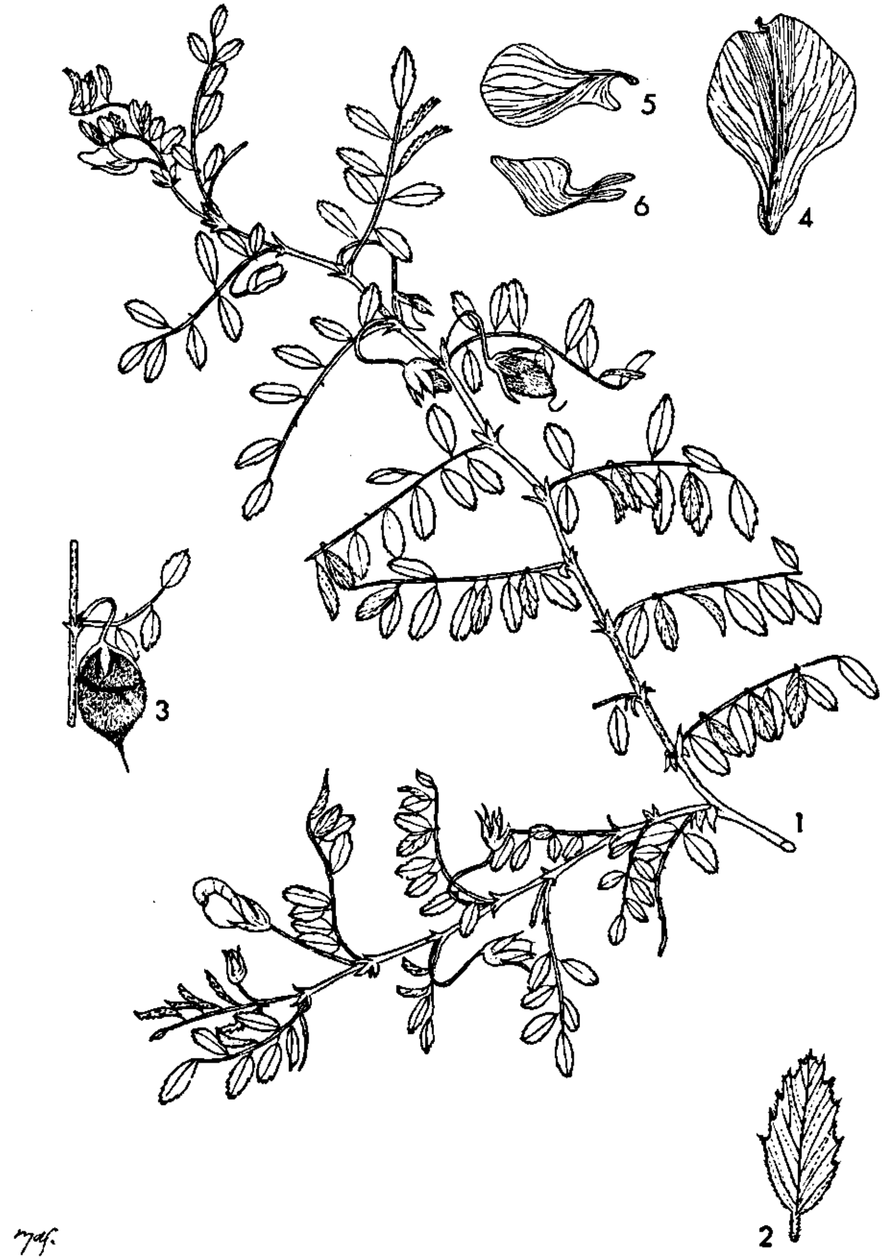


FIG. 9. *C. echinospermum* P. H. Davis – 1. branch, $^{5}/_{6}$ ×; 2. leaflet, $2^{1}/_{2}$ ×; 3. young pod, $^{5}/_{6}$ × (Sintenis 747, WU); 4. flag, $2^{1}/_{2}$ ×; 5. wing, $2^{1}/_{2}$ ×; 6. keel, $2^{1}/_{2}$ × (VAN DER MAESEN 1191, WAG)

Specimens examined: Turkey: Davis and Hedge 28291, E of Siverek, prov. Urfa (BM, E); id. 28545, Savur, prov. Mardin (BM, E); Davis 42509, 13 km fror Savur to Midyet, prov. Mardin (E); van der Maesen 1191, near Karahbahçe, 50 km W of Diyarbakır to Siverek (WAG); Sintenis 747, Urfa, Tel Pinar (type, E, WU).

11. C. fedtschenkoi Lincz. **Fig. 10, p. 53; Map 10, p. 54**

Not. Syst. Herb. Inst. Bot. Acad. Sci. USSR 9: 108 (1948?) 1949; and in Fl. USSR 13: 399. 1948; FREYN, Bull. Herb. Boiss. Sér. 2-6: 203. 1906; FEDTSCHENKO, Acta Hort. Petrop. 28-1: 108. 1907 (both as *C. songaricum* Steph. β. *imparipinnatum* Rgl and Herd.); KITAMURA and JOSHI, Add. Reports Kyoto Univ.: 103. 1966; PODLECH and DEML, Mitt. Bot. Staatssamml. München 7: 34. 1970.

Type: Schugnan, Badzhan-kutal, 27-7-1904, FEDTSCHENKO (LE, holotype, not seen).

Synonyms: *C. songaricum* DC var. *pamiricum* Lipsky ex Paulsen, Bot. Tidskr. 29: 162. 1909; *C. songaricum* Steph. var. *schugnanicum* M. Pop., op. cit. 219. 1929.

Perennial. Roots woody, branching from the base, glandular pubescent, in full grown specimen copiously, hairs up to 2 mm.

Stems straight, faintly ribbed, 18-30(35) cm long.

Leaves (7)9-15(30) leaflets, imparipinnate, rachis (3)4-8(10) cm long, grooved above, ending in an endleaflet.

Leaflets fairly close, opposite or nearly so, obovate, base rounded-cuneate, top rounded, 5-13(15) mm long, 4-7(10) mm wide, both sides clearly veined; margin dentate at the top, halfway to the base, teeth triangular-obtuse, tooth of midrib prolonged-incurved, especially of endleaflets.

Stipules as large as or larger than lower leaflets, ovate or ovate-elongate, more or less deeply incised, 7-12(15) mm long, 5-10(13) mm wide.

Flowers in 1-flowered axillary racemes; peduncle 30-70 mm long, ending in an arista, (2)4-10 mm long, with a tiny incised leaflet, 1-5 mm long and wide; bracts minute incised or bipartite perules, up to 1 mm; pedicels short, 3-5 mm.

Calyx dorsally gibbous at the base, tube 4-7 mm, teeth elongate-triangular, obtuse-acuminate, 5-8 mm long.

Corolla veined, deep blue-violet, when fading reddish (Roemer 229); vexillum obovate, pedicelled, (20)23-27(30) mm long, ca 20 mm wide; alae obovate, base auriculate, auricle incurved, 18 mm long, 8 mm wide; carina rhomboid, frontal side of ventral margin adnate, ca. 15 mm long.

Stamens 9 + 1, filaments ca. 17 mm (fused part 13 mm, free part 4 mm, upturned), anthers dorsifix.

Ovary rhomboid-elongate, ca. 7 mm long, 8 ovules; style ca. 10 mm, upturned, pubescent over 5 mm from the base.

Pods rhomboid-elongate, 25-30 mm long, ca. 10 mm wide.

Seeds (unripe) triangular-obovate, beaked, bilobular (Linczevski: ca. 4 mm); seed coat reddish brown, wrinkled, finely tuberculate.

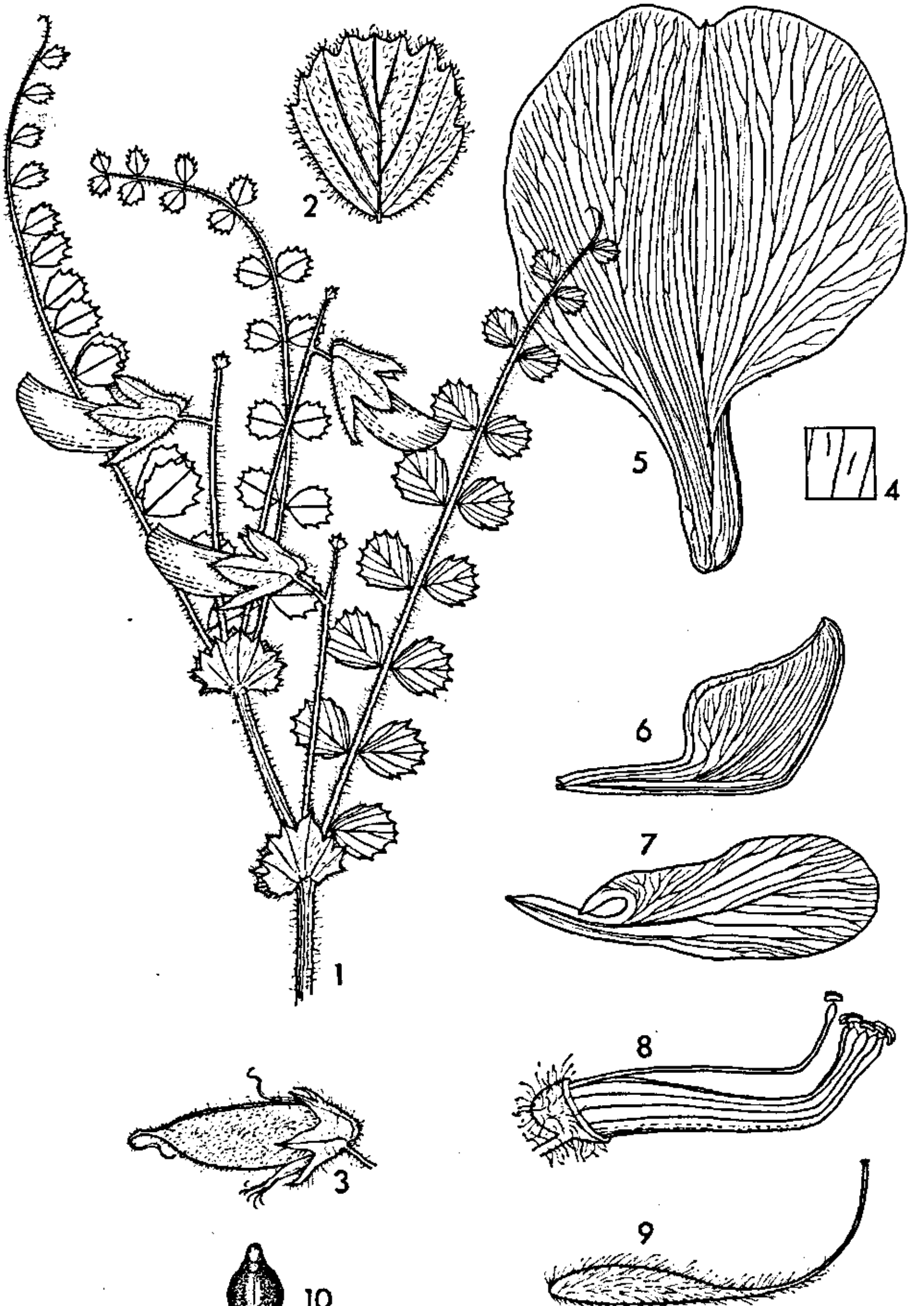
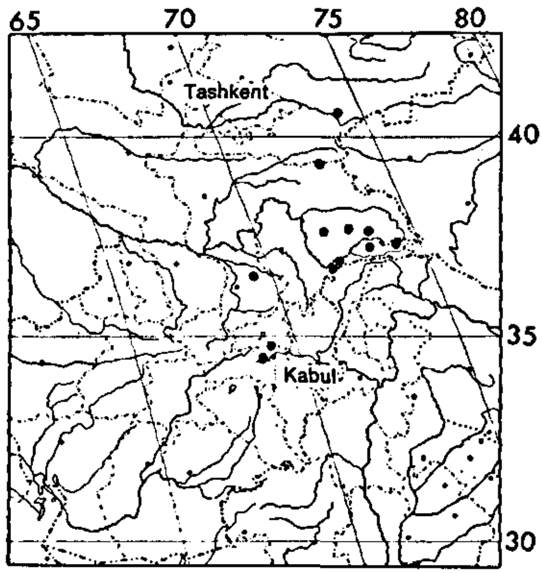


FIG. 10. *C. fedtschenkoi* Lincz. – 1. branch, $^{5}/_{6}$ ×; 2. leaflet, $2^{1}/_{2}$ ×; 3. young pod, $^{5}/_{6}$ ×; 4. details of flag, hairs, 5 ×; 5. flag, $2^{1}/_{2}$ ×; 6. keel, $2^{1}/_{2}$ ×; 7. wing, $2^{1}/_{2}$ ×; 8. anthers, $2^{1}/_{2}$ ×; 9. pistil, $2^{1}/_{2}$ ×; 10. seed, $2^{1}/_{2}$ × (1, 2, 10: TOLMATSHEVA 7110, LE; 3: GRÖTZBACH 15, W; 4–9: ROEMER 229, W)

Note

This species can easily be distinguished from related *C. songaricum* Steph. ex DC. by the lower habit, imparipinnate leaflets, copious hairiness and acuminate calyx-teeth.

Distribution: S. Kirghizia, Pamir, N.E. Afghanistan.
Altitudes: 2500–4200 m
Ecology: dry stony slopes or valleys, granitic, exposed to the south, also near lakes, streambeds. In Badakhshan near *Salix pseudolirida*. Flowering: (June) July-August.



MAP 10. *C. fedtschenkoi*

Specimens examined: Afghanistan: Frey 284, Darrah-i-Parshin, C Hindukush (W); Gamerith 80, Kishnik Valley, Wakhan (W); Gratzl 12, Warg Valley, Eilag Spurditsh, prov. Wakhan (W); Grötzbach 15, Piu Valley (N side-valley of Farkhar Valley), prov. Farkhar (W); Hedge and Wendelbo W 5248, Darrah Rastagal, Panjshir Valley, prov. Parvan (E); Renz 67, Khandud Valley, prov. Wakhan (W); Roemer 229, E Noshaq area, W Wakhan (E, M, W); Volk 60937, Paghman, W of Kabul (W).

USSR-Kirgizia: Ferganskii Khrebet, Dzalal-Abadskii Goselok Alame (M).

USSR-Tadzhikistan: Fedtschenko s.n., Pamir, near Lake Jashil-kul (K); Ikonnikov 3650, 9906, Badakhshan, mts (LE); Paulsen 1104, near Lake Yashil-kul (C); Rickmers s.n., Muskulak Glacier, Zaalayskiy Khrebet (M); Tolmatsheva 7110, Badakhshan (LE).

12. C. flexuosum Lipsky **Fig. 11, p. 56; Map 11, p. 57**

Acta Hort. Petrop. 23: 102. 1904; POPOV, Bull. Univ. As. Centr. 15 suppl.: 14. 1927; POPOV, op. cit. 209. 1929; LINCZEVSKI, Fl. USSR 13: 392. 1948; RECHINGER, Biol. Skrift. Kong. Dansk. Vidensk. Selsk. 9–3: 200. 1957; KITAMURA, Fl. Afghan.: 223. 1960.

Type: C. Asia, Kuletshek, Karatau; REGEL 200 (LE, holotype, isotypes in E, K, P, lectotypes, choosen from the eight specimens cited in the protologue).

Paratypes: Angren riv., MUSSA s.n. (LE, not seen; isotype at C); Karagus, REGEL s.n. (LE, not seen; isotypes at BM, C); Baroldai, SEWERZOV s.n. (LE, not seen; isotype at M); Karatau, MAEV s.n. (LE, not seen); Tashkent, MAEV s.n. (LE, not seen); Gosai, REGEL s.n. (LE, not seen); Pskiem, FEDTSCHENKO s.n. (LE, not seen).

Synonyms: *C. flexuosum* Lipsky subsp. *tianschanicum* var. *robustum* M. Pop, l.c. 1927; *C. flexuosum* Lipsky subsp. *robustum* M. Pop., op. cit. 210. 1929.

Perennial. Roots woody, plant branched from the base, glandular pubescence fairly dense.

Stems flexuous, especially at the base, sometimes straight at the top, ribbed, 30–40 cm.

Leaves (6)10–16(20) leaflets; rachis (5)6–15 cm, grooved above, ending in a ramified or single tendril, at the lower leaves sometimes an endleaflet.

Leaflets paripinnate, not very close, opposite or nearly so, cuneate-obovate, (5)7–12(15) mm long, (2)4–9(12) mm wide, top rounded-acuminate, sometimes incised, base cuneate or rounded-cuneate, upper half of margin dentate, teeth c. 7–11, triangular-acuminate, tooth of midrib mostly curved and longer than the lateral ones.

Stipules flabellate with (1)3–4(6) triangular teeth, smaller than the leaflets, 3–5 (7) mm long, 3–6(8) mm wide.

Flowers in (1)–2–flowered axillary racemes, peduncles 3–6(8) cm, ending in an arista, 8–15(18) mm long; bracts small triangular or incised perules, 0.5–3 mm; pedicels 5–12 mm, recurved when bearing fruits.

Calyx broadly gibbous at the base, tube 3–5 mm, teeth triangular, top rounded-acuminate or obtuse-mucronate, 6–8 mm long, midrib prominent.

Corolla veined, bluish purple; vexillum obovate, 20–26 mm long, 18–22 mm wide, top emarginate-mucronate, base spoonshaped; alae oblong-obovate, shortly auriculate, 17–19 mm long, 8–9 mm wide; carina rhomboid, frontal side of ventral margin adnate, ca. 13 mm long, petiole ca. 5 mm.

Stamens 9 + 1, persistent, ca. 14 mm long (fused part 9 mm, free part 5 mm, upturned).

Ovary ovate-elongate, ca. 6 mm long, 2 mm wide, 5 ovules, style ca. 9 mm, upturned.

Pods oblong-elliptic, 20–25 mm long, ca. 8 mm wide, 1–2 seeds, sometimes more.

Seeds obovate, beaked, ca. 7 mm long, ca. 4 mm wide; seed coat brown, irregularly rigulate-tuberculate, chalazal tubercle not very prominent, connection from chalazal tubercle to hilum grooved, black.

Distribution: S. Kirghizia, Pamir, Tian-Shan.

Altitudes: 500–2400 m

Ecology: rocks, scrubble, near riverbeds, tree and scrub vegetation. Flowering: May-July.

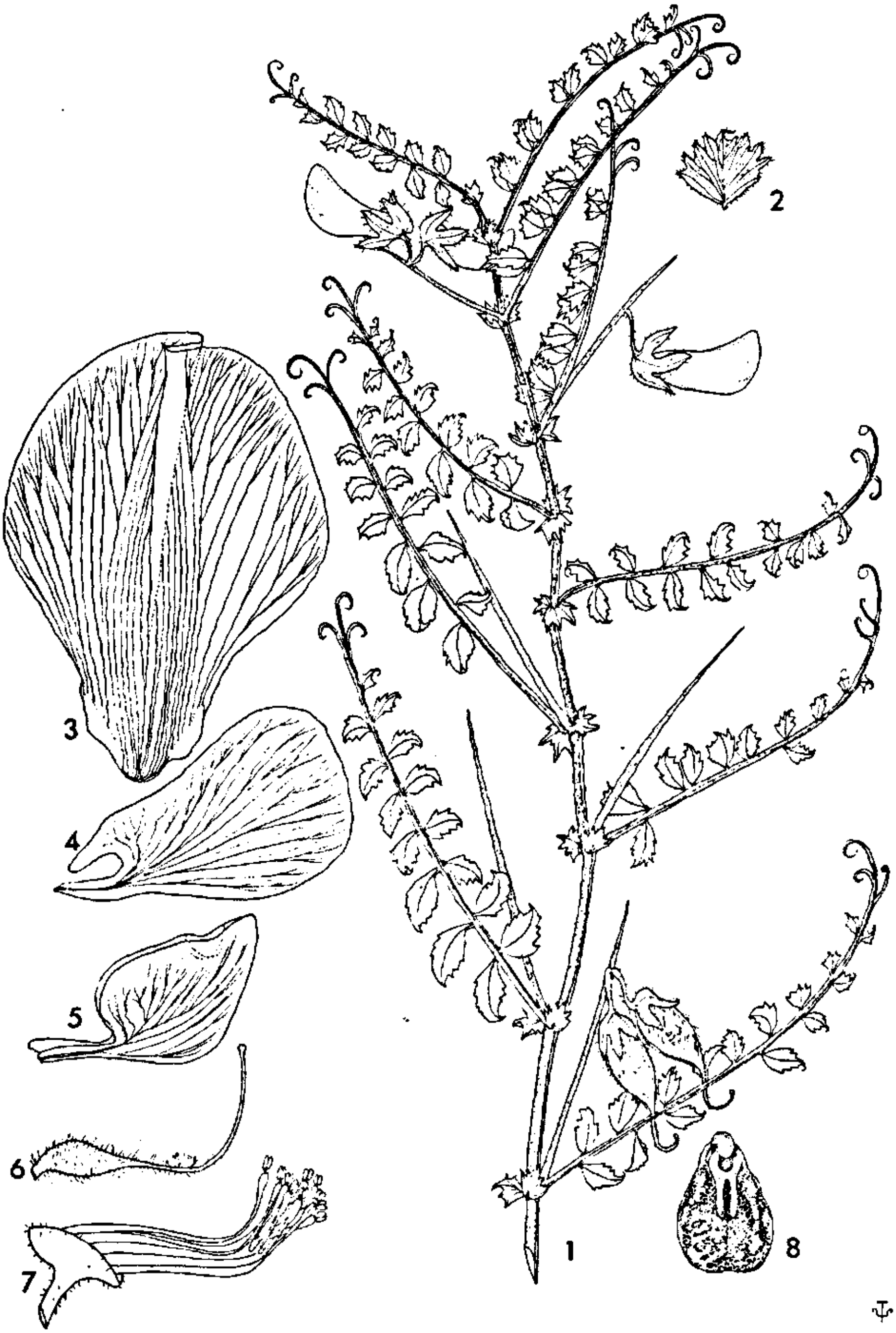
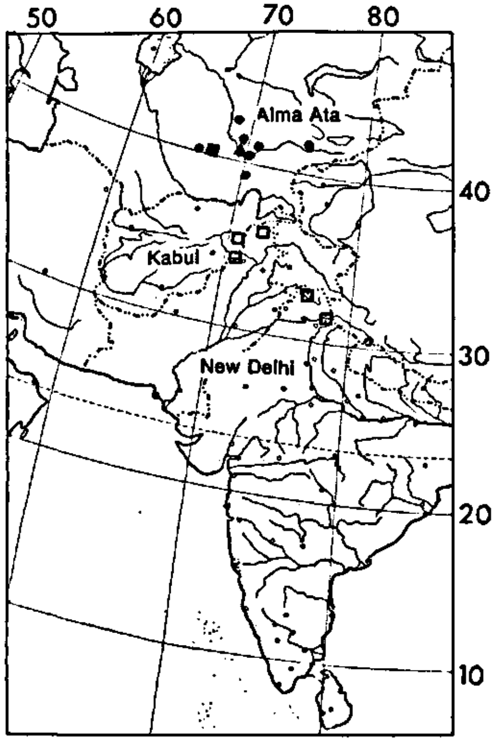


FIG. 11. *C. flexuosum* Lipsky – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. flag, $2^1/_2$ ×; 4. wing, $2^1/_2$ × 5. keel, $2^1/_2$ ×; 6. pistil, $2^1/_2$ ×; 7. anthers, $2^1/_2$ ×; 8. seed, $2^1/_2$ × (BOTSHANTSHEV 497, LE)



MAP 11. ● *C. flexuosum*, ■ *C. grande*, ▲ *C. mogoltavicum*, □ *C. nuristanicum*

Specimens examined: USSR: ? 119, Karatau Khrebet (MW); Botshantshev 497, Aksu (LE); Fedorov and Ilina 237, Alasj, bank of Erienda R., Ferganskii Khrebet, Dzhalal-Abadskii Rayon (M); Lipsky 2003, Tshopuch, Shakhrisyaba, Buchara Reg. (LE); Mussa s.n., Gossai, bank of Angren R. (C, paratype); Neustrueva, Markova, and Medvedeva s.n., Karatau Khrebet, Kazakhstan (LE); Parventyeva s.n., Biresek, Karatau Khrebet (MW); Pryachin s.n., Kuraminskii Khrebet, above Jantakom and Almalyk (K); Regel s.n., Tshokal Valley (near Issyk-kul Lake?); Regel 200, Kuletschek (Kulantschek?), Karatau Khrebet (paratype, E, K, LE, P); Regel s.n., Karagus (Karakash?) (paratype, BM, C); Regel s.n., Baroldai, Karatau Khrebet (paratype, G, LE, W, WU); Regel s.n., Aksu R. (C); Sewerzov s.n., Boroldai R., Karatau Khrebet (M); Vlasov s.n., 125 km from Tashkent to Kabaid (MW); Vregeikiy 39, Karatau Khrebet (LE).

13. C. floribundum Fenzl **Fig. 12, p. 59; Map 12, p. 63**

Pugillus Plant. Nov. Syr. Taur. occ. 1: 4. 1842; FENZL, Ill. Descr. Pl. Nov. Syr. Taur. occ. in RUSSEGGER, Reise 1 (Anhang): 892. 1842; ALEFELD, Oest. Bot. Zeitschr. 9: 356. 1859; BOISS., Fl. Orient. 2: 561. 1872; BORNMÜLLER, B.B.C. 19–2: 248. 1906; POPOV, op. cit. 199. 1929; DAVIS, Fl. Turkey 3: 268. 1970.

Type: Turkey, Taurus Mts, Gülek, Kotschy 167 (W, holotype).

Perennial. Erect, densily glandular and eglandular pubescent, indument of leaflets less dense, eglandular.

Stems erect, ribbed, 15–30 cm.

Leaves 9–13 leaflets, imparipinnate, rachis 3–6 cm, grooved above, ending in a topleaflet, seldom in a simple tendril.

Leaflets opposite or nearly so, close, oblong-elliptical, base rounded, top rounded or sometimes acute, 8–15 mm long, 3–8 mm wide, upper side dark green with light green prominent nerves, lower side greyish green with prominent nerves, margins nearly entirely dentate, except near the base, about 17–23 triangular-acuminate dents, 1 mm, ending in a spinelet, midrib sometimes ending tendrillous.

Stipules oblique-triangular or flabellate, with about 5–10 inequal acuminate teeth, less at the lower and subsoil perules, (3)5–10 mm.

Flowers in 1–5 flowered axillary racemes, peduncle up to 4 cm, bearing 1–5 nodes with 1 pedicel each, ending in the last bract, or a linear-spathulate arista, up to 6 mm; bracts flabellate with 3–5 straight or curved teeth, 2–4 mm; pedicels ca. 7 mm.

Calyx strongly dorsally gibbous at the base; tube ca. 5 mm; teeth lanceolate-acuminate, ca. 7 mm.

Corolla veined, bluish violet, vexillum obovate, shortly based, top emarginate, 15–17 mm long; alae oblong-obovate, auriculate; calyx rhomboid.

Pods oblong-ellipsoid, ca. 27 mm, about 3 seeds.

Seeds nearly globular, diameter 3–4 mm, seed coat black, warty.

Note

Due to scanty material floral details were taken from the protologue, and according to DAVIS (1970).

This rare species is closely related to *C. graecum* and *C. isauricum*. According to the protologue no tendrils exist on the leaves, but SIEHE 233 shows a simple tendril at one leaf and some topleaflets with a tendrillous top. The species differs from *C. isauricum* by the size of its leaflets, the larger bracts and the eglandular indumentum. The flowers are violet or purplish, and those from *C. isauricum* and *C. montbretii* white. *C. montbretii* is larger, has more leaflets, minute bracts and very long hairs.

Distribution: S. Anatolia.

Altitudes: 800–1700 m

Ecology: mountain slopes, *Fagus orientalis* forest, *Quercus coccifera* scrub. Flowering: June-July.

Specimens examined: Turkey: Akman 225, Dörtyol, near Topaktaz (Yayland village), prov. Hatay (ANK); Siehe 233, Tarbas Mt, Cilicia (GE, JE, K).

Specimen indicated: Turkey: 1 km below Yarpuz, prov. Adana (Hub.-Mor.).

14. C. garanicum Boriss. **Map 3, p. 26**

BORISSOVA, Novit. Syst. Plant. Vasc. 6: 170–172. 1970.

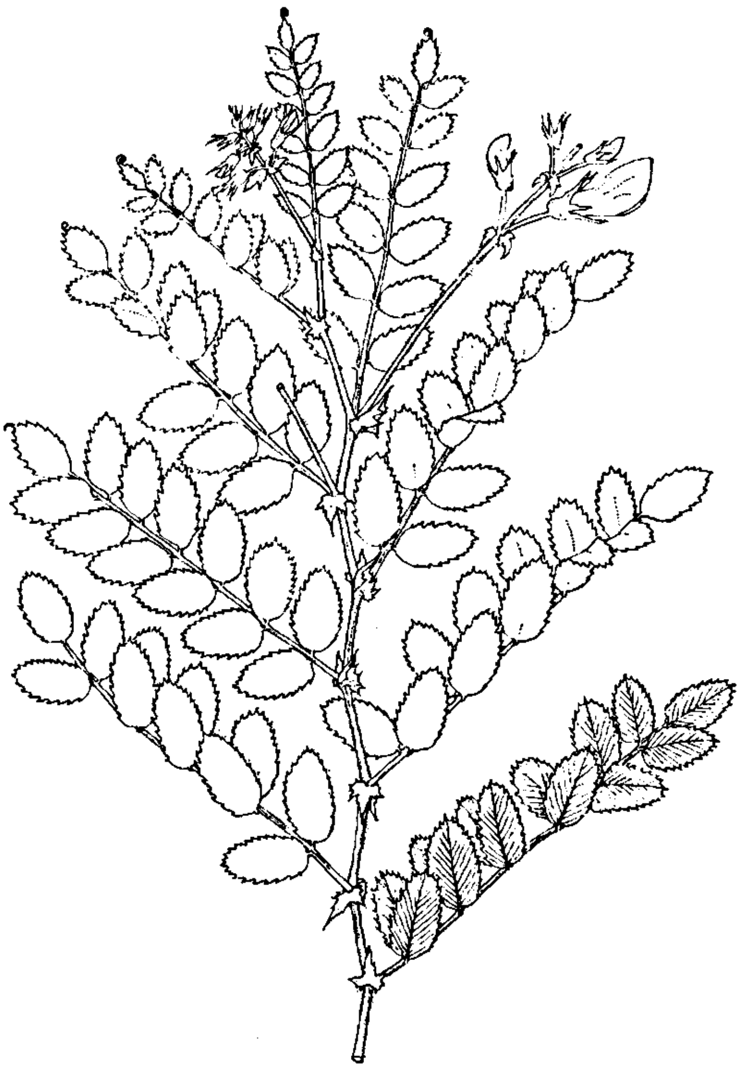


FIG. 12. *C. floribundum* Fenzl – flowering branch, $^5/_6$ × (SIEHE 233, K)

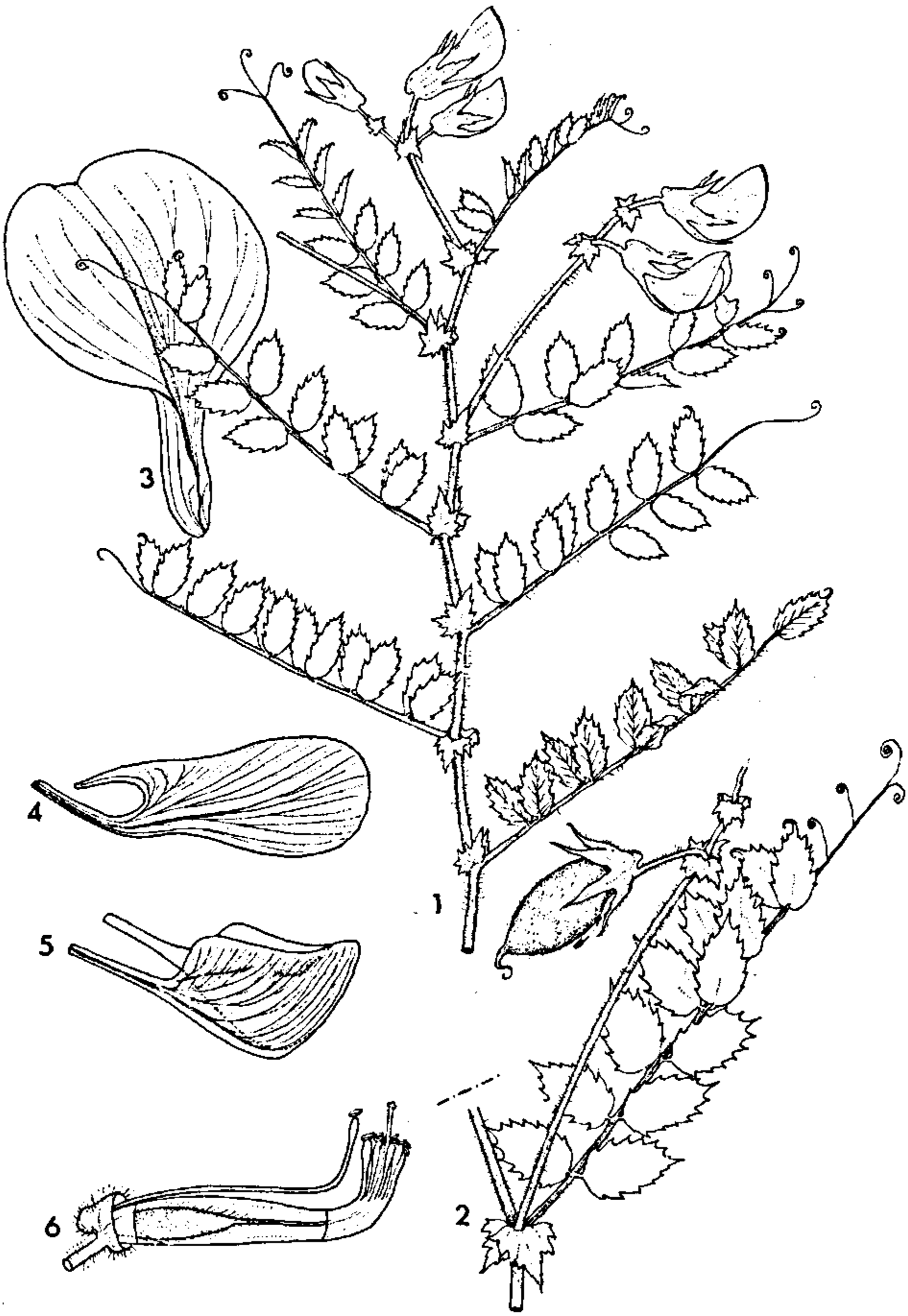
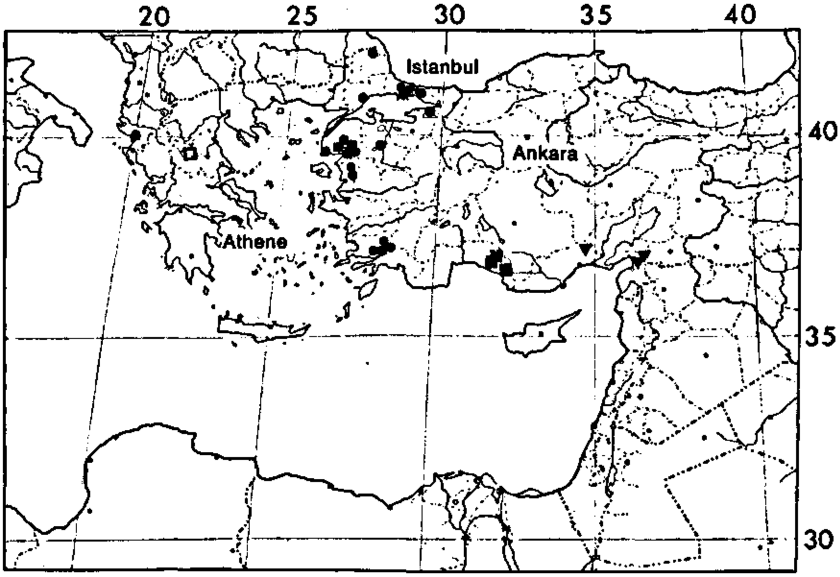


FIG. 13. *C. graecum* Orph. – 1. flowering branch, $^5/_6$ ×; 2. part of fruiting branch, $^5/_6$ ×; 3. flag, $2^1/_2$ ×; 4. wing, $2^1/_2$ ×; 5. keel, $2^1/_2$ ×; 6. anthers and pistil, $2^1/_2$ × (LEMPERG 434, K)



MAP 12. □ *C. graecum*, ▼ *C. floribundum*, ■ *C. isauricum*, ● *C. montbretii*

16. C. grande (M. Pop.) Korotk. **Fig. 14, p. 65; Map 11, p. 57**

KOROTKOVA, Bot. Mat. Herb. Inst. Bot. Akad. Sci. Uzbek. *10: 18. 1948.*

Syntypes: Pamir-alaï, Kugitang, POPOV and VVEDENSKY 494, 495 (TAK, holotypes, not seen).

Basionym: *C. flexuosum* Lipsky ssp. *grande* M. Pop., Bull. Univ. As. Centr. 15, suppl.: 15. 1927; POPOV, op. cit. 210.

Synonym: *C. grande* (M. Pop.) Lincz., Fl. USSR 13: 392. 1948 (in obs.); LINCZEVSKI, Not. Syst. Inst. Bot. Acad. Sci. USSR 9: 113. 1949.

Perennial. Rootstocks woody, sparsely laterally branched, aerial parts glandular pubescent.

Stems straight or slightly flexuous, ribbed, 20–50 cm long.

Leaves 8–12 leaflets; rachis 6–11 cm, grooved above, ending in a single tendril (lower leaves) or a tendril branched in 3–5 (upper leaves), sometimes lower leaves have endleaflets.

Leaflets opposite or not, rather close, elliptic or obovate-elongate, 10–25(27) mm long, 6–12 mm wide; base rounded-cuneate, top rounded or slightly truncate; margin dentate except near the base, teeth triangular-acuminate, up to 3 mm long, at the top of the leaflets mostly incurved or shaped as a tendril, lower side of the leaflets more pubescent than the upper side.

Stipules obliquely flabellate, toothed, 5–10 mm long, 5–9 mm wide (lower leaves) or small incised perules, 2–5 mm long, 2–4 mm wide (upper leaves), prominently veined.

Flowers in 1–2–flowered axillary racemes; peduncle 3–4 cm, ending in a spiny arista, ca. 3 mm; bracts 2 small lanceolate perules, nearly 1 mm; pedicels 7–10 mm, recurved when bearing fruits.

Calyx dorsally gibbous at the base; tube 3–4 mm; teeth triangular-lanceolate, 4–6 mm long.

Corolla (partly taken from the protologue) veined; vexillum oblong-obovate; exterior pubescent; 23 mm long, 14 mm wide, top emarginate, mucronulate, base spoonshaped; alae oblong-obovate, 15–18 mm long, 6–9 mm wide, at the base longly auriculate, top dilatate, rounded; carina rhomboid, 13–14 mm long, 5–6 mm wide.

Stamens 9 + 1, persistent, filaments ca. 12 mm long, fused part 9 mm, free part 3–4 mm, upturned.

Ovary ovoid, style 7–9 mm, recurved, stigma slightly broadened.

Pods rhomboid-oblong, 25–30 mm long, 10 mm wide.

Seeds (unripe) obovate, beaked, 7 mm long, 5 mm wide, seed coat brownish, irregularly tuberculate (greyish), chalazal tubercle prominent.

Distribution: Uzbekistan; Nuratau (W. Pamir-Alai).
Altitudes: 1000–2000 m?
Ecology: mountains. Flowering: June.

Specimens examined: USSR-Uzbekistan: Nieustrueva et al. 165 Tori-Ak-gau, 10–12 km from Tshia, upper Tugak-saja slope, Khrebet Nuratau (LE).

17. C. incanum Korotk. **Map 3, p. 26**

Korotkova in Not. Syst. Herb. Inst. Bot. Zool. Acad. Sci. Uzbek. 10: 17. 1948.

Type: W. Pamir-Alai, Jaccabag-darja, Botshantshev and Butkov 720 (TAK, holotype, not seen).

Synonym: *C. pungens* Boiss. var. *horridum* M. Pop. cf. Borissova, Nov. Syst. Pl. Vasc. 6: 172. 1969.

Perennial. Densely pubescent with glandular and eglandular hairs, greyish.

Stems erect, flexuous, terete, 20–30 cm long.

Leaves 8–12 leaflets; rachis 2.5–4 cm long, ending in a spine.

Leaflets broadly cuneate or obovate, 2–6 mm long, 4–5 mm wide; top truncate, dentate, teeth of midrib shorter and broader than the lateral ones.

Stipules foliolate, 3–7 mm long, deeply incised in triangular parts with aristate-acuminate top.

Flowers in 1–2–flowered axillary racemes; peduncles 15–25 mm, ending in a spinose arista.

Calyx gibbous at the base, 7–10 mm long, sparsely pubescent, teeth elliptic, shorter than or equal to the tube, top acuminate with a spinelet.

Corolla veined; vexillum suborbicular, exterior pubescent, ca. 20 mm long, base 7–8 mm; alae oblong-obovate, 14–15 mm long, 6–7 mm wide, base

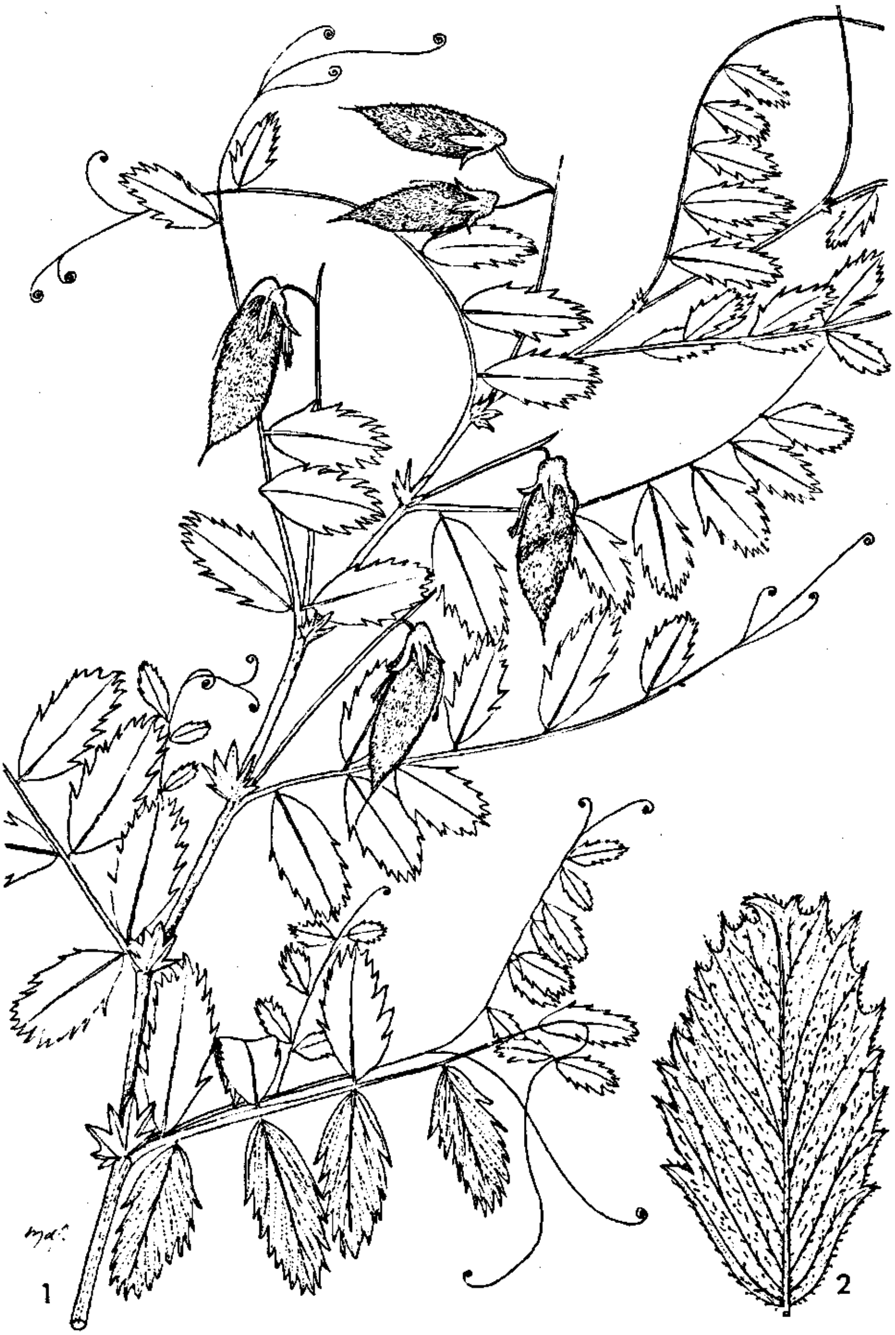


FIG. 14. *C. grande* (M. Pop.) Korotk. – 1. fruiting branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ × (NIEUSTRUEVA et al. 165, LE)

4 mm, shortly auriculate, 2 mm; carina rhomboid, 13–14 mm long, 6–7 mm wide.

Note

From this species no material or illustration was seen, and so the protologue was used for the description. The differences with *C. macracanthum* are: the number of leaflets (4–6 pairs, not 6–9), the tooth of the midrib of the leaflets smaller than or equal to the lateral ones (not longer) and the foliolate stipules.

Distribution: S. Tadzhikistan, Pamir-Alai.
Altitudes: ca. 2000–3000 m
Ecology: calcareous rocks.

18. C. incisum (Willd.) K. Maly **Fig. 15, p. 68; Map 13, p. 69**

In ASCHERSON and GRAEBNER, Syn. Mittel-Eur. Fl. 6 Suppl.: 16. 1927; BOISSIER, Fl. Orient. 2: 561, 562. 1872; HALACSY, Consp. Fl. Graec. 1: 462. 1901; HAYEK, Prodr. Penins. Balc. 1: 795. 1927; POPOV, op. cit. 183. 1929; PARSA, Fl. Iran 2: 436. 1943; RECHINGER, Fl. Aeg.: 322. 1943; LINCZEVSKI, Fl. USSR 13: 390. 1948; GROSSGEIM, Fl. Kavk.: 378. 1952; RECHINGER, Arkiv. f. Bot. 5-1: 257. 1959; MAKHADZHJANA, Fl. Arm. 4: 271–275. 1962; FÜRNKRANZ, Oest. Bot. Zeitschr. 115: 407. 1968; DAVIS, Fl. Turkey 3: 270. 1970.

Type: Greek Archipelago (Crete), Herb. WILLDENOW (B, holotypes, photographs seen).

Basionym: *Anthyllis incisa* Willd., Spec. Pl. 3-2: 1017. 1802.

Synonyms: *C. Adonis* Orph. ex Nyman, Consp. Fl. Europ.: 200. 1878; *C. caucasicum* Bornm., Fedde Repert. 50: 139. 1941; *C. ervoides* (Sieb.) Fenzl, Ill. Syr. Taur. in RUSSEGGER, Reise 1: 892. 1841 (basionym *Ononis ervoides* Sieb., Reise n.d. Insel Kreta 1817 band 1: 325. 1823); *C. incisum* Woronow, Trudi Tiflissk. Bot. Sada 12-2: 69. 1914 and Fl. Cauc. 2: 356. 1930; *C. incisum* (Willd.) K. Maly var. *libanoticum* (Boiss.) Bornm., Fedde, Repert. 50: 138. 1941 (basionym *C. ervoides* (Sieb.) Fenzl var. *libanoticum* Boiss., Fl. Orient. 2: 562. 1872); *C. minutum* Boiss. et Hoh., Diagn. Sér. 1, 9: 130. 1849; *C. pimpinellifolium* Jaub. et Sp., op. cit. 228. 1842.

Perennial. Small, prostrate, alpine plantlet, rootstocks slender or woody, more or less branched from the base, creeping in rubbles, up to 0.5 cm thick. All parts densely glandular pubescent.

Stems straight or hardly flexuous, ribbed, leaved part 5–15 cm long.

Leaves 3–5, up to 7 leaflets; rachis 5–10 mm, grooved, ending in a topleaflet, greyish green.

Leaflets opposite or nearly so, obovate to lanceolate, 3–7 mm long, 2–6 mm wide, base narrowly or broadly cuneate, top rounded-incised with 3–7 dents, lower surface more prominently ribbed than upper one, teeth half-ovate or triangular, up to 2 mm, top obtuse or acuminate.

Stipules ovate-acuminate to flabellate, 1–4(5) teeth, nearly as large as the leaflets up to 5 mm.

Flowers in 1(rarely 2)-flowered axillary racemes; peduncle 10–20(40) mm, ending in a small perule, up to 2 mm, or a slender arista, 3 mm, bracts two small perules; pedicels 10–27 mm, straight or recurved.

Calyx only slightly dorsally gibbous at the base, tube 2–3 mm, teeth lanceolate 4–5 mm, one prominent midrib.

Corolla veined, purplish violet, pink or bluish; vexillum obovate, 9–12 mm long, 8 mm wide; alae obovate, at the base auriculate, 8 mm long, 3 mm wide; carina rhomboid, base short, $\frac{3}{4}$ of frontal side of ventral margin adnate, ca. 8 mm long.

Stamens 9 + 1, persistent, filaments 8 mm long (fused part 6 mm, free part 2 mm, upturned), anthers basi-dorsifix.

Ovary ovoid, ca. 3 mm, pillose, 2 ovules, style ca. 6 mm, recurved.

Pods obovate, 10–14 mm long, ca. 6 mm wide, glandular pubescent, dehiscent.

Seeds obovate, subglobular, beaked, ca. 5 mm long, 4 mm wide, seed coat light brown, margin of hilum lighter coloured, minutely tuberculated, chalazal tubercle indistinct.

Note

This species is rather widely distributed, and local variation is therefore difficult to separate from environmental modification. The var. *libanoticum* was segregated by BOISSIER because of its shorter stature, more densely leaved habit, and the stipules which equal the short leaflets. Most of the Lebanese and Syrian specimens, at altitudes of 3000–3300 m, show this habit invariously, though others (DAVIS *10182*, WÜRTTEMBERG s.n.) have a less crowded habit. In Turkey, specimens from Berit Dağ, Ala Dağ and Munzur Dağ possess longer peduncles, larger flowers and fruits and somewhat broader leaflets (DAVIS, 1970).

In specimens from Crete and Turkey characteristics of var. *libanoticum* are always present in (lower) parts of the specimens. These characteristics seem to be of quantitative habit, which led DAVIS to reduce var. *libanoticum* to synonymity. DAVIS 31201 (Munzur Dağ) has 2-flowered peduncles.

As both POPOV and DAVIS admitted that they had doubts about whether to segregate *C. minutum* Boiss. et Hoh. from *C. incisum* (Willd.) K. Maly, the time has come to accept synonymy. KOTSCHY 542, the type specimen from the Elburz mountains in Iran, is identical to specimens of *C. incisum*. The leaves are crowded, and contrary to the data in the protologue, have very often more than two pairs of leaflets. The only real difference is the length of the peduncle and pedicel not exceeding the leaf rachis, though a marginal specimen exists (P, HERBIER DRAKE!). The variations in *C. incisum* are at present known and are so large that there remains no sufficient reason to keep the taxa separated. More material from Iran is needed, since recent specimens are scarce.

Distribution: Greece, Crete, Anatolia, Soviet Armenia, Lebanon, Iran.

Altitudes: 1400–2700 m

Ecology: (sub)alpine vegetation, rubble slopes, e.g. calcareous, igneous. Flowering: Caucasus: May. Greece: June-July. Turkey, Lebanon: July, August (September).

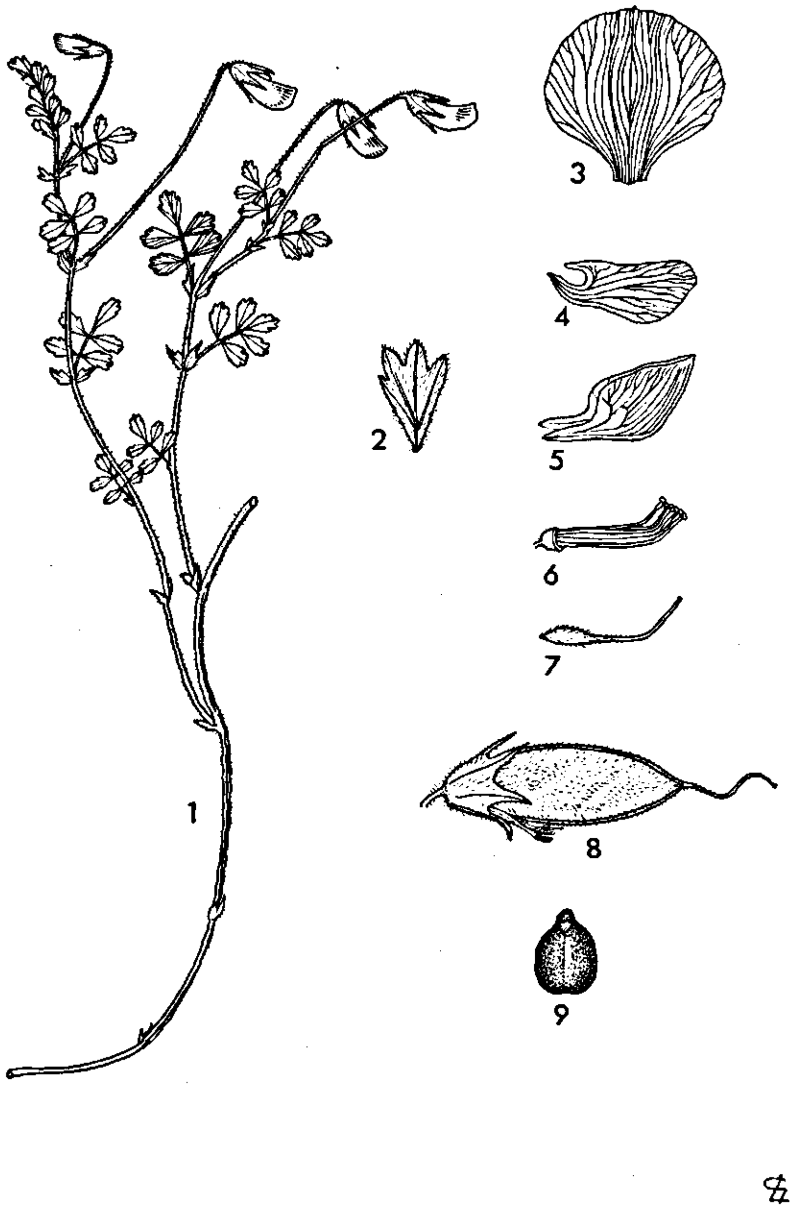
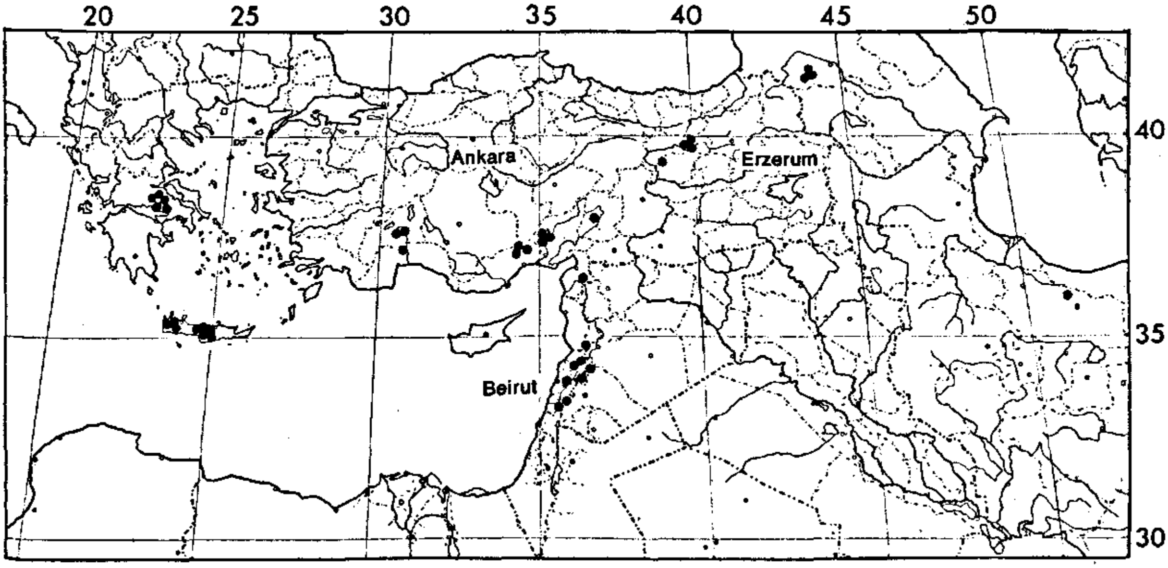


FIG. 15. *C. incisum* (Willd.) K. Maly – 1. branch, $^{5}/_{6} \times$; 2. leaflet, $2^{1}/_{2} \times$; 3. flag, $2^{1}/_{2} \times$; 4. wing, $2^{1}/_{2} \times$; 5. keel, $2^{1}/_{2} \times$; 6. anthers, $2^{1}/_{2} \times$; 7. keel, $2^{1}/_{2} \times$; 8. pod, $2^{1}/_{2} \times$; 9. seed, $2^{1}/_{2} \times$ (1, 2: DAVIS and HEDGE 31201; 3–7: DAVIS 10182; 8, 9: DAVIS 307, E)



MAP 13. *C. incisum*

Specimens examined: Crete: Baldacci 179, Mt Psiloritis (Ida), distr. Amari (G, K, P, W, WU); id. 221, Mylopotamos R., Mt Psiloritis (G, K, M, P, W, WU); Davis 18119, Mt Srourichti, Hagion Pneuma (White Mt) (E, K); Dörfler 1109, Mt Psiloritis (GZU, W, WU); Greuter 4835, Xeroliminöl, Top of Trocharis Mt, Sphakia reg. (G); Heldreich 1632, Mt Stravopodia, Sphakia reg. (BM, G, K, L, P, W, WAG); id. s.n., Mt Psiloritis (BM); Lemperg 541, Levka Ori, Hagion Pneuma (White Mt) (GZU, W); id. 542, Hagion Pneuma (K); Rechinger 13843, Levka Ori, Mt Pachnes, Sphakia distr. (BM, G, K, M); id. 14302. Mt Timios Stavros, Mt Psilioriti, Mylopotamos distr. (BM, G, K, M, W); Reverchon s.n., Mt Volokia (G); Raulin 688, Le Sozo, mts near Sphakia (P); Sieber 181, Mt Psiloritis (BM, M, W); Spreitzenhofer s.n. (WU); Webb s.n., mts near Sphakia (K).

Greece: Mt Parnassus: Davis 307 (BM, E); Guicciardi s.n. (BR); Guicciardi 232, Akrinopero (G, JE, K, P); id. 2962 (C, E, K, L, M, W); Guiol 2419, Lugari, Phocis (BM); Maire and Petitmengin 1236, between Gourna Cleft and Agros Nikolaos Chapel (K); Orphanides 495, near Longar (BM, C, E, G, GZU, JE, K, L, M, MPU, OXF, P, W).

Lebanon: Anon s.n., Jebel Sannin (Sunnin) (E); Anon s.n., Jebel Makmel (E); Binton s.n., Top of Mt Lebanon (Jebel Libnan) (BM); Blanche s.n., Jebel Makmel, below Ehedin (Ihdin) (K); id. s.n., Jebel Libnan, Ain Karna near Ihdin (JE); Boissier s.n., tops of Jebel Libnan (G, K, P); Bornmüller 501, Mt Hermon (Jebel es Sheikh) (G, J, K, W, WU); Bunge s.n., Jebel Libnan, Ain Karna near Ihdin (P); Chaudhary s.n. (1971), Qornet-es-Sauda (WAG); Davis 9813, Qornet-es-Sauda (E, K); id. 10182, Qornet Aachara, Hesjr Shin above Hermet (Hermil?) (E, K); Hartmann s.n., Jebel es Sheikh (W, WU); Hamta ? s.n., Jebel Libnan, Tripoli, descending Kasna-t-Essaud (G); Haussknecht 3042, Mt Milhud?, Eden (Idhin) (JE); Hooker and Hanbury s.n., top of Jebel Libnan (K); Kotschy 178, Jebel es Sheikh (K, P, W); Post s.n. 1868, Hum el Meezah? (Holy Land) (OXF); id. s.n., 1872, Hum et Meezah? (OXF); Postian s.n., Jebel Makmel (BM, G, K); id. s.n., top of Jebel Sannin (G, K); id. 795, Bedars (K); Württemberg, Prince Paul, Duke of, s.n., Jebel Libnan, Barut, Haman, Tharano (Baruk?, Hammâna?) (M).

Iran: Kotschy 542, Loura Valley, Meidan-Abdallah, Elburz Mts (BM, G, K, M, OXF, P, WAG) (as *C. minutum* Boiss. et Hoh.); Iranshahr 14626–E, Ostoronkuh, Lorestan: Galeh Rostam to Gahar (W); id. 14774–E, Gotour, Azerbaijan (W); Rechinger 41677, Qotur Valley, W of Khvoy near Turkish border (W).

Turkey: Aucher-Eloy 1125, M. Olympo, Keşiş Dağ, prov. Erzincan (BM, G, K, MPU, OXF, P); Balanza s.n., Boulgamarden, Taurus Mts (Bulghar-Maden, Bolkar dağları) (G, P); Bisby 66, Kaldı Dağ, Seyhan R., prov. Adana (OXF); Davis 15656, Bozburun Dağ, prov. Antalya (E, K); id. 16554, Bolkar Dağları, between Meydan and Sari Tepe, prov. Adana, distr. Karaisah (K); Davis and Hedge 28291, (ANK); id. 31201, Munzur Dağ above Ovacık, prov. Tunceli (BM, K); id. 31619, Keşiş Dağ above Cumin, prov. Erzincan (E, K); Haradjian 3847, Amanos Mts, Mt Dülоül (G); Haussknecht s.n., Mesopotamia, above Tirek (JE); id. s.n., Beryt Dağ (JE); Heldreich 1422, Mt Boudroun, above Sagalassun (Aglasun), prov. Burdur (BM, E, G, K, L, P, W, WAG); Kotschy 170, Taurus Mts (BM, G, K, OXF, P, W); id. 14, 132, 143a, Bolkar Dağları (BR, G, K, L, M, P, W, WU); Montbret 2417, Keşiş Dağ, prov. Erzincan (K, P); Roinet (?) 67, Aigurs-Norden ? (W); Siehe 296, Karli Boğaz, prov. Içel (BM, E, G, JE, K, OXF, WU); Wood and Gibson 219, Narpiz Gorge, Ala Dağ, prov. Niğde (E); id. 272, Ala Dağ, prov. Niğde (E).

USSR-Caucasus: Fomin s.n. (= Woronow and Schelkownikow 130), prov. Tiflis, distr. Gori, Tana Valley near Ateni-Karthalinia (JE, K, WU).

Uncertain: Alioth s.n., la Treille près Marseille, as *Onobrychis acquidentata* DC., obviously a wrong label (W); Herb. Hasskarl s.n., inter Medicaginem mollisimam Sprng a Streinz distribut. e Cerina Insule Dalmat a Botter collecti in herbario aeroepi (Zirona, Dalmatic Islands?).

19. C. isauricum P. H. Davis **Fig. 16, p. 71; Map 12, p. 63**

Not. Royal Bot. Gard. Edinb. 29–3: 311, 1969; DAVIS, Fl. Turkey 3: 268. 1970.

Type: Turkey, Akseki, HUBER-MORATH 17174 (Hb. HUBER-MORATH, holotype, not seen).

Paratypes: Turkey, Durbanas, DAVIS 14396 (K) and Akseki, SORGER 65–37–8 (?, not seen).

Perennial. Branching from the base, woody vertical rootstock, eventually branched at lower nodes, glandular pubescent except for the subglabrous leaflets.

Stems erect, flexuous, ribbed, sparsely glandular pubescent, 20–40 cm long.

Leaves 7–11(13) leaflets, imparipinnate; rachis 3.5–8 cm long, ending in a leaflet, rather crowded, opposite or not, subcoriaceous, oblong-obovate, shortly petiolulate (1 mm long), 7–24 mm long, 5–15 mm wide, base broadly rounded to nearly heartshaped; top rounded or truncate; both sides prominently veined, veines merging; upper side vividly dark green, lower side greyish green, both sides greyish green when older; margin dentate except near the base, teeth ca. 20–25, triangular-acuminate-spinulate, up to 2 mm.

Stipules 1–3 dentate or incised triangular perules, 2–5 mm long.

Flowers in (1)2–3(4)-flowered axillary racemes, peduncles 25–35 mm long; arista 5–12 mm, ending in a cupular or lanceolate perule; bracts (tri)dentate perules, up to 2 mm long; pedicels 5–10 mm, recurved when bearing fruits. Peduncle and pedicel strongly glandular pubescent.

Calyx strongly dorsally gibbous at the base, densely glandular pubescent, tube 5–6 mm; teeth 6–8 mm, triangular-lanceolate, acute.

Corolla veined, white; vexillum broadly obovate, 20 mm long, 13 mm wide, base broadly pedicellate, top incised-mucronulate; alae obovate-pedicellate,

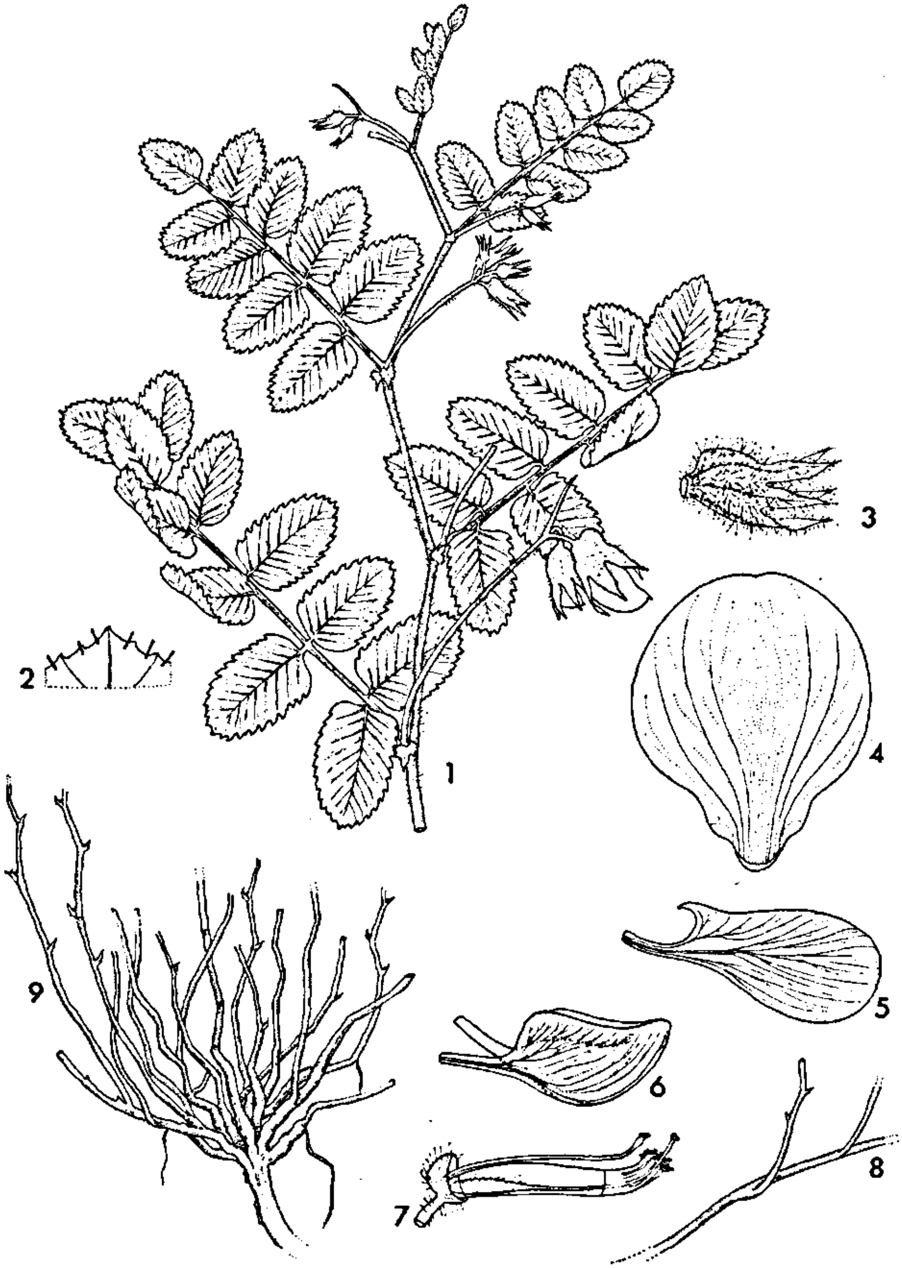


FIG. 16. *C. isauricum* P. H. Davis – 1. branch, $^{5}/_{6}\times$; 2. detail of leaflet, $2^{1}/_{2}\times$; 3. calyx, $2^{1}/_{2}\times$; 4. flag, $2^{1}/_{2}\times$; 5. wing, $2^{1}/_{2}\times$; 6. keel, $2^{1}/_{2}\times$; 7. anthers and pistil, $2^{1}/_{2}\times$; 8. detail of main roots, $^{1}/_{4}\times$; 9. habit of shrub, $^{1}/_{4}\times$ (VAN DER MAESEN 1347, WAG)

14 mm long, base auriculate; carina rhomboid, pedicelled, 12 mm long, frontal side of ventral margin adnate (dimensions after Davis).

Stamens 9 + 1, filaments ca. 11 mm (fused part 9 mm, free part 2 mm, upturned), anthers dorsifix.

Ovary ovoid, 4 mm long, hairy, 8 ovules, style 10 mm, incurved.

Pods oblong-ellipsoid, ca. 25 mm long, 10 mm wide, densely glandular pubescent (cf. Davis).

Seeds (immature) suborbicular, tuberculate (cf. Davis).

Note

I found *C. isauricum* growing near the locality of one of the paratypes, ± 9 km N of Akseki. The deep-going woody rootstocks fix the plants solidly in the steep slopes and are very hard to dig out. Each specimen forms several stems in spring. Small specimens have few stems and small leaflets, big ones possess many stems on a kind of knob and have large leaflets. At the end of May only flower buds could be found, showing the greenish white colour also known in *C. montbretii* Jaub. et Spach. *C. isauricum* is eaten by goats etc. The relationship to the cultivated chickpea is expressed by the people by the vernacular name 'tuzlu nohut', the 'saltish chickpea'.

Distribution: S. Anatolia.

Altitudes: 1000–1500 m

Ecology: grey volcanic rocks and screes, *Abes cilicia, Pinus nigra* forests. Flowering: June, July (August).

Vernacular name: Tuzlu nohut (saltish chickpea).

Specimens examined: Turkey: Davis 14396, Kargi Çay, between Durbanas and Derince De, distr. Alanya, prov. Antalya (K, paratype); van der Maesen 1347, 9 km N of Akseki, prov. Antalya (WAG).

20. C. judaicum Boiss. **Fig. 17, p. 74; Map 18, p. 106**

Diagn. Sér. 2–9: 130. 1849; Boiss., Fl. Orient. 2: 560. 1872; Popov, op. cit. 176. 1929; Popova, Kult. Fl. SSSR 4: 66. 1937; Bornmüller, Fedde Repert. 50: 138. 1941; Zhukovsky, Cult. Plants and their wild relatives: 26. 1962; Davis, Fl. Turkey 3: 271. 1970.

Type: Palestine, Jerusalem, Boissier (G holotype, further specimen of Jerusalem from Roth (M), determined by Boissier, were inspected).

Annual. Herb, branched mainly from the base, densely glandular pubescent.

Stems slender, prostrate or slightly ascending between stones etc., 14–40 cm.

Leaves (7–9)11–13 leaflets, imparipinnate; rachis 15–40 mm, grooved above ending in 1–2 leaflets; petiole short, 5–12 mm.

Leaflets rather close, opposite or not, subsessile, obovate or rounded-obovate, 4–7(9) mm long, 2–5(8) mm wide, lower surface slightly more prominently veined and more pubescent than the upper one; base cuneate, margin rather irregular incised, at the base entire, at the top mostly doubly incised-serrate, teeth triangular-acute, 7–12.

Stipules ovate or ovate-lanceolate, 2–3 mm, 2–5 unequal teeth.

Flowers in 1-flowered axillary racemes; peduncle 10–20 mm, ending in an arista, 0–3 mm; pedicel 5–7 mm.

Calyx hardly dorsally gibbous at the base, tube ca. 2 mm, teeth lanceolate-acuminate, 3–4 mm.

Corolla veined, pinkish purple, fading into blue-violet when old; vexillum broadly ovate, top slightly emarginate-mucronate, base broad, 5–6 mm long, 5 mm wide, alae obovate, auriculate or not, ca. 4 mm long, ca. 1.5 mm wide; carina rhomboid, ca. 5 mm long, frontal side of ventral margin adnate.

Stamens 9 + 1, filaments 4 mm long (fused part 3 mm, free part 1 mm, upturned).

Ovary ovoid, 2 mm long, densily glandular pubescent; style ca. 2 mm, upturned.

Pods rectangular ovate, 10–13 mm long, 5–6 mm wide, style and stamens persistent, (1)2–3 seeds, shattered when ripe.

Seeds triangular arietinoid, hardly bilobular, beaked, 3–4 mm long, 3–4 mm wide, hilum ½ mm, seed coat brown or greyish brown (to black), unevenly tuberculated, chalazal tubercle rather prominent.

Taxonomical notes

The status of *C. judaicum* Boiss. has changed repeatedly. First BOISSIER reduced his own species (1849) into synonymy (in Fl. Orient., 1872) with *C. pinnatifidum* Jaub. et Spach. POPOV (1929) published var. *judaicum* M. Pop. (not: var. *judaicum* (Boiss.) M. Pop.) in *C. pinnatifidum* and based the variety on another specimen (PASTUCHOV, Jerusalem) while *C. judaicum* Boiss. was referred to as a synonym.

The epithet *judaicum*, however, was used for a species during decennia. POPOVA (1937) declared that *C. judaicum* Boiss. should be maintained as a species, and she based this view on specimens brought by VAVILOV from Jerusalem. It is remarkable that the varietal division of *C. pinnatifidum* of POPOV has been repeated without comment. The material consulted by POPOV has probably not been seen by POPOVA, since she did not refer to it in her article.

The characters mentioned by former authors and by DAVIS (1970) though important, are insufficient to separate *C. judaicum* and *C. pinnatifidum*. I found additional characters in the seeds, their shape. The distribution of these species is very interesting and in adjoining areas *C. judaicum* specimens occur with some '*pinnatifidum*' characteristics, suggesting possible hybridization.

Morphological notes

When cultivated under the same circumstances sufficient differences appear to exist between *C. pinnatifidum* and *C. judaicum*, and these characteristics are found to be constant in the herbarium collections, so that I decided to keep the species apart. *C. judaicum* has more leaflets per leaf (11–13), shorter petioles (1–1.5 × the length of the leaflets, in *C. pinnatifidum* 2–3 ×), less deeply incised stipules and shorter, smaller seeds with a slightly different structure of the seed coat. *C. pinnatifidum* seeds are more clearly bilobular (see Fig. 28). Es-

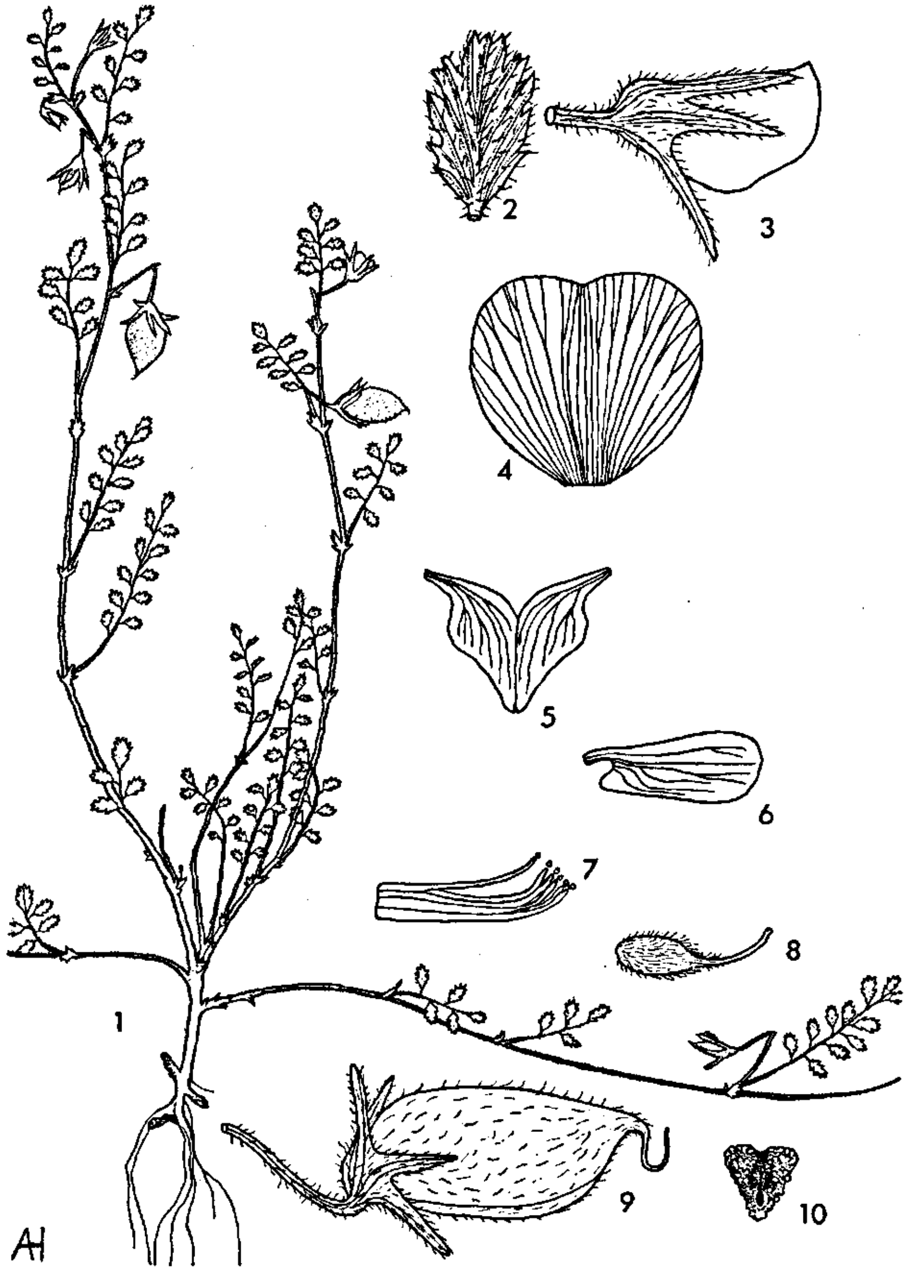


FIG. 17. *C. judaicum* Boiss. – 1. plant, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. flower, $2^1/_2$ ×; 4. flag, $2^1/_2$ ×; 5. keel, $2^1/_2$ ×; 6. wing, $2^1/_2$ ×; 7. anthers, $2^1/_2$ ×; 8. pistil, $2^1/_2$ ×; 9. pod, $2^1/_2$ ×; 10. seed, $2^1/_2$ × (VAN DER MAESEN 973, WAG)

pecially in BALANSA (1856) the seeds are nearly divided in two. Only in cultivated *C. judaicum* (received from Jerusalem, collected in situ) had the alae no auriculum, while in the *C. pinnatifidum* specimen (cultivated, received from Gatersleben and Copenhagen, most probably originating from Turkey) the alae were strongly auriculate. This, however, was not present in the wild material. The auriculae in wild *C. judaicum* (ZOHARY and AMDURSKY 345, DAVIS 4339) might be a little shorter than in most *C. pinnatifidum*, but the difference is very slight.

The stature of *C. judaicum* is more prostrate with longer stems and internodia. The prostrate habit is often obscured when a specimen is mounted. In cultivation *C. pinnatifidum* reached 27–30 cm, *C. judaicum* had stems of 37 cm after 9 weeks. The wild specimens are either small or large plants, according to the date of collection and ecology. In cultivation *C. pinnatifidum* has predominantly 7 leaflets per leaf only, while *C. judaicum* possesses mainly 9-foliolate leaves, which for both species is less than in the wild. *C. judaicum* leaflets are more rounded than in nature. Freshly harvested seeds all show dormancy, after a year this character has almost disappeared.

The specimens from the Libanon accepted as *C. judaicum*, show an approach to *C. pinnatifidum*. BLANCHE (Beirut) has few leaflets per leaf, and up to 11 leaflets. ROESSLER 5013 has a few doubly-serrate leaflets and up to 11 leaflets. ROESSLER 5121 possesses the same characteristics, but its habit is more typical for *C. judaicum*. PEYRON (1893) s.n.grows like *C. judaicum*, but the length of the petiole and form and number of leaflets is somewhat intermediate to *C. pinnatifidum*.

Geography of C. judaicum and C. pinnatifidum

The area of *C. judaicum* is very small. The species is endemic to the coastal and inland hills and mountains of Israel and the Lebanon, while *C. pinnatifidum* occurs over a large area both in mountanous areas and flatlands of Turkey, Syria and Iraq. The 'Damascus' collections and that from Iskenderun (LETOURNEAU, GAILLARDOT) need more geographical detail. Neither species occurs in the area of the other, except for the Damascus area, where typical *C. pinnatifidum* occurs near to *C. judaicum*, making natural crossings possible. *C. pinnatifidum* occurs also in the Kaukasus, since '*C. ervoides*' listed in the FLORA KAVKAZA (GROSSHEIM 1952) by the accompanying illustration proves to be *C. pinnatifidum* (DAVIS, 1970).

Distribution: Israel, Lebanon.
Altitudes: 0–500 m
Ecology: rocky places, fields. Flowering: March-May.

Specimens examined: Israël: American Colony 635, Jerusalem (K); Davis 4339, Binyamina-Kabara, W slopes of Carmel (E, K); Jouannet-Marie 272, Mt Zion, Jerusalem (W); Kotschy 453, Jerusalem (W); Linnaean Herbarium 908.2 (LINN); van der Maesen 973, ex Ladiszinski, Campus Hebrew University, Jerusalem (WAG); Meyers and Dinsmore 4635, Jerusalem (G, L); Roth s.n., Jerusalem (M); Zohary and Amdursky 345, Mt Scopus, Jerusalem (BM, BR, C, CAIM, G, L, MPU, P, RAB, U, W, WAG).

Lebanon: Aaronsohn 976, between Saida (Sidon) and Kefr er Raï (MPU); Blanche, fields near Beirut (BR, C, W, WU); Meinertzhagen s.n., Beirut (BM, K); Peyron s.n., Beirut-Debbayé (G, P); Roessler 5013, Jubeil (Byblos) near Eddé (M); id. 5121, Nahr ed Damur, between Beirut and Saida (M).

21. C. kermanense Bornm. **Fig. 18, p. 77; Map 21, p. 120**

Bull. Herb. Boiss. Sér. 2–5: 969. 1905 (nomen, in obs.); BORNMÜLLER, B.B.C. 57B: 288. 1937; PARSA, Fl. Iran 2: 437–438. 1943.

Syntypes: Iran, Kerman prov., Kuh-i-Dschupar, BORNMÜLLER 3676 (JE holotype; isotypes in BM, BR, G, OXF, P, W, WU), Kuh-i-Nasr, BORNMÜLLER 3677 (JE, holotype), Kuh-i-Dschupar, BORNMÜLLER 3678 (JE, holotype; isotypes in G, WU) and Kuh-i-Häsar, BORNMÜLLER 3680 (JE, holotype, not seen), Kuh-i-Häsar, BORNMÜLLER 3679 (JE, holotype, not seen; isotypes in E, G, W). According to the first communication nrs 3676–3679 are considered as the original material, the protologue gives nrs 3677, 3678 and 3680 as type material.

Synonym: *C. spiroceras* Jaub. et Spach subsp. *kermanense* (Bornm.) M. Pop., op. cit. 196. 1929.

Perennial. Bushy plant, shortly puberulous.

Stems straight or flexuous, ribbed, 30–50 cm long.

Leaves (6)12–24 leaflets; rachis 4–13 cm, grooved above, ending in a curly tendril.

Leaflets remote, paripinnate, broadly cuneate-flabellate, base cuneate or slightly rounded, 5–9 mm long, 5–15 mm wide, both sides prominently veined, teeth (3)5–10, broad-acuminate, sometimes sharper, up to 2(4) mm, ending in a spinelet, dent of midrib often with a recurved spine, lateral dents mostly longer.

Stipules triangular-lanceolate perules, with 1 dent, at the base of the plant broader and with up to 4 dents.

Flowers in 1–2-flowered axillary racemes, peduncle 4–6 mm long, with a more or less sturdy arista, 1–2 cm, bearing 1–2 flowers on the same height; bracts minute triangular perules; pedicels up to 11 mm, straight.

Calyx dorsally gibbous at the base; tube 2–3 mm; teeth lanceolate-acuminate, 7–10 mm.

Corolla veined pink (to white ?), vexillum ovate, top mucronate, broad at the base, 18 mm long, 13 mm wide; alae clavate, base auriculate, 13 mm long, 5 mm wide; carina rhomboid, topmost half of ventral margins entirely adnate, perpendicular to the lower margin, 7 resp. 8 mm.

Stamens 9 + 1, filaments 15 mm long (fused part 10 mm, free part 5 mm), perpendicularly upturned.

Ovary ovoid, 7 mm long, 2 mm wide, ± 10 ovules; style 6 mm, glabrous, curved within the staminal tube.

Pods rhomboid-elongated, 18 mm long, 10–11 mm wide (cf. Bornm.).

Seeds obovate, beaked, 4 × 5 mm, reddish brown (cf. Bornm.).

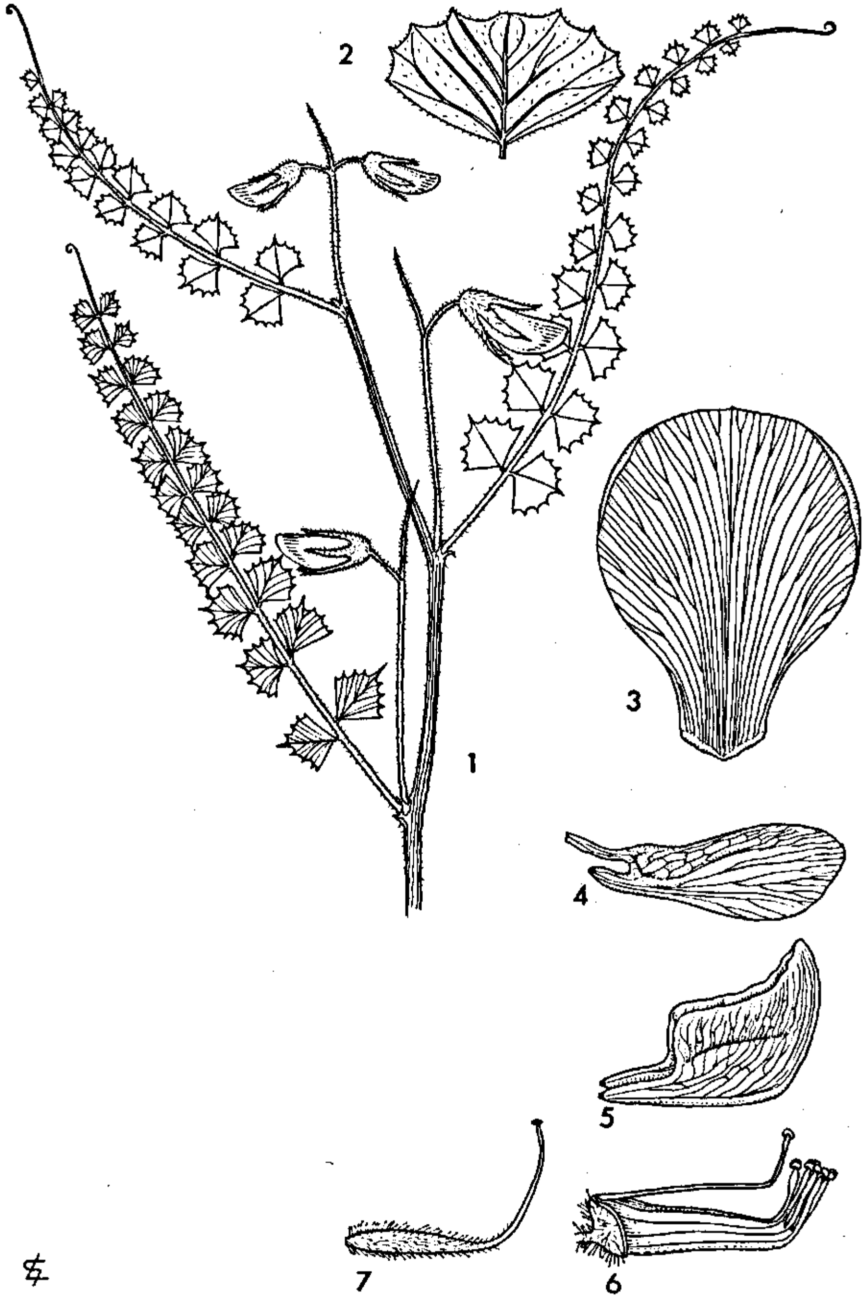


FIG. 18. *C. kermanense* Bornm. – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. flag, $2^1/_2$ ×; 4. wing, $2^1/_2$ ×; 5. keel, $2^1/_2$ ×; 6. anthers, $2^1/_2$ ×; 7. pistil, $2^1/_2$ × (BORNMÜLLER 3676, BR)

Note

The pedicels, described as shorter than in *C. spiroceras* (BORNM., 1905) are in reality of the same length. In the protologue (BORNM., 1937) this has not been repeated. Although the description of POPOV (1929) gave 6–16 leaflets for *C. spiroceras*, *C. kermanense* (with 12–24 leaflets) is adopted as a subspecies. *C. kermanense* has also closely placed leaflets, and contrary to the statement of BORNMÜLLER, these are often bigger, including those in the original material. The most obvious difference is the cuneate-flabellate form of the leaflets, while the lateral teeth often exceed the central one.

Distribution: S.E. Iran.
Altitudes: 2700–3300 m
Ecology: mountains, rocky places. Flowering: May-June (July).

Specimens examined: Iran, near Kerman: Biggs 13153, Valley above Seguch (K); Bornmüller 3676, Kuh-i-Jupar (BM, BR, G, JE, OXF, P, W, WU); id. 3678, Kuh-i-Jupar (JE, holotype; G, WU); id. 3679, Kuh-i-Häsar (E, G, W).

22. C. korshinskyi Lincz. **Fig. 19, p. 79; Map 6, p. 40**

Not. Syst. Inst. Bot. Acad. Sci. USSR 9: 110. (1948?) 1949; LINCZEVSKI, Fl. USSR 13: 396. 1948.

Type: C. Asia, Imam-askara Mt, Darvaz, LINCZEVSKI 1179 (LE, holotype, not seen).
Paratype: Pamir, Bidzhan river, KORSHINSKY 2185 (3319) (LE)

Perennial. Rootstocks woody, hardly branched from the base, aerial part glandular pubescent.
Stems straight or slightly flexuous, slightly ribbed, 50–80 cm long.
Leaves 10–12 leaflets, rachis 4–7 cm, grooved above, ending in a spiny curl, sometimes a foliolate curl or a leaflet (lower leaves) or a tendril (upper leaves).
Leaflets opposite or not, rather close, obovate or broadly cuneate; base more or less broadly cuneate; top irregularly rounded; (6)10–17(20) mm long, (4)6–10(13) mm wide; margin dentated except near the base, teeth broadly acuminate, several times doubly dentate, up to 3 mm, top spiny, tooth of midrib turned down.
Stipules semi-ovate or rounded (lowest leaves), deeply toothed, $\frac{1}{2}$–1 × the leaflets, 5–10 mm long, 5–12 mm wide, teeth acuminate-acute, 2–4 mm long.
Flowers in 1-flowered axillary racemes; peduncle 2.5–6 cm, ending in a short spiny arista, 4–9 mm. (Details taken from the protologue).
Calyx dorsally gibbous at the base, ca. 15 mm long, teeth lanceolate.
Corolla not known.
Pods (immature) obovate-oblong, 25–30 cm, densely glandular pubescent.
Seeds not known.

Distribution: N.W. Pamir.
Altitudes: 2500 m
Ecology: dry rocky slopes. Flowering: August.

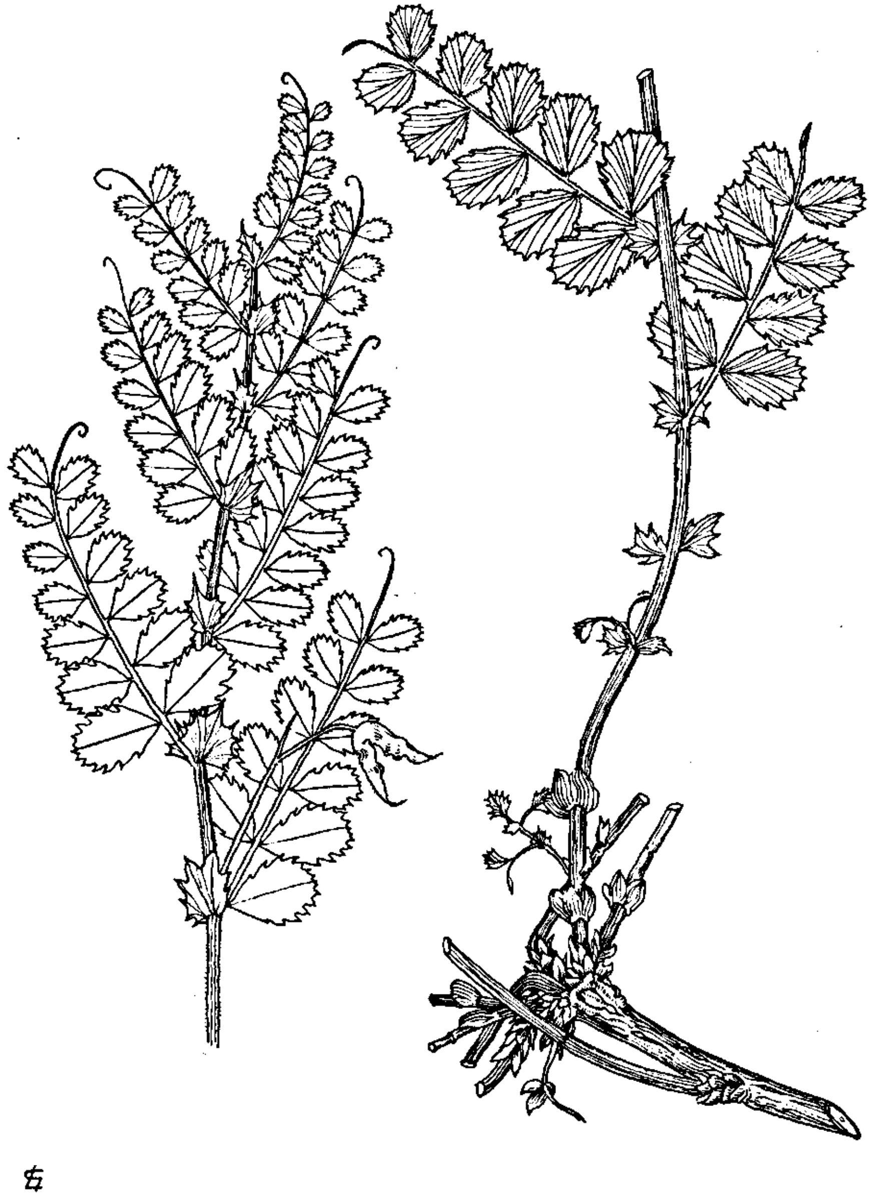


FIG. 19. *C. korshinskyi* Lincz. – branch and plant base, $^5/_6$ × (KORSHINSKY 2185, LE)

Specimens examined: USSR, Tadzhikistan: Shtshukin s.n., NW Pamir, upper Vanch stream, Garmo R. (MW); Korshinsky 2185, W Pamir, Bidzhan R. (LE, paratype).

23. C. macracanthum M. Pop. **Fig. 20, p. 81; Map 3, p. 26**

Bull. Univ. As. Centr. 15, suppl.: 16. 1927; Popov, op. cit. 226. 1929; Wendelbo, Nytt. Mag. for Bot. 1: 45. 1952; Rechinger, Biol. Skrift. Kong. Dansk. Vidensk. Selsk. 9: 202. 1957; Kitamura, Fl. Afghan.: 225. 1960; Kitamura, Pl. of W. Pak. and Afghan.: 91. 1964; Borissova, Novit. Syst. Plant. Vasc. Leningrad 6: 167. 1970.

Type: C. Asia, Pamir-Alai, Guralash, Popov in Herb. As. Med. 265 (TAK, holotype, not seen; isotypes in BR, C, E, G, P, W (seen), further in LE (not seen).

Synonym: *C. songaricum* Steph. var. *spinosum* Aitch., J. Linn. Soc. Bot. 18: 49. 1881.

Perennial. Rootstock vertical, woody, prickly bushlet, branched, mostly at the base, glandular pubescent.

Stems flexuous or not, ribbed, 25–35 cm long.

Leaves (6)8–18(22) leaflets, at the base with less leaflets, rachis 2–6.5 cm, grooved above, ending in a spine.

Leaflets not close, paripinnate, obovate or obovate-elongate, both sides prominently veined, base rotundate or cuneate, top truncate-incised (2)3–5(8) mm long, 2–5 mm wide, teeth unequal, (1–3)5–7(9), midrib ending in a spinelet, up to 2 mm long, often twisted or even covering other dents.

Stipules of lower leaves ca. 5–8 mm long perules, entire or incised or consisting of 2 triangular parts, most upper stipules spiny; a long horizontal one, (3)6–25 mm, regularly unequal to the one of the other side of the leaf, seconded by a small spiny stipule, 1–4 mm, seldom two or three secondary stipules.

Flowers in 1 (seldom 2–3)-flowered axillary racemes; peduncle 2–5 cm long, sometimes longer than the leaves, ending in a spiny arista, (5)10–20(25) mm; bracts small triangular perules, up to 1 mm; pedicels 5–13 mm, recurved when bearing pods.

Calyx strongly dorsally gibbous at the base; tube 4–6 mm; teeth lanceolate or triangular-acuminate, 5–7 mm, ending in a spinelet, midrib prominent.

Corolla veined, dark blue or violet, keel whitish with violet tip; vexillum obovate with a long, broad base, 15–25 mm long, 8–15 mm wide; top incised-mucronulate; alae obovate, 12–15 mm long, 5–8 mm wide, base auriculate; carina rhomboid, $\frac{3}{4}$ part of frontal side of ventral margin adnate, ca. 13 mm long.

Stamens 9 + 1, fused part 9 mm, free part 4 mm, incurved, anthers dorsifix.

Ovary lanceolate-ovate, 9 mm, 2 mm wide, 8 ovules; style 8 mm, incurved, stigma broadened.

Pods ovate-oblong to rhomboid-oblong, 20–25 mm long, 7–9 mm wide, long glandular hairs, valves curling when ripe.

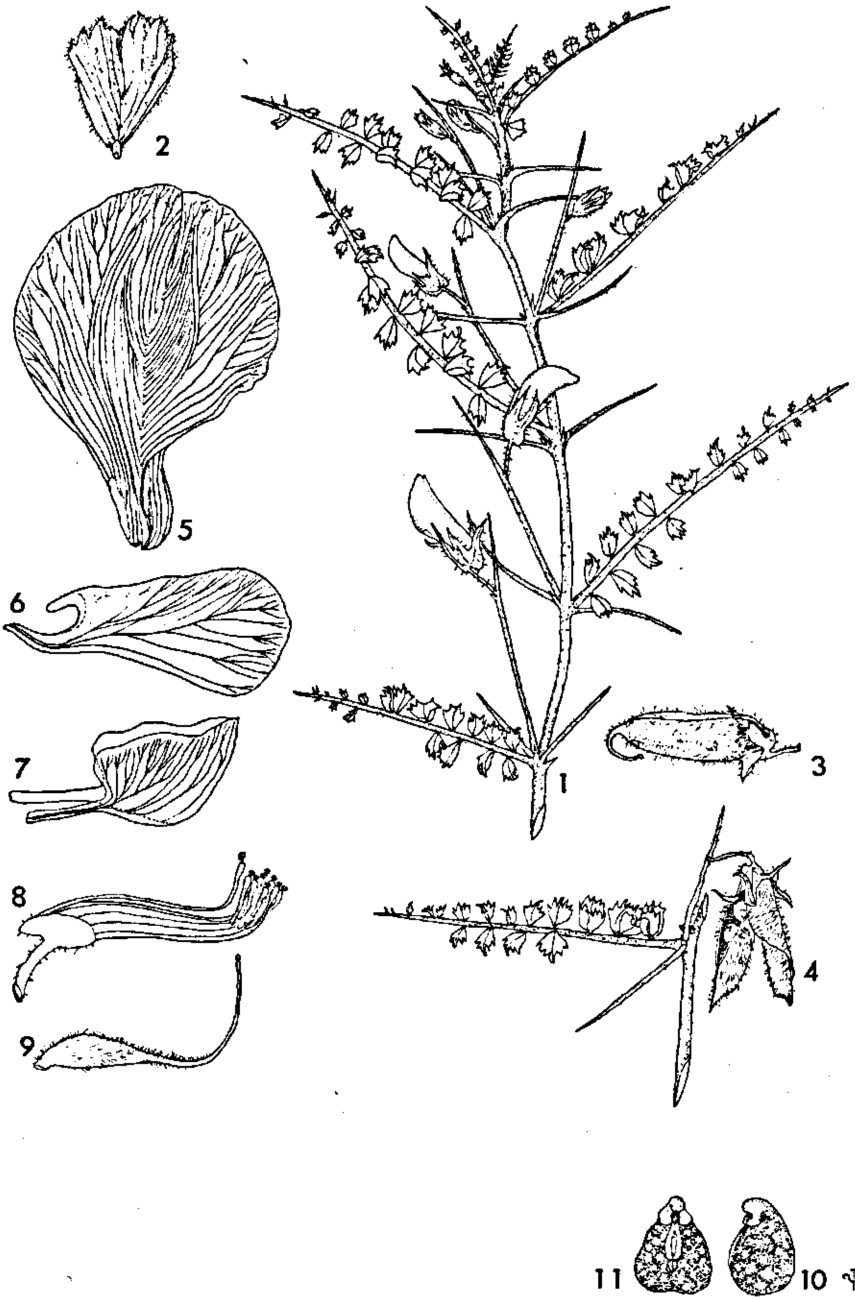


FIG. 20. *C. macracanthum* M. Pop. – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. pod, $^5/_6$ ×; 4. part of branch with open pod, $^5/_6$ ×; 5. flag, $2^1/_2$ ×; 6. wing, $2^1/_2$ ×; 7. keel, $2^1/_2$ ×; 8. anthers, $2^1/_2$ ×; 9. pistil, $2^1/_2$ ×; 10, 11. seed, $2^1/_2$ × (POPOV, HFAM 265, BR)

Seeds elongated-ovate, beaked, 4–5 mm long, 3 mm wide (unripe), hilum sunken, seed coat brown, tuberculated, with fine whitish scales, chalazal tubercle not (yet?) protruding.

Note: see *C. acanthophyllum.*

Distribution: Afghanistan, Kashmir, Uzbekistan, Tadzhikistan (Turkestan Mts).

Altitudes: 2200–3600 m

Ecology: dry stream-beds, valleys, dry stony and rubble slopes. Flowering: June-August.

Specimens examined: Afghanistan: Aitchison 819, Kurram Valley, Seratigah (K); Collett 87, Safed Kuh (K); Giles 211, Ishikoul, Badakshan (CAL, K); id. 432, Shah Janah, SO Hindukush (K); Kerstan 1079, Pitwei Valley, between Pirdum Pass and Kulam (Munui), W Nuristan (W); Koelz 12641, Sanglich, prov. Badakhshan (W); Podlech 12349, E slope of Anjuman Pass (M).

Kashmir (India and Pakistan): Bowes Lyon 88, Shandur, near Chitral (W); id. 382, Oïkor Gol near Chitral (W); Clarke 28716, Hirpoor (BM, K); Giles s.n., Gilgit Exp., N Hindukush (E); id. s.n., Gilgit (BM, E); Kerstan 1564, above Bomosto, Tirich-Mir region, Chitral (W); Rahman 88, Sho Nala, Swat area, Kohistan (W); Stainton 2691, Chitral Gol, W of Chitral (BM); Stamm and Wöhrl 96, Chatibo Glacier, Chitral area (W); Stewart and Rahman 25177, Sho Nala, near Kalane, Swat area, Kohistan (BM); id. 25296, above Ushu, Swat area (K); Toppin 512, Madah Lasht, Chitral area (K).

USSR, Tadzikistan: Popov HF AM 265, Khrebet Mogol-tau, near Katar-Bulak and Turkestanskii Khrebet, Guralash Pass (BR, C, E, G, P, W); Varivshteva and Kuzneshtov 623, Alichur Valley (MW).

USSR, Uzbekistan: Pyangayeva 62, Turkestanskii Khrebet, Zaamin region, Guralash R., where Kul Cai R. joins Tyuya-tasht-caem (BM); Xox? s.n., Turkestan (W).

24. C. microphyllum Benth. **Fig. 21, p. 84; Map 14, p. 85**

in Royle, Ill. Bot. Himal.: 200. 1839; Baker in Hooker, Fl. Brit. India 2: 176. 1879; Popov, op. cit. 220. 1929; Linczevski, Fl. USSR 13: 403. 1948. As *C. songaricum* Steph.: Aitchison, J. Linn. Soc. Bot. 18: 49. 1881; Watt, Dict. Econ. Prod. India 3: 428. 1890.

Type: India (Shalkur, Bashar, Himachal Pradesh) Shalkur, Hungarung, Royle s.n. (K, holotype).

Heterotypic synonym: *C. jacquemontii* Jaub. et Sp., Ann. Sci. Nat. Sér. 2–18: 231. 1842; Boissier, Fl. Orient. 2: 563. 1872; Popov, op. cit. 220. 1929; Linczevski, Fl. USSR 13: 400. 1948; Rechinger, Ann. Naturhist. Mus. Wien 65: 32. 1961.

(Type *C. jacquemontii*: Himalaya, Yurpo, Kanaor Reg., Jacquemont 1733 (P, holotype; isotypes no. 1734, P, also in K, and s.n., L. K.).

Perennial. Slender spreading shrublet, branched from the woody vertical rootstock, glandular pubescent, hairs more or less crowded.

Stems slender, ascending, sometimes partially flexuous, ribbed, 20–40 cm.

Leaves (8)14–20(30) leaflets, mostly paripinnate, rachis (4)7–13 cm, grooved above, ending in a tendril, sometimes in a tendrillous leaflet or a leaflet.

Leaflets remote to fairly close, narrowly cuneate or cuneate-obovate, (1)5–10 (17) mm long, (1)2–6(9) mm wide, top more or less rounded or truncate, base cuneate or cuneate-rounded, upper half of margin incised-dentate, both sides clearly veined, teeth (5)7–10(13), irregularly triangular, acute or obtuse, dent of midrib mostly incurved, often shorter than the lateral ones, but upper pairs of leaflets sometimes tendrillous.

Stipules a-symmetric, triangular-incised, nearly as large or as large as the leaflets with longest tooth, 2–12 mm, basal width 1–5(9) mm, base rounded, teeth (1–2)–3–7.

Flowers in 1(2)–flowered axillary racemes; peduncle 2.5–9 cm long, ending in an arista, 2–6 mm long; bracts minute triangular or incised perules; pedicels 5–10 mm.

Calyx dorsally gibbous at the base, tube 3–4 mm, teeth triangular or lanceolate, acuminate or elongate, 4–8 mm long, midrib faintly prominent.

Corolla veined, purple, purplish white or white, if purplish fading into blue; vexillum broadly obovate, top emarginate, 18–25 mm long, 10–18 mm wide; alae obovate, auriculate, 14–18 mm long, 5–8 mm wide; carina elongate-rhomboid, 16 mm long, frontal side of ventral margin adnate.

Stamens 9 + 1, loose filaments 14–16 mm (fused part 9–11 mm, free part ca. 5 mm, upturned).

Ovary elongate-elliptic, 6 mm long, 10 ovules, style 9 mm, upturned.

Pods elongate-elliptic, acuminate, dehiscent, valves curling when ripe, 20–30 mm long, 8–10 mm wide.

Seeds subglobular to obovate, beaked, 4–5 mm long, 3–4 mm wide, seed coat blackish brown, irregularly greyish rigulate, minutely tuberculate, chalazal tubercle (spermotylium) not very prominent.

Taxonomical note on C. microphyllum

Most of the Himalayan material, classified traditionally under *C. songaricum* Steph. ex DC. is judged to belong to *C. microphyllum* Benth. *sensu lato*. Several taxa have been described since Popov accepted the polymorph concept of *C. songaricum*. The view of Baker's to consider *C. microphyllum* and *C. jacquemontii* to be synonymous with *C. songaricum* is partially right. Since he probably had no real *C. songaricum* at his disposal he saw the similarity of *C. microphyllum* and *C. jacquemontii* to the Himalayan '*C. songaricum*' specimens he had (see note under *C. songaricum*).

Since *C. microphyllum* has priority over *C. jacquemontii*, this former name is chosen although it was applied to small plants with very small leaflets as the type material. The original material on which *C. jacquemontii* was based, is exactly similar to *C. microphyllum*, but larger in measurements. A wide range of specimens shows all intermediate sizes among the leaflets. Linczevski (Flora USSR) already proposed a wider concept of *C. jacquemontii*, excluding much material from *C. songaricum*. Due to the paucity of material he avoided a radical step but merely pointed to the possibility to revise these taxa. Although the epithet '*microphyllum*' may be less suitable than '*jacquemontii*' in the con-

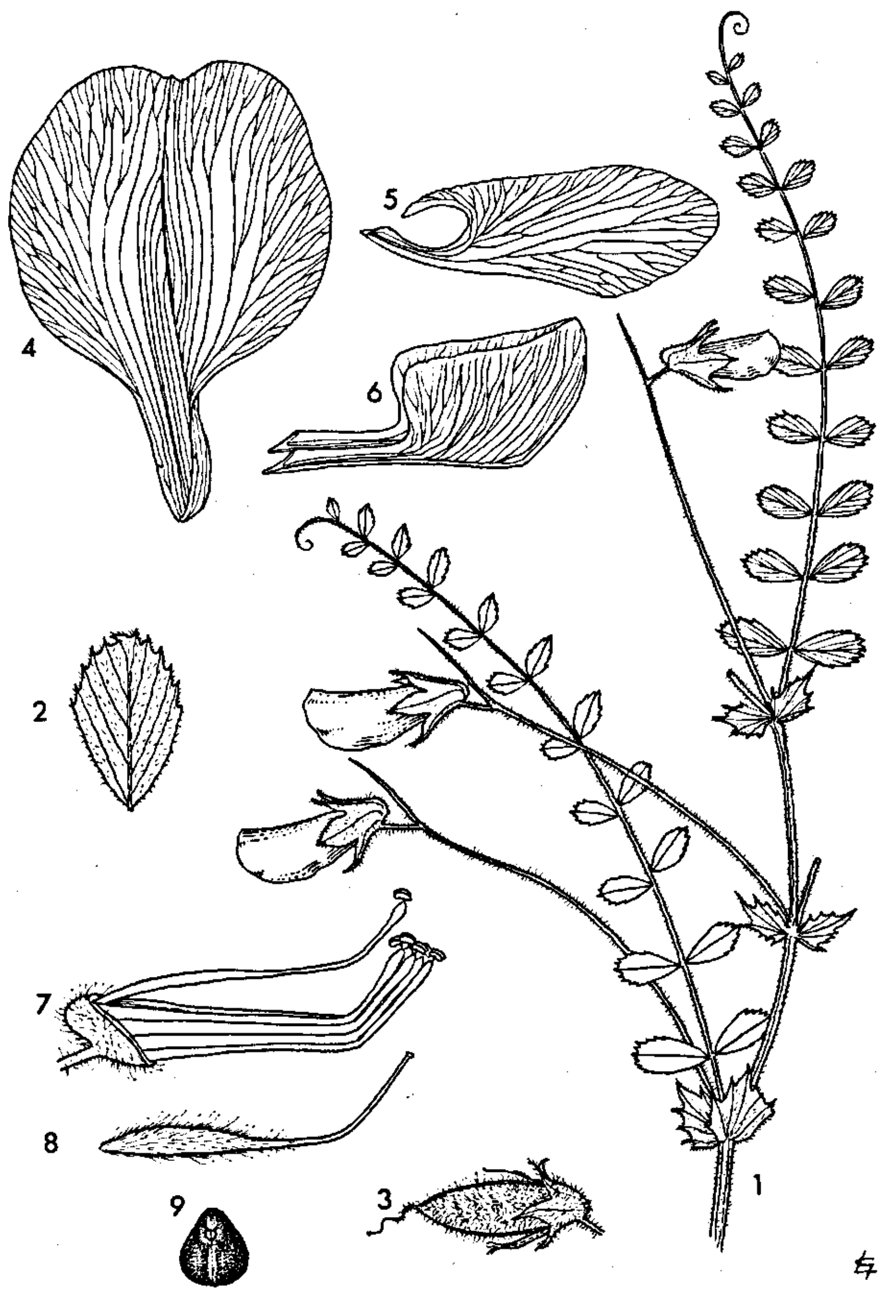


FIG. 21. *C. microphyllum* Benth. – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. pod, $^5/_6$ ×; 4. flag, $2^1/_2$ ×; 5. wing, $2^1/_2$ ×; 6. keel, $2^1/_2$ ×; 7. anthers, $2^1/_2$ ×; 8. pistil, $2^1/_2$ ×; 9. seed, $2^1/_2$ × (VISSER–HOOFT 19 and 19 II, U)

text of descriptive names for *Cicer* species, it should be used, and *C. jacquemontii* falls into synonymy. The Himalayan material always known as *C. songaricum* Steph. ex DC., thus belongs to *C. microphyllum* Benth.

Note on flowering

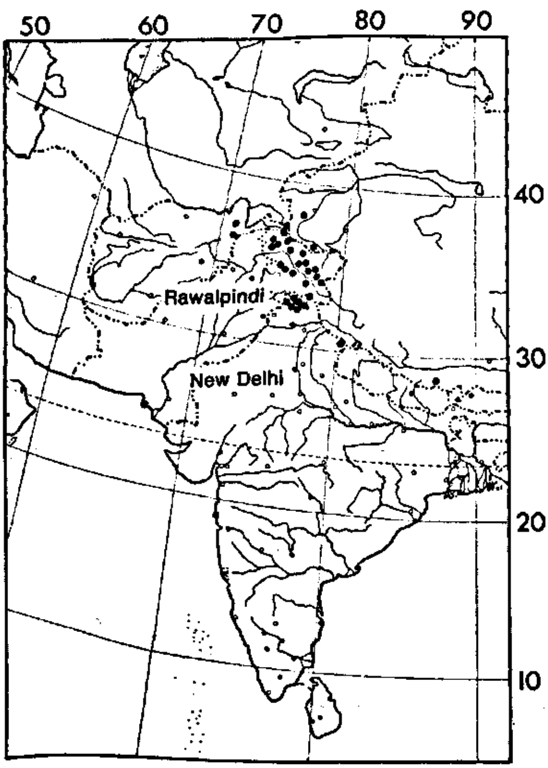
DR. SHAW (West Pak. Agric. Univ., Lyallpur) stated that after considerable difficulties to grow the species, it proved to be morphologically self-sterile as the pistil grows much longer than the stamens. Hand-pollinating was required. Most attempted crossings aborted but two (from eighteen) succeeded. Whether the crossings were successful is not yet reported. This statement is remarkable since the staminal tube is expected to grow near the pistil. In most species the style is slightly longer than the stamens, but it is recurved and remains trapped in the keel. This process occurs 1–2 days before the flower opens, so cleistogamy is the rule.

Distribution: W. Himalaya, Hindukush (E. Afghanistan, Kashmir, W. Tibet, Pamir).

Altitudes: (2000) 3000–5600 m

Ecology: rocks, moraines, dry riverbeds, in pastures, in the open or near trees, in rubble, subalpine *Betula* forest. Ripe pods explode and the seeds are scattered. Flowering: June-August (September).

Vernacular names: tizhu-jawané, banyarts, sárri or serri.



MAP 14. *C. microphyllum*

Specimens examined: Afghanistan: Allan s.n., Darra Sakhi Valley, Hindukush (K); Aitchison 740, Kaiwas, Kurram Valley (K); Lindberg 850, Kuh-i-Chognan Djiroudj, slope of Mian Kuh (W); Stoliczka s.n., Kuri and Changrezing, Badakhskan (?).

China: Conway s.n., between Hispar (Glacier) and Chokutenz, Chinese Turkestan (K); Henderson nrs div., Yarkand Exp. (K); Manoe 132, Bhong Chu (Phung Chu) (Arun) Valley, Tibet, near Mt Everest (K); ascent to Kukli-Pass (Kukliang, N Karakorum ?) (E).

Kashmir (India and Pakistan): Baltistan: Duthie s.n., Marpu nullah (BM, E); id. s.n., Shingo Valley (WU); id. 13849, Bhatpain nala (BM, E); Gregory s.n., Biafo Glacier (BM); Ludlow 356, Hushe Hallah (BM); Schmid 1869, Ulter nullah, behind Baltit (BM); Siddiqi and Zafflar Ali 4130, Upper Satpura (BM, K, W); Webster and Nasir 6002, Upper Hushe Valley, Chogolisa Glacier basin (G, K, M).

Gilgit area: Giles 219, Doyan (P); Lankester and Pearson 1228, SW of Astor, Rama Valley (BM).

Hunza and Karakoram: Kenneth Mason 36, Lupgaz Tilga, Taghdumbash Pamir (CAL); Lacoste 12, bank of Beïk R., Pamir (P); Lobblicher 126, 132, 153, Daintar (M, W); id. 297, 326, Kutto Darukush (M, W); Paffen 103, 144, 233, Baltar (M); Polunin 6312, NW of Hispar village (E, G); Schmid 1869, behind Baltit (Hunza) (G); id. 1964, Nolskal, near Nagar (G); Visser-Hooft 19, Khunjerab Valley (U); id. 19 II, Batura (U); Weiler s.n., lower Baltoro Glacier, between Gasherbrum and Shigar (W).

Ladakh (Little Tibet): Burt 142, Khardong Pass (E); Duthie 25567, Drás Valley (K); Huidton 549, Umlung Karatschau Trade Route (BM); id. 580, Aktash Glacier, Shyok Valley (BM); Koelz 2366, Tsaka La (E, K, W); Ludlow and Sheriff 8399, Khardong La, N of Leh (BM, E); id. 8547, Khardong La (BM); Hb. Martii (BR); Osmaston s.n., Bod Kharbu (K); Schlagintweit s.n., near Maximo Glacier (Loko Oura Mt) and Mt Achursbott (Diamer Glacier Group) (BM); id. 991, Leh (P); id. 1961, Leh (BM, G, M); id. 2372, near Nubra, Tsangkung, up to top of Tsangkung Pass (M, P); id. 7264, to Masenno Glacier (Lolo Duru Mt) and Achursbott (Diamer Glacier group, Hasora prov.) (G, WU); Stewart 7564, Mitsahoi-Dras (K); id. 13278, Dras, Ladakh road (G); Thomson s.n. 1852, Sapa (K); id. s.n. 1866, W Tibet (L); Visser-Hooft 80, Nubra Valley (K).

Pangi range: Stewart s.n., Bumbull Hills (E); id. s.n., Burzil Pass, Kishenganga Valley, road to Nanga Parbat via Gangabal Lakes) (K).

Zaskar region: Ellis 523, upper Chenab R.

Kashmir, NW Himalaya, *insufficient data*: Aitchison 66 (BM); Anon. s.n. (BM, K); Duthie s.n., Sanamarg, Snid Valley (K); Hans s.n., legit. Heide, Kyclacy (P); Hans 840, legit. Täschke, Mt Satoribus (WU); Hooker and Thomson s.n., Tibet Occ., Regio alp., R. bank of Jungelium (BM, BR, C, E, G, K, L, M, P, U, WU); Jacquemont 1733, Yurpo in reg. Kanaor (1830), type *C. jacquemontii* Jaub. et Spach (P); id. 1734, do (P, K); id. s.n., do (note of Munro, 1850; *C. Jacquemontianum* Jaub. et Spach, Nisung-Aungiea, Chinese Part, highly esteemed as fodder) (K, L); Leideck 1629 (OXF); id. 2106 (OXF); id. 3124 (OXF); Madden 170, Milung (E); Strachey 30 (K); Sutton and Sons 995 (K); Royle, NW India (holotype, K); Watt 2494, Rolung Pass (E).

India, Punjab and Himachal Pradesh: Bor 9723, Lahul, Jhala, S of Kyelang (E, K); id. 14744, Lahul, Kardang (E, K); id. 15009, Lahul, Keulung (K); id. 16460, Lahul (E, K); Cooper 5444, Keulung, Lungti (E); Drummond 23515, Kulu-Lahul, Kandang Mt (E, K); id. 23516, Kulu-Lahul, Sisu-Gondla (E, G, K, P); id. 23517, Kulu-Lahul, Yohe-Kolang (E, G, K); id. 23518, Kulu-Lahul, Zanskar-Zu (K); Giles 137, Gilgit, Kulu Pass (K); Gill 1936, Spiti, Ki Chu (K); Hay 86, Spiti (OXF); Jaeschke 230, Lahul (K); Lace 2052, Chamba, Rangi Forest (E); Parker s.n., Chamba Lahul, Triloknath (K); Schlagintweit 4114, Lahul, Dártse to Tsankar Sumdo Mt (P).

India, Uttar Pradesh: Schlagintweit 7292, Gharwal, Nelong Pass (Nilang), Gnari Khórsum, Poling to Bulla La Mt (K); Strachey and Winterbottom 1, Milaun, Kamaon (Kumaun Div.) (BM, BR, K, P).

USSR: Chaffanjon 1052, Mont Schist, 2000 m (P).

25. C. mogoltavicum (M. Pop.) A. Koroleva **Fig. 22, p. 88; Map 11, p. 57**

in Fl. Tadzhik. 5: 600. 1937; LINCZEVSKI, Fl. USSR 13: 397. 1948; KOMAROV, Opred. Rast. Severn. Tadzhik.: 283. 1967.

Type: Central Asia, Mogoltau Mts, Katar-bulak, POPOV and VVEDENSKY, Herb. F. As. Med. 264 (TAK, holotype, not seen; isotypes in LE (not seen) and in BR, C, G, K, MW, P, W).

Basionyms: *C. flexuosum* Lipsky subsp. *tianschanicum* var. *mogoltavicum* M. Pop., Bull. Univ. As. Centr. 15, suppl: 15. 1927; *C. flexuosum* Lipsky subsp. *mogoltavicum* M. Pop., op. cit. 211. 1929.

Perennial. Roots woody, profusely branched from the base, sparsely eglandular and glandular pubescent.

Stems straight or flexuous, ribbed, 60–70 cm long.

Leaves paripinnate, 16–22 leaflets, rachis 8–16 cm long, grooved above, ending in a simple or ramified tendril.

Leaflets opposite or nearly so, remote, broadly cuneate, flabellate, 3–7 mm long, 2–8 mm wide, base rounded-cuneate, top truncate or incised-truncate, lateral margins entire, top margin dentate, teeth triangular, acuminate, the teeth of midrib longer than the lateral ones, but not exceeding these for its placement in the incision, inflexed.

Stipules triangular, 2–4 mm long, 1–4 mm wide, with 2–3(4) teeth.

Flowers in (1)2-flowered axillary racemes; peduncle 25–55 mm long, ending in a sturdy arista, 5–12 mm; bracts single lanceolate perules, 0.5 mm; pedicels 5–10 mm, recurved when bearing pods.

Calyx dorsally gibbous at the base, tube ca. 4 mm, teeth lanceolate, acuminate, 6–8 mm, midrib prominent.

Corolla veined, violet; vexillum obovate, ca. 17 mm long, ca. 12 mm wide, base spoonshaped, top emarginate, mucronate, exterior pubescent; alae obovate, ca. 14 mm long, ca. 5 mm wide, base longly auriculate; carina rhomboid, ca. 16 mm long, base ca. 4 mm, frontal side of ventral margin adnate.

Stamens 9 + 1, persistent, filaments 12 mm long (fused part 9 mm, free part 3 mm, upturned).

Ovary obovate-elliptic, ca. 8 mm long, ca. 3 mm wide, densely pubescent.

Pods rhomboid-elongate, ca. 25 mm long, ca. 9 mm wide, glandular pubescent.

Seeds ovate-globular, beaked, ca. 5 mm long, 3 mm wide (not fully ripe), seed coat dark brown, finely tuberculated, chalazal tubercle black.

Note

This species, of which only few specimens are extant, can be distinguished from the related *C. flexuosum* by broader and more remote leaflets, small stipules and sparse hairiness.

Distribution: Tadzhikistan, Mogoltau Mts.

Altitude: ca. 1500 m?

Ecology: mountains. Flowering: June.

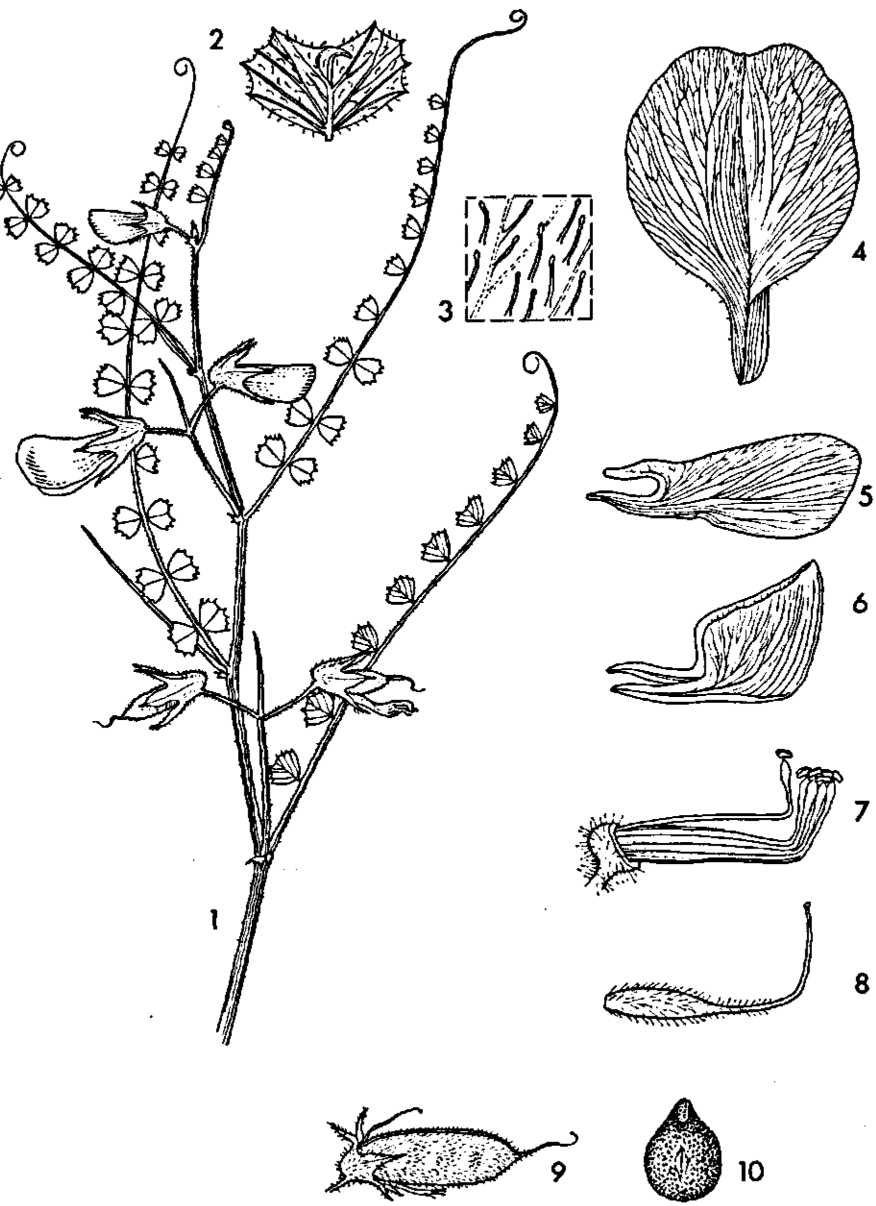


FIG. 22. *C. mogoltavicum* (M. Pop.) A. Koroleva – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. detail of flag, hairs, 10 ×; 4. flag, $2^1/_2$ ×; 5. wing, $2^1/_2$ ×; 6. keel, $2^1/_2$ ×; 7. anthers, $2^1/_2$ ×; 8. pistil, $2^1/_2$ ×; 9. fruit, $^5/_6$ ×; 10. seed, $2^1/_2$ × (POPOV and VVEDENSKY, HFAM 264, P, E, W)

Specimens examined: USSR: Popov and Vvedensky, HFAM 264, Khrebet Mogoltau, Katar Bulak, W Tian Shan (BR, C, G, K, MW, P, W).

26. C. montbretii Jaub. et Spach **Fig. 23, p. 90; Map 12, p. 63**

Ann. Sci. Nat. Sér. 2-17: 229. 1842; JAUB. and SPACH, Ill. Pl. Orient. 1: 87. 1842; GRISEBACH, Spic. Fl. Rum. Bith 2: 542. 1844; BOISSIER, Fl. Orient. 2: 561. 1872; NYMAN, Consp. Fl. Europ.: 200. 1878–82; DEGEN, Oest. Bot. Zeitschr. 41-7: 232. 1891; AZNAVOUR, Magyar Bot. Lapok 2: 141. 1903; POPOV, op. cit. 203. 1929; FÜRNKRANZ, Oest. Bot. Zeitschr. 115: 406. 1968; DAVIS, Fl. Turkey 3: 268. 1970; QUÉZEL, Candollea 25-2: 374. 1970.

Syntypes: Turkey, Mt Gargaro (Gassdagh = Kaz Dağ) COQUEBERT DE MONTBRET (W) and AUCHER-ELOY 1146 (P, holotype; isotype in OXF).

Perennial. Erect herb, occasionally branching, all parts glandular pubescent, hairs very long (0.5–2 mm).

Stems erect, top flexuous, slightly ramified, ribbed, 40–60 cm.

Leaves 15–17 leaflets, imparipinnate; rachis (3)5–7 cm, grooved above, with endleaflet.

Leaflets opposite or not, lanceolate-ovate or elliptic, top acute or obtuse, base broad, 12–25(30) mm long, 5–17 mm wide, petiole short, 1 mm. Nerves more distinct on upper surface.

Stipules broadly ovate, triangular or ovate-lanceolate, up to 7 mm long, up to 5(8) mm wide, dents inequal.

Flowers in 1–3-flowered axillary racemes, peduncles 1.5–6 cm long bearing 1–2 nodes with 1–2 flowers each, arista linear or slightly clavate, 7–15 mm, top leaflet lanceolate-acuminate, ribbed; bracts small incised perules, 1 mm, pedicels 5–12 mm, recurved after fruits have set.

Calyx strongly dorsally gibbous at the base, pedicel seems to be attached at the ventral side of the calyx. Tube $\pm$ 5 mm long, dents $\pm$ 10 mm long, lanceolate, sometimes curved, midrib slightly prominent.

Corolla veined, vexillum ovate, $\pm$ 20 mm long, 15 mm wide, white cream before opening, tip of the carina violet; alae clavate, auriculate, 14 mm long, 6 mm wide, white; carina rhomboid with a long petiole, frontal side of ventral margins for $\frac{2}{3}$ adnate, 10 mm.

Stamens 9 + 1, filaments 15 mm (fused part 10 mm, free part 5 mm, perpendicularly upturned.

Ovary ovate, 4 mm long, 1 mm wide, $\pm$ 5 ovules, style 12 mm, glabrous at the top, upturned.

Pod oblong-rhomboid, dehiscent, valves curling when ripe, $\pm$ 25 mm long, 3–7 seeds.

Seeds nearly globular, beaked (owl's head), up to 5 mm diameter, seed coat black, faintly tuberculated.

Note

When I collected *C. montbretii* at the end of May, 10 km N of Bergama,

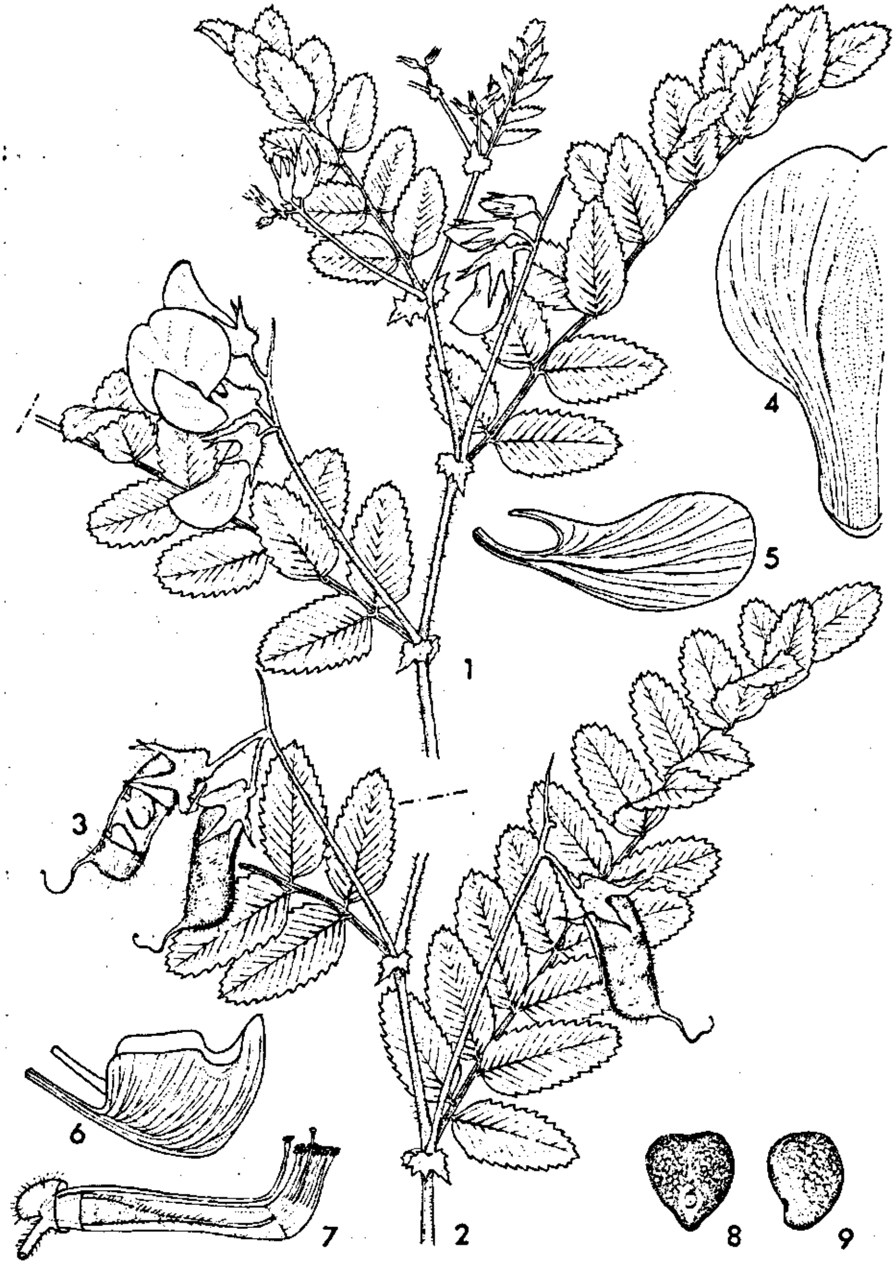


FIG. 23. *C. montbretii* Jaub. et Spach – 1. branch, flowering part, $^5/_6$ ×; 2. branch, fruiting part, $^5/_6$ ×; 3. young seeds attached in pod, $^5/_6$ ×; 4. flag, $2^1/_2$ ×; 5. wing, $2^1/_2$ ×; 6. keel, $2^1/_2$ ×; 7. anthers and pistil, $2^1/_2$ ×; 8, 9. seed, $2^1/_2$ × (VAN DER MAESEN 1376, WAG)

flowering was in its final stage, few flowerbuds could be found. The seeds were not ripe yet. Since it was a cloudy, rainy day, the flowers were not open and appeared cream in colour. When brought into a dry place, the flowers opened next day showing the white corolla. The keel was violet tipped. *C. montbretii* grows on long, slender, deep going, woody roots, in a vertical position. Each year the aerial part dies; few remnants of stems can be found on the perennial roots.

Distribution: W. Anatolia, Bulgaria, Thracia, Albania.

Altitudes: 0–1200 m

Ecology: hill slopes, *Pinus nigra* forest, *Quercus* forest, rocky places (calcareous, sandstone) and near water. Flowering: March-June (July, August).

Specimens examined: Albania: Alston and Sandwith 1642, slopes of valley dividing Lunxheriës and Nemerçka Ranges, near Lhej, Çajup, Distr. Gjinokastër (Argirokastron) (BM, K).

Bulgaria: Stoianov and Steffanov 902, Mt Strandja (Istranza daghlari) (K); Wisniewski 1535, Mt Megalos Popria (K).

Turkey, Thracia: Aznavour s.n., near Djébedji Kioy (village), 14 km NW of Istanbul (W); Başarman s.n., Rumelikisar-Bosporus (Istanbul) (ISTF); id. s.n., Kamli Kavak-Bosporus (Istanbul) (ISTF); Degen s.n., Tekir Dağ, between Koumbaos and Yenikeni (G); Noë 174, Istanbul (P, W); id. 189, Istanbul (ANK, C, P, W, WAG); id. 247, Istanbul (ANK, C, G, P, W, WAG); id. 1077, Istanbul (WAG); id. s.n., Istanbul (W); Post s.n., Baltaliman, Istanbul (E).

Turkey, Anatolia: Akbaş s.n., Bayramiç Isl., Kaz Dağı-Çeşme sinti Ra (E); Aucher-Eloy 1146, Mt Gargaro (Kaz Dağ) near Troy, prov. Balıkesir (syntypes, P, OXF); Baytop 2583, between Orhangazi and Iznik, prov. Bursa (E, ISTE, WAG); id., ISTE 20774, Kaz Dağ (ISTE, WAG); Dudley 35109, 26 km from Muğla to Kale, prov. Muğla (K); Hikmet Birand 45, Yilantı Dag, prov. Muğla (K); Karamanoğlu 602, Edremit, Kaz Dağ, prov. Balikesir (ANK); van der Maesen 1376, 10 km from Bergama to Kozak, prov. Izmir (WAG); Montbret s.n., Mt Gargaro (Kaz Dağ) (syntype, W); Huber-Morath 5096, 27 km from Muğla to Kale Tavas, prov. Muğla (JE); Peşmen 274, Gürün-Geyliki Dağları, Dikili, prov. Izmir (IZM); id. IZM 6198, Bursalikanı, prov. Balıkesir (IZM); id. 536, Kiranlı Köyü, Kozak, prov. Izmir (IZM); id. 870, Edremit, Arcilar Köyü, prov. Balıkesir (IZM); Reese s.n., 27 km from Muğla to Tavas, Denizli, prov. Muğla (JE); Sintenis 673, Mt Ida (Kaz Dağ), near Kareikos.

27. C. multijugum van der Maesen sp. nov. **Fig. 24, p. 93; Map 15, p. 94**

Type: Afghanistan, Koh-i-Baba, Köie 2630 (C, holotype; isotypes in E, W).

Paratypes: see specimens examined.

Planta perennis, multicaulis, copiose glanduloso-pubescens, pilis usque ad 1 mm longis. *Rhizoma* lignosa. *Caules* procumbentes vel ascendentes, (obsolete costatae), 10–30 cm longi. *Folia* imparipinnata, (9)18–36-foliolata, rachis (3)6–9(13) cm longa, supra canaliculata. *Foliola* opposita, vel fere opposita, approximata, obovata usque oblongo-obovata, 3–9(11) mm longa, 2–5(7) mm lata, apice rotundata, truncata vel acuminata, basi cuneato-rotundata, marginibus integris, sed apice irregulariter dentatis; denti ultimo longiori et saepe acuminato, ± 1 mm longo. *Stipulae* triangulares usque ovatae, profunde incisae, 5–10 mm longae, 3–7 mm latae, dentibus 4–5 acutis. *Pedunculus* axillaris, 1-florus, 35–70 mm longus, arista 2–6 mm longa (inclusus). *Bracteae* minutae, triangulares; *pedicelli* 5–9 mm longi, fructiferi recurvati. *Calyx* basi gibbosus, tubo 4–5 mm longo, dentibus 4–6 mm longis, obtusis vel obtuse acuminatis. *Corolla* venosa, purpurea vel violacea; vexillum obovatum, 20–22 mm longum, 15 mm latum, ungui cochleariformi; alae obovatae, ca. 17 mm longae, 6 mm latae, basi breviter auriculatae; carina longe unguiculata, rhomboidea, 13–14 mm longa. *Stamina* 9 + 1, persistentia; filamenta 15 mm longa, usque ad 10 mm alte connata, parte libera incurvata; antherae basi-dorsifixae. *Ovarium* ovatum, 8 mm longum, 3 mm latum, 10-ovulatum, stylo 10 mm longo, incurvato. *Legumina* elongato-elliptica, 25 mm longa, 9 mm lata. *Semina* immatura triangularia, 3 mm longa, 2 mm lata, fusca, tuberculata, rostrata, rostello decurvato.

A *C. microphyllo* differt statura minori foliolis numerosioribus et indumento copiosiori, stipulis majoribus et obtusioribus.

Perennial. Roots woody, bushily and laterally branched from the base, entire plant profusely glandular pubescent, hairs up to 1 mm.

Stems procumbent or ascendent, more of less flexuous, faintly ribbed, 10–30 cm long.

Leaves (9)18–36 leaflets; rachis (3)6–9(13) cm, grooved above, ending in an endleaflet.

Leaflets opposite or nearly so, rather close, obovate to oblong-lanceolate, 3–9(11) mm long, 2–5(7) mm wide, top rounded, truncate or acuminate; base cuneate-rounded; lateral margin entire, irregularly toothed at the top, tooth of midrib longer than the lateral ones and often acuminate, teeth about 1 mm.

Stipules triangular to oval, deeply incised, 5–10 mm long, 3–7 mm wide, 4–5 acute teeth.

Flowers in 1-flowered axillary racemes, peduncles 35–70 mm long, ending in an arista, 2–6 mm long; bracts minute triangular perules; pedicels 5–9 mm, recurved when bearing fruits.

Calyx dorsally gibbous at the base, tube 3–5 mm, teeth 4–6 mm, obtuse or obtuse-acuminate.

Corolla veined, purple or violet; vexillum obovate, 20–22 mm long, 15 mm wide, base spoonshaped; alae obovate, ca. 17 mm long, 6 mm wide, base shortly auriculate; carina rhomboid, base long, 5 mm, frontal side of ventral margin adnate, 13–14 mm long.

Stamens 9 + 1, persistent, filaments 15 mm long (fused part 10 mm, free part 5 mm, upturned), anthers basi-dorsifix.

Ovary ovate, 8 mm long, 3 mm wide, 10 ovules, style 10 mm, upturned.

Pods elliptic-elongate, ca. 25 mm long, 9 mm wide.

Seeds triangular, beaked, 3 mm long, 2 mm wide (unripe), seed coat brown, crudely tuberculated.

Note

This new species is related to *C. microphyllum* in a similar manner as is *C. fedtschenkoi* to *C. songaricum*. The keys in current use lead to *C. jacquemontii* Jaub. et Spach when *C. multijugum* specimens are named. *C. multijugum* has

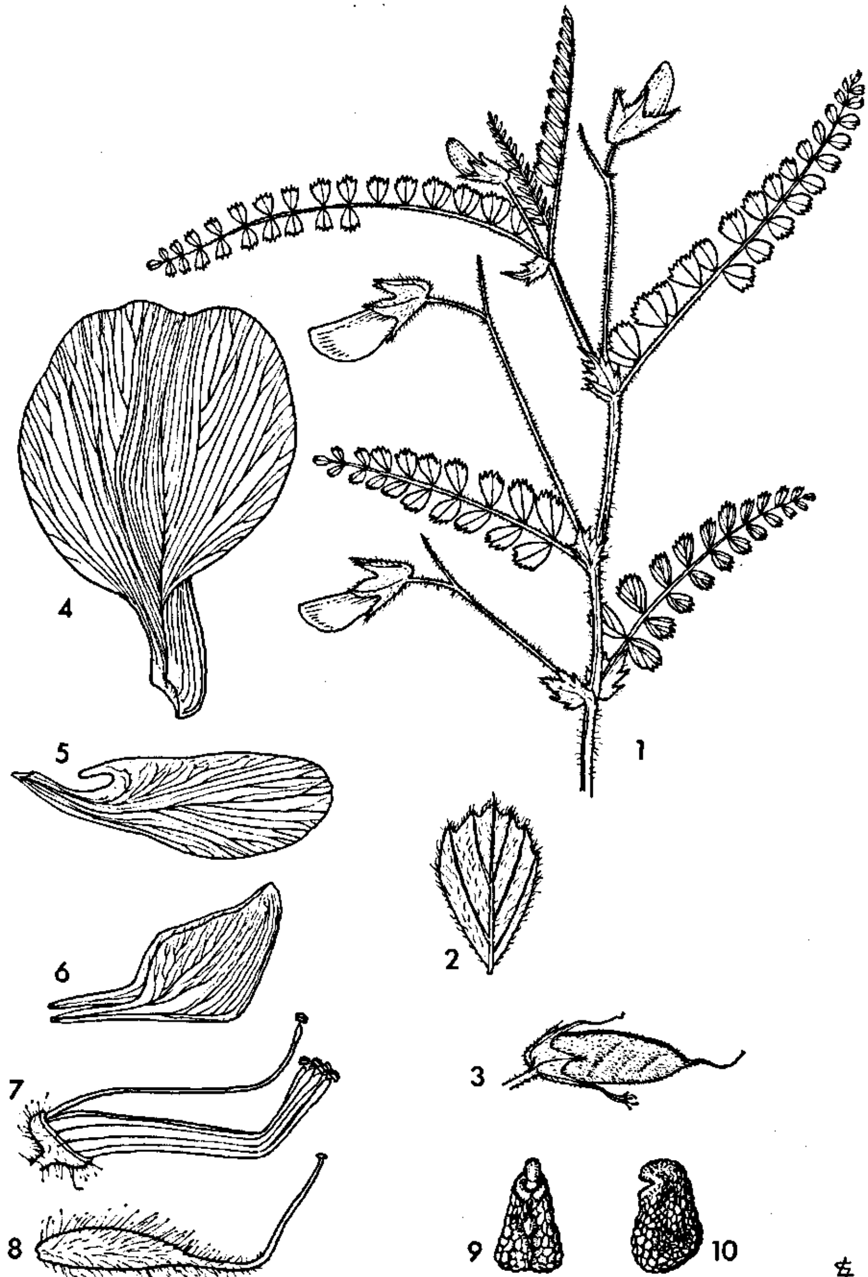
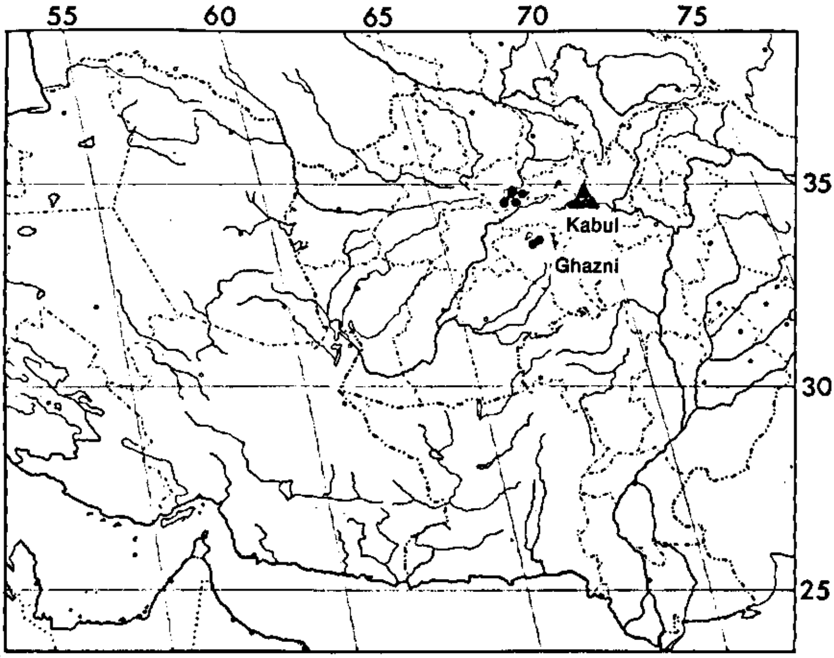


FIG. 24. *C. multijugum* van der Maesen – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. pod, $^5/_6$ ×; 4. flag, $2^1/_2$ ×; 5. wing, $2^1/_2$ ×; 6. keel, $2^1/_2$ ×; 7. anthers, $2^1/_2$ ×; 8. pistil, $2^1/_2$ ×; 9, 10. young seed, 5 × (GILLI 1723, 1724, W)

more numerous leaflets and a more profuse indumentum than *C. microphyllum*. The plant, its leaflets and flowers are smaller than of *C. microphyllum*. The stipules are as large as or larger than the lower leaflets, and larger and more obtuse compared with *C. microphyllum*.

Distribution: Afghanistan.
Altitudes: 3000–4200 m
Ecology: Mountains, limestone hillsides, moving screes.



MAP 15. ● *C. multijugum*, ▲ *C. yamashitae*

Specimens examined: Afghanistan: Freitag 1459, Seperlo Buli, mts SE of Dasht-i-Nawar (GOET); Gilli 1723, near Bamian, Koh-i-Baba (W); Griffith 1609, 1862–63, Herb. East India Comp. (K, P); Köie 2630, Koh-i-Baba (C, holotype; isotypes in E, W); Rechinger 37351, Saperlebuli, SE of Dasht-i-Nawar, prov. Ghazni (W); Stewart s.n.s.d. (E); Thesiger 45, N of Koh-i-Baba (W); Weiler (Gilli 1724), Koh-i-Baba near Sarddana (W).

28. C. nuristanicum Kitamura **Fig. 25, p. 96; Map 11, p. 57**

Acta Phytotax. Geobot., Kyoto 16: 136. 1956; RECHINGER, Biol. Skrift. Kong. Dansk. Vidensk. Selsk. 9-3: 200. 1957 (as *C. jacquemontii*); KITAMURA, Fl. Afghan.: 224–225. 1960.

Type: Afghanistan, Nuristan, Voma-Chatrass, KITAMURA s.n. (KY, holotype, not seen; no isotypes distributed).

Perennial. Woody rootstock, branching from the base, multistemmed, glandular puberulous.

Stems straight or slender, faintly ribbed, 25–40 cm long.

Leaves (9)16–26(28) leaflets, paripinnate or imparipinnate, rachis (3)6–14 cm, ending in a tendril or an endleaflet.

Leaflets not very close, opposite or nearly so, obovate or obovate-elliptic, base cuneate, top rounded, 5–15(18) mm long, 4–8(13) mm wide, margin dentate except near the base, teeth triangular-acuminate, tooth of midrib mostly incurved, sometimes curled or tendrillous (upper pairs of leaflets).

Stipules small, triangular-incised, 3–7 teeth, 2–4(7) mm.

Flowers in 1(2)-flowered axillary racemes; peduncles 15–35 mm long, ending in an arista, 5–20 mm long, bearing the flowers at the same or different height; bracts 1–2 lanceolate perules or triangular-incised, about 1 mm; pedicels short, 5–10 mm.

Calyx stongly dorsally gibbous at the base, glandular pubescent; tube 3–6 mm, teeth lanceolate or elongate-acuminate, 5–10 mm long.

Corolla veined, bluish violet, dorsal side faded-yellowish; vexillum obovate, base long, spoonshaped, 18–23 mm long, 16–19 mm wide, dorsal side conspicuously glandular pubescent; alae obovate, auriculate, ca. 19 mm long, ca. 8 mm wide; carina rhomboid, $\frac{2}{3}$ of frontal side of ventral margin adnate, 15 mm long.

Stamens 9 + 1, filaments 14 mm (fused part 9 mm, free part 5 mm, upturned), anthers basi-dorsifix.

Ovary ovate-acuminate, 8 mm long, style 10 mm long, upturned.

Pods elongate-elliptic, acuminate, 20–35 mm long, 9–12 mm wide, strongly glandular pubescent.

Seeds (according to the protologue) ovate-cordate, beaked, 5.5 mm long, 5.5 mm wide, testa black with whitish tubercles.

Morphological note

The eastern specimens outside Afghanistan have a somewhat firmer appearance and are less crowded in habit. STAINTON 2672 bears a label indicating greenish white flowers, although the flowers definitely show a bluish colour even when dried.

Distribution: Afghanistan, Kashmir.

Altitudes: 2300–4600 m

Ecology: *Abies* forest, pastures, shady humid, limestone rocks.

Flowering: June-July (August).

Vernacular names: koksul, hommair (?) (Bashar).

Specimens examined: Afghanistan: Edelberg 913, Pashki, Nuristan (C, W); id. 974, Pashki (C); Hedge and Wendelbo W 8991, Safed Kuh, Mt Sikaram, prov. Paktya (E); Kerstan 867, Parum Valley (upper Petsh Valley), near Gulnisha, C Nuristan (W).

India, Himachal Pradesh and Punjab: Watt 4882, Ralda Forest, Bashahr (E, OXF); Parker s.n., Chota Bambal Reserve, Pangi, Chamba (K); id. s.n., Bara Bambal Reserve, Pangi, Chamba (K); Lace 235, Ralda Forest, Bashahr (CAL, E, OXF); Harsukh s.n., Luj Forest, Pangi, Chamba (CAL).

Kashmir (India and Pakistan): Brandis 3816, NW Himalaya (M); Hooker and Thomson s.n., Tibet Occ., Regio alp. (mixed with *C. microphyllum*); Toppin 447, Chitral, Drosh (K); Stewart s.n. (1871), NW India (E); Stainton 2672, Chitral Gol, W of Chitral (W).

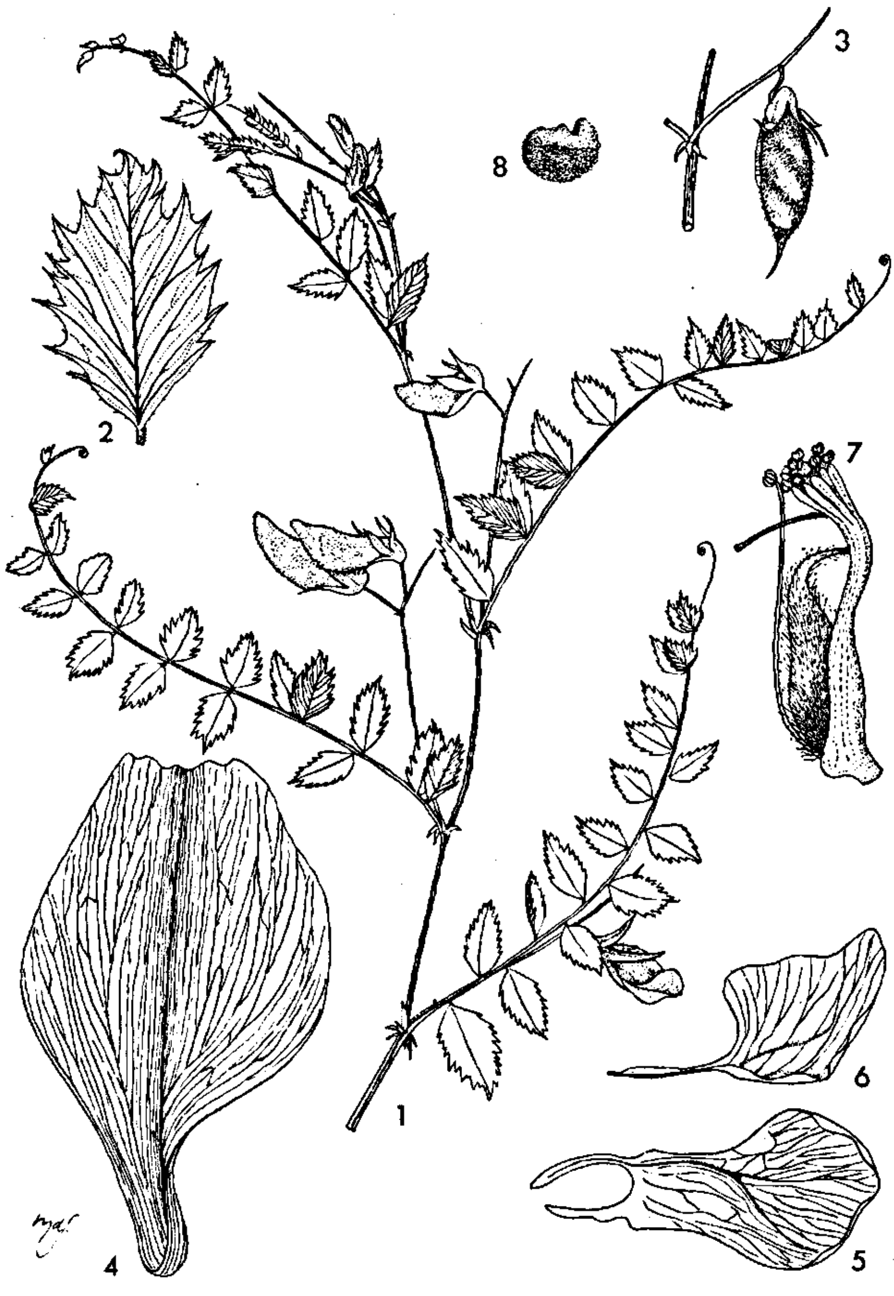


FIG. 25. *C. nuristanicum* Kitamura – 1. branch, $^5/_6$ ×; 2. leaflet, $^5/_6$ × (Edelberg 913, C); 3. inflorescence with pod, $^5/_6$ ×; 4. flag, $2^1/_2$ ×; 5. wing, $2^1/_2$ ×; 6. keel, $2^1/_2$ ×; 7. anthers and pistil, $2^1/_2$ × (STAINTON 2672, W)

29. C. oxyodon Boiss. et Hoh. **Fig. 26, p. 98; Map 16, p. 99**

Diagn. Sér. 1-9: 129. 1849; ALEFELD, Oest. Bot. Zeitschr. 9: 357. 1959; BOISS., Fl. Orient. 2: 563. 1872; BORNMÜLLER, B.B.C. 19-2: 248. 1906; POPOV, op. cit. 190. 1929; TROLL, Vergl. Morph. Höh. Pflz. 1: 1933. 1939; PARSA, Fl. Iran 2: 437. 1943; RECHINGER, Biol. Skrift. Kong. Dansk. Vidensk. Selsk. 9: 202. 1957; KITAMURA, Fl. Afghan.: 225. 1960.

Type: Persia, Mt Elburz, Uston Bag near Passgala, KOTSCHY 287 (P, holotype; isotypes in BM, G, K, L, M, P, OXF, WAG, WU).

Perennial. Branched at the base, glandular pubescent except corolla.
Stems erect, slightly flexuous, ribbed, 25-55 cm long.
Leaves paripinnate, (4)8-10(12) leaflets; rachis 5-10(20) cm, ending in a tendril, simple or ramified.
Leaflets opposite or nearly so, rather remote, orbicular or broadly fanshaped, 5-15 mm long, 5-17 mm wide, base broadly cuneate, top rounded, sometimes incised; margin dentate except near the base, 8-16 teeth triangular or obtuse-acuminate, up to 2 mm, ending in a spinelet, tooth of midrib often recurved.
Stipules semi-ovate or triangular, 2-5 mm long with 2-4 acute teeth.
Flowers in 1-2-flowered axillary racemes; peduncles 20-45(70) mm, ending in an arista, 5-10(20) mm, bracts minute, 1-2-toothed perules, ½ mm, pedicel 5-10 mm, recurved when bearing pods.
Calyx dorsally gibbous at the base, tube ca. 3 mm, teeth 8-12 mm, lanceolate-acuminate, top curling.
Corolla veined, lilac (Kotschy) or white (Popov); vexillum obovate, 14 mm long, 12 mm wide, top hardly emarginate; alae elongate-obovate, 13 mm long, 3 mm wide, longly auriculate at the base; carina rhomboid, major part of frontal side of ventral margin adnate, ca. 11 mm.
Stamens 9 + 1, persistent, filaments ca. 12 mm (fused part 8 mm, free part 4 mm, upturned).
Ovary ovate-acuminate, ca. 4 mm, 5 ovules, style ca. 7 mm, upturned.
Pod elliptic, 20-30 mm long, densily glandular pubescent.
Seeds ovate-globular, strongly incurved beak, 5-6 mm long, 4-5 mm wide, seed coat black, tuberculated, chalazal tubercle flat, black.

Note

Although not very abundant in number, the accessory material belonging to *C. oxyodon* needs a wider concept of the description. The Kurdistan specimen RECHINGER 10443 is much larger in habit, and has more pairs of leaflets but the same size of flowers. Ecological variations again caused variability in the material. STAPF 626 with large leaves and leaflets apparently originated from a humid or otherwise favourable habitat.

Distribution: Iran, Afghanistan, N. Iraq.
Altitudes: 1250-1350 m (Iraq), 2000-2500 m (Iran).

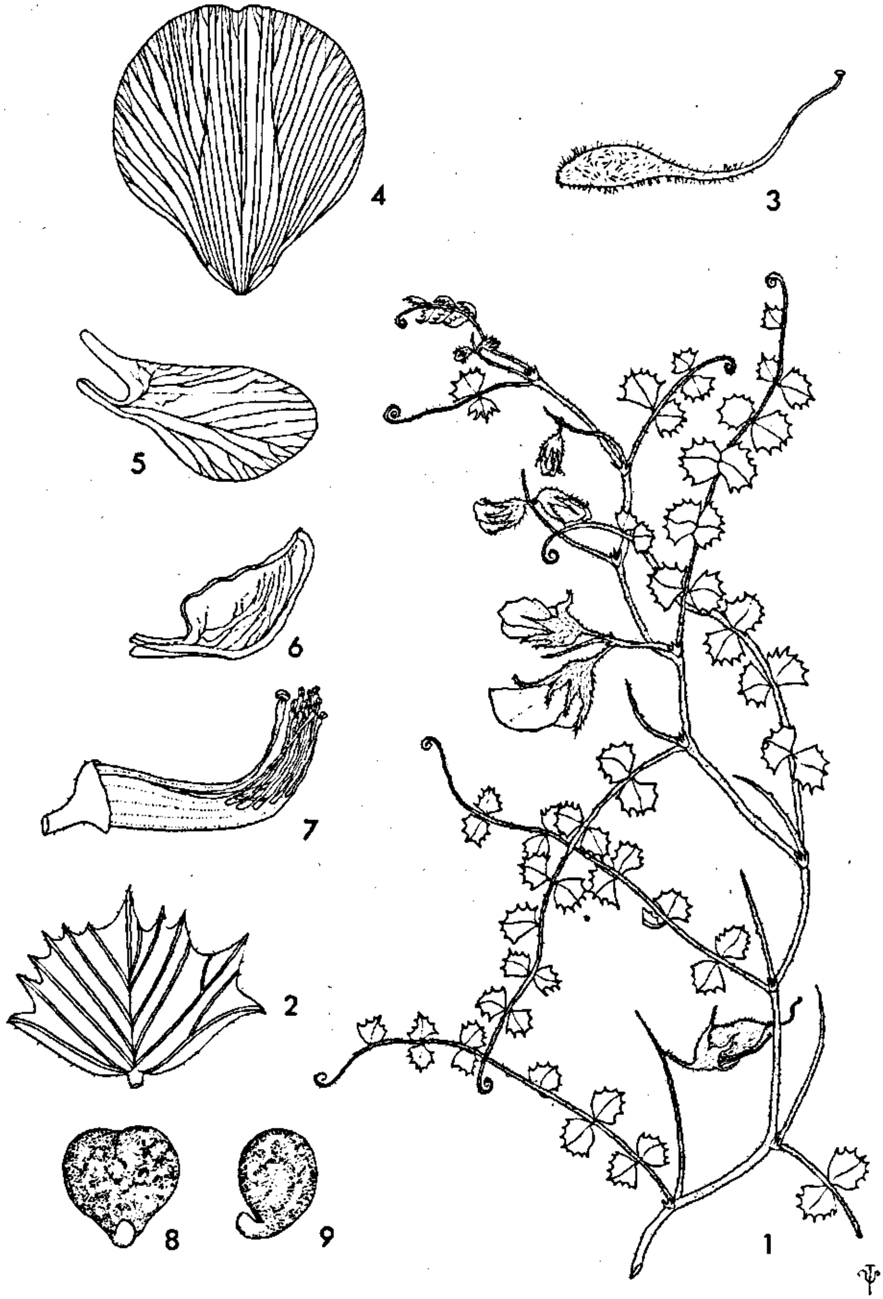
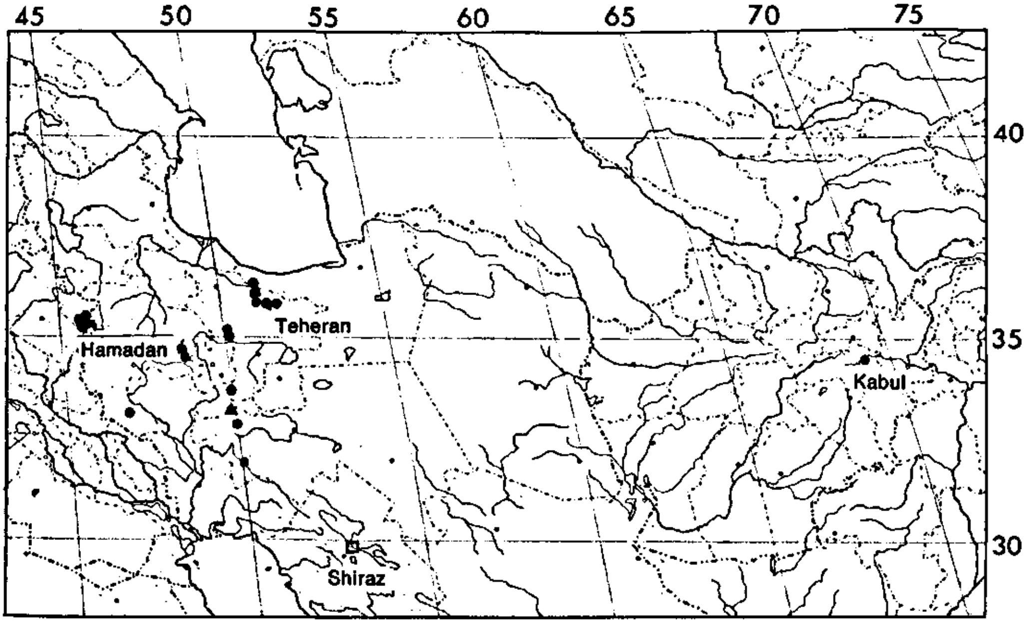


FIG. 26. *C. oxyodon* Boiss. et Hoh. – 1. branch, $^{5}/_{6}$ ×; 2. leaflet, $2^{1}/_{2}$ ×; 3. pistil, $2^{1}/_{2}$ ×; 4. flag, $2^{1}/_{2}$ ×; 5. wing, $2^{1}/_{2}$ ×; 6. keel, $2^{1}/_{2}$ ×; 7. anthers, $2^{1}/_{2}$ ×; 8, 9. seed, $2^{1}/_{2}$ × (GAUBA 578, W)



MAP 16. • *C. oxyodon*, □ *C. subaphyllum*

Ecology: rocky slopes, rubble and earth slopes, cultivated fields, *Rhus-Quercus* forests. Flowering: (May) June-July.

Vernacular name: nohut kuhi (mountain chickpea, Afgh. cf. Honigberger).

Specimens examined: Afghanistan: Honigberger s.n., Kabul (W).

Iran: ex Herb. Beck s.n., above Gendjiname near Hamadan (W); J. and A. Bornmüller 6634, Mt Totschal, Lädd and Dosderre Tops, W Elburz Mts (BM, E, G, JE, K, M, MPU, P, W, WU); id. 6635, Lur Valley, near Getschesär (BM, G, JE, K, P, W, WU); Bunge s.n., near Teheran (K, P); Furse 2624, Gochisar, Elburz Mts, NE of Karaj (E, K); Furse and Synge 427, Mazandaran, S side of Chalus Pass (K); Furse 2624, Gochisar, Elburz Mts, NE of Karaj (W); Gauba 578, Kuh-e-Dashte, near Karaj, prov. Qazvin (W); Haussknecht s.n., Kuh Eshker, Luristan (JE); Koelz 15930, Thi, W Luristan (W); id. 17867, Gahar, prov. Bakhtiari (W); Kotschy 287, near Passgala, above Uston Bag, Elburz Mts, Derwent bey Tehran? (P, holotype; isotypes in BM, G, K, L, M, OXF, WAG, WU); Lindsay 576, Sharastanetz (BM); Pichler s.n., above Gendjnâme, Mt Elwend (Kuh-e-Alvand) (G, K, WU); Pott 284, Elburz Mts, N of Teheran (K); Stapf 626, 1294, upper part of Tang-i-Abdui (K); id. s.n., Tang-i-Kaedu near Daescht-aerdschen (K); Strauss s.n., Sultanabad, Khalajestan (WU); id. s.n., Howdere, near Sultanabad (K, WU); Wendelbo 985, Kuhreng near the dam, Bakhtiari (W).

Iraq: Rawi 12271, Penjwin village, S Kurdistan, distr. Sulaymaniyah (K); id. 22544, ibid. (K); id. 22662, ibid. (K); Rechinger 10443, Penjwin (W).

30. C. paucijugum Nevski **Fig. 27, p. 101; Map 17, p. 102**

Acta Inst. Bot. Acad. Sci. USSR, ser. 1–4: 260. 1937; LINCZEVSKI, Fl. USSR 13: 397. 1948.

Type: C. Asia, Revat, KOMAROV s.n. (LE, holotype, not seen).

Basionym: *C. songaricum* var. *paucijugum* M. Pop. (illustration without description), op. cit. 217. 1929.

Synonym: *C. popovii* Nevski, Acta Inst. Bot. Acad. Sci. USSR, ser. 1–4: 261. 1937.

Perennial. Rootstocks woody, bushily branched from the base, aerial parts glandular pubescent.

Stems straight or ascending, faintly ribbed, 20–35 cm long.

Leaves 5–9(11) leaflets; rachis 2–4 cm, grooved above, ending in an end-leaflet or foliolate spinelet.

Leaflets opposite or nearly so, not very close, obovate, 4–11 mm long, 3–5(6) mm wide, base cuneate, top rounded, truncate or (especially in top leaflets) acuminate; margin dentate except near the base, teeth triangular-acuminate, up to 2 mm, at the top of the leaflets recurved, in top leaflets slightly longer.

Stipules obliquely flabellate, 2–7 mm long, 2–7 mm wide, toothed, ca. 5–8 teeth, up to 2 mm long.

Flowers in 1-flowered axillary racemes; peduncles 15–25 mm, ending in a sturdy or spiny arista, 3–9 mm; bracts triangular perules, up to 1 mm; pedicels 6–9 mm, recurved when bearing fruits.

Calyx strongly dorsally gibbous at the base, tube 3–5 mm, teeth elongate triangular, more or less broadly acuminate, 5–7 mm long.

Corolla veined, bluish violet; vexillum elongate-obovate, 24 mm long, ca. 15 mm wide, base spoonshaped, top emarginate, exterior shortly pubescent; alae obovate, 12 mm long, 7 mm wide, at the base longly auriculate; carina rhomboid, base long, frontal side of ventral margin adnate, ca. 13 mm long.

Stamens 9 + 1, persistent, filaments 15 mm long (fused part ca. 11 mm, free part ca. 4 mm, upturned), anthers basi-dorsifix.

Ovary elongate-ovate, ca. 8 mm long, ca. 3 mm wide, style ca. 10 mm, upturned.

Pods (taken from the protologue) oblong-ovate ca. 2 cm long.

Seeds not known.

Taxonomical note

C. paucijugum Nevski and *C. popovii* Nevski are (for the time being) judged to be conspecific, although the illustration points to a specimen with large leaflets and flowers, only occasionally met in the material seen. The original type specimen could not be inspected. The epithet *paucijugum* is chosen in prefeience to *C. popovii*, being a very apt name.

Distribution: Z. Tadzhikistan, E. Kazahkstan?

Altitudes: 2900 m

Ecology: stony slopes, *Juniperus salina* vegetation. Flowering: June-July.

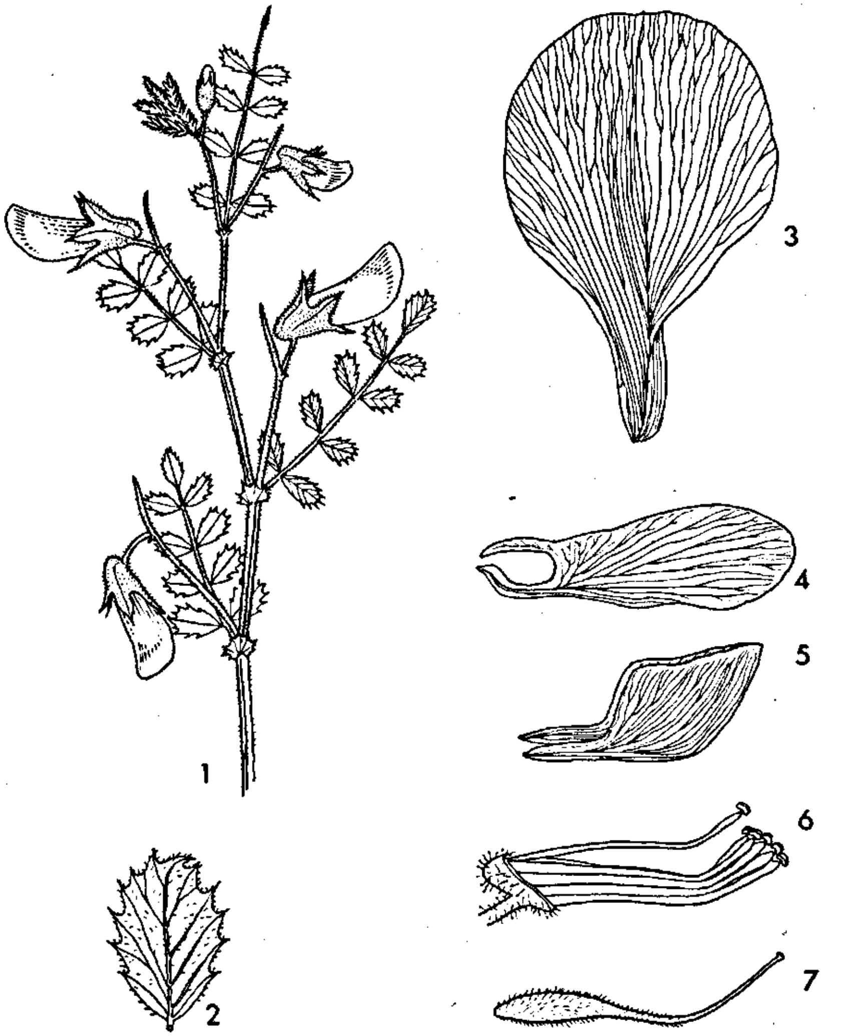
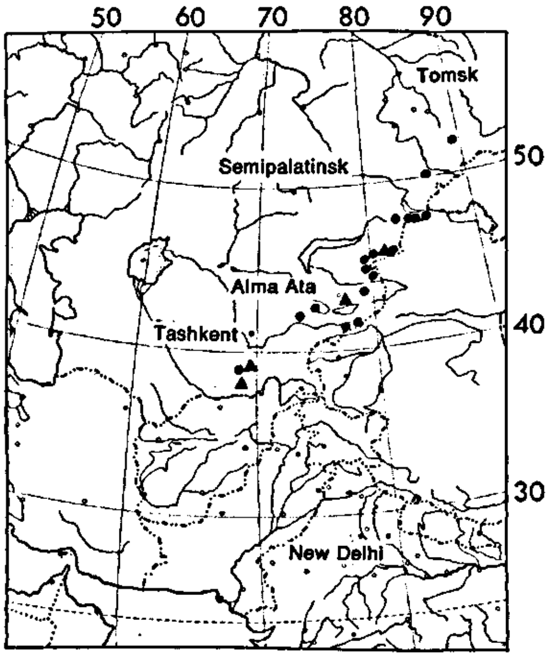


FIG. 27. *C. paucijugum* Nevski – 1. branch, $^{5}/_{6}$ ×; 2. leaflet, $2^{1}/_{2}$ ×; 3. flag, $2^{1}/_{2}$ ×; 4. wing, $2^{1}/_{2}$ ×; 5. keel, $2^{1}/_{2}$ ×; 6. anthers, $2^{1}/_{2}$ ×; 7. pistil, $2^{1}/_{2}$ × (ENGEN 243, LE)



MAP 17. ▲ *C. paucijugum*, ● *C. songaricum*

Specimens examined: USSR: Engen 243, Turkmenia, Kurniang Mts (Kugitang tau?) (LE); Golorosov s.n., Khrebet Dzhungarskii Alatau (MW); Smirnov and Tronkovskii 162, near Issyk-Kul Lake, Alatau Mts (Kumgey-Alatau) (MW); Zakrzhevskii 816, Guralash, Turkestanskii Khrebet, Bassein (LE).

31. C. pinnatifidum Jaub. et Spach **Fig. 28, p. 104; Map 18, p. 106**

Ann. Sc. Nat. Sér. 2-18: 227. 1842; JAUB. and SPACH, Ill. Or. 1: 82, t. 42 A. 1842; BOISS., Fl. Orient. 2: 560. 1872; POST, Fl. Syr., Palest. Sinai: 284-5. 1896; POPOV, op. cit. 173-177. 1929; POPOVA, Kult. Fl. SSSR 4: 67. 1937; ZOHARY et al. in Palest. J. Bot. 11. 1948; ZOHARY, Plant Life of Palestine: 127. 1962; DAVIS, Fl. Turkey 3: 271-272. 1970.

Type: Asia Minor, MONTBRET s.n. cultiv. at Paris (not seen).

Synonym: *C. sintenisii* Bornm., B.B.C. 19-2: 248. 1906 and Fedde, Repert. 50: 139. 1941.

Annual herb. Branched mainly from the base, densely predominantly glandular pubescent.

Stems slender, semi-erect or prostrate, 10-30(40) cm.

Leaves 4-9(11) leaflets, imparipinnate; rachis 2-5 cm, grooved above ending in 1 or 2 leaflets; petiole long 10-17 mm.

Leaflets fairly close, opposite or not, shortly petiolulate (0.5 mm), obovate or obovate-cuneate, 4-11(12) mm long, 2-5(7) mm wide, lower surface more prominently veined than upper one; margins rather irregularly incised, basal $\frac{1}{3}$–$\frac{1}{4}$ part entire; teeth (3)7–9(11) triangular-acuminate.

Stipules ovate to fanshaped, 2–3(5) lanceolate unequal teeth, up to 5(7) mm long.

Flowers in 1–flowered axillary racemes; peduncle 5–25(30) mm long, ending in an arista, 1–5 mm long; bracts two minute, sometimes incised perules; pedicel 5–10 mm, recurved when bearing pods.

Calyx hardly dorsally gibbous at the base, tube ca. 2 mm, dents lanceolate, 3–4 mm.

Corolla veined, pinkish purple, fading into violet when old; vexillum broadly ovate, top faintly emarginate-mucronate, 6–8 mm long, 6–10 mm wide; alae obovate, base strongly auriculate, 4 mm long, 2 mm wide; carina rhomboid, ca. 7 mm, about $\frac{1}{2}$ of frontal side of ventral margin adnate.

Stamens 9 + 1, filaments 3–4 mm (fused part 2–3 mm, free part 1 mm, upturned).

Ovary ovoid, 2 mm long, densely glandular pubescent, style upturned, 3 mm, 3–4 ovules.

Pods ovate-rhomboid, 10–15 mm long, 6–8 mm wide, yellowish brown when ripening, shattering the seeds.

Seeds angular, ovoid (arietinoid), bilobular, curved beak, 4–6 mm long, 3–5 mm wide, seed coat pinkish or greyish brown, strongly unevenly tuberculated, chalazal tubercle prominent.

Morphological notes.

Within *C. pinnatifidum* can be distinguished var. *anatolicum* M. Pop. and var. *syriacum* M. Pop.; var. *cuneatum* M. Pop. ought to be rejected since this variety is based on a cultivated specimen. These differ in habit from wild specimens but only in dimension and this is not a base for separation. The var. *cuneatum* most probably is synonymous with var. *anatolicum*, since most *C. pinnatifidum* material originates from Anatolia. Only from BALANSA (15–6–1856) are both wild and cultivated specimens available, showing similarity to my own cultivated specimens, obtained without geographical data.

POPOV also suggested to merge var. *anatolicum* and var. *syriacum* into one variety when more material became available, because their areas are adjoining. Var. *syriacum* consists of several HAUSSKNECHT specimens from Urfa and Gaziantep, in the Turkish provinces bordering Syria though from meadows near Gaziantep (Aintab) a specimen from var. *anatolicum*, very like a cultivated one, originated. Some ecological research could solve this problem. At this moment two varieties remain in *C. pinnatifidum*.

1. Var. *anatolicum* M. Pop. Leaflets obovate-cuneate, thick, incised-dentate with triangular broad teeth. Stipules mostly 2–3–partite, dents lanceolate, up to 5 mm (Fig. 28).
2. Var. *syriacum* M. Pop. Leaflets narrowly-cuneate, top leaflets sometimes broader, thin, lanceolate, deeply incised-dentate, with lanceolate narrow teeth. Stipules with linear long dents, up to 7 mm. Seeds strongly bilobular.

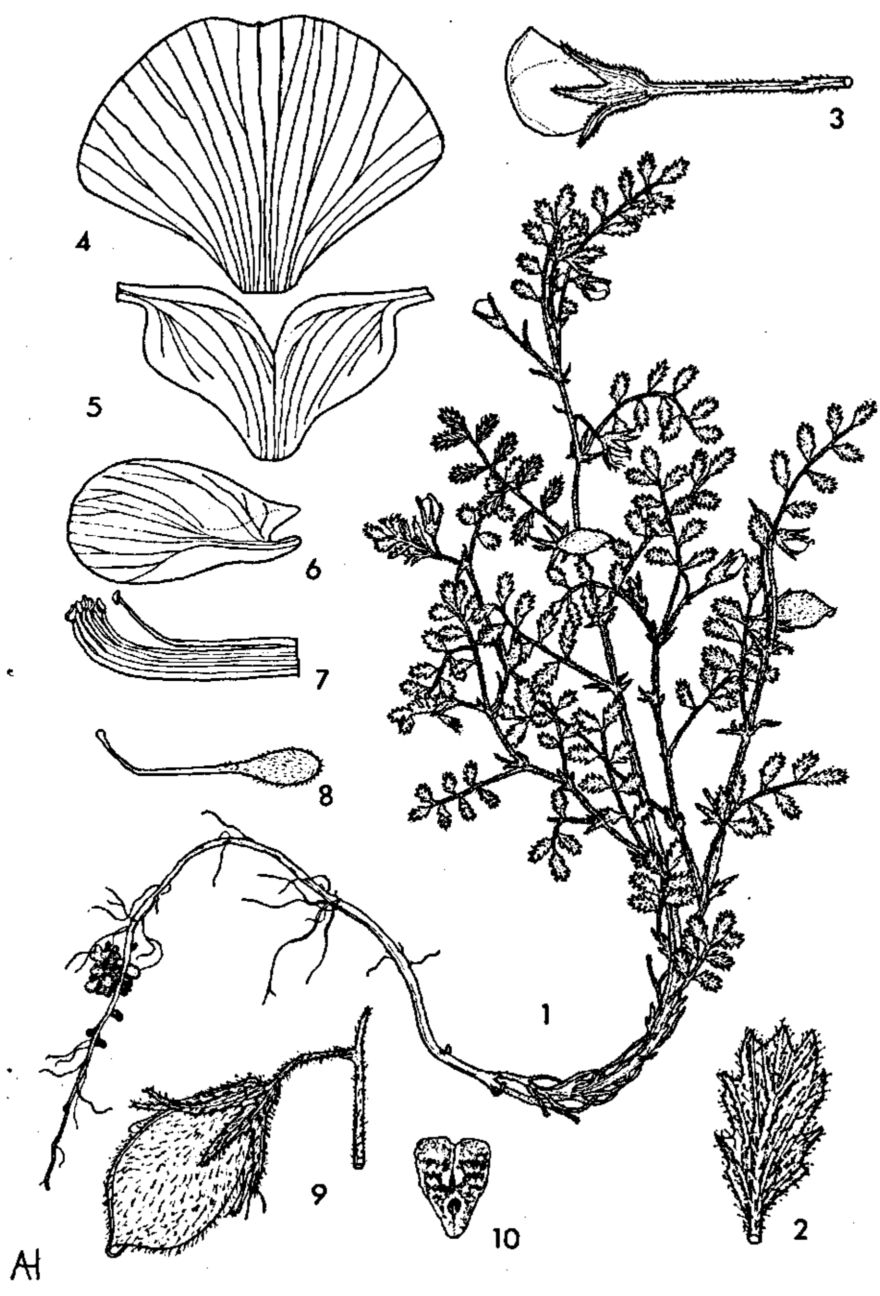


FIG. 28. *C. pinnatifidum* Jaub. et Spach – 1. plant, $^{5}/_{6}$ ×; 2. leaflet, $2^{1}/_{2}$ ×; 3. flower, $2^{1}/_{2}$ ×; 4. flag, 5×; 5. keel 5 ×; 6. wing, 5 ×; 7. stamens, 5×; 8. pistil, 5 ×; 9. pod, $2^{1}/_{2}$ ×; 10. seed, $2^{1}/_{2}$ × (VAN DER MAESEN 564 and 1278, WAG)

The variability within *C. pinnatifidum* is caused by different habitats. Thus the size of plants and leaflets varies within the limits given in the description. No correlation of geography and habit exists. For instance near Maraş both large and small specimens were collected. From Harput and Tokat the specimens are rather large, with more rounded leaflets.

GAILLARDOT 2509 (near Damascus, in Beit Kashbo forest) is *C. pinnatifidum* but GAILLARDOT 1729 (near Damascus, Jebel Khairoun) consists of very small specimens, difficult to classify. I consider them to be *C. pinnatifidum*, with 7–9 leaflets and rather relatively long petioles, no double-incised leaflets and deep incised or simple stipules.

The other available specimen from Damascus, LETOURNEAU? (1881), is *C. pinnatifidum* resembling the var. *syriacum* but it has unusually broad leaflets.

In cultivation *C. pinnatifidum* yields firm plants, with larger leaves and leaflets, with less hairs per unit of area, longer peduncles and pedicels. Aristae are present or absent. Leaflets of seedlings are very narrowly cuneate. Fresh seeds show dormancy, to a certain degree. Only 2 out of 12 seeds sown emerged within a week, the other had to be scratched to allow uptake of water. Older seeds dit not exhibit this character: they germinate readily.

When drying harvested plants of *C. pinnatifidum* for seeds, the pods snapped open with an audible crack and the seeds were ejected and landed about one meter away. In *C. microphyllum* this character has been reported by LUDLOW and SHERIFF (no. 8399, sheets in BM and E). Thus in rocky places and on slopes dispersal is effected. In other species the same mechanism can be expected, except for most lines in cultivated *C. arietinum*. The non-dehiscent pods make *C. arietinum* suitable for cultivation.

Distribution: Anatolia, Soviet Armenia, Syria, N. Iraq, Cyprus.

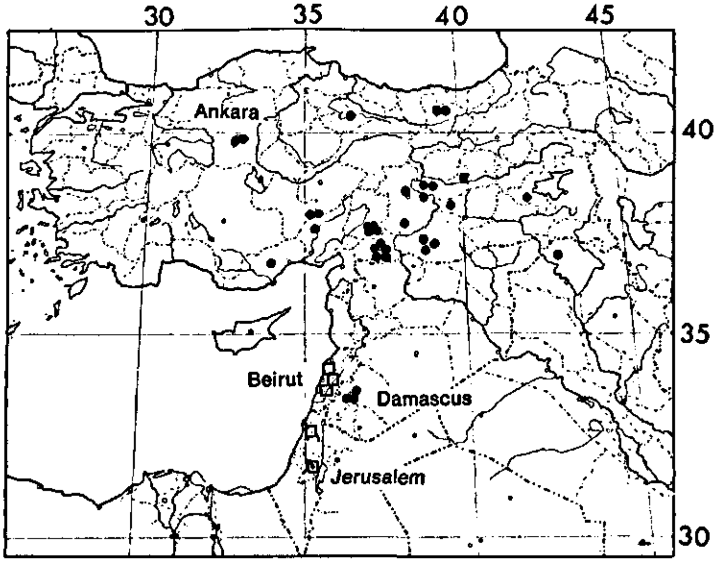
Altitudes: 250–1400 m

Ecology: rocky or rubble slopes, igneous or limestone, grassy places, vineyards. *Pinus brutia* and scrub vegetation. Flowering: April-June (July), in Syria February-March.

Specimens examined: Iraq: Haussknecht 302, in graminis m. Sindscha (Jebel Sinjar)(JE). Cyprus: Labillardiere (G).

Syria: Letourneau? s.n., between Ain Fidja and Wadi Barada, Anti-Libanon (Damascus!) (P); Gaillardot 1792, Jebel Khairoun, SW of Damascus (JE, P); id. 2509, Beit Katchbo Forest (Beitkashbo), Kasrouan (Jebel Kasiun, near Damascus?) (P).

Turkey: Attila s.n., 13 km from Mut to Mağara (Kirobaşı) (ISTF); Bağda ISTE 1430, Ankara, Incesu Valley (ISTE); Balansa s.n., Kamişli R., Bereketli (Maden, Kızıl Dağ) (P); Balls 757, Hasanbeyli, prov. Adana (K); id. 957, Ahır Dağ, near Maraş (BM, K); Baytop ISTE 20147, 3 km from Ergani and Maden, prov. Dyarbakır (ISTE, WAG); Bourgeau s.n., near Gümüşane (C, K, P, W); Brown 2447, lake shore, Gölcük, prov. Elazığ (K); Campbell 43, Euphrate Valley between Malatya and Elazığ (K); Davis and Hedge 29090, N side of Hazar Gölü, prov. Elazığ (BM, E, K); id. 29179, above Elazığ, W of Harput (BM, K); id. 27464, Ceyhan R. Valley, 15 km W of Maraş (ANK, BM, E, K); Davis 43077, 28 km from Siirt to Baykan (K); Fatma Sayi s.n., Elazığ (ISTF); Gassmer 457, Ankara, Incesu Valley (ANK); Görz 528, near Gümüşane (BM); Haradjian 38, near Aintab (Gaziantep) (G); id. 64, ibid. (G); Haussknecht s.n., Isoglu Dağ, between Malatia and Harput; id. 436, near Aintab (Gaziantep) (JE) and Urfa (JE); id. s.n., Urfa (BM, K); id. s.n., Aintab (flor. 25-4-1865) and



MAP 18. • *C. pinnatifidum*, □ *C. judaicum*

Urfa (fruct. 15-5-1865) (W); id. s.n., Aintab (K), in lapidosis (JE); id. s.n., Aintab (JE, P); id. s.n., Aintab, in graminis (BM, K, P); Gaillardot s.n., NE of Iskenderun (JE); Kotte s.n., Ankara, Incesu Valley (K, M); van der Maesen 1220, Ahır Dağ slopes, 13 km NW of Maraş (WAG); id. 1240, ibid., 29 km NW of Maraş (WAG); id. 1250, ibid., 35 NW of Maraş (WAG); id. 1278, 1 km S of Çiftehan to Pozantı, prov. Niğde (WAG); Reino Alava 6956, 39 km N of Gölbaşi, road to Maraş, prov. Adiyaman (E); id. 7067, near Kozluk village, river above Ismetpaşa, prov. Malatya (E); Sintenis 226, Kızıl Tepe, Harput, prov. Elazığ (E); id. 574, Schuschnas, Harput (BR, JE, K, WU); Wiedemann 68, Tokat (K).

Cultivated or with undefined location: Anon. s.n., cult. Würzburg (JE); Anon., cult. Copenhagen (C); Blixt s.n., cult. Scania, Tofta, Sweden, ex Gatersleben, E-Germany (BR); Dangui, cult. Paris (P); Have and Thorvaldsen, 17-8-1895, Joh. Lange (C); van der Maesen 523, cult. Wageningen ex Gatersleben (WAG); id. 563, idem (WAG); id. 564, idem (WAG).

32. C. pungens Boiss. **Fig. 29, p. 108; Map 19, p. 109**

Diagn. Sér. 2-2: 44. 1856; BOISSIER, Fl. Orient. 2: 565. 1872; FRANCHET, Ann. Sci. Nat. Bot. Sér. 6-15: 267. 1883; FEDTSCHENKO, Acta Hort. Petrop. 28: 108-9. 1908; POPOV, op. cit. 223. 1929; LINCZEVSKI, Fl. USSR 13: 403. 1948; RECHINGER, Biol. Skrift. Kong. Dansk. Vidensk. Selsk. 9: 202. 1957; KITAMURA, Fl. Afghan.: 225. 1960; KITAMURA, Plants of W. Pak. and Afghan.: 90. 1964; KITAMURA, Add, Rep. Kyoto Univ.: 104. 1966.

Type: Afghanistan, Yomutt, near Kabul, GRIFFITH 1608 (K, holotype; isotypes in C, K, L, M, P, W).

Synonym: *C. spinosum* M. Pop., Bull. Univ. As. Centr. 15, suppl.: 15. 1927 (see note).

Perennial. Branching from the woody root, spiny shrublet, glandular and eglandular pubescent.

Stems slightly flexuous, faintly ribbed, 20–40 cm.

Leaves 6–10 leaflets; rachis (2)3–5.5 cm, grooved or flattened above, ending in a spine.

Leaflets fairly close, paripinnate, flabellate, base rounded-cuneate, (3)5–10(13) mm long, (2)3–8(9) mm wide, both sides prominently veined; teeth (4)5–9 at the top, triangular, ending in a 1–3 mm long spinelet, spine of midrib mostly recurved.

Stipules at the base of the stem oblique-ovate, incised, 4–7 mm long, at the top bi(tri)–partite perules, sometimes simple, with teeth 2–5 mm long, nearly spiny.

Flowers in single-flowered axillary racemes, peduncle 15–40 mm long, spiny arista 10–30 mm long, bracts lanceolate perules, 1 mm, pedicels 8–12 mm, recurved when bearing fruits.

Calyx dorsally gibbous at the base, bluish green; tube 4 mm; teeth lanceolate-acuminate, the lateral ones with rotundate-cuspidate top, 4–6 mm long, midrib prominent.

Corolla veined, blue violet, greyish or greenish at the outside, (also reported as rose-purple), base of carina white; vexillum obovate-unguiculate, top incised-mucronulate, 17 mm long, 10 mm wide, dorsal side glandular pubescent; alae oblong, base auriculate, about 12 mm long, 4 mm wide; carina rhomboid, frontal side of ventral margin adnate, 10 mm long.

Stamens 9 + 1, filaments ca. 12 mm long (fused part 8 mm, free part 4 mm, upturned), anthers dorsifix.

Ovary elliptic-acuminate, 6 mm long, pubescent; 5 ovules; style 8 mm, upturned, stigma broadened.

Pods rhomboid-elongated, dehiscent, 20–25 mm long, 6–7 mm wide, covered with very short, velvety hairs. Pigmented in some specimens.

Seeds obovate, beaked, 5 mm long, 4 mm wide, seed coat brown, irregularly tuberculate with greyish roughness. Chalazal tubercle not prominent.

Note

BORISSOVA (1970) accepted *C. spinosum* M. Pop. as a separate species. POPOV has described *C. spinosum* in 1927, but rejected it in favour of *C. pungens* Boiss. from Afghanistan in 1929. According to BORISSOVA, who compared many Central-Asian specimens with an isotype of *C. pungens* Boiss., the stipules of *C. spinosum* are foliolate (not spiny, 1–2 mm), the leaflets are broadly obovate (not cuneate-elongate) and have no long sharp teeth. *C. spinosum* aristae are shorter than the pedicel (not longer), its calyx-teeth are triangular-elongate, sharp (not acuminate). Probably BORISSOVA had an upper part of a *C. pungens* specimen (isotype!) at her disposal, since most stipules of *C. pungens* are either foliolate (at the base) or long flattened bi(tri)-partite spiny perules. The few Central-Asian specimens which I could examine only superficially, appeared to fit within the range of variability present in *C. pungens*. In *C.*

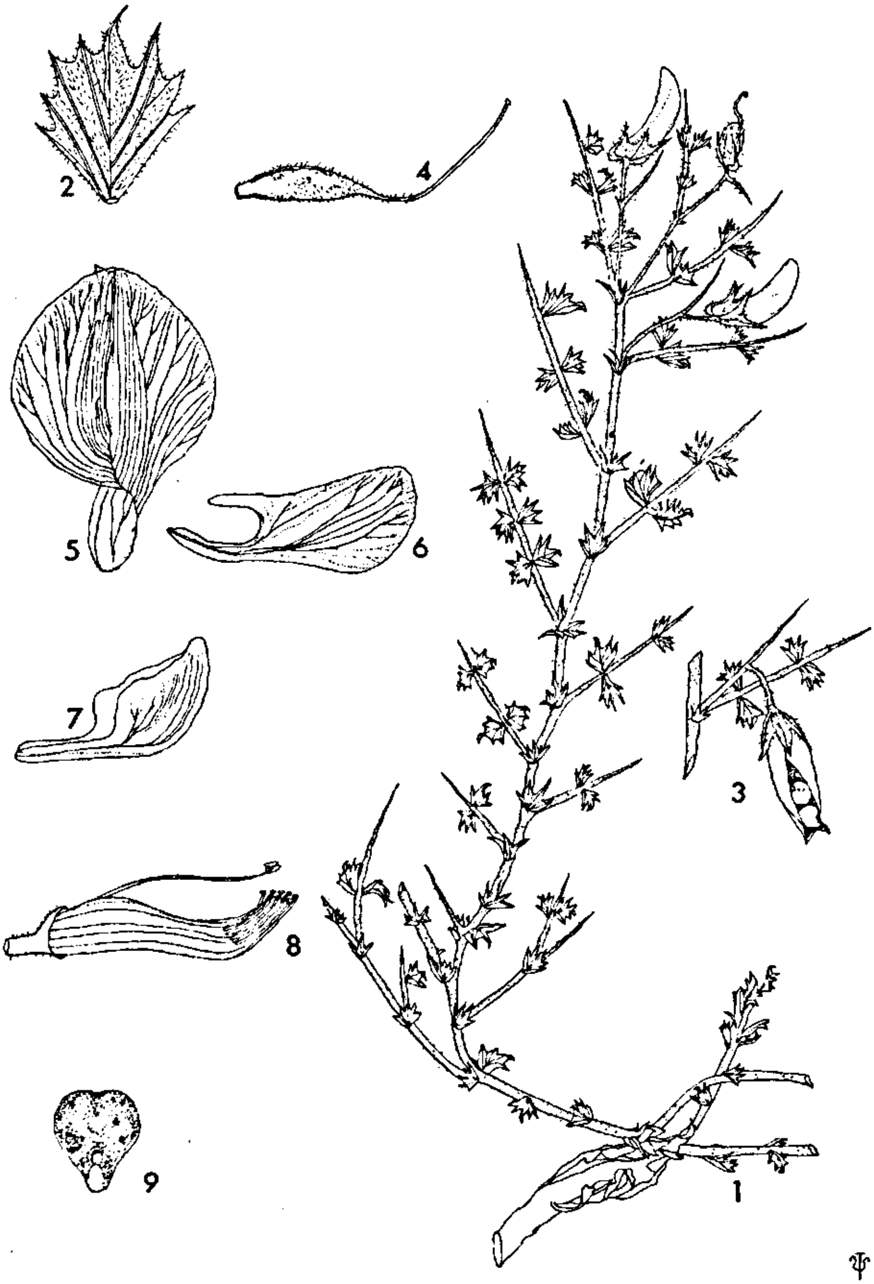


FIG. 29. *C. pungens* Boiss. – 1. branch, 5/6 × (RECHINGER 17592, W); 2. leaflet, 2 1/2 ×; 3. inflorescence with open pod, 5/6 ×; 4. pistil, 2 1/2 ×; 5. flag, 2 1/2 ×; 6. wing, 2 1/2 ×; 7. keel, 2 1/2 ×; 8. anthers, 2 1/2 ×; 9. seed, 2 1/2 × (RECHINGER 36187, W)

pungens more or less obovate leaflets and short aristae also occur.

Between the geographical areas is a wide gap. *C. pungens* has been abundantly collected in Afghanistan at altitudes of 2300–2400 m, '*Cicer spinosum*' occurs in Tadzhikistan at 1800–2000 m. In absence of the *C. spinosum* material I prefer to maintain the POPOV concept and consider *C. spinosum* as a synonym of *C. pungens*.

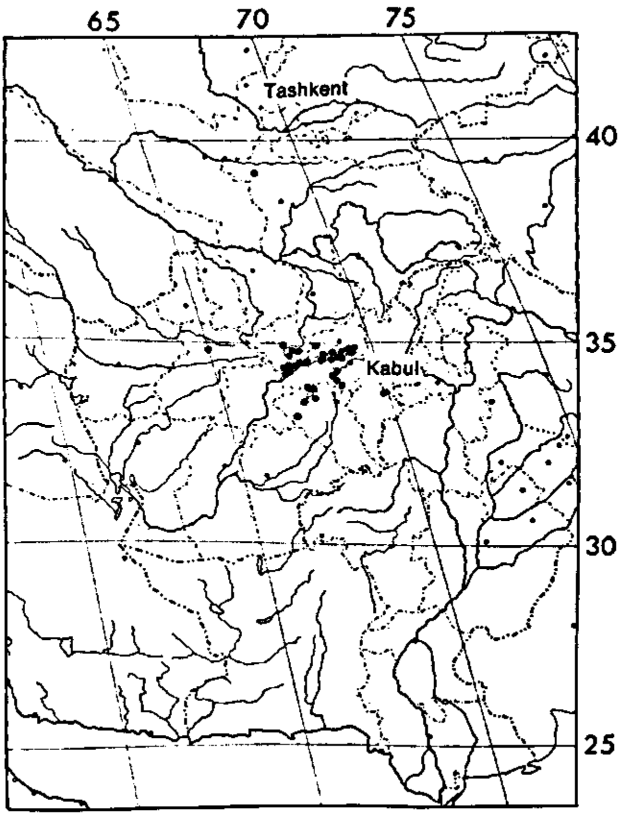
BORISSOVA classified *C. pungens* in the series *Macracantha* Lincz., and kept *C. incanum* Korotk. and *C. spinosum* M. Pop. in the series *Pungentia*. I admit that *C. pungens* is a border case but its foliolate stipules are too numerous to put the species in the series *Macracantha*.

POPOV distinguished a var. *horridum* with dense short glandular hairs, crowded habit and smaller flowers (see *C. incanum*).

Distribution: Afghanistan, W. Tadzhikistan.

Altitudes: 2300–4200 m, 1800–2000 m (Tadzhikistan).

Ecology: stony and rubble slopes, volcanic ashes, also limestone, dense alpine meadows. Flowering: (May) June-August.



MAP 19. *C. pungens*

Specimens examined: Afghanistan: Capus 379, Intarr, Kohistan (NNW of Kabul) (P); Edelberg 1836, Behsud, prov. Maydan (C, W); id. 2308, mts, prov. Ghor (C); Freitag 1192, Shibar pass, prov. Parvan (GOET); id. 1503, Seperalo Buli, SE of Dasht-i-Nawar (GOET); id. 1558, 15 km NE of Dasht-i-Nawar (GOET); id. 6124,road Behsud-Bom(GOET); id. 6263, Unai Pass (GOET); id. 6370, Hajigak Valley, prov. Bamyan and Maydan (GOET); id. 6648, 40 km SSW of Sangcharak, mts above Damardan (GOET); Furse 8495, Hajigak Pass, Koh-i-Baba, prov. Bamyan (K); Gilli 1725, Unai Pass, Kabul to Bamyan (W); id. 1726, Paghman Mts (W); id. 1727, Paghman Mts, E of Kotal-i-Kotandar (W); id. 1728, Koh-i-Baba, above Bamyan (W); id. 1729, Koh-i-Baba, above Sard darra (W); Griffith 1147, alpine Oonge (Oonnoo) Pass, or Haahbung, about fields (K); id. 1410 (without leaflets) (W); id. 1608, Yomutt, (K, holotype; isotypes in C, L, M, P, W); Hedge and Wendelbo W 4202, W of Shibar Pass, prov. Bamyan (E); id. W 4415, Paghman, valley above village (E); id. W 4608, Siah Sang, prov. Kabul (E, W); id. W 4956, Kotal-e-Narges, W of Panjao, prov. Kabul (E); Koelz 12017, Nozi, (E, W); Köie 3237, Koh-i-Baba (C, W); id. 2378, Hauz-i-Mahiha (C, E, W); Neubauer 501, 537, Unai Pass, W of Kabul (W); id. 583, upper Paghman Valley (W); Rechinger 16776, between Bulola and Shibar Pass (W); id. 17090, Paghman Valley, near Kabul (W); id. 17658, Ghoutch Kol Mts, NNE of Sang-i-Masha, prov. Ghazni (W); id. 17829, Say Khoshak (Nawar Kota), between Okak and Behsud (Diwal Kol), prov. Ghazni (W); id. 17860, ibid. (W); id. 18085, Qala-e-Wazir, between Sar-i-Chashma and Unai Pass, prov. Kabul (W); id. 18520, Hajigak Pass, prov. Bamyan (W); id. 18565, Unai Pass, prov, Kabul (W); id. 18581, Behsud Distr., Dahan-e-Abdila, 35 km E of Sar-i-Chasma, prov. Ghazni (W); id. 18720, near Mandjigak, between Kotal Deraz Kol Pass and Panjao, prov. Bamyan (W); id. 18789, near Dorahi Tarbulah, between Panjao and Lal, prov. Orozgan (W); id. 31801, Safed Kuh, W of Altimur Pass, 23 km N of Gardez (W); id. 36029, Unai Pass, prov. Kabul (W); id. 36187, in valley, 12 km E of Panjao (W); id. 36265, between Panjao and Shahtu Pass, prov. Panjao (W); id. 36344, Shahtu Pass, prov. Bamyan (W); id. 36447, Kuh-i-Hisar, between Sauzak Sumaj and Serdah near Sad Bark Pass, prov. Bamyan (W); id. 37340, Saperlebuli Mt, near Dasht-i-Nawar (W); Renz 114, Zangi, Hajigak Pass, prov. Parwan (W); Volk 2120, Unai Pass (W).

USSR: Lehman 410, Reliq. bot. Al. de Bunge (P); Nevessky s.n., Korolkow Mt, Turkestan (LE); Niript.?, C.A. 198, 12-7-1931 (LE); Ovczinnikov 226, W Zeravshan, Tadzhikistan (LE).

33. C. rechingeri Podlech **Fig. 30, p. 111; Map 20, p. 112**

Mitt. Bot. Staatssamml. München 6: 587. 1968.

Type: Afghanistan, Baghlan: Middle Andarab valley, NE of Deh-Salah in the Upper Kasan Valley, 2400 m, PODLECH 11700 (M, holotype; isotypes in E, W).

Perennial. Branching from the more of less woody base, almost glabrous. *Stems* rather straight, faintly ribbed, about 40 cm long.

Leaves (8)10–20 leaflets, paripinnate; rachis 4–6 cm, grooved or flattened above, ending in a spine.

Leaflets fairly close, rotundate-ovate, base rounded, top truncate-emarginate, incised, 2–5 mm long, 3–5 mm wide; both sides prominently veined, teeth 3–7, broad-triangular, obtuse, an often recurved spinelet prolonging the midrib.

Stipules triangular-lanceolate perules with 1 tooth, at the base up to 3 teeth, 2–6 mm long; 1 mm wide, at the base up to 2.5 mm.

Flowers in 1–2–flowered axillary racemes, peduncle 3–4 cm long with a spiny

FIG. 30. *C. rechingeri* Podlech – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. flag, $2^1/_2$ ×; 4. wing, $2^1/_2$ ×; 5. keel, $2^1/_2$ ×; 6. anthers, $2^1/_2$ ×; 7. pistil, $2^1/_2$ ×; 8. seed, $2^1/_2$ × (HEDGE and WENDELBO 5225, W)

arista (1–1½ cm), bearing 1–2 flowers at the same height; bracts minute, triangular perules, pedicels up to 8 mm, recurved.

Calyx dorsally gibbous at the base, glandular-pubescent, tube 3–5 mm, teeth triangular-lanceolate, acuminate, 4–5 mm long.

Corolla veined, pale violet or violet; vexillum obovate, top mucronulate, broadly based, 12–15 mm long, 10 mm wide; alae oblong, base shortly auriculate, about 10 mm long, 3 mm wide; carina rhomboid, topmost third of frontal side (upturned front of) ventral margin adnate, 10 mm long.

Stamens 9 + 1; filaments 11–12 mm long (fused part 8 mm, free part 3–4 mm), upturned, anthers dorsifix.

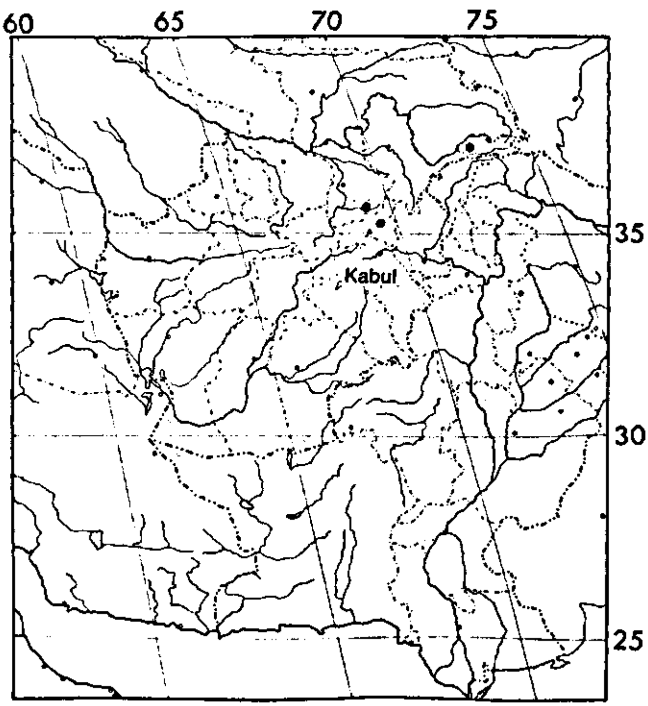
Ovary ovoid, 4 mm long, glandular-pubescent; 5 ovules; style 8 mm, perpendicularly upturned.

Pods rhomboid-elongated, immature, densely glandular-pubescent.

Seeds not known.

Note

The specimen HEDGE and WENDELBO 5225, clearly belongs in *C. rechingeri* Podlech. It appeared necessary to add to the data found in the protologue, since many 2–flowered inflorescences are present. The type-material (protologue) has only 1–flowered peduncles.



MAP 20. *C. rechingeri*

Distribution: Afghanistan.

Altitudes: 2400–3600 m

Ecology: dry slopes, granitic scree, moraine near gletscher. Flowering: July-August.

Vernacular name: abobak.

Specimens examined: Afghanistan: Hedge and Wendelbo W 5225, Darrah Rastagal, Panjshir Valley, prov. Parwan (E,W); Gamerith 61, Kishnik Valley, Wakhan (W); Podlech 11700, middle Andarab Valley, upper Kasan Valley, NE of Deh-Salah, Kotal-i-Yawnu Mt, prov. Baghlan (M, holotype; isotypes in E, W).

34. C. songaricum Steph. ex DC. **Fig. 31, p. 114; Map 17, p. 102**

Mem. Lég. 8: 349. 1825; DC., Prodr. 2: 354. 1825; KARELIN, Bull. Soc. Imp. Nat. Moscou 14–3: 411. 1841; ibid. 15–2: 346. 1842; LEDEBOUR, Fl. Rossica 1: 660. 1842; LASÈGUE, Mus. Bot. de M. Benjamin Delessert (Paris): 99, 330, 334, 338. 1845; ALEFELD, Bonpl. 9: 348. 1861; REGEL, Bull. Soc. Imp. Nat. 39–2: 31. 1866; TRAUTVETTER, Acta Hort. Petrop. 3: 33. 1875; FRANCHET, Ann. Sci. Nat. Sér. 6–15: 267. 1883; AUTRAN, Hort. Boiss.: 72. 1896; FEDTSCHENKO, Acta Hort. Petrop. 21: 319. 1903; Lipsky, Acta Hort. Petrop. 23: 97. 1904; FEDTSCHENKO, Acta Hort. Petrop. 28: 108. 1908; FEDTSCHENKO, B.B.C. 18–2: 245. 1909; Popov in Bull. Univ. As. Centr. 15, suppl.: 15. 1927; POPOV, op. cit. 213. 1929; KRILOVA, Fl. Zapadn. Sibirj. 7: 1782. 1933; LINCZEVSKI, Fl. USSR 13: 397. 1948.

Type: Songaria, STEPHAN (OXF, holotype; isotype at LE, not seen).

Synonym: *C. alaicus* Kuschak. ex O. and B. Fedtsch. (nomen nudum).

Perennial. Branching from the woody rootstock, glandular pubescent.

Stems straight or slightly flexuous, faintly ribbed, 25–40 cm long.

Leaves (8)10–14(16) leaflets, mostly paripinnate, rachis 3–6 cm, grooved above, ending in a tendril or tendrillous leaflet.

Leaflets fairly close, flabellate, base cuneate or slightly rounded, top rounded, incised, (2)4–12 mm long, 2–8 mm wide; both sides clearly veined, upper side puberulous, lower side glandular pubescent; teeth 7–11, sharp, triangular-elongate, top tooth of lower pairs of leaflets shorter than the lateral ones, in the smaller upper pairs elongate and longer than the lateral ones.

Stipules symmetric or nearly so, circular or ovate, larger or as large as leaflets, 5–11 mm long, toothed, 7–11 teeth, triangular-acuminate, 2–3 mm long.

Flowers in 1-flowered axillary racemes; peduncle 13–45 mm long, arista (5)8–16 mm long, sometimes ending in a leafy perule; bracts minute simple or incised perules; pedicels 6–10 mm long, recurved when bearing pods.

Calyx dorsally gibbous at the base; tube ca. 5 mm; teeth lanceolate-elongate or acuminate, nearly a tendril, 7–9 mm long.

Corolla veined, purplish; vexillum broadly obovate, top incised-mucronate, 22–30 mm long, 20–23 mm wide, dorsally faintly puberulous; alae obovate, auriculate, 18–20 mm long, 9–11 mm wide; carina rhomboid, ca. 15 mm long, frontal side of ventral margin adnate.

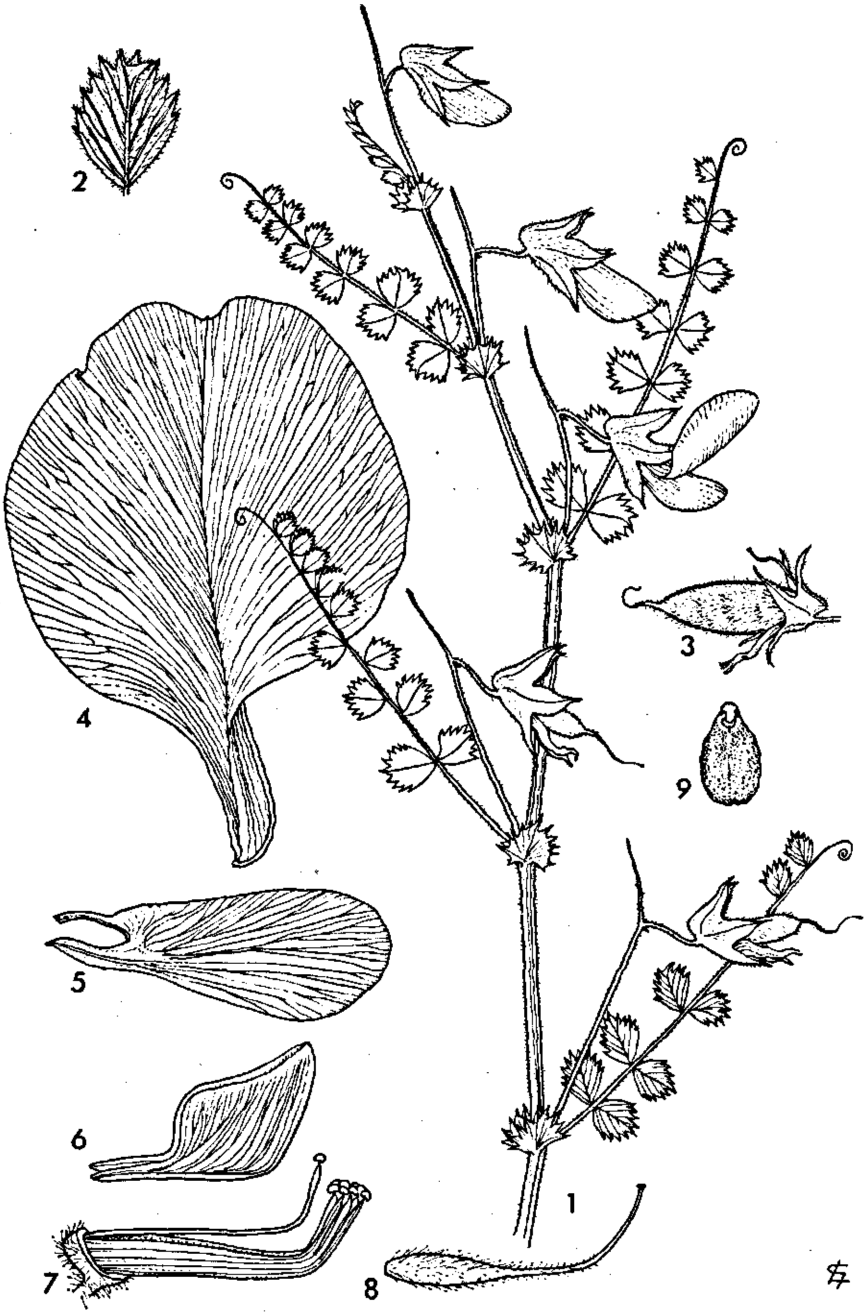


FIG. 31. *C. songaricum* Steph. ex DC. – 1. branch, 5/6 ×; 2. leaflet, 2 1/2 ×; 3. pod, 5/6 ×; 4. flag, 2 1/2 ×; 5. wing, 2 1/2 ×; 6. keel, 2 1/2 ×; 7. anthers, 2 1/2 ×; 8. pistil, 2 1/2 ×; 9. seed, 2 1/2 × (SAPOZHNIKOV s.n., C)

Stamens 9 + 1, filaments ca. 16 mm (fused part ca. 12 mm, free part 4 mm); anthers basi-dorsifix.

Ovary elongate-ovate, ca. 6 mm long, 2 mm wide, 8 ? ovules, style ca. 9 mm, upturned.

Pods elongate-ovate, 20–25 mm long, ca. 10 mm wide.

Seeds obovate-beaked, 6–7 mm long, 4–5 mm wide, ca. 4 per pod, seed coat brown, ridged and finely tuberculated, chalazal tubercle faintly prominent.

Taxonomical notes

C. songaricum Steph. ex DC. (1825) from Songaria was spelt in various ways when quoted. In literature and on herbarium labels the epithet can be found spelt as *soongaricum*, *soongoricum* and *songoricum*. However, *songaricum* is the original (and correct) spelling.

In 1825 *C. songaricum* was published by DE CANDOLLE as the second species in Cicer. He referred to the specimen brought from Songaria by STEPHAN. The protologue consists in reality of not much more than an illustration by FISCHER. DE CANDOLLE further referred to an additional Persian specimen collected by MICHAUX, now in P (also quoted by JAUBERT and SPACH). This latter specimen was used by JAUBERT and SPACH for the description of '*C. songaricum* Steph.' but MICHAUX's specimen is a different species, later described as *C. anatolicum* Alef. *C. songaricum* DC. therefore ought not to be confused with *C. songaricum* DC. *sensu* Jaubert et Spach (= *C. anatolicum* Alef.).

Meanwhile all authors after DC. did not see the type specimen collected by STEPHAN. This specimen is preserved in the FIELDING Herbarium (OXF) to where Herbarium PRESCOTT, which contains the STEPHAN material, was transferred (DE LASÈGUE, 1845). Although the sheet only bears in pencil the indication '*Cicer songaricum* Sibir' and in ink 'cfr. DC Prodr. 2, p. 354', it perfectly matches the original illustration and therefore surely is the holotype specimen. LINCZEVSKI (FLORA USSR) said that the type was in Leningrad, which must be an isotype.

The numerous forms which were united up till this day received several epithets. The nomenclatural history therefore may follow.

C. microphyllum Bentham in Royle (1839) and *C. jacquemontii* Jaub. et Spach (1842) were described and without comment reduced to synonymy with *C. songaricum* by Baker (1879). *C. songaricum* Jaub. et Spach *non* Steph. was based on several specimens, from Persia (i.a. MICHAUX). Much Turkish and Persian material still remained labelled as '*C. songaricum* Steph.' due to the JAUBERT et SPACH monograph and in literature references are also confused.

In 1904 LIPSKY correctly claimed to have made the first adequate description of *C. songaricum* and he segregated *C. flexuosum* Lipsky from the Central Asian material known at that time.

Note on the synonymy of C. songaricum

C. alaicus Kuschakewicz ex O. and B. Fedtschenko (1909) was published as a nomen nudum in synonymy with *C. songaricum* and was referable to a sheet labelled by KUSCHAKEWICZ. The FEDTSCHENKO's also reduced *C. flexuosum* Lipsky to a synonym of *C. songaricum*, for which POPOV (1927) unaccurately cited 'SCHRENK' as the author, so: *C. songaricum* Schrenk (*ex* Popov). POPOV (1929) however, re-adopted *C. flexuosum* Lipsky in his monograph. Then BORNMÜLLER quoted *C. flexuosum* Schrenk (sic!) as a synonym (1937). He saw POPOV's publication of 1927 but not POPOV's monograph of 1929, as was suggested by RECHINGER (1959).

POPOV expressed doubts (1929) about the status of *C. songaricum*, *C. jacquemontii* and *C. microphyllum*. He distinguished several infraspecific taxa in *C. songaricum*. LINCZEVSKI (FLORA USSR) confronted with the same difficulties, placed some specimens accepted by POPOV as *C. songaricum*, in *C. jacquemontii*, and reduced *C. popovii* Nevski and *C. paucijugum* Nevski provisionally to synonyms of *C. songaricum*. Authors of the FLORA OF THE USSR are not expected to make complete revisions, and so LINCZEVSKI only partially studied *Cicer*. Thus LINCZEVSKI explained that he could contribute but little to the understanding of polymorph *C. songaricum*. He suggested that after new collections in unexplored localities, more date would lead to a clearer segregation, a better insight regarding synonyms and doubtless also to the discovery of new species.

In this revision with rather more material available now and the holotype at my disposal, I feel the necessity to confine the name of *C. songaricum* to the material from E. Kazakhstan, Kirgizia and Tadzhikistan only. This conclusion inevitably rejects specimens from the Himalaya's, which were known as *C. songaricum*. The present narrow-limited species that is currently accepted ought to be maintained.

Note on the subspecific taxonomy of C. songaricum

Within the wide concept of *C. songaricum* (current before 1904) the following taxa have been distinguished. REGEL and HERDER (1866) described the varieties *typicum* and *imparipinnatum*, of which the latter possessed no tendrils. To these varieties, variety *pamiricum* Lipsky ex Paulsen was added in 1909. I refer var. *imparipinnatum* to *C. paucijugum* Nevski, without any infraspecific status. Also, I refer var. *pamiricum* to *C. fedtschenkoi* Lincz., also without any infraspecific status.

FRANCHET (1883) distinguished the varieties *turkestanicum* (CAPUS 380) and *glutinosum* (CAPUS 381), each based on a single collector's number. CAPUS 381 is more glutinous, perhaps for an ecological reason. It was collected two months later, which also accounts for an increased secretion.

LIPSKY (1904) described var. *cirrhiferum* (= var. *typicum* Rgl et Herd.) and var. *ecirrhosum* (= var. *imparipinnatum* Rgl et Herd. = var. *turkestanicum* Franch. = var. *glutinosum* Franch.), while he published the above repeated synonymy.

Finally POPOV (1929) subdivided *C. songaricum* into four described varieties and added an illustration of a fifth, which was only mentioned by name in the legend to the illustration. These varieties are: **1.** var. *oxyodon* M. Pop. (= var.

cirrhiferum Lipsky *ex parte*), calyx teeth bristle-pointed, subtendrillous (DIVNOGORSKY 21–6–1907). **2.** var. *alaicum* M. Pop. (= var. *ecirrhosum* Lipsky *ex parte*), dwarfed form, 10–15 cm high, small leaves, less than 4 pairs of leaflets, narrow cuneate, small stipules, endleaflets sparsely tendrillous (KUSCHAKEWICZ 17–7–1878). **3.** var. *schugnanicum* M. Pop., densely glutinous-pubescent, small, ca. 20 cm, folioles in many pairs, rather large, suborbicular-obovate, terminal or cirrhiferous, flowers intensely blue, 22 mm long. LINCZEVSKI raised to this variety species rank and described it as *C. fedtschenkoi* Lincz. (1948). Both POPOV and LINCZEVSKI based their new names on specimens collected by TUTURIN and BESEDIN. **4.** var. *songorico-pungens* M. Pop. (like *C. songaricum* × *C. pungens*), folioles 4–6 pairs, obovate-cuneate, weaker than in *C. pungens*, not spinelike toothed. Stipules large, weak, petioles thin, rather weak, but the top spiny, without a leaflet, habit as *C. pungens* (LIPSKY 3624; not seen by me). **5.** var. *paucijugum* M. Pop. only as illustration (Fig. 40a), leaflets 3–6 pairs, ovate, deeply serrate, top dent long, stipules ½–1 × the lower leaflets, deeply incised, 7–9 toothed, calyx teeth obtuse-acuminate (KOMAROV; not seen by me). This taxon has been raised to specific rank by Nevski (1937) as *C. popovii* Nevski, but LINCZEVSKI reduced *C. popovii* to the synonymy of *C. songaricum* in FLORA USSR (1948). *C. paucijugum* Nevski (not based on var. *paucijugum* M. Pop.) was also treated as a synonym. I consider *C. popovii* and *C. paucijugum* conspecific and designate *C. paucijugum* Nevski as the correct name (*C. popovii* being simultaneously published).

Since the specimens available at present show no differences leading to taxonomic segregation I wish to maintain *C. songaricum* without infraspecific taxa. The Himalayan forms are *C. microphyllum*, an other species, which includes '*C. jacquemontii*'. In the Edinburgh Herbarium is a sheet of KUSCHAKEWICZ ('var. *alaicum* M. Pop.') with more leaflets, tendrils and with a length of 40 cm. The specimen belongs to the same collector's number as the small ones. Apparently POPOV dit not see this sheet. The remaining differences as measure of leaflets, degree of occurrence of imparipinnate leaves, more or less tendrillous calyx teeth etc. do hardly allow a subdivision. The studied material could be classified under var. *oxyodon* M. Pop. (also the KUSCHAKEWICZ sheets), but as stated above, var. *oxyodon* is not distinguished in my revision.

Distribution: E. Kazakhstan, Kirghizia, Tadzhikistan.
Altitudes: 2300–2500 m (Kuschakewicz: 4000 m)

Specimens examined: USSR, Kazakhstan: Herb. Drake, Annenkol, Soongaria (Dzhungarya) (P); Goloskorov s.n., Koksu, Dzhungarskiy Alatau (LE); Karelin and Kirilov 222, Tsheherak-Assu R., Khrebet Tarbagatay (BM, BR, G, K, M, MW, W, WU); id. 1437, ibid. (BM, WU); id. 1867, Semireczje Alatau (S of Alma Ata!) (C, G, WU); Krassnov s.n., Sharyn R. (G, K, P); Ptashicki 622, distr. Dsharkent (Panfilov) (G); Sapozhnikov s.n., Khrebet Saur (C); Sapozhnikov and Shishkin s.n., above Dzharkent (Panfilov) (LE); Schrenk s.n., Khrebet Tarbagatay and Alatau (Dzhungarskiy Alatau?) (K, W); id. s.n., Soongaria (Dzhungarskiy Alatau) (C, K, M, P, U, W, WU); id. s.n., Soongaria, Dshill Karagai Valley (Karagai R.) (JE); id. s.n., Dshill Karagai Mt (JE); id. s.n., Kuhlasu, Soongaria (BM, BR); id. Kukle (W); Stephan s.n., ex Herb. Prescott, Sibir (OXF, holotype!).

USSR, Kirgizia: Avietin s.n., near Sokolovka village, near Frunze (E); Herb. de Bunge,

Alatau (P); Korshinsky 2281, Kugart Pass, Ferganskiy Khrebet (BM); Kuschakewicz s.n., Tyan Shan Mts (C, G, K); id. s.n., Turkestan (E); Semenov s.n., Tyan Shan Mts (K).
USSR, Tadzhikistan: Capus 380, Gorge de Tschoukalik, en face d'Ouroumitane (Urmetan) (P); id. 381, Ona Oulgane Valley (P).
USSR, Uzbekistan: Namangan area (MW).

Ecology: rubble slopes, near streams, also dry places. Flowering: June-August

35. C. spiroceras Jaub. et Spach **Fig. 32, p. 119; Map 21, p. 120**

Ann. Sci. Nat. Sér. 2-18: 233. 1842; JAUB. and SPACH., Ill. Pl. Orient. 1: 89, t. 44. 1842; BOISSIER, Fl. Orient. 2: 564. 1872; BORNMÜLLER, B.B.C. 27 Abt. 2: 344. 1910; POPOV, op. cit. 193. 1929; PARSA, Fl. Iran 2: 437. 1943.

Type: Iran, Ispahan, AUCHER-ELOY 1126 (P, holotype; isotypes in G, K, P).
Paratype: Iran, sine locus, AUCHER-ELOY 4357 (P, and in BM, G, K, OXF, WU).

Perennial. Roots woody, bushy plant, branched from the base, thinly glandular pubescent.
Stems inflexed, ribbed, 40–75 cm.
Leaves (5)6–16 leaflets; rachis 3–12 cm, grooved above, ending in a curly tendril.
Leaflets very remote, flabellate, top incised, base broadly cuneate or rotundate; 3–7(11) mm long, 3–9(15) mm wide. Both sides prominently veined. Teeth 7–12, triangular-acuminate, up to 2 mm, ending in a spinelet, tooth of midrib with a recurved spine.
Stipules triangular perules with up to 5 unequal teeth or flabellate with 5 teeth, 1–5 mm long.
Flowers in 1–4(mostly 2)-flowered axillary racemes, peduncle 25–40 mm long, with a short spiny arista, 2–10 mm, bearing 1–2 flowers per 'node', bracts minute perules with 2 unequal dents, pedicels 5–10 mm, long glandular hairs, recurved when bearing pods.
Calyx irregular, dorsally gibbous at the base; tube 3–4 mm; teeth lanceolate-acuminate ending more or less spiny, 6–8 mm.
Corolla veined, lavender; vexillum ovate, with a broad base, 15 mm long, 11 mm wide, top emarginate, mucronate; alae triangular, long-auriculate, 12 mm long, 5 mm wide, auricles 2–3 mm; carina rhomboid with a short base, 2 mm, frontal side of ventral margin adnate, margins 7 mm.
Stamens 9 + 1, filaments 12 mm (fused part 8 mm, free part 4 mm, upturned), top inflated, anthers dorsifix.
Ovary elliptic, 5 mm long, 6 ovules, style 10 mm, stigma broad.
Pods ovate, 15–22 mm long, ca. 9 mm wide, densily glandular pubescent, 3 seeds.
Seeds globular, beaked, 5–6 mm, seed coat chocolate brown, tubercular-scaly.
Distribution: Iran.
Altitudes: 2600 m

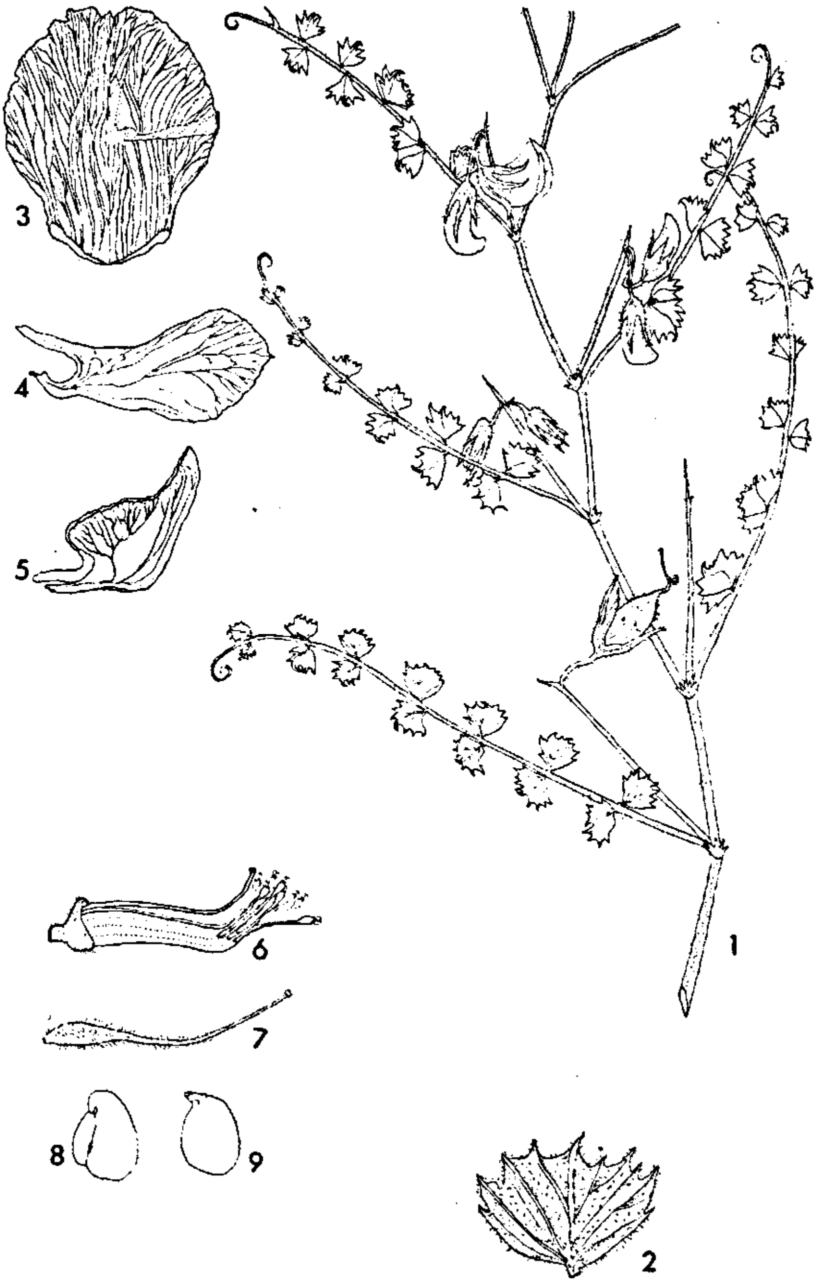
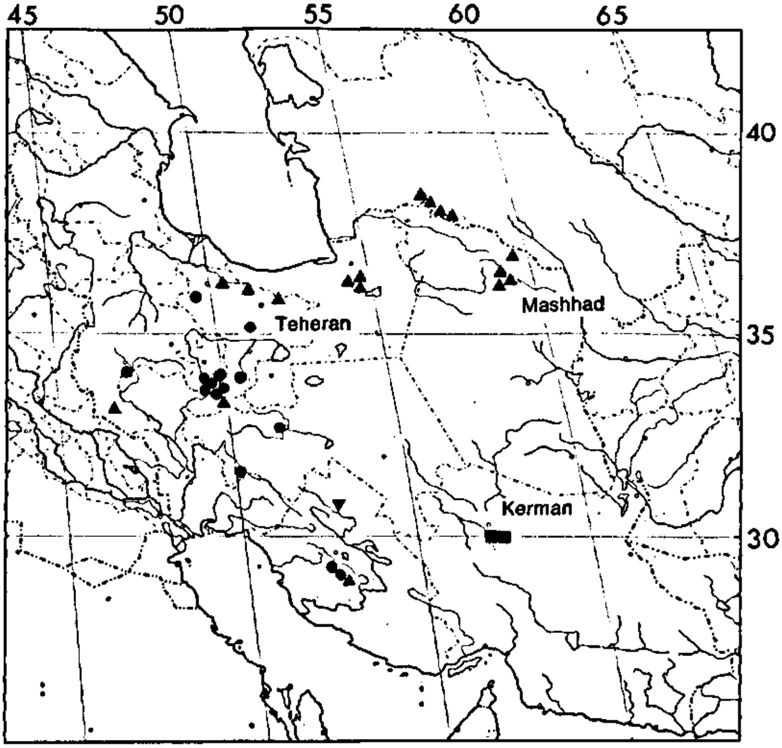


FIG. 32. *C. spiroceras* Jaub. et Spach – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. flag, $2^1/_2$ ×; 4. wing, $2^1/_2$ ×; 5. keel, $2^1/_2$ ×; 6. anthers, $2^1/_2$ ×; 7. pistil, $2^1/_2$ ×; 8, 9.seed, $2^1/_2$ × (AUCHER-ELOY 1126, holotype, P)



MAP 21. ● *C. spiroceras*, ■ *C. kermanense*, ▲ *C. tragacanthoides*, ▼ *C. stapfianum*

Specimens examined: Iran: Aucher-Eloy 1126, Mts near Isfahan (P, holotype; isotypes in G, K); id. 4357, Euphrate?, Isfahan? (BM, G, K, OXF, P, WU); Behboudi 1057, Sičaani, Sissakhl, Kuh-e-Dena, prov. Fars (W); Koelz 17575, Safed Kuh, Luristan (W); Sawyer (Watt 13041), Bakhtiary country (E); Stapf 631, Tang-i-Kaeldu (Qeydu?) (W); Strauss 6/1889, Sultanabad (Arak) below Girdu (JE); id. 8/1889, Mt Raswend (JE); id. 1890, Mt Schuturunkuh (Ostoronkuh) (JE); id. 37, 5/1892, Mowdere (Mowdarr), W Sullwend (?) (JE); id. 5/1899, between Sultanabad (Arak) and Kum (Qom) (JE); id. 5/1902, Mowdarr, near Sultanabad (Arak) (JE); id. 7/1902, Mt Sinahzinde (Shahzind, Khalajestan) (JE); id. 7/1903, Kuh Gerre, Nehavend (JE); id. 7/1903, Dschekab R. (?), between Kashan and Arak (JE); id. 7/1903, Mt Raswend (JE); id. 6/1905, Schuturunkuh (Ostoronkuh) (JE); id. 7/1908, Kuh Douine, Feredein (JE).

Ecology: rubble slopes, *Quercus* forests. Flowering: May-July (August).

36. C. stapfianum K. H. Rech. **Fig. 33, p. 121; Map 21, p. 120**

in Engl., Bot. Jahrb. 75: 339. 1951.

Type: Iran, Fars prov., Kuh Bul, STAPF 625 (W, holotype; isotype in K).

Perennial. Branched shrublet, almost subglabrous.

Stems flexuous, ribbed, 25 cm.

Leaves (4)6–10 leaflets, mostly transformed into spines; rachis (20)30–55 mm, grooved above, ending in a spine.

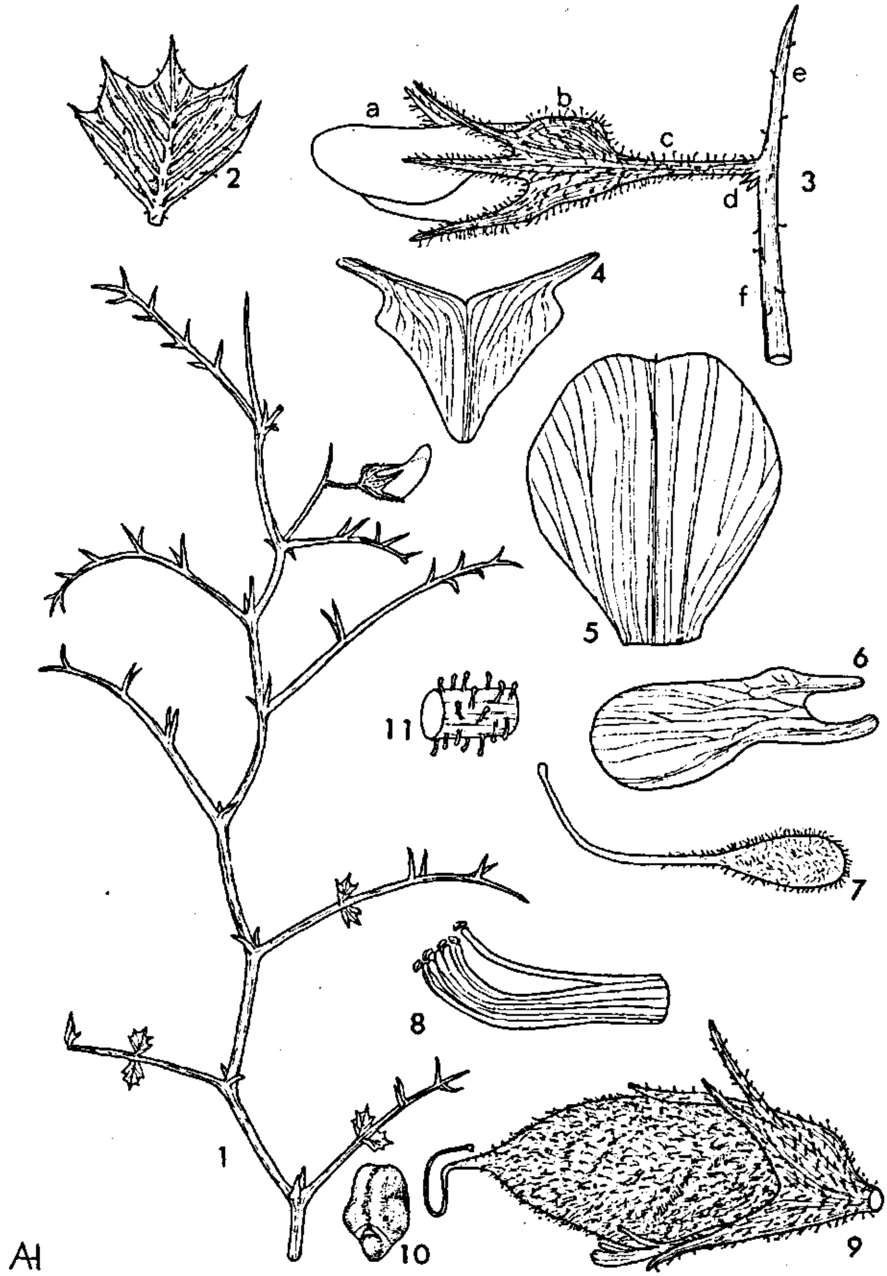


FIG. 33. *C. stapfianum* K. H. Rech. – 1. branch, $^5/_6$ ×; 2. leaflet, $2^1/_2$ ×; 3. inflorescence, a. corolla, b. calyx, c. pedicel, d. bracts, e. arista, f. peduncle, $2^1/_2$ ×; 4. keel, $2^1/_2$ ×; 5. flag, $2^1/_2$ ×; 6. wing, $2^1/_2$ ×; 7. pistil, $2^1/_2$ ×; 8. anthers, $2^1/_2$ ×; 9. pod, $2^1/_2$ ×; 10. seed, $2^1/_2$ ×; 11. detail of pedicel, $7^1/_2$ × (STAPF 625, types, W)

Leaflets fairly close, paripinnate, opposite, spine-shaped, 3–9 mm, occasionally 1 or 2 lower pairs of basal leaves normal, flabellate, base cuneate, top rounded-dentate, (3)5–10 mm long, 3–7 mm wide, both sides prominently veined, especially the midrib, teeth 3–5, triangular, ending in a spinelet.

Stipules lanceolate perules, 2–5 mm long, 1 mm wide, mostly with small side-perule, 1–2 mm long, at the base both parts wider, up to 3 mm.

Flowers in 1–2 flowered axillary racemes, peduncle 20–30 mm long, with a spiny arista, 5–12 mm; pedicels up to 7 mm, recurved when bearing pods.

Calyx dorsally gibbous at the base, glandular pubescent; tube 4 mm; teeth lanceolate, acuminate, 6 mm long, midrib prominent.

Corolla veined, vexillum elliptic-ovate, top hardly mucronulate, broadly based, 18 mm long, 10 mm wide; alae oblong, base auriculate, 11 mm long, 4 mm wide; carina rhomboid, 12 mm, frontal side of ventral margin adnate.

Stamens 9 + 1, filaments 13 mm (fused part 8 mm, free part 5 mm, upturned), anthers dorsifix.

Ovary ovoid, 5 mm long, 3 mm wide, glandular pubescent, 4 ovules, style 10 mm, upturned.

Pods elliptic, glandular pubescent, up to 20 mm long, 7–10 mm wide.

Seeds obovate, beaked, 5 mm long, 3 mm wide, brown, seed coat irregular.

Note

This species, only found once, resembles *C. pungens* as *C. subaphyllum* resembles *C. spiroceras*. Its character, though clearly tragacanthoid, also offers resemblance to *C. subaphyllum*. From the ecology is little exact known, therefore speculations about a status as derived form from *C. pungens* (similarly *C. subaphyllum* from *C. spiroceras*) remain entirely speculative. Unluckily no accessory material is known, so special attention should be paid to look for this species.

Distribution: Iran.
Altitude: ca. 4000 m
Ecology: mountains. Flowering: August.

Specimens examined: Iran: Stapf 625, Kuh-e-Bul, NNE of Shiraz (W, holotype; isotypes at K, W).

37. C. subaphyllum Boiss. **Fig. 34, p. 123; Map 16, p. 99**

Diagn. Sér. 1–6: 44. 1845; ALEFELD, Oest. Bot. Zeitschr. 9–11: 357. 1859; BOISS., Fl. Orient. 2: 564. 1872; POPOV, op. cit. 196. 1929; TROLL, Vergl. Morph. Höh. Pflz. 1: 1933. 1939; PARSA, Fl. Iran 2: 438. 1943.

Type: Iran, Kuh-Ajub Mts, Mt Jobi near Persepolis, KOTSCHY 403 (P, holotype; isotypes in BM, C, G, JE, K, L, M, OXF, W, WAG).

Perennial. Sturdy bushlet, glabrous, only pedicel and pod glandular pubescent.

Stems erect, ramified, ribbed, 30–40 cm.

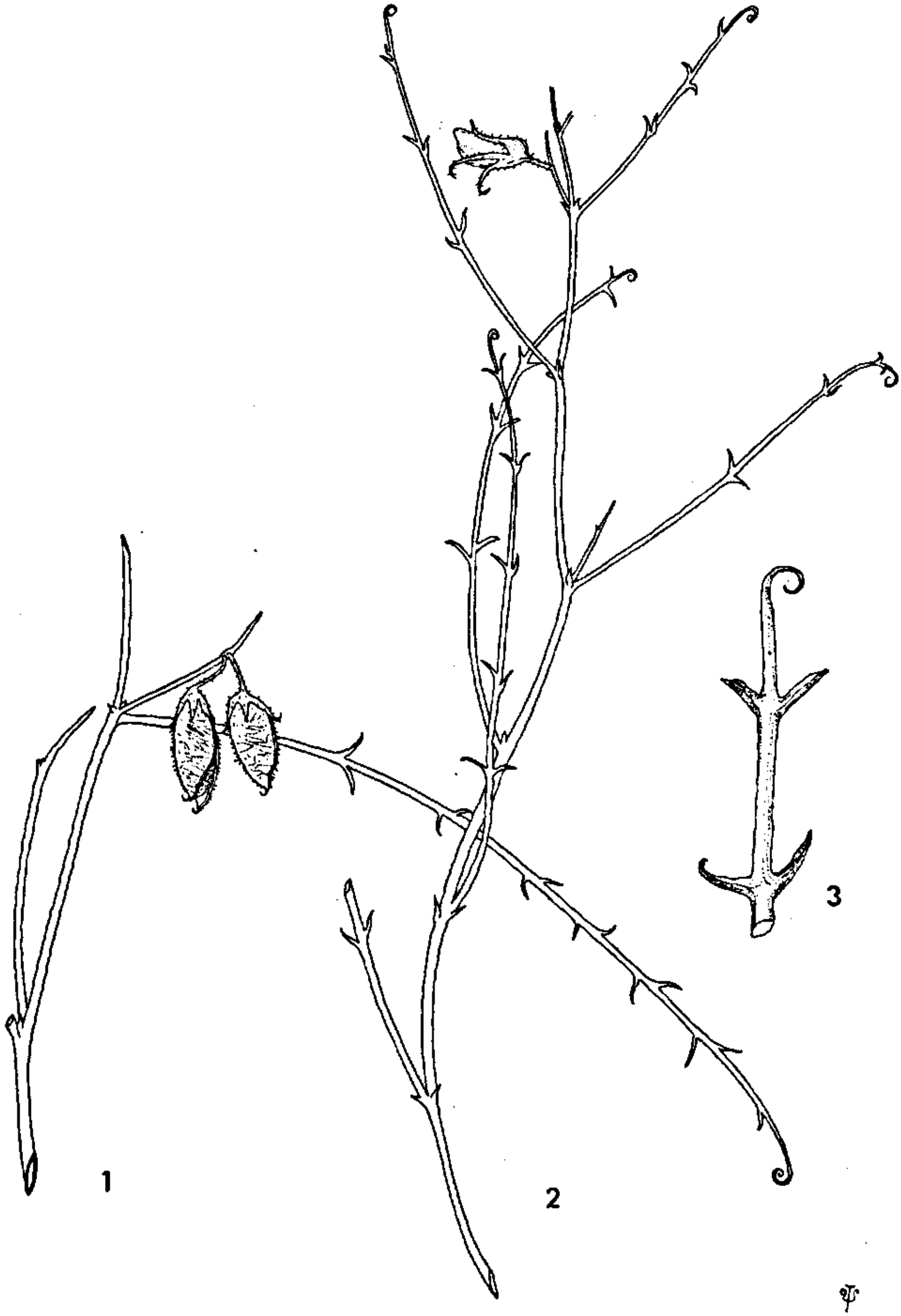


FIG. 34. *C. subaphyllum* Boiss. – 1. fruiting branch, $^5/_6$ ×; 2. flowering branch, $^5/_6$ ×; 3. detail of leaf, $2^1/_2$ × (KOTSCHY 403, isotype, OXF)

Leaves 4–12(16) leaflets, paripinnate, transformed into spines, rachis (4)8–14 cm, as thick as the twigs, ribbed, ending in a spiny curl.

Leaflets opposite or nearly so, 3–8 mm small, spiny, straight or incurved at the acute top.

Stipules of the lower leaves triangular-acuminate with 2–3 dents, upper ones mostly entire, teeth with 3 riblets each, 1–4 mm long.

Flowers in 1–2-flowered axillary racemes, peduncles 10–45 mm, as thick as the leaf rachis, ending in a spiny arista, 5–15 mm, bracts minute 2–3 dentate perules, pedicels 5–10 mm, recurved when bearing pods, glandular pubescent.

Calyx dorsally gibbous at the base, glandular pubescent, tube ca. 3 mm, dents 7–10 mm, shorter than or slightly exceeding the corolla, lanceolate-acuminate.

Corolla veined; vexillum obovate, ca. 10 mm long, ca. 8 mm wide, top emarginate-mucronulate; alae elongate-obovate, ca. 8 mm long, 3 mm wide, base long-auriculated; carina rhomboid, ca. 9 mm long, frontal side of ventral margin adnate (cf. Popov).

Stamens 9 + 1, persistent, up to 9 mm.

Pods ovoid-acuminate, up to 2 cm long, 1 cm wide.

Seeds obovate, beaked, 5 mm long, 4 mm wide, brown, seed coat rough.

Note

This peculiar xerophytic species has been found only once in the Kuh-Ajub mountains near the ruins of Persepolis. It seems derived from *C. spiroceras*. Contrary to a statement in the protologue, a few differences do exist between the stipules of both species. The leaflets of *C. subaphyllum* are transformed into spines, the rachis ends in a curl and not in a tendril, the arista is firmer and longer than in *C. spiroceras*.

Distribution: Iran.
Altitude: 2000 m
Ecology: in rubbles. Flowering: May.

Specimens examined: Iran: Kotschy 403, Kuh-Ajub (Mt Jobi), near ruins of Persepolis (Kuh-e-Ashube) (P, holotype; BM, C, G, JE, K, L, M, OXF, P, W, WAG).

38. C. tragacanthoides Jaub. et Spach **Fig. 35, 36, p. 126, 127; Map 21, p. 120**

Ann. Sci. Nat. Bot. Sér. 2–18: 234. 1842; JAUB. and SPACH, Ill. Pl. Orient.: 90, t. 45. 1842; ALEFELD, Oest. Bot. Zeitschr. 9–11: 357. 1859; BOISS., Fl. Orient. 2: 565. 1872; TRAUTVETTER, Acta Hort. Petrop. 3: 33. 1875; Popov, op. cit. 230. 1929; TROLL, Vergl. Morph. Höh. Pflz. 1: 1933. 1939; Parsa, Fl. Iran 2: 438. 1943; Linczevski, Fl. USSR 13: 405. 1948.

Type: Iran, Elamout Mts, AUCHER-ELOY 4337 (P, holotype; isotypes in BM, G, OXF, P, W).

Heterotypic synonyms: *C. straussii* Bornm., Beih. Bot. Centralbl. 27–2: 344. 1910; *C. kopetdaghense* Lincz., Not. Syst. Herb. Bot. Acad. Sci. USSR 9: 111. 1949.

Perennial. Sturdy branched shrublet, woody roots, sparsely pubescent.

Stems flexuous, ribbed, 15–35 cm long.

Leaves paripinnate, 5–16 leaflets, lower ones 2–4; rachis 1.5–4(9) cm, terete or flattened above, ending in a slightly recurved or straight spiny tendril.

Leaflets remote, paripinnate, ovate, subrotundate or flabellate, base rounded, cuneate to narrow cuneate, top acute with 1–3(5) dents, 1–6 mm long, 1–5 mm wide, midrib ending spiny, lateral spines smaller.

Stipules triangular perules, 1–4 mm long, 1–2 mm wide, with 1–2(4) acute dents, prominently ribbed.

Flowers in 1-flowered axillary racemes; peduncles 20–50 mm, ending in a spiny arista, 5–20 mm, point often recurved; bracts minute perules; pedicel 5–10 mm, recurved when bearing pods.

Calyx strongly dorsally gibbous at the base; tube 3–4 mm; teeth 3–5 mm, broadly acuminate, midrib prominent.

Corolla veined, purplish blue; vexillum obovate, top emarginate, mucronate, 18–25 mm long, 12–15 mm wide; alae narrow-obovate, auriculated, 13–16 mm long, base 5 mm; carina oblong, ca. 13 mm long, topmost half of frontal side of ventral margin adnate.

Stamens 9 + 1, filaments 11 mm long, (fused part 8 mm, free part 3 mm, nearly perpendicularly upturned).

Ovary ovate, 5 mm long, 6 ovules; style 8 mm, glabrous at the top.

Pods ovate, 15–20 mm long, dehiscent, valves curling when ripe.

Seeds globular, beaked, 5–6 mm long, 3–4 mm wide, beak strongly recurved, black, seed coat finely tuberculated, chalazal tubercle circular, slightly elevated.

Note

Most specimens of *C. tragacanthoides* have a height of 15–20 cm, while KULTYASOV s.n. from Kopet-dagh (labelled as *C. kopetdaghense* Lincz. by LINCZEVSKI) possesses all characteristics of *C. tragacanthoides* except for its height which is up to 35 cm. The rigidity of its leaflets, the size and number of its leaflets support my view that *C. tragacanthoides* is at hand. It is one of the forms in the eastern part of the area: the Khorasan and the Kopet-dagh mountains. All specimens from Khorasan and Kopet-dagh, except two, have larger leaflets than is usual in *C. tragacanthoides* and they are either more rigid, or they have the less tragacanthoid, slender habit on which var. *turcomanicum* M. Pop. is based. *C. kopetdaghense* Lincz. is the same taxon as var. *turcomanicum* M. Pop., as is shown by intermediate specimens (e.g. KULTYASOV) while the type material of var. *turcomanicum* was used by LINCZEVSKI for *C. kopetdaghense* (LITWINOW 242 and 243 from Kopet-dagh).

In the Khorasan, a gradual change towards slenderness in the species can be observed. In Afghanistan, the species *C. rechingeri* Podlech is very near. In *C. tragacanthoides* the majority of the stipules is shorter and broader than in *C. rechingeri*. The majority of the leaflets is smaller, with a more cuneate base, longer than wide and more remote. The habit of KULTYASOV s.n. coincides reasonably well with the habit of *C. rechingeri*. In *C. tragacanthoides* the calyx-

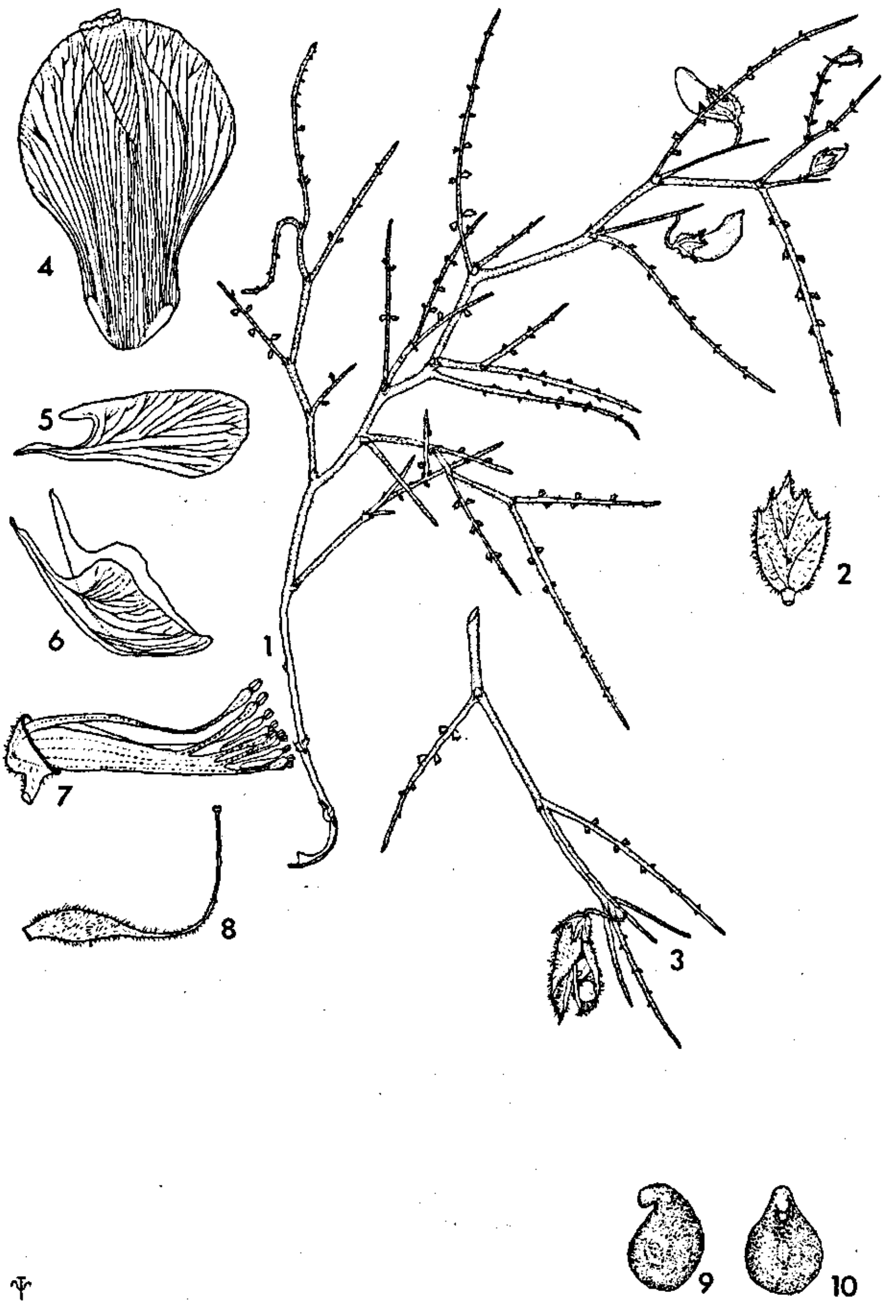


FIG. 35. *C. tragacanthoides* Jaub. et Spach – 1. branch, $^5/_6$ ×; 2. leaflet, 5 ×; 3. fruiting branchlet, $^5/_6$ ×; 4. flag, $2^1/_2$ ×; 5. wing, $2^1/_2$ ×; 6. keel, $2^1/_2$ ×; 7. anthers, $2^1/_2$ ×; 8. pistil, $2^1/_2$ ×; 9, 10. seeds, $2^1/_2$ ×; (BORNMÜLLER 6633, E)

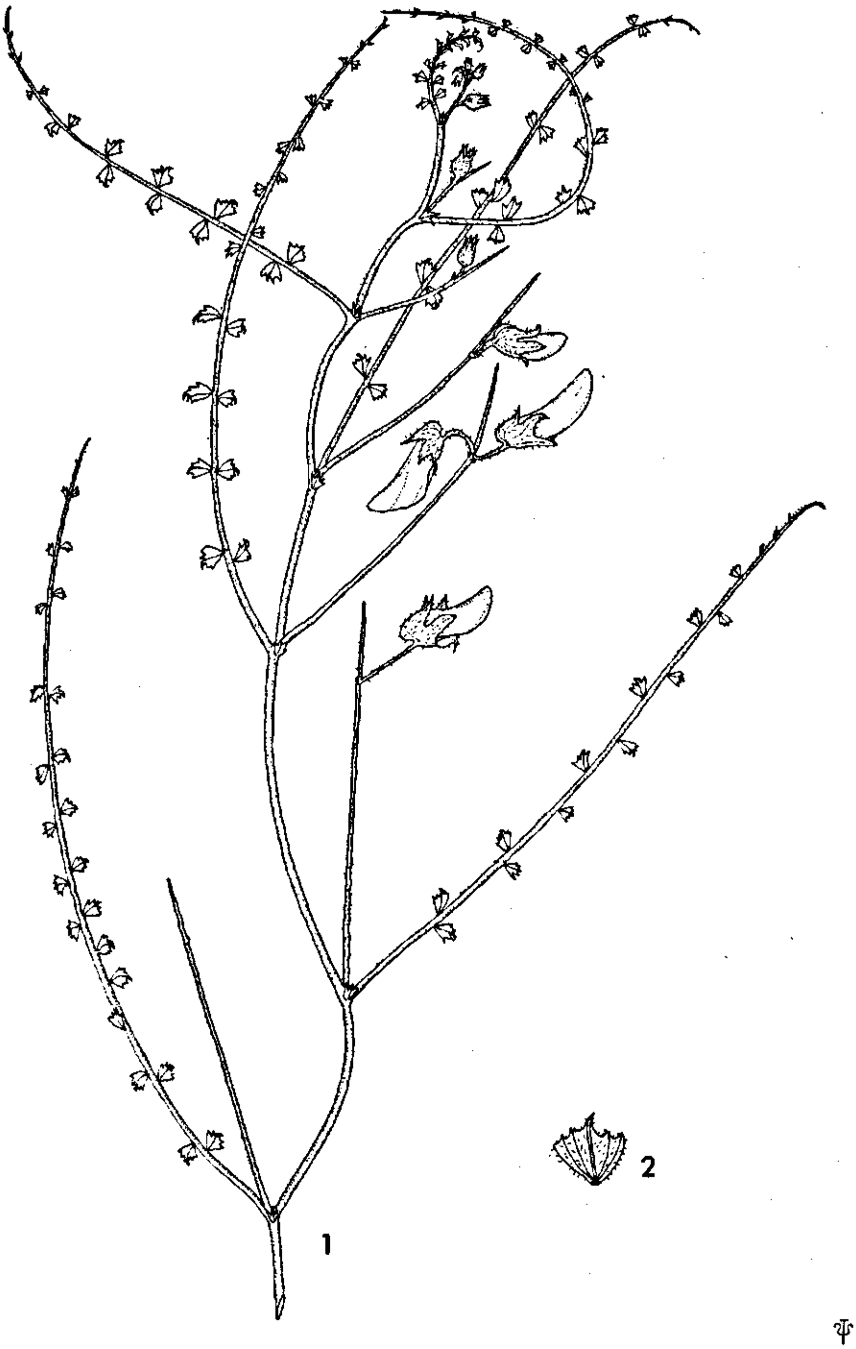


FIG. 36. *C. tragacanthoides* Jaub. et Spach var. *turcomanicum* M. Pop. – 1. branch, $^{5}/_{6}$ ×; 2. leaflet, $2^{1}/_{2}$ × (LITWINOW 243, E)

teeth are clearly shorter and acuminate, in *C. rechingeri* the calyx-teeth are lanceolate.

Note on C. straussii Bornm.

C. straussii Bornm. is judged to belong in *C. tragacanthoides* var. *turcomanicum* because of its stature, leaves and calyx shape. The broad calyx-teeth with a rounded-cuspidate top, especially the lateral ones, is not only present in STRAUSS, 8/1903, but also in AUCHER-ELOY 4337, the type specimen of *C. tragacanthoides*. SCHMID 6217 and even BORNMÜLLER 6633, being good examples of this species, similarly posses broad calyx-teeth. The size of the flowers of the '*C. straussii*' specimen is conspicuously larger than most of the *C. tragacanthoides* specimens, which size I merely ascribe to the ecological conditions. As yet our knowledge on the ecology, geography and cytology is very scanty, so better information on these points should clarify the present problem.

Distribution: Iran, S. Turkmenia.

Altitudes: 1900–3800 m

Ecology: mountanous and alpine regions, dry rocky slopes, screes. Flowering: June-July (August).

Vernacular name: nochudi kuhi (mountain chickpea).

Specimens examined: Iran: Aucher-Eloy 4337, Mt Elamout (Kuh-e-Alvand?) (BM, G, OXF, P, W); id. 4387, ibid. (JE); Bornmüller 6633, top of Totschal Mt. Elburz Mts (BM, C, E, G, JE, K, L, P, W, WU); Bunge s.n., between Nischapur and Mashhad (C, K, L, P); Daly 46, near Mashhad (K); Furse 2568, Elburz Mts above Ab Ali, E of Teheran (K, W); Haussknecht s.n., Mt Kellal, Luristan (JE, K, P); Koelz 16341, Shahkuh, Mazandaran (E, W); Kotschy 655, Kuh Daena (BM, C, G, K, OXF, P, W, WAG); id. 684, Elburz Mts near Dambak, near Passgala village (W); Rechinger, K.H. and F. 5054, Mt Hazar Masdjid, prov. Khorasan (E, G, K, M, W); id. 5982, Mt Shahwar, above Nekarman (Nigarman), above Rahé, prov. Shahrud-Burtam (W); id. 6013, Mt Shahwar, near Ostmaidan, prov. Gorgan (Asterabad) (E, G, K, W); Sawyer (Watt 13051), Bakhtiary country (E); Schmid 6217, Ostang, near Mughan, N of Kuh-i-Binalud (W); Strauss s.n., 8/1903, Mt Schuturunkuh (Ostoronkuh) (JE, holotype '*C. straussii*'); Wendelbo 1260, Nezva Kuh, Mazandaran (W).

USSR, Turkmeniya: Kultyasov s.n., C Khrebet Kopet -dagh (W); Litwinow 242, Mt Saandah (G); id. 243, Karanky near Ashkhabad (E, G, JE, P, WU); id. 388, Mt Ludsha, near Ashkhabad (E, W).

39. C. yamashitae Kitamura **Fig. 37, p. 130; Map 15, p. 94**

Acta Phytotax. Geobot. Kyoto 16: 135. 1956; KITAMURA, Fl. Afghan.: 225. 1960.

Type: Afghanistan, between Sarobi and Kabul, YAMASHITA and KITAMURA (KY, holotype, not seen).

Heterotypic synonym: *C. longearistatum* K. H. Rech., in Biol. Skrift. Kong. Dansk. Vidensk. Selsk. 9-3: 201. 1957.

Annual. Herb, more or less branched at the base, densely glandular pubescent.

Stems erect and procumbent, faintly ribbed, 10–30 cm long.

Leaves imparipinnate, (3)5–7 leaflets; rachis 1–3 cm, grooved above, ending in a leaflet.

Leaflets fairly close, opposite or not, shortly petiolulate, lanceolate or elliptic-oblong, (5)10–15(17) mm long, 1–5 mm wide, base cuneate, top rounded, generally only the upper half of margin incised, teeth (3–5–)7–13, acuminate, up to 1 mm.

Stipules (1)2(3) dentate perules, dents triangular to lanceolate, (1)2–2.5 mm.

Flowers in single-flowered axillary racemes, peduncles (5)9–15 mm, ending in a very long, slender arista, 5–20 mm; bracts simple lanceolate minute perules; pedicels 2–5 mm, recurved when bearing pods.

Calyx slightly dorsally gibbous at the base, tube 1–2 mm, teeth lanceolate-acuminate, 4–5 mm, prominently trinervate.

Corolla veined, pink; vexillum narrowly obovate, broadly based, ca. 7 mm long, ca. 3 mm wide; alae oblong, base shortly auriculate, ca. 5 mm long, ca. 2 mm wide; carina rhomboid, frontal side of ventral margin adnate, ca. 5 mm.

Stamens 9 + 1, filaments 5 mm, (fused part 3 mm, free part 2 mm long, upturned) anthers dorsifix.

Ovary ovoid, 3 mm long, 2 ovules, style 3 mm, upturned.

Pods ovate-oblong, 10–12 mm long, 5 mm wide, 1–2-seeded.

Seeds rather flat-arietinoid, heart-shaped, beak recurved, 5 mm long, 4 mm wide, seed coat brownish, whitish irregularly tuberculated, chalazal tubercle prominent.

Note

This annual species, closely related to *C. bijugum* K. H. Rech., by its habit, takes a singular place in the Afghan flora. The species has only been found between Kabul and Sarobi (prov. Kabul) at medium and high altitudes. It is endemic and seems to be confined to a very small area. *C. yamashitae* should be used for hybridization with other species.

The main differences from related species are the very long awn (therefore the epithet *longearistatum* for a synonymous species) and the 5–7 foliolate leaflets.

Distribution: Afghanistan.

Altitudes: 900–2800 m

Ecology: rocks (gneiss), rubble slopes. Flowering: May-June.

Vernacular name: wogi.

Specimens examined: Afghanistan: Kerstan 583, Tisin, on the road Kabul-Jalalabad (W); Rechinger 34482, Kabul R., E of Sarobi (W); Volk 1887, near Sarobi, prov. Kabul (type of *C. longearistatum* K.H. Rech.) (W); id. 1888, ibid. (W).

Nomina excludenda

C. ervoides Brign., Fasc. Pl. Forojul.: 27. 1810 = *Lens lenticula*

C. lens Willd., Sp. Pl. 3: 1114. 1808 = *Lens culinaris*

C. nigrum hort. ex Steud., Nom. Bot. ed. 2–1: 361. 1840 = *Lens culinaris*

C. nummulariaefolium Lam., Encyc. 2: 2. 1786 = *Crotalaria biflora*

C. punctatum hort. ex Steud., Nom. Bot. ed. 2–1: 361. 1840 = *Lens lenticula*

C. punctulatum hort. ex Ser. in DC. Prodr. 2:366. 1825 = *Lens culinaris*

C. soloniense, Schranck ex Don, Gen. Syst. 2: 312. 1832 = *Lens lenticula*

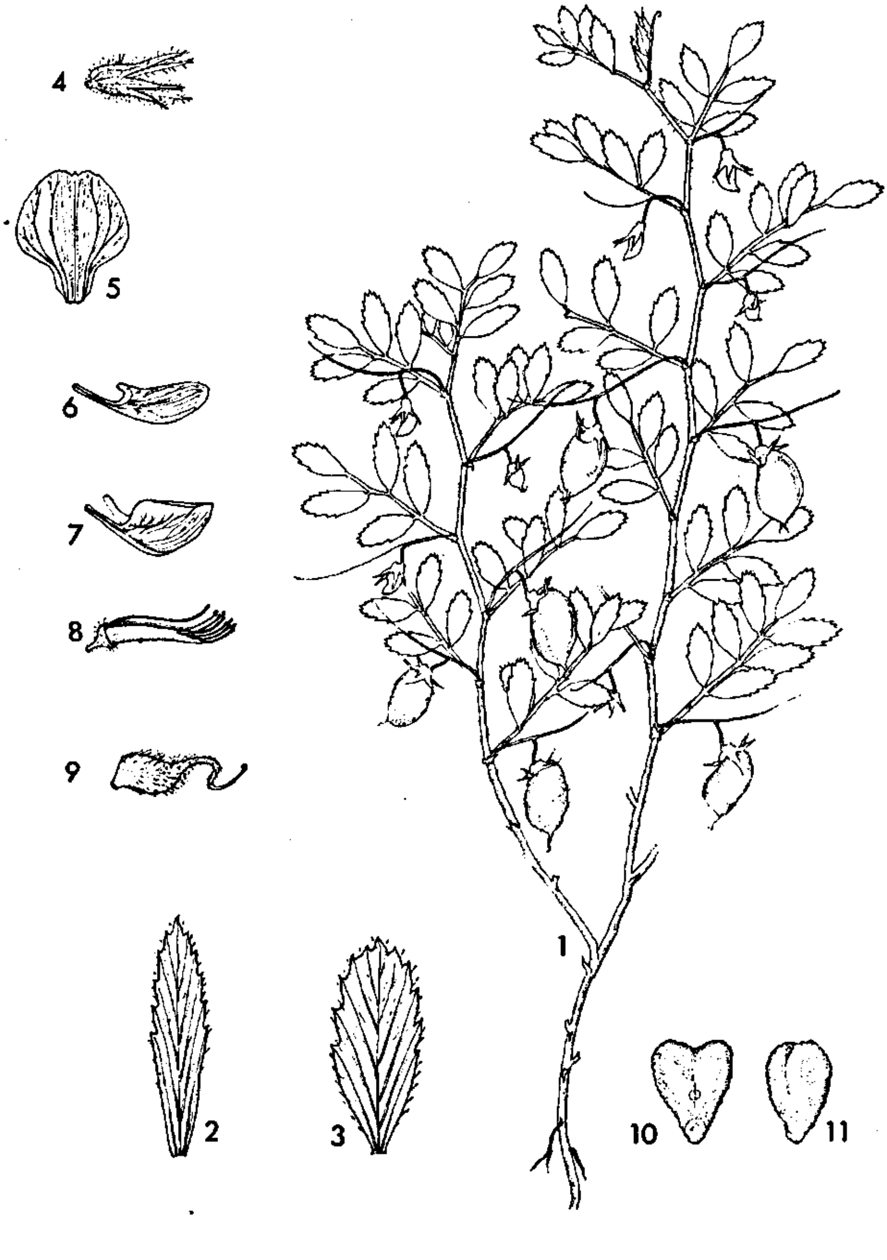


FIG. 37. *C. yamashitae* Kitamura – 1. plant, $^5/_6$ ×; 2, 3. leaflets, $2^1/_2$ ×; 4. calyx, $2^1/_2$ ×; 5. flag; $2^1/_2$ ×; 6. wing; $2^1/_2$ ×; 7. keel, $2^1/_2$ ×; 8. anthers, $2^1/_2$ ×; 9. pistil, developing into pod, $2^1/_2$ ×; 10, 11. seed, $2^1/_2$ × (1, 3: VOLK 1887, holotype '*C. longearistatum*', W; 2, 4–12: RECHINGER 34482, W)

2.7. Infraspecific classification of *Cicer arietinum* L.

2.7.1. *Existing classifications*

The oldest subdivisions of the cultivated *Cicer* species, *C. arietinum* L., are based on the morphology of the seeds. These taxa remained without an author's name; e.g. var. *nigrum* hort. Since the colour and form of the seeds are of considerable economical importance and conveniently used in the trade, these characters are much used.

Jaubert and Spach (1842) distinguished three varieties:
1. *vulgare* (pods oval to rhomboid, 17–19 mm, 1–2-seeded, seeds small, ca. 4 mm, smooth or reticulate, base mostly egibbous) (= *C. arietinum* L., *C. physodes* Reichb.). **2.** *rytidospermum* (pods rhomboid, 1–2-seeded, seeds small (3 mm), wrinkled, dorsal side carinulate, base hardly gibbous. In Egypt, also cultivated, legit Coquebert de Montbret.). **3.** *macrocarpum* (pods oblong, much inflated, 1-seeded, seeds large (± 8 mm), more or less reticulate, dorsal side ± reticulate, base bilobular, gibbous) (= *C. sativum* Schkuhr).

Alefeld (1859, 1861) proposed five varieties: a. Flowers blue-red: **1.** Var. *nigrum* Alef. (1859) (= *C. nigrum* hort.). Seeds black, deeply grooved. **2.** Var. *fuscum* Alef. (1861). Seeds brown, deeply grooved. **3.** Var. *cruentum* Alef. (1861). Seeds blood-red, rounded except for the beak. b. Flowers white: **4.** Var. *globosum* Alef. (1859) (= *C. rotundum* Jord.). Seeds orange, rounded except for the beak. **5.** Var. *album* Alef. (1859) (= *C. album* hort.), seeds white, deeply grooved.

In 1866 Alefeld split his var. *nigrum* into the small-seeded (1842) var. *vulgare* Jaub. et Sp. and the large-seeded var. *macrospermum* Jaub. et Sp. (non *macrocarpum*). (Landwirthsch. Flora: 36. 1866). Burkart (1943) put var. *nigrum* Alef. into synonymy with var. *vulgare* Jaub. et Sp.; var. *cruentum* Alef. with var. *rytidospermum* Jaub. et Sp. and var. *album* Alef. with var. *macrocarpum* Jaub. et Sp.

Popov (1929) did not tackle the problem of the infraspecific classification of *C. arietinum*. The material available and collected by Vavilov and his colleagues was studied by Prosorova (1927). Her classification in 21 kinds ('varieties') was not available except for the 10 Afghan varieties as published by Vavilov and Bukinich (1929). She conserved the three major varieties of Alefeld (var. *album*, var. *fuscum* and var. *nigrum*) and added several others, based on flower colour and seed characteristics. **1.** White flowers: **1.1.** Var. *album* Alef. Seeds angular-rounded, wrinkled, yellowish white. **1.2.** Var. *albo-angulatum* Prosorova. Seeds angular, yellowish. **1.3.** Var. *albo-testaceum* Prosorova. Seeds terracotta-brown. **2.** Red flowers: **2.1.** Var. *roseum* Prosorova. Seeds rather angular, prominently wrinkled, hazelnut brown with greyish shade. **2.2.** Var. *gilvum* Prosorova. Seeds angular-rounded, light yellowish. **2.3.** Var. *reticulatum* Prosorova. Seeds angular or nearly globular, brownish with light beak. **3.** With red-violet (= purplish) flowers. **3.1.** Var. *fuscum* Alefeld. Seeds rather angular, prominently wrinkled, rusty or chestnut brown, rather large. **3.2.** Var. *nigrum* Alef. Seeds rather angular, black. Rare. **3.3.** Var. *pallido-rostratum* Prosorova. Seeds rounded, smooth or slightly wrinkled, light yellowish or brick-red, mosaic with black dots and stripes, beak small. **4.** With blue flowers. **4.1.** Var. *azureo-coloratum* Prosorova. Seeds globular, without wrinkles, yellowish brown with a violet stripe.

In 1937 the FLORA of CULTIVATED PLANTS, Vol. 4 was published in the USSR, two years after the Latin description became necessary for valid publication of taxa. Since the work is entirely in Russian the taxa adopted are not published validly. Because of the difficult accessibility of the language and of the (pre-)war situation this work apparently is very badly known in the West. The meritorious and detailed classification of POPOVA were accepted by KOINOV (1968) who added four new varieties. In the USSR literature I saw no reference is made to this flora, which stood under the general editorship of VAVILOV. POPOVA distinguished four subspecies in *C. arietinum*, 13 proles and 64 varieties. The subspecies are distinguished on account of dimensions, 1000-seed weight, colour of the seeds, and geography. The proles are distinguishable by the form of the plant and the seed characteristics. The varieties are distinguishable within the proles by form and colour of the seeds.

On a more regional and adapted-agronomical base the cultivars (cultivated varieties) of the India subcontinent were classified. HOWARD, HOWARD and KHAN (1915) classified *Cicer arietinum* into 25 kinds ('types') distinguished by dimension, shape and colour of the seeds, the colour of the pedicel, the dimension and colour of the leaflets and the vegetation period. SHAW and KHAN (1931) increased these kinds to 84. The kinds ('types') received numbers, which are still used, although some confusion exists, since some research stations also use the code T with a number. The kinds are known as 'Pusa types'.

SOOMRO and BALUCH (1968) reviewed the literature on 'varietal' classification in *Cicer arietinum* L. All comprehensive fundamental work was taken into account, including the work of SIDDIQUE and AZIZ (1960) and AN (1967). Classifications in *Phaseolus radiatus* L., *Ph. mungo* L., *Cajanus cajan* (L.) Millsp., *Lens culinaris* Medik. and *Lathyrus sativus* L. were used as a model to establish classes or groups. Only 9 cultivars were described, meant to be used in practice. In general their 'classes' may be used when describing a cultivar, but as they limited their research to the 9 cultivars much work remains to be done.

POPOVA and PAVLOVA (1933) subdivided the Turkish chickpeas into three subspecies: **1.** ssp. *arieticeps* (rams-head shaped), **2.** ssp. *pisiforme* (pea-shaped), **3.** ssp. *intermedium* (seed-coat wrinkled superficially) with 29 varieties, distinguishable on characters such as size, seed coat colour, flower and foliage colour. The subspecies were subdivided into proles, of which the proles *mediteraneum* G. Pop. and proles *orientale* G. Pop. (in ssp. *pisiforme* G. Pop. et A. M. Pavl.) reappear in the 1937 work of Popova as a subspecies, in an entirely different concept. GENÇKAN (1958) based his infraspecific classification on this work but accepted the JAUBERT and SPACH – ALEFELD classification later (1961).

2.7.2. *Discussion*

HARLAN and DE WET (1971) pointed out that the methods of formal taxonomy are not always satisfactory when classifying cultivated plants. Plant breeders and agronomists use informal and intuitive classifications of their own, or none at all. HARLAN and DE WET proposed the use of an informal way to classify the cultivars of a species, so both taxonomical-natural systems and agronomical-practical systems may operate with a minimum of confusion, as long as it is made clear which method is followed.

They distinguished primary, secondary and tertiary gene pools. *Cicer arietinum* is confined to a primary gene pool (= biological species), since no other species are known to cross with *C. arietinum*. A secondary or tertiary gene pool (species which can be crossed with *C. arietinum*, with (secondary) or without (tertiary) fertile hybrids) is not known to exist. I assume that if secondary and tertiary gene pools are discovered, it will be found in the Section *Monocicer* M. Pop.

On the infraspecific level no Subspecies B (spontaneous races) seems to exist, except for perhaps the blue-flowered types with very small seeds, which are rather rare (India) and hardly preferred for cultivation.

Within the cultivated chickpea, therefore, the categories race, subrace, cultivar and lines remain when the above–mentioned proposals of HARLAN and DE WET are accepted. POPOVA's more detailed classification is difficult to apply in practice, and of limited utility. Within a cultivar lines are rarely distinguishable, but nevertheless are met with at various breeding and multiplication stations. The traditional cultivars (landraces) are a mixture of lines, which results in different crops from allegedly the same cultivar.

A classification based on geography may be hazardous, because of the considerable exchange of chickpea material.

The classification of POPOVA reflects the situation in cultivated *Cicer* around 1937 and before, and can be used despite much exchange between different regions of cultivation. An entire revision of the forms seems to be possible, after a comparative study of the collections at New Delhi, Teheran, Izmir and Leningrad. This would involve many years of painstaking research and considerable expense but it is of first importance for breeding the chickpea. A very simple classification on seed characters is presented in Chapter 6.

2.7.3. *Informal infraspecific classification in Cicer arietinum L.*

Judging from the available material, literature, and other information I propose to adopt the nomenclature of POPOVA (1937) with the following modifications.

The subspecies distinguished by POPOVA should be regarded as races, the proles can be considered as subraces. The 'botanical varieties' of POPOVA, which she distinguished in the proles on seed shape and colour, occur in different subraces. These characteristics are dependent on a few genetic factors only, as shown in Table 40 (Chapter 7).

The following races are keyed out according to the system of POPOVA (as adapted from the Russian). The *Latin names* indicate *groups of cultivars*.

Key to the races of *Cicer arietinum* L.

1. Seeds very small; 6–7 mm long, 5–6 mm wide, 1000 seed weight 100–120 g, dark coloured: black, brown or brown-red, rarely lighter or white. Seed shape angular (ram's head), rarely otherwise. Flowers small (flag up to 7 mm), pinkish red (= purplish?), rarely otherwise. Leaflets small, 6–9 mm long. Plant small with thin stems, except for the mountaneous forms. Stems mostly coloured with anthocyane . . . . . . race *orientale* (5 subraces)
   Ethiopia, Sudan, Egypt, India, Pamir, Tadzhikistan, also in Iran.
– Seeds larger, mainly light coloured or white, rarely dark 2
2. Seeds small, but larger than in race orientale, 1000 seed weight 140–200 g, white, or red, very rarely brown. Seed shape rounded (owl's head), if coloured angular (ram's head). Flowers white or red. Plant of medium height . . . . race *asiaticum* (4 subraces)
   Central Asia, Afghanistan, Western China, Iran, East Turkey.
– Seeds medium large or large 3
3. Seeds very large, 1000 seed weight more than 350 g, white (= cream). Seed shape rounded (not angular) (owl's head). Pods large, inflated to a larger degree than in the other races. Flowers white, leaflets large. Plants of medium height or very tall. Stems green, no anthocyane present . . . . race *mediterraneum* (1 subrace)
   Spain, Italy, Morocco, Algeria, Tunisia, West Turkey, C. America.
– Seeds medium large, 1000 seed weight 200–300 g, white. Seed shape rounded (owl's head). Rarely coloured seeds of angular shape. Plant large, partly ascending . . . . race *eurasiaticum*
   Syria, Palestine, Turkey, (subraces) Armenia, Azerbaydzhan, Ukraine (and up till central Soviet Union) and near large cities in the eastern part of the area.

Key to the subraces in *Cicer arietinum* L.

Race *orientale*.

1. Plant prostrate, seeds hardly angular, dark coloured. Flowers deep pink. Anthocyane intense. Early cultivars . . . . subrace *iranicum*
– Plant more erect 2
2. Small plant 3
   Tall plant 4
3. Stems with few branches, at the top perpendicularly incurved. Seed shape angular, sometimes globular (pea-shape) or rounded (owl's head). Mainly dark coloured. Flowers pinkish red, rarely white. Anthocyane present . . . . subrace *abyssinicum*
– Stems densily branched, erect or semi-erect, leaves sometimes yellowish green. Seeds angular, coloured, seldom rounded, white. Cultivars medium or late. Anthocyane present or not . . . . subrace *indicum*
4. Plant densily branched over entire length of the stems, rather thinly foliolated. Seeds hardly angular (ram's head), dark or red brown. Seeds very small, 1000 seed weight 90–140 g. Flowers pinkish red. Late cultivars . . . . subrace *pamiricum*

– Plant densily branched from the base, rosette-shaped, erect but young plants ascending. Very late cultivars . . . . subrace *montanum*

Race *asiaticum*

1. Plant ascending from the base, but stems horizontal at the top. Seeds small, 1000 seed weight 140–170 g up to 200 g. Seeds white or reddish, sometimes dark coloured. Flowers white or red, seldom pinkish red. Leaflets 10–12 mm long. Medium late cultivars . . . . subrace *turkestanicum*
– Plant erect 2
2. Plant densely branched and foliated, closed but spreading at the top only. Seeds white or pinkish, small . . . . subrace *kashgaricum*
– Plant with few branches and thinly foliated, semi-erect. Seeds bigger than of subrace *kashgaricum* . . . . subrace *afghanicum*

Race *eurasiaticum*

1. Plant spreading, seeds white or rarely pinkish. Medium late cultivars . . . . subrace *palestinicum*
– Plant erect 2
2 Plant of medium height, spreading at the top only. Seeds white, rarely pinkish or otherwise . . . . subrace *turcicum*
– Plant higher, closed 3
3. Plant narrow below (branches close) and widening in the upper part by renewed and divergent branching. High plant only in some cultivars. Seeds pea-shaped, reddish brown, flowers pinkish red . . . subrace *bohemicum*
– Plant branched all along the stems, somewhat lower than subrace *bohemicum*. Seeds white, rounded (owl's head) or reddish and angular (ram's head) . . . . subrace *transcaucasicum*

Race *mediterraneum*

Plants erect, spreading at the top, broad, of medium height (in fact fairly high). Leaflets very large. Flowers, pods and seeds largest of all races . . . . subrace *hispanicum*

In this key many quantitative characters had to be used. Even the shape of the plant may vary, along with the size of all parts, in relation with its environment.

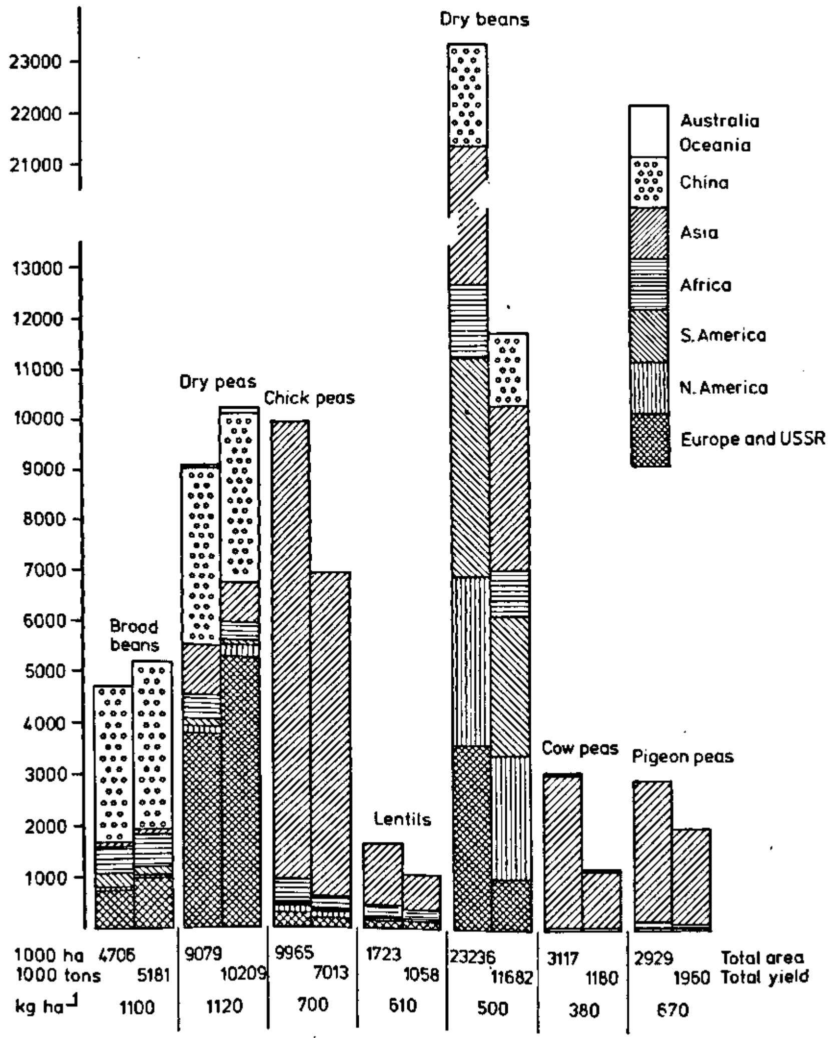
POPOVA (1937), PAVLOVA (1933) and KOINOV (1968) distinguished the sequence of the following 'varieties' (as conserved by KOINOV, varieties named by G. POPOVA without author's name): Var. *iranico-nigrum*; *i.-brunneum*. Var. *abyssinico-albescens*; *a.-roseum*; *a.-fulvum*; *a.-brunneum*; *a.-nigrum*; *a.-nigritum*; *a.-lutescens*; *a.-rubidum*. Var. *indico-albescens*; *i.-roseum*; *i.-fulvum*; *i.-brunneum*; *i.-nigrum*; *i.-xantholeucum*; *i.-aurantiacum*; *i.-songoriciforme* (subvar. *albiflorum*, subvar. *azureum*); *i.-lutescens*; *i.-carotinum*; *i.-rosaceum*. Var. *pamirico-brunneum*; *p.-fulvum*. Var. *montano-brunneum*; *m.-roseum*. Var. *turkestanico-albescens*; *t.-roseum*; *t.-viridescens*; *t.-fulvum*; *t.-brunneum*; *t.-lateritium*; *t.-vaccineum*; *t.-lutescens*; *t.-pallidobrunneum*. Var. *kashgarico-lutescens*; *k.-roseum*; *k.-fulvum*. Var. *afghanico-albescens*. *a.-roseum*; *a.-fulvum*; *a.-brun-*

neum; *a.-lateritium*; *a.-vaccinum*; *a.-lutescens*; *a.-pallidobrunneum*; *a.-aurantiacum* G. K. Var. *palestinico-carneum*; *p.-rubescens*; *p.-rufescens*. Var. *turcico-rubescens*; *t.-rufescens*; *t.-brunneo-violaceum*; *t.-nigritum*; *t.-eborinum*; *t.-rubiginosum*; *t.-carneum*; *t.-castaneum*; *t.-hybridum*; *t.-aurantiacum* G. K. Var. *bohemico-vaccineum*; *b.-atrum* G. K. Var. *transcaucasico-carneum*; *t.-rubescens*; *t.-rufescens*; *t.-brunneo-violaceum*; *t.-lutescens* A. Pavl. Var. *hispanico-flavescens* G. Pop. (subvar. *pirocarpum*, subvar. *macrocarpum*); h.-*cerinum* G. Pop.; h.-*aurantiacum* G. K.

3. AREA, PRODUCTION AND TRADE

3.1. Area

In 1970 the total area cultivated with chickpeas was estimated to be 9,965,000 ha (FAO, 1970). The largest areas are situated in India and (mainly West) Pakistan, with 77.79% and 9.35% of the world acreage, respectively (Table 1). This crop ranks as the 15th most important in area planted annually. On the



Graph 1. Area and production of pulses in the major regions of the world (1970)

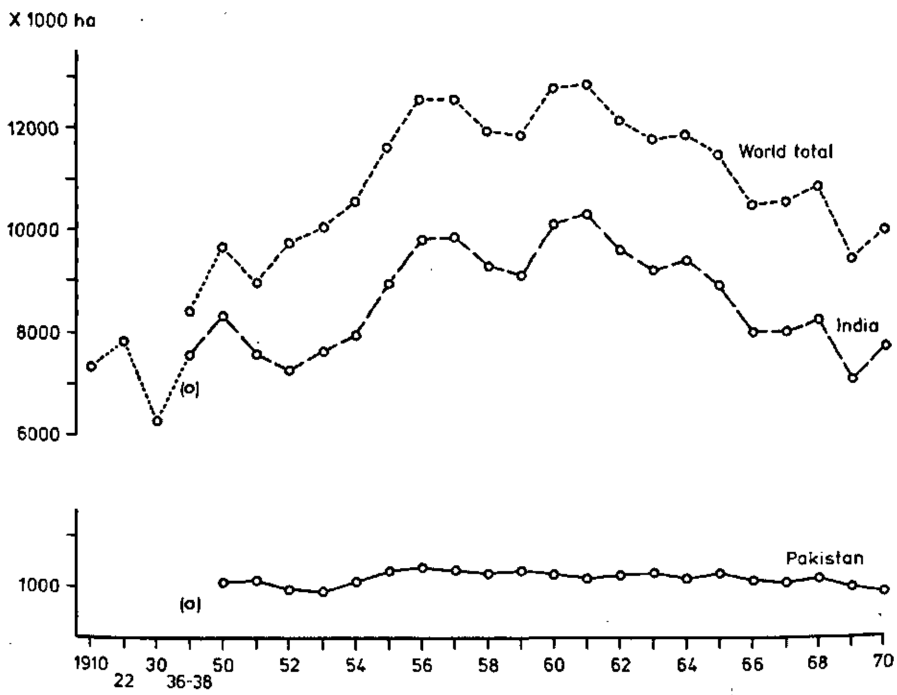
TABLE 1. Countrywise chickpea statistics

	Area in 1000 ha						Production in 1000 metric tons						Yield per ha in 100 kg					
	1948/52	61/65	1969	1970	66/70	%*	48/52	61/65	1969	1970	66/70	%*	48/52	61/65	1969	1970	66/70	%*
Europe																		
Bulgaria	9	1	1	1	2	— 77.8	6	1	1	1	2.2	— 63.4	7.0	10.2	12.3	13.8	13.4	+ 91.4
Greece	24	20	13	14	15.4	— 35.9	15	15	10	14	14.4	— 4.0	6.3	7.2	7.5	10.2	9.3	+ 47.0
Italy	108	66	46	41	49.8	— 53.9	51	41	38	35	37.8	— 25.9	4.8	6.2	8.2	8.7	7.7	+ 59.6
Portugal	45	71	70	52	71.0	+ 57.8	17	23	21	21	24.2	+ 42.4	3.6	3.2	3.1	4.0	3.5	— 3.4
Spain	354	237	165	164	199.8	— 44.6	141	124	107	97	126.4	— 10.4	4.0	5.2	6.5	5.9	6.3	+ 56.5
Yugoslavija	2	5	3	3	3	+ 50.0	1	4	2	2	2	+ 50.0	4.0	8.1	5.9	6.8	6.6	+ 64.0
NC America																		
Mexico	125	134	182	180	181.6	+ 45.3	92	118	138	150	144.4	+ 57.0	7.3	8.8	7.6	8.3	8.0	+ 9.0
S America																		
Argentina	6	6	6	4	4.8	— 20.0	5	5	9	5	5.2	+ 4.0	8.1	9.1	7.9	10.3	9.2	+ 13.5
Chile	8	8	9	11	10.8	+ 35.0	4	4	3	6	5.4	+ 35.0	5.4	4.9	4.0	5.3	5.5	+ 2.2
Peru	9	6	4	4	3.6	— 60.0	3	4	3	3	2.2	— 26.7	5.9	7.0	7.5	7.5	6.7	+ 14.0
Africa																		
Algeria	24	21	35	35	30.5	+ 37.7	11	10	16	18	14.6	+ 32.7	4.5	4.7	4.6	5.1	4.8	+ 6.7
Ethiopia	261	272	280	280	280.0	+ 7.1	154	165	175	175	73.2	+ 12.5	5.9	6.0	6.3	6.3	6.2	+ 5.4
Morocco	81	136	85	100	116.2	+ 43.5	39	65	73	59	76.8	+ 96.9	4.8	4.8	8.5	5.9	6.8	+ 41.3
Sudan	3	2	1	2	2.0	+ 50.0	3	2	2	2	1.8	— 40.0	9.8	7.1	10.6	10.7	8.8	— 9.8
Tunisia	16	21	26	26	24.6	+ 53.7	6	8	10	10	9.8	+ 63.3	3.6	3.8	3.7	3.8	3.9	+ 8.9
Uganda	6	4	4	4	4	— 66.6	2	1	2	2	2	0.0	2.5	3.4	5.0	5.0	5.0	+100.0
U.A.R.	7	5	3	3	3.8	— 45.8	11	8	4	5	4.6	— 58.2	16.1	16.5	15.9	16.7	15.5	— 3.9
Asia																		
Burma	87	117	115	135	109	+ 25.3	31	56	75	90	62	+100.0	3.5	4.8	6.5	6.7	5.6	+ 60.0
India	7763	9257	7106	7752	7822.4	+ 0.8	3989	5537	4310	5546	4731.2	+ 18.6	5.1	6.0	6.1	7.2	6.6	+ 29.4
Iran	60	90	95	95	98.4	+ 64.0	43	45	50	50	49	+ 14.0	7.2	5.0	5.3	5.3	5.2	— 37.8
Iraq	3	5	6	6	5.4	+ 80.0	2	3	4	4	3.8	+ 90.0	6.0	6.2	7.1	7.1	7.6	+ 5.6
Israel	1	2	2	2	2	+100.0	-	1	3	2	2.2	-	4.3	7.3	11.2	10.0	10.3	+138.6
Jordan	4	6	3	2	2.8	— 30.0	2	4	2	1	1.8	— 10.0	5.4	6.7	6.0	3.5	5.4	0.0
Lebanon	2	1	3	2	2.8	+ 40.0	2	1	2	1	2.8	+ 40.0	9.6	8.8	6.1	5.0	7.6	— 20.8
Pakistan	1073	1225	1027	932	1073.4	0.0	658	675	583	589	572.2	— 13.0	6.1	5.5	5.7	6.3	5.4	— 11.8
Syria	29	41	60	25	41.8	+ 44.1	16	26	50	15	36.2	+126.3	5.5	6.4	8.3	6.1	8.2	+ 48.4
Turkey	80	86	90	90	87.6	+ 9.5	81	89	111	110	101.8	+ 25.7	10.2	10.3	12.3	12.2	11.6	+ 11.4
World total	10187	11839	9440	9965	1024.7	+ 0.6	5385	7029	5800	7013	6209.6	+ 15.3	5.3	5.9	6.5	6.0	5.9	+ 12.1

* Percentage increase or decrease of 1966/70 over 1948/52

Indian subcontinent it ranks 5th after rice, wheat, millets and sorghum and is the most important pulse crop. In grain leguminosae the chickpea has the second place in the world after dry beans (Graph 1).

The distribution of the crop in India illustrates its ecological demands. Of importance is the Northern tract: Punjab and Haryana, the Ganges plain with Uttar Pradesh (U.P.), Bihar and to a lesser degree West Bengal. In Madhya Pradesh and Rajasthan large areas are cultivated, although they are less important than in the Northern States. Mysore also produces a fairly important amount of chickpeas. Cultivation is of little importance in Assam, Gujerat, Jammu and Kashmir, Orissa and Tamil Nadu. In the federal Delhi area it is an important crop. In West Pakistan, the major chickpea-growing districts are situated in the plains and lower foothills of the Indus tract up to Peshawar. The partition of the area and production over the Indian states and Pakistan divisions are presented in Tables 1, 2, 3, 4. Statistics are available for most districts (N.N., Agric. Situ. India, 1966, 1970; RAB, 1961).



GRAPH 2. Area cultivated with chickpeas in Pakistan, India and the world (1912–1970), (0): area split up over 1970 India and Pakistan areas

TABLE 2. Statewise area and production of chickpeas in India

1000 ha	1952	1953	1954	1955	1956	1957	1958	1959
Uttar Pradesh	2323.0	2434.1	2669.1	2600.1	2719.6	2489.5	2575.8	2720.0
Madhya Pradesh	558.2	548.0	548.8	550.8	1485.5	1545.1	1469.3	1545.1
Punjab	753.7	931.1	1084.6	1564.9	2555.6	2588.0	2453.9	2585.1
Haryana								
Rajasthan	466.2	562.1	737.9	874.0	1309.8	1544.3	1239.7	1556.0
Maharashtra*	307.8	265.6	283.5	302.5	654.5	638.7	557.7	636.3
Bihar	541.9	597.8	552.0	326.4	496.1	495.7	450.0	552.0
West Bengal	197.6	166.1	196.8	177.4	192.0	177.8	171.3	193.2
Mysore	14.6	17.4	13.4	12.2	169.3	162.8	164.4	157.1
Hyderabad	315.9	324.0	346.3	374.2	***			
Madhya Bharat	573.1	553.6	588.5	593.7				
Vindya Pradesh	209.8	198.0	200.1	189.9				
P.E.P.S.U.	332.5	436.6	525.7	682.4				
Bhopal	116.6	113.4	114.2	110.1				
Other states**	138.5	113.8	112.4	142.7	201.2	185.5	177.0	115.4
All India	6834.8	7261.6	7974.0	8501.3	9783.6	9827.3	9259.1	10060.2
1000 metric tons								
Uttar Pradesh	1294.4	1597.2	1767.8	1724.2	1468.1	1531.1	1439.7	1782.1
Madhya Pradesh	264.2	236.7	239.8	331.2	817.9	1007.9	600.5	919.5
Punjab	494.8	724.4	1005.8	1219.2	1723.1	2054.4	1850.1	2405.9
Haryana								
Rajasthan	161.5	303.8	303.8	479.6	718.3	1189.7	587.2	1140.0
Maharashtra*	71.1	57.9	88.4	101.6	230.6	223.6	166.6	200.2
Bihar	224.6	326.1	294.6	171.7	209.3	145.3	218.4	269.2
West Bengal	166.6	141.2	154.4	154.4	140.2	110.7	91.4	110.7
Mysore	5.1	4.1	4.1	4.1	52.8	50.8	53.8	56.9
Hyderabad	84.3	100.6	127.0	140.2	***			
Madhya Bharat	236.7	237.7	231.6	275.3				
Vindya Pradesh	94.5	92.5	103.6	124.0				
P.E.P.S.U.	216.4	296.7	420.6	363.7				
Bhopal	43.7	51.8	52.8	69.1				
Other states	29.4	37.6	37.8	48.7	56.0	50.7	51.3	40.5
All India	3387.3	4208.3	4832.1	5207.0	5426.3	6364.2	5059.0	6925.0

* Upto 1959: Bombay State. ** In order of declining 1970 areas: Andhra Pradesh, Gujerat, Orissa, Delhi (Source: AGRIC. SITU. INDIA, data partly recalculated to metric units)

3.2. PRODUCTION AND PRODUCTIVITY

The production of chickpeas ranks 28th among all crops of the world when all harvested products are taken into account. When only cereals, pulses and oilseeds are considered, it ranks 15th. From the pulses only dry beans and dry peas have a higher total production in the world. India and Pakistan also provide the bulk of Asian and world production (79.3% and 8.4% of 7,013,000

1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2696.1	2554.5	2578.2	2470.1	2600.0	2627.1	2583.7	2383.5	2263.3	2244.9	2261.5
1667.0	1496.8	1552.4	1451.6	1600.8	1474.4	1599.4	1633.3	1669.9	1573.0	1538.9
2507.0	2435.3	2278.1	2249.8	2188.4	2080.0	604.0	634.0	560.0	317.0	450.0
						868.0	1069.0	1160.0	800.0	1059.0
1720.0	1379.2	1623.8	1528.6	1525.8	1368.5	1112.7	1116.6	1322.6	994.2	1285.1
452.4	441.9	422.9	399.8	384.3	367.2	335.6	363.6	392.8	391.2	369.8
578.3	542.3	535.3	512.5	500.0	465.9	450.9	299.0	331.1	237.6	237.6
220.7	151.1	165.0	162.6	157.7	151.9	142.5	200.9	167.5	165.8	165.8
162.0	159.5	151.9	145.3	144.6	139.2	127.0	148.8	204.3	210.2	212.7
272.2	349.0	392.8	256.7	234.5	221.5	169.7	145.7	185.2	171.6	171.1
10275.7	9510.6	9551.9	9177.0	9376.1	8895.7	7993.5	8003.2	8256.7	7105.5	7751.5

1510.8	1831.2	1518.0	1547.4	1423.8	1926.9	1565.8	967.0	1650.9	1544.6	1775.9
1021.1	860.9	880.8	873.8	802.7	844.6	847.1	615.5	906.1	756.6	893.2
1658.1	2004.6	1760.7	1474.2	1116.6	1645.0	372.0	508.0	472.0	216.0	400.0
						385.0	513.0	1267.0	600.0	1143.0
775.2	919.4	1002.6	766.1	542.5	722.3	413.9	518.0	1049.1	600.0	782.6
136.1	140.7	141.8	156.5	112.8	122.1	77.6	112.5	108.4	129.0	101.9
243.8	324.1	299.6	283.5	249.7	281.5	334.4	113.3	247.0	158.8	156.8
103.6	87.6	80.0	89.4	90.0	79.9	106.7	146.4	95.8	133.7	133.7
47.8	58.8	44.3	41.8	41.4	56.1	44.0	56.8	90.1	98.6	90.7
93.5	78.8	99.1	110.3	119.4	106.8	59.2	53.4	85.1	72.2	67.8
5590.0	6360.0	5827.0	5343.0	4498.9	5785.2	4205.7	3622.0	5971.5	4309.5	5545.6

Himachal Pradesh, Jammu and Kashmir, Tamil Nadu (Madras) and Assam *** Note repartition of states.

metric tons, respectively). Productivity is 720 and 630 kg ha^{-1}, respectively. The highest yields per ha are obtained in Egypt (1670 kg), followed by Turkey (1220 kg), Bulgaria (1380 kg) the Sudan (1070 kg) and Israel (1000 kg). Important producers outside the Indian subcontinent are Ethiopia, Spain and other Mediterranean countries, and Mexico.

Production and productivity with respective downward or upward trends are given in Tables 1, 3, 6 and Graph 3.

TABLE 3. Statewise distribution of chickpea production and area in India (1970)

State	% of total chickpea production	% of total chickpea area	% of net cultivated area of the state	% of total area of the state
Andhra Pradesh	0.37	1.00	0.68	0.28
Assam	0.02	0.02	0.08	0.02
Bihar	2.83	3.06	2.78	1.36
Delhi	0.08	0.13	12.47	6.54
Gujerat	0.36	0.57	0.46	0.24
Haryana	20.61	13.66	33.37*	24.04
Himachal Pradesh	0.10	0.14	4.03	0.20
Jammu and Kashmir	0.01	0.04	0.35	0.01
Madhya Pradesh	16.11	19.85	9.20	3.47
Maharashtra	1.84	4.77	2.03	1.20
Mysore	1.64	2.74	2.04	1.10
Orissa	0.24	0.30	0.39	0.15
Punjab	7.21	5.80	12.39*	8.93
Rajasthan	14.11	16.58	8.89	3.75
Tamil Nadu (Madras)	0.04	0.05	0.07	0.03
Uttar Pradesh	32.02	29.17	12.34	7.68
West Bengal	2.41	2.14	3.05	1.89
Total	100.0 (5 545 600 t)	100.02 (7 751 500 ha)	4.90	2.37

* Cultivated area estimated on 62.3% of total area, as in the erstwhile Punjab. (Based on: AGRIC. SITU. INDIA, 1970; FERTIL. STATIST. 1967–68 (1964–65 data); INDIA, a reference annual 1970)

3.3. TRENDS IN PRODUCTION

The highest total world yield was attained in 1960 (8,300,000 tons) and the largest acreage was recorded in 1961 (12,800,000 ha). In 1968, a rather large harvest (7,477,000 tons) was reaped from 10,849,000 ha. The highest average yield per ha (700 kg) was reached in 1970. However, there are discrepancies in data between different FAO yearbooks.

Several reasons for the downward trend in acreage cultivated with chickpeas are obvious. The product is not so popular, that increase per capita is needed. The chickpea is very nutritive, rich in protein and wholesome, but it has a neutral taste. This is less important in Indian cuisine, where the majority of chickpeas are used in spiced dishes or flour. In the Mediterranean and the Americas, peas and beans with a more pronounced flavour are preferred, although for certain preparations chickpeas are indispensable. Moreover the idea that chickpea is a poor man's food has not yet disappeared.

An important reason for the decrease in acreage is the level of agricultural development. The yield per hectare rises when the level of agriculture improves, but at the same time the rather primitive *Cicer* is replaced by other profitable

TABLE 4. Area and production of chickpeas in Pakistan (1948–1967)

Year	Area in 1000 ha			Production in 1000 tons			Yield per ha in 100 kg		
	Pakistan	West	East	Pakistan	West	East	Pak.	West	East
1947–48	963.1	882.5	84.2	524.3	472.4	51.8	5.4	5.4	6.1
49	1216.2	1132.8	83.4	816.9	766.1	50.8	6.7	6.8	6.1
50	1052.6	971.2	81.4	661.4	608.6	52.8	6.3	6.8	6.5
51	1197.2	1116.2	81.0	803.7	755.9	47.8	6.7	6.8	6.5
52	935.6	854.6	81.0	481.6	428.8	52.8	5.1	5.0	5.9
53	904.8	823.0	81.8	374.9	321.1	53.8	4.1	3.9	6.6
54	1119.4	1037.2	82.2	625.9	571.0	54.9	5.6	5.5	6.7
55	1321.1	1233.6	87.5	667.5	603.5	64.0	5.1	4.9	7.3
56	1386.3	1315.0	71.3	743.7	699.0	44.7	5.4	5.3	6.3
57	1347.4	1280.6	66.8	727.5	691.9	35.6	5.4	5.4	5.3
58	1269.3	1214.2	55.1	699.0	663.4	35.6	5.5	5.5	6.5
59	1277.4	1220.3	57.1	615.7	577.1	38.6	4.8	4.7	6.8
60	1196.4	1142.5	53.9	637.0	607.6	29.5	5.3	5.3	5.5
61	1166.8	1106.5	60.3	646.2	609.6	36.6	5.5	5.5	5.5
62	1252.7	1195.2	57.5	660.4	622.8	37.6	5.3	5.6	6.2
63	1283.0	1227.1	55.9	716.3	681.7	34.6	5.6	5.6	6.5
64	1166.0	1114.2	51.8	643.1	609.6	33.6	5.5	5.5	6.5
65	1262.8	1211.4	51.4	709.2	671.6	37.6	5.6	5.5	7.3
66	1125.1	1070.4	54.7	583.2	539.5	43.7	5.2	5.0	8.0
67	1103.2	1044.1	59.1	578.1	529.3	48.8	5.2	5.1	8.3

(From: Pakistan, Statistical Yearbook 1967, recalculated to metric units)

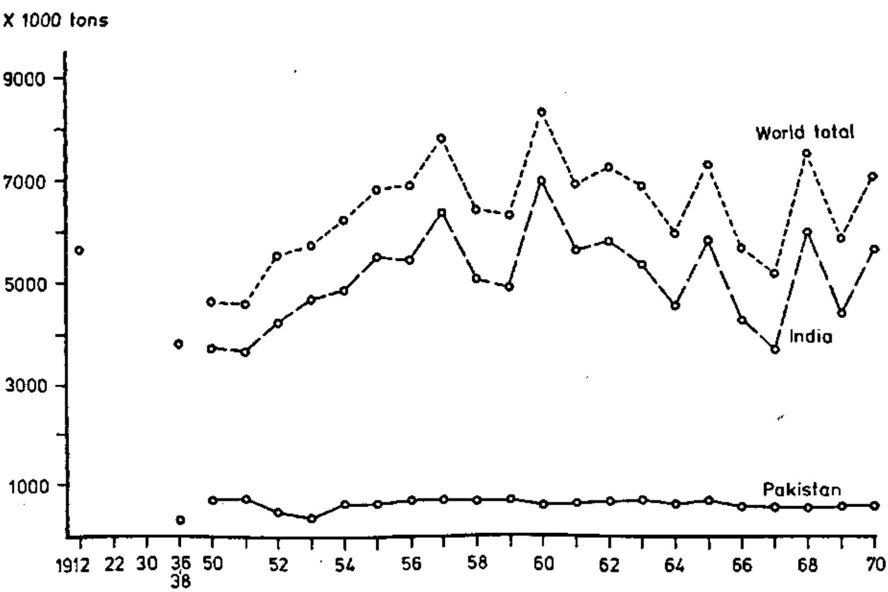
TABLE 5. Divisionwise distribution of chickpea area in Pakistan

West Pakistan	
Hyderabad	5.670 ha
Quetta	6.885 ha
Peshawar	35.235 ha
Lahore	104.085 ha
Bahawalpur	126.360 ha
Rawalpindi	165.240 ha
Khairpur	178.605 ha
Multan	190.755 ha
Dera Ismail Khan	251.910 ha
	1.064.745 ha
East Pakistan	
Chittagong	810 ha
Dacca	9.720 ha
Rajshahi	69.660 ha
	80.190 ha
Pakistan	1.144.935 ha

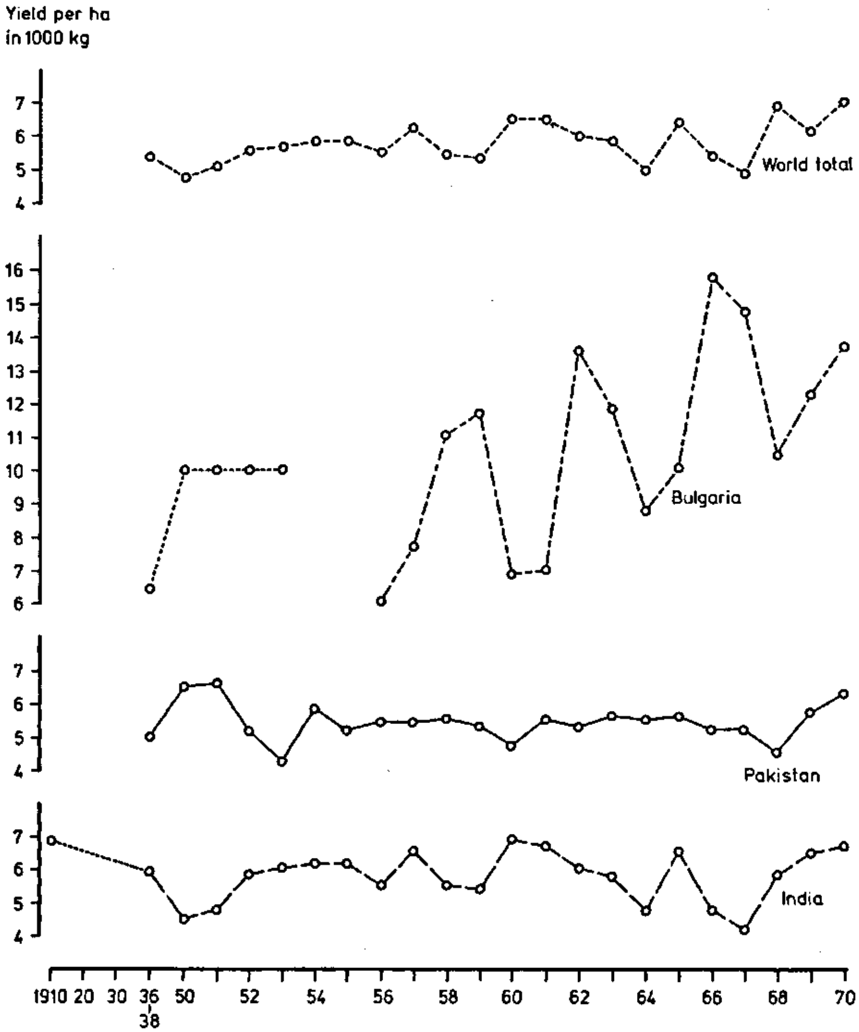
(From: Naqvi and Aziz, 1963, most probably the 1954 distribution)

TABLE 6. Index numbers (1949-50 = 100) for cereal and pulse production in India

	Cereals	*Cicer arietinum*	*Cajanus cajan*	other pulses	all pulses
AREA					
1951	99.4	91.2	93.5	92.2	91.9
56	110.7	118.0	98.0	115.3	116.8
61	116.7	111.9	104.3	122.2	118.3
66	117.1	96.7	109.4	125.3	114.0
67	118.1	96.6	107.9	119.6	111.0
68	125.2	99.7	114.0	120.9	113.6
69	125.7	85.8	108.2	119.9	106.7
70	128.7	93.6	114.2	119.6	110.5
PRODUCTION					
1951	90.3	98.0	91.8	85.6	91.7
56	114.9	138.9	99.4	103.9	118.4
61	138.3	160.4	106.0	105.1	129.0
66	124.4	108.4	87.4	95.2	99.0
67	129.5	93.0	57.0	85.9	85.3
68	164.2	153.3	87.8	104.9	123.5
69	165.7	106.1	88.5	102.6	102.3
70	176.0	142.3	92.9	102.8	118.5
PRODUCTIVITY					
1951	90.8	107.5	89.2	92.8	99.8
56	103.8	117.7	101.4	90.1	101.4
61	118.5	143.3	101.6	86.0	109.0
66	106.2	112.1	79.9	76.0	87.6
67	109.7	96.3	52.8	71.8	76.8
68	131.2	153.8	77.0	86.8	108.7
69	131.8	123.7	81.8	85.6	95.9
70	136.8	152.0	81.3	86.0	107.2

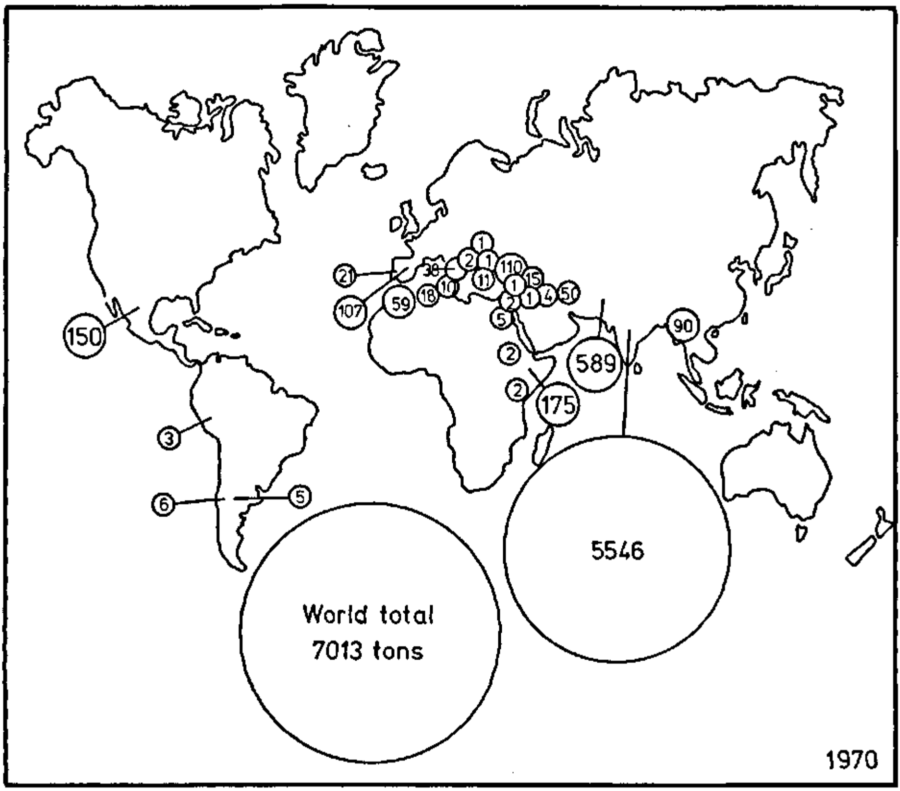


GRAPH 3. Production of chickpeas in Pakistan, India and the world (1912–1970)



GRAPH 4. Average yield per ha in some chickpea-producing countries (1910–1970)

crops, with a higher input of labour, machines, fertilizers and irrigation. Since 1968 this situation exists in some areas of Northern India: the Punjab, Haryana and U.P. The new wheat cultivars, which have high yields, are replacing chickpea in the 'green revolution'. Although these 'Mexican' cultivars fetch a lower price per kg than the old ones, they are becoming very popular for their high total yield and income. As a result the demand for chickpea increases, while production remains about the same. Therefore the pulse fetches a better price on the market now, and consequently the returns per ha increase. The third and most important influence on acreage is the weather at the time of sowing



MAP 22. Division of chickpea production in different countries

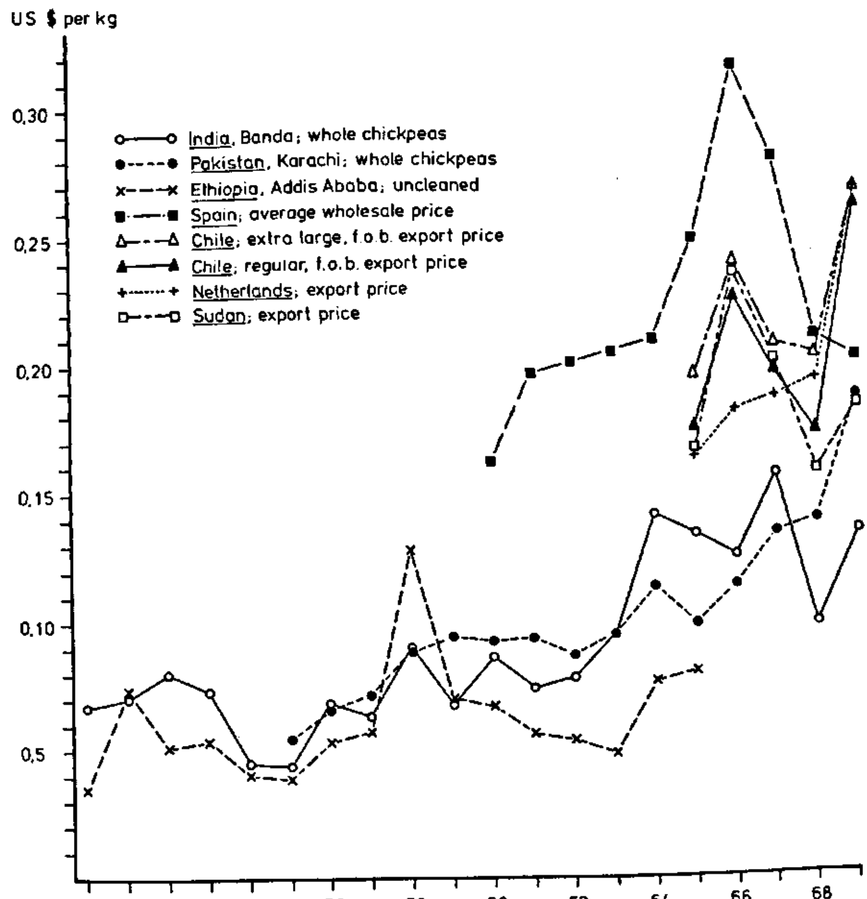
(GILL and JOHL, 1970). When soils are doo dry or too moist, sowing is postponed or is not carried out at all. Lower production is the result. This accounts for the largest fluctuations in production. An input of 40–60 kg of sowing seed is equivalent to several months of protein-rich food for a farmer's family, or an investment of (crudely) 90 rupees (± $ 12.00).

3.4. TRADE

Internal trade in India takes place on a fairly large scale. Goods are transported by rail and road to the main market centres, the cities and the states which are deficient in a particular product. The 'export' to the deficit states is sometimes restricted to ensure a good supply of food within the state. Hapur (U.P.) and Banda (U.P.) are two of the most important staple centres for grain. Sirsa is the largest market in Haryana. The U.P. and Haryana are the main exporting states. Especially Bihar and West Bengal are obligated to import large quantities of gram.

There is little international trade nowadays. Reliable statistical data on exports are scarce. The FAO Trade Yearbooks do not mention chickpea separately. Some wholesale and export prices are included in the Production Yearbooks (Graph 5).

Pre-war surplus from the Indian subcontinent was exported to Britain and other West European countries as fodder, especially for racehorses and foals. These exports were very important and amounted to about 8% of production. The quantities were very variable and ranged between about 5000 tons in the years after the first World War to 327,000 tons in 1917/18 and even 346,000 tons in 1911/12. Due to general shortages no important amounts have been exported from India since World War II.



GRAPH 5. Some prices of chickpeas (1950–1969)

Nowadays small quantities are shipped to countries where immigrants from India and Arabic countries have settled, Britain naturally receives a quantity of some importance. Morocco, Turkey, Spain and Portugal serve the West European countries.

Morocco exports varying quantities to other Mediterranean countries except Portugal and Turkey, which export chickpeas in normal years. France and Algeria are the largest importers with 6041.8 and 4764.0 tons in 1962, respectively. The USA takes 260 tons (1962) to 2600 tons (1960). Almost two thirds of the Moroccan production is exported annually. In post-war years (1945–'47) a deficit in Morocco had to be covered by imports. KEBBAJ (1965) was not optimistic about the future of export, so accordingly the production should be directed to internal consumption.

The present (1970–'71) situation on the small Tunisian market (total production 10,000 tons) is one of rising prices, since Lybia is purchasing more and more food in neighboring countries. The oil revenues facilate this trend in favour of the larger agricultural areas outside the country. Lybia's own agriculture can only be extended with considerable capital investments.

Market countries for Turkish chickpeas are for instance Syria, the Lebanon, Malta, Great Britain and the Netherlands.

Mexico is an exporting country and supplies the Caribbean markets, for instance Cuba and Surinam, and the U.S.A.

Two non-producer countries, where the chickpea is rather popular as a snack are Malaysia and Indonesia. The whole of the consumed amount must be imported. Malaysia imported from Morocco 1616.8 tons (1960), 792.4 tons (1961) and 1053.3 tons (1962).

In general, political and weather disturbances urge to cover deficits in normal producer-countries, as happened in Algeria in the early sixties. Chickpeas can be exported to economically more prosperous countries which intensify their own agriculture and change to horticultural crops (France, Italy). It may be difficult to obtain chickpea in non-producing countries. Only specialized shops, delicatessens and markets in cosmopolitan centres sell chickpeas.

3.5. PRICES OF CHICKPEAS

For India price statistics are abundant, since internal trade is considerable. To obtain prices for other countries is difficult. The price structure of chickpeas in India is that of a particular food grain. In Indian newspapers and statistic literature the chickpea is listed under food grains or coarse grains. The 'dhal' sometimes appears in the column of pulses. GILL and JOHL (1970) studied price structure for the Punjab (comprising the recently formed Haryana and Himachal Pradesh states). Normally prices go down when production is high, but in recent years prices have continued to rise due to a general shortage of food grains (also in other states) and to inflation.

During May and June about 70% of the cultivator's produce is for sale.

For Sirsa, Punjab, the seasonal index is highest in May (270.05) while the price index is lowest (92.59 vs 107.39 in January) (average of 1952–66). Therefore these post-harvest sales should be avoided by building more warehouses, and improving banking facilities.

At small markets prices are lower for lack of competition. GILL and JOHL recommended easy credit facilities, building warehouses and processing plants, and tarmacing roads to improve transport to big markets.

It is possible for the government to influence prices by purchasing emergency and defence stocks (advantageous when prices are low, to promote trade and induce better prices) and by control orders. In years of scarcity (1964–'65 and later) the export to neighbouring states was partially or entirely banned (e.g. The Punjab Gram Regulation and Distribution Order 1964: no more than ⅓ of the stocks and new purchases could be exported without permission). These restrictions, however, could not check prices before exports were totally forbidden (1965–'66). Unexpected price fluctuations and malversations took place, but these were mainly caused by the traders and not by the farmers.

GILL and JOHL concluded that rainfall at the time of sowing and not prices influence the acreage of gram. However, when the general trend of replacing chickpea by new wheat varieties increases the relative price for chickpeas, then the better prices may cause an increase of the acreage under this pulse crop, as acreage outturn increases.

In consumer markets (and the cities) the prices are significantly higher than in producer markets.

As the top yields of the new wheat cultivars induce lower acreages under chickpea the relation of chickpea prices to wheat prices has changed fundamentally. For decades gram was at par with or cheaper than wheat; nowadays the pulse fetches 1½ times the price of wheat and the fancy qualities (Kabuli gram) even 2 times.

The high prices in 1964–'67 (graph 4) in India and Pakistan clearly show the period of scarcity. In the lower dollar price of 1966 the devaluation of the rupee is included, as the price was Rs 63.70, Rs 85.70 and Rs 117.90 per 100 kg in 1965, 1966 and 1967, respectively. A trend towards lower production in Pakistan keeps the prices high. The high prices in Spain may have been caused by lower availability on the export markets. The record price for Ethiopia in 1958 is probably due to temporary demands for export, since production remained stable.

3.6. GRADES

Official commercial grades exist in Spain, Mexico and Morocco, according to classes in seed weight or size. MATEO BOX (1961), CHENA (1967) and KEBBAJ (1965) gave the data as summarized in Table 7. In Mexico the smaller grades are mostly used. The lowest marketable grade is 140 grains in 30 g (21 g per 100 seeds) which is known as 'rezago'. In India no seed weights are given; the quality depends mainly on the cultivar. Most available is the 'desi gram'

TABLE 7. Commercial grades used in Spain, Mexico and Morocco

Country	Grade	nr of seeds per 30 g	100 seed weight
Spain	Extra	38–40	78.5–75.0 g
	00	41–43	73.0–70.0 g
	0	45–47	66.6–63.8 g
	No. 1	48–51	62.5–58.8 g
	2	54–57	52.6–55.5 g
	3	60–64	50.0–46.8 g
	4	68–72	44 –41.6 g
Mexico			
(not sifted for export)	Fancy	40–42	75 –71 g
	Catedrales	42–44	71 –68 g
	Selectos	44–46	68 –65 g
	Supremos	46–48	65 –62.5 g
	Sultanes	48–50	62.5–60 g
	Capitanes	50–52	60 –58 g
	Standars	52–54	58 –55.5 g
	Ases	54–56	55.5–53.5 g
(sifted for export)		nr of seeds per 28 g	
	Extra	36–38	77 –74 g
	Fino	38–40	74 –70 g
	Sublime	40–44	70 –63.5 g
Morocco		seed measure	
	Calibre 32	9.5 mm	
	Calibre 28	7.5 mm	

(local gram) with brown, angular and small seeds. In every local market this type is for sale. In smaller quantities the 'Kabuli gram', sometimes classified as 'Punjab' is preferred, with white or yellowish bold seeds. Further the 'green grains' (not green gram = *Phaseolus aureus* Roxb.) which are fancy too, with rather big, angular, green seeds.

4. ANATOMY

The anatomical structure of *Cicer arietinum* has been fairly well studied. Even a comparative study on related species has been carried out. STREICHER (1902) compared the leaves of *C. arietinum* with those of 11 wild species, including *C. pinnatifidum*, and other *Vicieae*. The perennial species have thick-walled sclerenchymatous strands in the pericycle of the woody parts.

A complete description is given by HOLM (1920), who also described the species morphologically. The seed was further investigated by BORDAS (1932), while SCHNEPF (1965) wrote a detailed account on the trichome hydathodes or glandular hairs of the chickpea. He studied the process of secretion but did not analyse the organic acids involved. As far as the anatomy concerns, the glandular hairs of *C. arietinum* consist of a basic cell, three long 'stem' cells and an oblong glandular head of seven to eight cells in four or more stocks. Each stock is divided in two cells or consists of a single cell. The aqueous solution is secreted through some fine pores in the cuticle on top of the hydathode, when the pressure in the subcuticular space reaches a certain value. The acids are produced in a fine material in the extraplasmatic space which surrounds the plasma. The glandular cells fill the secretion vesicles, apparently built up as folds of the plasmalemma. The secretion products pass through the outer cellulose layers of the cell wall to the subcuticular space. A quantity of 1000 μm^3 per min. can be produced by one glandular hair. A high amount of mitochondria points to a process which requires a high amount of energy.

The drought-resistant character of *C. arietinum* is reflected in the firm anatomic structure of the deep-going roots and the stems. The tetrarch roots have much sclerenchyma (four primary stereome strands and later a scattered secondary stereome). The increase in thickness commences in the stele proper. Older primary roots have several layers of cork and a secondary cortex. The stem possesses a hypodermal collenchyma and pericyclic stereome, thick-walled libriform in the secondary xylem and a thick cuticle. Together with the densily pubescent surface of stems and leaves these characteristics define the plant as a xeromorph within the *Vicieae*.

The influence of vernalization treatments on the anatomy was investigated by CHAKRAVARTI (1952). The vernalized plants developed more mature characteristics than the control plants. Radicle and cotyledon showed earlier vascicular differentiation. The cells of the phloem, the medullary rays and the pericyclic fibres had thicker walls. The cambium ceased its activity sooner. This difference was noticed when the plant was nearly mature. The small shortening of the vegetative period could have been performed through processes facilitating the growth and transport of minerals and photosynthetic products.

ATABEKOVA (1968) studied the development of different tissues which are related to pod dehiscence of grain leguminosae, including *C. arietinum*. STA-

ROSTIN (1968) considered the chickpea to be more evolved than red clover and lucerne. He based his opinion on the veins of the cotyledons which appear to be more derived, though they are not as specialized as in soya beans and peas.

5. CULTIVATION

5.1. Introduction

The popularity of the chickpea does not change much. In Chile, Israel, Burma and Northern Africa the area under chickpea increases, in India the area decreases due to the more remunerative wheat crop. In the Punjab, Haryana and Uttar Pradesh, the most important areas for chickpea, the joint efforts of agricultural research and extension have motivated farmers to grow new wheat cultivars instead of chickpeas. Where chickpeas are grown, yields are increasing, so that total production is stable. Prices are rising too.

Chickpea is seldom grown as a cash crop (India), and is cultivated with less care than wheat. It is mostly sown on rain-fed, rather poor soils of various structure and texture and is only irrigated if surplus water is available. In Egypt and Afghanistan, land is usually irrigated because of lack of rainfall. When agriculture is intensified irrigation becomes more feasible.

Chickpea's hardiness to drought and neglect, and the resistance of some cultivars to cold gave this crop the reputation of a low potential yielder. With proper management and utilization of good seeds from a suited cultivar, yields can nevertheless reach over 4000 kg per ha. In breeding, cultivars suited to poor conditions are developed as well as for better environments.

5.2. Soil preparation

The chickpea does not require thoroughly prepared land. A coarse tilth suffices and a fine tilth even seems to depress germination. Ploughing is done one to four times and sometimes more often. NN, Indian Farming (1967) claimed that one ploughing gives the highes yield. Menon (1968) found an increase in yield with four ploughings instead of two, when the field was irrigated more than once. With dry farming practices Chowdury and Bains (1970) advised against ploughing too often.

As chickpea is a deep rooting species, the plant may grow well if the soil is prepared to a good depth. Moreover, it improves the soil by its deep rooting habit. The depth of ploughing varies little between 15–20 cm (Spain) and 25 cm (Mexico). Deep tillage is recommended for compact and badly aerated soils also to reduce the incidence of wilt disease.

Ploughing is done in autumn or winter to clean out the stubble. A second ploughing is done at the end of January, followed by sowing in early spring (Mediterranean area, Bulgaria). In India and Pakistan the soil is ploughed at the end of the rainy reason, previous to the cool winter period. After the last rains a second ploughing is carried out, which often coincides with the sowing, or may be carried out just before sowing. In 1882, Duthie mentioned that in the

Bundelkhand area in India land was ploughed four times, and in the present state Uttar Pradesh even twelve ploughings were carried out! In the Ganges plains, with its heavy alluvial soils, areation was thus achieved with the simple ploughs then available.

Before the autumn rains start, ploughing helps to store moisture. In chickpea cultivations the plough used varies from the simple indigenous plough drawn by bullocks, which only stirs the soil, to a tractor-drawn turning plough.

To achieve a level seed bed, planking (levelling with a beam or a board) is the practice in India, Pakistan and Afghanistan. Even small irregularities in the field surface may cause soil erosion. Bunding and contour ploughing to conserve moisture are especially needed in rain-fed areas.

When chickpeas are sown in a standing or recently harvested crop, for instance rice in Bihar and Bengal, the soil is not prepared at all before sowing. Cultivation can only take place during the vegetative growth of the crop. This, in fact, is a zero-tillage growing method without the use of herbicides and rough-land sowing machines. With these methods it may be possible to combat wind and water erosion on vast accidented surfaces.

In Israel, practice has shown that chickpeas respond very well to tillage. Chickpea has not yet been included in the no-tillage trials (STIBBE and ARIËL 1970).

5.3. SOWING

5.3.1. *Sowing seed*

It is evident that for sowing seed with a good germination capacity should be used. The germination capacity largely depends on the cultivar and storage facilities. The longevity of chickpea seed can be high under optimum conditions. In sealed glass bottles with naphtalene balls at room temperature the 'desi' type germinated for 60% after 10 years of storage (90% after 9 years). The 'kabuli' type could be kept similarly for 7 years. Total failure of germination took place for the 'kabuli' type after 9 years, for the 'desi' type it was not established (SONAVNE, 1934). The germination capacity remained above 90% (ADAMOVA, 1964), but the germination energy went down to 30 and 76%, for two cultivars after 14–16 years. BRYSSINE (1955) complained about the unfavourable characteristic of the most fancied, large white seeded cultivars in Morocco to loose seed viability after 1–2 years. My observations were similar for the cv. Vilmorin. Even after storage in closed containers the seed was not sufficiently viable one year after harvest. Storage in full, closed bottles at a low temperature would certainly be a remedy. Only in breeding is this practice used. The seed collections of the Institute of Plant Introduction at Izmir need to be sown for multiplication only once per 10 years because of the cold storage.

The hygroscopicity of the seed coat of the Mediterranean types is apparently larger than for Indian cultivars. Breeding for softness of the seed coat and good cooking qualities thus adversely influence the storage capacity. Non-germinated seeds can be found back in the soils in a capsule around the rotten material, formed by bacteria and moulds.

5.3.2. *Ways of sowing*

In more primitive agriculture, the seeds are broadcast pure or mixed with other crops. More profitable (SEN, 1956) is sowing in rows, either behind the plough with simple or multiple homemade seed drills or with sophisticated sowing machines. Rows can be made throughout the field (India). Sometimes the third is not sown when soil moisture is suboptimum, or, to facilitate mechanization and e.g. in Spain and Mexico on heavy soils.

In West Bengal and Bihar, chickpeas can be sown in the standing rice crop when this is grown in rows, to economize on time and available water during the short winter season. The chickpea then emerges in relatively straight rows too. This practice is nowadays recommended by the extension services for higher yielding cultivars with a longer growing period.

I have been unable to discover what extent seeds are still ploughed in after scattering on untilled fields. This practice is an emergency measure to economize on soil humidity.

Seeds are placed on top of low ridges where an excess of water might occur, or in the furrows for irrigation.

5.3.3. *Sowing date*

The sowing date is of utmost importance and is one of the factors that is easily organized. Much research has been carried out on the optimum date in most areas. The data over a couple of years are only valid for the area and cultivars tested, so that such information is an important item for local farmers, and tests are carried out by local stations. Adverse weather conditons may prevent recommendation from being completely reliable, but when sowing is done at the proper time progress can be made even with local cultivars. The optimum sowing date depends on the local climate and the incidence of pests and diseases.

For a number of countries and areas, the correct sowing date has been depicted in relation to the temperature (6.5.1, Graph 28). In the Mediterranean countries chickpeas are a spring crop, and therefore sown from February to April. In Egypt and Israel chickpeas are sown from middle October to middle December. In Iran and Afghanistan the summer is the main growing season, so that sowing is done in March and April. However, in the Khuzestan region of Iran sowing is carried out in October and November. In India and Pakistan the crop is cultivated in 'rabi', the cool winter period. Here the sowing time extends from late September to mid December or later, with the most successful time in October. From East Pakistan sowing is reported to take place from mid September till as late as mid March (NAQVI and AZIZ, 1963). In Ethiopia chickpeas are mostly sown after the most important rainy season, end of September (Northern and Central Ethiopia, Chercher Highlands, Awash river valley). The sowing period may last till January. In the Yerer-Kereyu highlands, east of Addis Ababa, a second chickpea crop is sown on the same field after the secondary rainy season at the end of April (WESTPHAL, 1972).

5.3.4. *Density of sowing*

Distances between rows and between plants within a row have been assessed in many trials. In broadcast chickpeas, the seed rate varies according to local tradition, but does not differ much from the rate for cultivation in rows. In general slightly more seed is needed. Recommendations for cultivation give alway the weight of seed needed and this is of course correlated with the specific weight of the seeds from a certain cultivar. For early sowings 25% more seed is needed. When weather is cold, more seed is also required. In rich soils a high density may be justified, in poorer soils more soil may be required per plant. A high seed rate improves earliness, provided the conditions do not promote extensive vegetative growth. The plants branch less, because the leaf canopy is closed sooner. I was told at Sehore that a range of seed rates from 40 to 80 kg per ha did not affect yields.

The distance between rows is generally 25–30 cm. On the Indian subcontinent recommendations range from 10 to 30 cm for the distance between plants in a row, but in Russia and Bulgaria inter-row distances of 15 cm give better yields. In Spain and Mexico distances up to 120 × 10 and 140 × 40 were established as optimum for some cultivars on alluvial soils. In Algeria the rows can be spaced at 1–2 m in cultivated fallow. KOINOV (1968b) gave 400,000–600,000 seeds per ha as optimum, which corresponds with spacings of 25 × 10 cm to 17 × 10 cm. The seeds needed will be 48–72 kg and 80–120 kg when the weight of 100 seeds is 12 and 20 g respectively.

5.3.5. *Sowing depth*

A uniform crop is obtained if the seeds are distributed at a suitable uniform depth. The chickpea, with its rather large seeds seems to react rather indifferently towards sowing depth. MATEO BOX (1962) recommends a depth of not more than 5–6 cm. There are no solid data for other regions, suggesting that not much precision with sowing depth is required. In India, seeds are usually sowed deeper if soil moisture is low, to prevent poor germination and early wilting. Plant height is often irregular in the driest and wettest parts of the fields, where germination could not take place normally. One irrigation may improve the regularity of the stand in case of drought.

My own trials showed that a sowing depth of 1 cm resulted in a quick start. When sown at 5 and 10 cm, the vegetative growth and flowering of the plants were delayed by 10–11% and 5–10 days, respectively. Less flowers appeared and flowering was slower. A minimum depth of 1 cm is inpractical (birds, drought). Even if chickpeas are sown at 25 cm below the soil surface, they will emerge (see section 6.1). Statistically significant differences in yield are given by RAHEJA and DAS (1957), who compared sowing depths of 6.25 and 12.5 cm. The deeply sown chickpeas germinated better, but the vegetative growth was retarded and flowering was less abundant. The susceptibility to late wilt, attacking mature plants during March, was aggravated by deep sowing. When wilts are not a problem, deep sowing improves stand when the initial quantity of moisture is suboptimum.

PLATE 1. A semi-erect, spreading type of chickpea, grown on a loamy sand near Jaipur, Rajasthan, India

PLATE 2. A chickpea crop with some cereals from last year's remnant seeds in Central India

5.4. Post-sowing cultivation treatments

Plantlets emerge about 10–12 days after sowing (Spain, India). In my trials, seedlings were visible after 4–5 days. When a crust has been formed, the growth of the plantlets was favoured by harrowing. This is only carried out in mechanized cultivation. The plantlets must be clearly visible to evade damage. When the plants are 20–25 cm high a cultivator can be used to cover the lower parts of the stems. In India cultivations are not yet much in use.

Irrigation

Irrigation can improve yields under dry conditions. Care is needed not to soak the soil, however, which promotes wilting. Accidental floods cause an irregular stand. After yellowing and/or wilting, whole patches in the crop may succumb. In Spain, France and Mexico irrigation, mostly applied as furrow irrigation, is carried out two to four times. In India depending on the winter rains, the crop is irrigated sometimes once or twice, especially the Kabuli forms. These are not as drought-resistant as the brown and black-seeded cultivars. In 'Wealth of India' (1950) is reported that 16% of the chickpea area was irrigated, usually in Agra, Allahabad, Jhansi (U.P.), Ferozepur (W. Punjab), Patna (Bihar) and in Maharashtra.

In Aghanistan, Iran and Egypt the crop is irrigated, but often only a few times. Homer and Mojtehedi (1970) indicated for Iran that one irrigation every ten days was preferable to a higher moisture stress. Grain yields decreased under too moist conditions, especially when irrigation was applied at flowering and early maturity. More straw was producted under these moist conditions and maturity was delayed. Irrigation every 17 days gave much lower yields but earlier maturity. Larger seeds were produced at the lower humidity levels, with a maximum size at 14-day intervals between irrigations (RPIP, 1969).

Fedorova (1966) described a method of using electricial resistance in plant tissues to time irrigation. In practice it is easy to see when supplementary water is needed.

Weeding

Chickpeas are not normally weeded out. In India the crop is considered to spread enough and to suppress weed growth sufficiently. Occasionally large weeds are removed manually. In mixed stands, the plant population is so dense, that weeds are rare. Research stations use simple rotary weeders and other implements to clean the trial plots. In the Punjab Athwal and Bajwa (1965) recommended the use of bar harrows and rollers. In their trials a gain in yield of about four times over the non-weeded control was reported.

In more advanced agriculture, several attempts have been made to evaluate herbicides for use on chickpeas. Besides mechanical weeding, chemical weeding is considered economically feasible. Koinov (1968a) advise prometryne (2–3 kg/ha) and simazine (2 kg/ha) for use in mechanized cultivation under Bulgarian conditions. This was confirmed by Kovachev et al. (1968), who obtained a control of weeds of 83% and an increase in grain yield of 50%. Aretit (5 kg/ha) also proved satisfactory. LYUBENOV (1967) doubled or tripled his yield with monolinuron (1.5 kg/ha), cycluron + chlorbugan (5 l/ha) and prometryne (3 kg/ha). The best application time was three days after sowing. MOOLANI (1951) tested 2–4–D for chickpeas in vitro. Concentrations of 10^{-3} to 10^{-5} were found lethal. Concentrations of 10^{-10} for 12–120 min or 10^{-7} for 12 min induced a higher germination percentage. Optimum germination occurred, also under field conditions, when the seeds were soaked in a solution of 10^{-9} for 20 or 10^{-6} for 12 min. Growth rates were better with concentrations of 10^{-6} and 10^{-7} for 12 min. Spraying 2–4–D under field conditions is advised at a rate of 1 kg per ha in 200–1000 l (concentration 2.10^{-2}–2.10^{-3}) for weeds in cereals. VERMA et al. (1963) preferred mechanical weeding to the spraying of 2–4–D. BHAN (1966), however, obtained good results when 2–4–D was applied twice in the rainy season before the cultivation of gram. Nut grass (*Cyperus rotundus* L.) growth even improved when weeding was done mechanically. MCPB (0.25 kg/ha) affected chickpea plants seriously (GUPTA and MANI 1964). EPTC, applied in granular form, resulted in poor weed control, whilst related compounds and other formulations damaged the crop. KASASIAN (1968) compiled the data of several authors and listed EPTC as a useful pre-emergence weedicide. HOROWITZ (1966) claimed that weedicides with triazines as active substances were useful before emergence, for both California and Bulgarian chickpeas in Israel. From trials carried out by the Regional Pulse Improvement Project in India it seems that all herbicides damage chickpeas to some extent, and that weed control is more sucessful when done by hand weeding. Treflan + epstam applied at low rates (0.5 + 2.0 kg/ha), however, could be useful in the future (RPIP 1969).

The weeds which are often troublesome in chickpeas are grasses and *Cyperaceae*, such as nut grass. In the Ganges plains, *Asphodelus tenuifolius* Cav. and *Euphorbia dracunculoides* Lamk. are two of the main examples. *Phalaris paradoxa* L. is a nuisance in Israel. In most publications weeds are not specified further. Of course a herbicide should eradicate all troublesome weeds, but these differ from place to place. The range of weed species in a certain locality should be known and the chemicals should be adapted to the weed flora.

As for pesticides (see Chapter 9), the use of herbicides depends on economic factors. Consideration for soil pollution will probably oppose wide application.

5.5. MIXED CROPPING

Growing crops in mixtures is an old farmers practice, especially in India. In Ethiopia, the crops are mainly raised as monocultures, but frequently mixtures are also grown. In Europe and other continents, the system of mixed cropping is not uncommon. Usually one of the crops promotes the other, the system makes full use of the land in recently planted orchards. Mixed cropping is probably the most important method by which soil fertility has been maintained during the past centuries on the Indian subcontinent (WATT 1890, MOLLISON cf. BAINS 1968, GUPTA 1964 and many others). It is a kind of insurance against failures. In mixtures of wheat and chickpea, the chickpea can still yield satisfactorily when the weather is too dry for wheat, whilst the wheat can still give a good crop when the weather is too wet for chickpea. In addition diseases and pests will rarely attack all species grown in a mixture. Trials to investigate influences on yield and economic return of the mixed crops have been extensively carried out in India. In other countries, more stress has been laid on the usefulness of rotation in which chickpeas are included. Besides ecological factors, the choice of a particular mixture, the method of sowing and the proportion of seed affect yield.

NARAYAN AYYER (1949) listed many mixed cropping practices and most publications report that both or all crops in a mixture stimulate yield (GUPTA and MATHUR 1964, GUPTA, M. O. 1955, GUPTA, M. L. 1955, CAMARA 1948, DAYAL and SINGH 1966, CHOWDRY 1953, BAIRASHEV 1961, KOINOV 1968a, SINGH and KATYAL 1966, SAHASTABUDDHE 1949). PELIPENKO (1958) reported the use of chickpeas for interplanting in young orchards in the Soviet Union. This is also a common practice in Central India. I saw *Cicer* grown between Citrus near Bhopal, Nagpur and at Kotal Fruit Research Station. Pulses are considered the best interculture in orchards, because they require less nutrients than a non-leguminous crop. However their water requirement remains, and should be taken into account.

BALASUBRAMANIAN (1947) did not obtain better yields from cotton when it was grown after a mixture of wheat and gram than after wheat alone. When annual crops are grown mixed, it is good to combine two crops exploiting different layers of the soil: *Cicer* has deep roots whilst wheat takes nutrients from the topsoil. A wheat-chickpea mixture is the most common type of mixture in India.

Usual mixtures of chickpeas with other crops, in order of importance, are: wheat, barley, India mustard (*Brassica juncea* (L.) Czern. et Coss.), oil flax, sorghum (sown in the previous season), rice (from the previous season), wheat + Indian mustard, maize, safflower, *Lathyrus sativus* and several others, such as vegetable crops (onions). The crops may be broadcast, but sowing in rows is better. In the wet season red gram (*Cajanus cajan* (L.) Millsp.) and sorghum are sown in alternating strips. After this sorghum is harvested, chickpeas may be sown in the strips between red gram. Strips of chickpea and safflower occur in Maharashtra. Although not mixed cropping in the strict sense the strips are often too narrow to speak of strip cropping. In the Madras area intercropping of chickpeas in cotton appears promising (CHATTOPADHYA 1967).

In West Bengal I saw mixtures of wheat, Indian mustard, oil flax, chickpeas and vetches (*Lathyrus sativus* L.). In Bihar, the same mixture with peas instead of vetches is not uncommon. Whether these complex mixtures are economic is questionable. Anyway they do insure some yield, and as local labour is plentiful and cheap, the several harvests do not cause difficulties. Wheat and gram were even sold as mixtures in earlier times (DUTHIE, 1890), but nowadays these products are not included together in the market reports and mostly pure products or flour only are offered to the buyer.

Mixed cropping can be done in different proportions. Widely used is the 1:1 wheat-gram mixture in a weight base. Similarly equal proportions of other crops are sown. Sometimes for home use only small proportions of chickpeas are sown in between a barley or wheat crop, or along the edges of the fields. Occasionally sorghum or safflower are mixed with chickpeas in central and northern Ethiopia and the Hararge highlands. In Konso (S. Ethiopia) most crops, including chickpeas, are sown mixed.

5.6. Crop rotation

Together with mixed cropping, in crop rotation the chickpea is very important restoring soil fertility. Without chickpea and other pulse crops, agriculture, especially in India, could not have taken place continuously for thousands of years. Farmers are well aware of the fertility level which is maintained at a moderate but rather constant level.

Many rotations are possible, depending on locality and custom. Strict patterns do not seem to exist, but a specific rotation may be prevalent in one area. Local needs and market prices determine whether wheat or chickpeas and other crops will be grown and in which proportion, although the weather at the time of sowing is of greatest importance. Raheja (1953) reviewed the double cropping systems in India, and Mirchandani (1956) studied the rotations.

In the Punjab, Haryana and Uttar Pradesh states of India, chickpea is usually rotated with wheat when only one crop is grown in a year. Often *Sorghum* or *Pennisetum* are the preceding hot wet season (kharif) crops and no fallow takes place except for the hot dry period before the monsoon rains. Sowing in a standing rice crop or immediately after harvesting of rice has been mentioned previously. In rotation schemes with chickpeas, most main field crops occur, or a fallow is included.

Westphal (1972) observed and listed from literature chickpeas as a main crop in several rotations in Ethiopian agriculture, usually on heavy black soils (Shoa, Begemdir), Wheat, t'ef (*Eragrostis tef* (Zucc.) Trotter) and niger seed (*Guizotia abyssinica* (L.f.) Cass.) are dominant as preceding crops. In the 'ensat' zone (*Ensete ventricosum* (Welw.) E. E. Cheesm.) in SW. Ethiopia, chickpeas are used in rotation with wheat. Moreover chickpeas are frequently used as a second crop.

In Mexico, chickpeas can be alternated with summer cereals. In Northern Africa, a spring crop leaves sufficient time to cultivate the soils for a crop of winter wheat or autumn potatoes.

Here we arrive at the question of multiple cropping: several crops per year. This practice is stressed whenever possible to increase production. When more short duration cultivars of crop plants become available, even up to four crops a year will be possible, provided irrigation facilities are available; sorghum-wheat-chickpeas-mustard, or sorghum-chickpeas-spring maize-mung beans.

A few trials have been carried out to establish the most profitable rotation. After a long series of trials it is not certain whether any conclusions made are economically feasible, because of the change in the market situations and the breeding of new cultivars.

CHAVAN and AMBEKAR (1936) and BHATNAGAR (1957) recommended to grow *Cicer* after irrigated, wet season rice. BALASUBRAMANIAN et al. (1947) recommended chickpeas as a good crop to precede cotton, although *Crotalaria juncea* L., more suited as green manure, gave higher yields of cotton. DARGAN (1965) found chickpeas, after peas, the best crop in rotation with cotton, and the difference with peas and other legumes was slight. CHATTOPADYAH (1967) found the same rotation to be promising, as did Singh (1967) for some regions of the Punjab, when yield was considered. However, in other regions other rotations were more profitable.

A profitable intensive cultivation pattern (CHAUGULE 1955) is to grow chickpeas immediately after a maize harvest. Thus fresh seeds can be harvested in December and premium prices obtained on the market. Soil preparation is replaced by drilling the seeds between the rows of the cut maize stalks and intercultivation after emergence.

PANOS (1954, 1959) in Greece stressed the importance of a (phosphate-fertilized) legume crop in rotation with wheat. Chickpeas gained second place in yield and a third in after-effect on wheat, after vetches or grass peas (*Lathyrus sativus* L.), after broad beans (*Vicia faba* L.) and pea. WAHHAB (1959) considered *Trifolium alexandrinum* L. as the most economical crop in preference to chickpeas and stressed that the choice of rotation depends largely on the market situation.

In conclusion it may be said that chickpeas are a suitable preceding crop for cotton, although economically not the most renumerative. Amongst pulses it ranks high in this respect as a preceding crop for wheat.

5.7. FERTILIZING AND MANURING

Irrespective of the effect of fertilizer and manure on the yield of *Cicer arietinum*, the soil will be improved by these treatments. A good crop, also of *Cicer*, extracts a certain quantity of nutrient from the soil. The relevant data are discussed in Section 6.7.2. Recommendations were tabulated (Table 8) from data obtained in several areas in connection with the prevalent situation.

Nitrogen is usually applied at sowing as ammonum sulphate or ammonium nitrate. Superphosphate is the commonest phosphate fertilizer for chickpeas; basic slag is sometimes used. Potassium is applied as sulphate or chloride in the areas responsive to K. The fertilizers should be drilled in. This is done best together with the sowing. Broadcasting the chemical fertilizers, however, often gives the same results. Around the Mediterranean phosphorus is preferably applied in autumn.

TABLE 8. Fertilizer recommendations for various countries

Country	Nitrogen kg per ha N	Phosphorus kg per ha P_2O_5	Potassium kg per ha K_2O	Reference
India				
(general)	10	30	–	Fertil. Ass. India, 1968
	5	20–25	–	ICAR, 1969
irrigated	10	40–60	–	Mann, 1968
unirrig.	10	20–30	–	
pre-cereals	20	40–60	–	
Maharashtra	–	50	–	Sangawe, 1970, pers. commun.
Gujerat				
irrigated	25	40	–	Joshi, 1968
unirrig.	12.5	25	–	
Punjab	–	30	–	Athwal and Bajwa, 1965
W. Pakistan	–	30	–	Aziz, 1960
Spain	20	50	35	Mateo Box 1961 (loose, poor, Ca-rich soils)
	–	45	25 presowing	(clay, Ca-rich)
	20	60	25 long before sowing	(soils poor in Ca)
Algeria	7.5–12.5	80–85	50–70	Calzecchi, 1953
	10–20	30–50	0–50	Golusic, 1970
Tunisia	–	75–80	–	Fr. Fidèle, pers. commun.
Bulgaria	25–37.5	75–80	–	Koinov, 1968
Mexico	–	–	–	CIAS, 1969
	–	–	–	Chena et al., 1967

Trace elements are economically uninteresting for most farmers, as their effects are small. They can be applied by spraying or together with the main fertilizers. The choice of a fertilizer that also contains trace elements is feasible.

Application of farmyard manure, which is often the only material available in many regions of the African and Asian chickpea area, is recommendable. As manure is used for fuel and both compost and manure are applied to horticultural crops, agricultural crops suffer. Chickpea is considered as inexhaustive. The crop usually responds to a dose of farmyard manure. Even after rice there is a residual effect of manuring. According to CHAUHAN (1962b, 1963b) organic matter helps to suppress *Fusarium* wilt. For pot trials the use of manure is recommended. Presumably because it is difficult to repeat the same treatment exactly, farmyard manure was not included in many field trials. Whenever poor or sandy soils should be improved, manure must be applied. When the growth of chickpea is too luxurious after manuring, the manure should be applied to cereals only or to other crops in the rotation.

5.8. Control of diseases and pests

Diseases and pests may be avoided by choosing resistant cultivars or they can be treated. By spraying or dusting with the suitable products, these dangers may often be controlled (see Chapters 8 and 9).

5.9. Harvesting

Chickpeas are mostly harvested by hand. The yellowing or fully dried plants are cut off just above the soil surface or the plants are pulled up. The crop is transported in bundles or heaps of complete aerial parts, which are brought to the drying-floors and the threshing-floors. In Spain the dry crop is also combined, the harvester-thresher is quite suited to deliver the dehusked grains. The distance between the rows must be adapted to the width of the machines. In Bulgaria and the USSR adapted, straight-growing (erect) cultivars are developed, such as cv. Plovdiv 19. In her taxonomical work Popova (1937) mentioned the suitability of several groups for mechanized cultivation.

The plants may also be pulled up in a green stage, when the seeds are used for green vegetable or as a snack.

5.10. Threshing

The heaps of dry plants with pods can be threshed by bullocks, driven in a team of four to seven, in a circle on a loam or cemented floor. Smaller quantities can be treated by beating with sticks. Threshing machines are widely in use in western countries, the threshing equipment now gaining popularity in the Punjab can easily be adjusted for chickpeas. The adjustment of the machines is important, because the traditionally threshed product still contains fewer broken parts. Winnowing is done traditionally by the wind, when the seeds are scattered from a certain height. Sieving and fanning are gradually replacing these methods. In modern threshing machines, the grains are cleaned in the same run.

5.11. Grading

Grading is done in Spain and Mexico, where weight classes are distinguished. In Mexico, distinction is made between sieved and non-sieved chickpeas (Chena et al., 1967). The 'extra' or 'fancy' grade is given to chickpeas with a weight of about 85 g per 100 seeds. For the classification and preferences see Section 3.6. Seed size, colour, uniformity and structure of the seed coat are the main economically important characteristics of the seeds. In India and Pakistan, the cultivars are kept and cultivated apart, but occasionally less preferable types of seed occur but they are seldom selected out. The largest diversity within one market sample is met in Ethiopia. Presumably the majority of the yield is also cultivated as a mixture of strains. For instance two samples, one of 600 g from

TABLE 9. Occurence of various kinds in two mixtures of chickpeas, purchased in Ethiopia

Group	HARAR Weight	HARAR 100 seed weight	HARAR % of sample	HAKKÉ (Bale Prov.) Weight	HAKKÉ (Bale Prov.) 100 seed weight	HAKKÉ (Bale Prov.) % of sample
A black	32.7 g	14.6 g	5.5	198.0 g	12.5 g	76.1
B small, brown, not angular	114.6 g	15.4 g	19.5	3.2 g	14.6 g	1.2
C large, light brown	91.4 g	21.5 g	15.5	–	–	–
D small, brown, angular	292.0 g	11.3 g	49.7	58.7 g	11.6 g	22.7
F small, rounded, yellowish	57.4 g	12.3 g	9.8	–	–	–
I as B, with mosaic patches	0.4 g	10.0 g	0.0	–	–	
	588.5 g		100.0	259.9 g		100.0

Harar and one of 260 g from Hakké contained several seed types (Table 9).

Each sample was harvested presumably from one field or at least by one grower. The characteristics of the different groups or strains, therefore, do not to differ very much in agricultural aspect, and selection pressures are not rigorous. Usually the seeds are not sorted out for the market nor for growing a new crop.

5.12. STORAGE

After grading, the threshed and winnowed grains of Cicer arietinum are either traded or stored. Heavy losses occur and it is necessary to improve storage facilities. Losses in stored grains in India are estimated at 25% a year (PARPIA 1968). Chickpeas are as palatable as any grain or grain legume; insects and rodents may even prefer the pulses. Thus chickpeas should be carefully dried and stored in air tight bins, or in clean jute bags in rat-free godowns. Modern aerated silos are very suiteable. Seeds should not contain more than 8–15% water when put in the store, all humidification should be prevented. The higher the storage temperature, the lower the humidity content which is allowed to keep a good product or to maintain a sufficient longevity. For sowing seed below 10°C, at 21°C and at 26°C the moisture content should not exceed 15%, 11% and 8%, respectively (BARTON, 1961, approximate values for beans and peas for safe storage during one year).

No specific properties for storage distinguish chickpeas from any staple crop. Pulse beetles cannot yet be destroyed easily, so prevention is the best remedy. A heat treatment can solve this problem, but keeping the seeds at 57°C for 2 or 3 h may meet financial objections. Sowing seed can be stored in closed tins or drums, with the addition of fungicides and pesticides. Fumigation is recommendable against pests, when technologically possible. Diseases do not spread in proper stores, because the medium for development, humidity, is insufficient for the release of spores and the growth of mycelium. The spores of rust, however, can reach all seeds in a store when the bulk is moved. Excessive humidity promotes mould, such as *Penicillium* and *Aspergillus*.

6. ECOLOGY

6.1. Introduction

In 1969, 1970 and 1971 trials were carried out to study the influence of light intensity, temperature and relative humidity on growth and development of chickpea. In addition the effects of leaf reduction and sowing depth was studied. The discussion of the influence of the edaphic factors is based on literature and field observations.

6.2. General description of material and methods

6.2.1. *Plant material used in the trials*

Chickpea cultivars were imported from different parts of the world. Mostly original cultivars were used from different geographical latitudes. Every trial included the same French cultivar (Pois chiches larges blancs from Vilmorin-Andrieux S.A., referred to as 'Vilmorin') as a control. When insufficient original seed was available, selfed seed was used.

Varietal names or numbers are indicated in Table 10 and referred to in the test with their names or with the catalogue numbers of the experimental stations that provided the seeds. Herbarium material of the cultivars used is deposited in the Herbarium Vadense at Wageningen for future reference.

6.2.2. *Plant characteristics of the chickpea*

The taxonomy and morphology of the chickpea and its wild relatives was discussed in Chapter 2. Differences that may be important to distinguish between the cultivars are pointed out here.

The chickpea is a short-growing semi-erect or erect, seldom prostrate, herb of 25–75 cm. The branching habit may be bushy, erect or umbrella-shaped, depending on the position of the branches on the nodes. The leaves are alternate and have 11–15 serrate leaflets. All parts bear glandular hairs. The first two leaves, which are reduced to perules or scale leaves, consist of two united stipules. The papilionaceous white, purplish or blue flowers are arranged in one-, seldom two-flowered axillary inflorescences on slender peduncles and pedicels. After a vegetative growth every node bears a raceme, sometimes even when a secondary branch originates from this node. In some cultivars the first flowers are reduced to little yellow buds, or are deformed, other dessicate without opening. This phenomenon lasts longer if conditions are suboptimum. Aziz (1960) called these buds pseudo-flowers. Other cultivars do not exhibit this phenomenon and flowering starts normally. Self-fertilization is a rule, but there may be bees on the flowers and as a consequence natural cross-pollination may occur to a very low extent. The inflated oblong pods contain 1–2 seeds,

TABLE 10. Plant material used in the experiments

Origin	Cultivar	Imported from	Cat. Nr or Code
France	Pois chiches, larges blancs	Vilmorin-Andrieux S.A.	—
India	from Poona	Madrid, Instituto Nacional de Investigaciones Agronómicas	1548
Spain	from Fuentesauco (Zamora)	id.	1007
Greece	Peloponnesus	Gatersleben, Institut für Kulturpflanzenforschung (DDR)	CIC 28/64
USSR	Kitanicka 199.	Gatersleben	CIC 54/63
	Sovchoznyj 14 Gibridnyj 27	Leningrad, Institute of Plant Industry	—
Sudan	Beladi	Khartoum, Faculty of Agriculture, University of Khartoum	—
Tunisia	—	Ariana, Institute National de la Recherche Agronomique Tunisienne	A64-7-A
Ethiopia	—	Debre Zeit, Agricultural Experiment Station, Imperial Ethiopian College of Agriculture	DZ 10-2 DZ 10-4 DZ 10-5 DZ 10-10
	green grain		—
		Alemaya Market, J. J. F. E. de Wilde	JM 522 B
Pakistan	Punjab 7	Lyallpur, W. Pakistan Agricultural Research Institute (also used in India)	Pb 7 C 107 C 727 382

very rarely 3. The seeds are angular to globular with a pointed beak, 0.5-1 cm in diameter. The seed coat can be yellowish white to red, brown, green and black. The seed weight varies between 11-55 g per 100 seeds.

6.2.3. *Methods of growing chickpea plants*

The chickpea plants were grown in various ways, depending on the trial, the location in the greenhouse or climate room and the general growing conditions. In addition methods were modified according to the experience obtained in the course of the trials, especially for the watering and soil aeration of plants, in order to improve uniformity and reproductivity of the trials, and to save labour.

In most trials, 7-9 seeds were sown in plastic pots of 10-12 l. Eventually the number of plants was reduced to 3-5.

Pretreatment

In the first year, the seeds were soaked in water or a 0,25% Germisan (organic mercury) solution for 2-4 h and pregerminated before sowing. After soaking, the seeds were placed between sufficiently moistened filter paper, in large Petri dishes for 20-22 h. Thermostatically controlled cases were kept at

20°C and a relative humidity of 95–100%. Pregermination had no significant influence on the dry weight and the length of the plants, harvested 50 days after sowing. Emergence after sowing was somewhat quicker, however, and the plantlets grew taller during the first weeks, but this difference disappeared later. After disinfection germination percentage was not improved.

Soils

An unfertilized garden soil was used in the first-year trials. This sandy soil contained 7.8% organic matter, its pH (water) was 6.5, pH (KCl) 5.5. Growth was reasonable, but some plants died, most probably from asphyxiation. The soil in the plastic pots which were placed in peat, needed watering every day so that the soil became compacted. A system of watering by capillary ascent gave satisfactory growth in pure river sand and river sand mixed with 10% china clay as a medium, to which nutritive solutions were added. Perlite, a water-absorbing sterile medium, did not produce good growth. The garden soil watered by capillary ascent remained too wet, so that dry weight production of the plants was lower than for sand. In the sand-clay mixture too many plantlets died, so that sand was chosen for the subsequent trials. The installation consisted of cisterns, mounted on rails that could be filled with water to a desired level. The pots with perforated bottoms were placed between pebbles in the first year, and hung between bars the following year to keep a water level of 1 cm above the lowest part of the pots. Thus the bottoms of the pots remained immersed in the nutrition solution.

Nutritive elements were added as 2 g Delta Spray (15% N–5% P_2O_5–15% K_2O); or Nutrifol (18% N–18% P_2O_5–18% K_2O) containing 0.13% Mn, 0.01% Cu, 0.04% Zn, 0.05% B, 0.007% Mo (trace elements as chelates) per pot of 10 or 12 l before sowing, and a second dose was added after one month. In the cisterns a concentration of 1 g Nutrifol/liter was established at the start of the trials only. This amount, however, with all the elements readily available resulted in a luxurious growth so that the normal appearence of flowers was disturbed to a certain extent.

The growing medium was kept in the pots by a nylon filter so that water was free to ascend by capillarity. The water supply was always sufficient, if the sand had been wetted previously. When contact was broken between the bottom of the pot and the water level in the cisterns, re-humidification of the sand was difficult.

In the climate rooms, plastic pots were used with outer buckets, of the Kick-Brauckmann type (manufactured by Baumann, Amberg, W. Germany). Water was refilled when necessary up to a 4–5 cm level.

Maintenance

The plants were supported collectively in each pot between 4 bars and some plastic bindings. Photoperiod treatments were applied immediately after sowing. Water was sprayed on top of the pots with garden soil. In outer buckets and cisterns the water level was brought to 4 cm every 2–3 days.

Observations

Observations were made on the emergence of the seedlings. The length of the main stem and the number of leaflets were noted every week. The number of branches was sometimes counted. The second year, the number of the node on which first flowering appeared was noted.

The date of flowering was taken as that date on which the first imperfect flower showed a yellow colour of the bud, or the first perfect flower a white or purple colour of the corolla. Normally other plants followed within a week but sometimes large differences of about ten days between plants within pots were noticed. In the greenhouses several subsequent flowers failed. For the cultivars 'Vilmorin' and 'Kitanicka', the latest flowering data were estimated by close inspection of the buds when the trial was terminated. In the same cultivars few pods set seed. In the cultivars of Ethiopian and Pakistani origin setting was reasonable.

All data on vegetative growth were taken from one of the 3–5 plants per pot, chosen at random. Flowering was taken from the first plant which flowered. After terminating the trials, the dry weight of all plants and the average weight per plant were determined. Drying took place in thermostatically controlled drying ovens at 80 °C for 48 h.

Equipment

The trials were carried out in greenhouses except for those with controlled temperatures and humidity. The temperature in the greenhouse could be controlled and was kept above 19 °C, later at 17° as this proved to be more favourable. The maximum temperature rose regularly to 30 °C (first month) for 1–2 h or to 35 °C (second and third months) for 3–5 h, and sometimes to 40 °C for short periods of 1–2 h only, despite maximum ventilation.

The relative humidity of the air was kept at about 50–60% with mist-delivering equipment controlled by a humidistat near the roof of the greenhouse. In the morning after watering, humidity rose to 80% for about 1 h and then dropped to the normal level. During the last month of the growth period the humidity increased to about 70% for about 4 h during the night.

Dark room equipment

For the photoperiodic treatments, the cisterns mounted on rails were kept for 9 h a day in daylight in the hothouse. For the other 15 h the cisterns were moved into separate compartments of a large shed. Strong fans changed the air of the dark rooms twice per minute. The temperature inside the dark rooms was kept at the same level as in the greenhouse.

The photoperiod was lengthened with two 40 W fluorescent tubes (Philips TLF 55) at an intensity of 0.021 cal cm^{-2} min^{-1} at plant level. The tubes, mounted on a panel and 12 cm apart, could be adjusted for height and were usually kept at about one meter above the stem tips. The equipment for supplementary light was operated by electric time switches and could be adjusted for any combination of photoperiod and nyctoperiod within a cycle of 24 h.

6.2.4 *Influence of sowing depths*

Treatments and design

Optimum sowing depth for the emergence of the seedlings, growth and flowering may depend on the characteristics of the seeds (dimension, growth vigour, age), the cultivation method (way of sowing, planking) and ecological factors such as soil and its aeration and available moisture. The chickpea is a large-seeded plant species and in general mot much attention is paid to seed bed preparation and sowing depth. A rough surface will do, seed drills can place seeds between certain depths and planking is often applied to cover the seeds. (Section 5.2).

To investigate the optimum sowing depth a randomized block trial was carried out with eight repetitions of twelve pots each in the hothouse. Two cultivars were included. Results (unpublished) of an early orientation carried out in 1966 had not been conclusive. The dry matter output of plants sown at a depth of 10 cm was equal to the yield from plants sown at 2.5 cm. Differences in the number of plants per pot, at the time unavoidable, made interpretation difficult.

Material and methods

In 1969, the trial was carried out under optimum moisture and soil-aeration conditions with the sand and nutritive solution procedure. Sowing depths of 1, 5 and 10 cm below surface were investigated. The cultivars used were 'Vilmorin' and 'C 612'.

Results

Emergence, dry matter yield after 67 days and number of days to flowering are compiled in Tables 11, 12, 13. The vegetative growth is expressed as % of the highest dry matter yield. In 'Vilmorin' seeds sown at 1 cm produced nearly 7% heavier plants and the number of branches was about 20% higher than if sown at 5 or 10 cm. The precocity is also expressed in the number of flowers, especially 56 days after sowing. The cv. C 612 showed similar but larger differences. Sown at 10 cm the dry matter yield was 27% lower than from seeds sown at 1 cm. Differences between sowing depths, between cultivars were statistically significant ($p < 0.005$). The interaction between cultivars and sowing depth was significant ($p < 0.05$).

TABLE 11. Mean percentage of emergence, calculated from 72 seeds per treatment

	Cultivar	Vilmorin			C 612		
Sowing depth	Days after sowing	6	8	10	6	8	10
1 cm		93.1	100	100	93.1	97.2	97.2
5 cm		79.2	94.0	94.0	91.7	100	100
10 cm		48.6	91.7	93.1	34.7	95.8	98.6

TABLE 12. Mean dry weight per plant (average of 40 plants) 67 days after sowing

Sowing depth	Cultivar	Vilmorin		C 612	
1 cm		4.51 g	100%	2.90 g	100 %
5 cm		4.21 g	93.4	2.49 g	86.0
10 cm		4.22 g	93.7	2.12 g	73.0

TABLE 13. Mean number of days from sowing to first flowering and number of flowers of 40 plants taken at three dates

		Date of flowering		Number of flowers			
Cultivar	Sowing depth	Pseudo-flowering	Flowering	up to 51st day	51–56th day	56–67th day	total
Vilmorin	1 cm	29	48	15	79	31	125
	5 cm	32	47	15	40	22	77
	10 cm	33	50	5	14	10	29
C 612	1 cm	37	43	20	113	63	196
	5 cm	40	43	22	63	38	123
	10 cm	42	49	1	35	26	62

6.2.5. *Maximum sowing depth*

Treatments and design

Practically no seeds can be sown deeper than 25 cm below the soil surface, and this was the maximum depth investigated. The other depths were 5, 15 and 20 cm. The observations were carried out in three containers with various soils. Two cultivars were included.

Material and methods

The two cultivars, 'Vilmorin' and 'DZ 10–2' were sown in 1.2 m high containers with a glass side panel, so that the root and epicotyl growth could be observed.

The soils mixtures were coarse river-sand (watered once with a Nutrifol-solution of 1 g per 1), garden soil and a mixture of $\frac{1}{3}$ garden soil, $\frac{1}{3}$ sand and $\frac{1}{3}$ peat to create three different media. Some observations on emergence and root growth are tabulated (Table 14).

Results

With a delay of 1–2 weeks plantlets from both cultivars emerged even from the depth of 25 cm. 'Vilmorin' only emerged to a reasonable extent in sand, 'DZ 10–12' gave reasonable emergence in all soil media, but in sand emergence was easiest. After 31 days, the germinated seeds had produced roots that extended to the bottom of the container. The deep sowing depths were unfavourable for early root growth, which shows a delay in both cultivars increasing with the sowing depth.

Table 14. Emergence and root growth of deeply sown chickpeas

Cultivar	Vilmorin												DZ 10–2											
Medium	Sand				Garden soil				Mixture				Sand				Garden soil				Mixture			
Days after sowing	5	8	13	19	5	8	13	19	5	8	13	19	5	8	13	19	5	8	13	19	5	8	13	19
Sowing depth	Emergence in %																							
5 cm	100	100	100	100	8	8	8	8	0	0	0	0	92	92	92	92	83	83	83	83	92	92	92	92
15 cm	0	67	75	92	0	8	17	17	0	0	17	17	0	75	83	83	8	75	75	83	42	83	83	83
20 cm	0	0	67	83	0	0	0	0	0	0	0	17	0	25	83	83	0	25	100	92	0	0	67	58
25 cm	0	0	58	75	0	0	0	0	0	0	0	8	0	0	67	75	0	8	58	58	0	0	33	42
Days after sowing		8	19	31		8	19	31		8	19	31		8	19	31		8	19	31		8	19	31
Sowing depth	Root length in cm																							
5 cm		24	65	115		–	47	–		–	0	–		31	74	115		33	76	115		33	75	115
15 cm		5	70	105		5	–	–		–	0	–		10	54	105		25	77	105		27	64	105
20 cm		4	57	100		–	12	–		5	0	–		14	35	100		30	64	100		22	56	100
25 cm		6	20	95		8	–	–		12	0	–		21	47	95		24	47	95		13	31	95

Discussion and conclusions

To sow seed shallowly seems advantageous as the dry matter yield and the flowering were significantly higher than for deeply sown seeds. With initial drought, however, deep sowing is better in practice. Apparently the French cultivar suffers more from deep sowing, than the cultivars of Indo-Pakistani and Ethiopian origin. No difference existed between dry matter yield of 'Vilmorin' sown at 5 or at 10 cm, while in 'C 612' the differences were larger. The size of the seeds ('Vilmorin' 50.12 g per 100 seeds, 'C 612' 11.21 g per 100 seeds) possibly plays a role. It is tentatively concluded, that the small delay in emergence for seeds sown at 10 cm depth is not likely to produce the differences found in subsequent growth and development. It seems probable that the longer hypocotyl, although forming accessory lateral roots, does not develop full-grown vascular elements as easily as the root or the stem. The whole distance from the seed to the surface is produced by the epicotyl so that development and flowering are retarded.

Even when sown at the exceptional depth of 25 cm, some plantlets emerged. 'Vilmorin' appears to need better aeration of the soil and is more susceptible to moulds. The seed coat is softer than for the other cultivars studied, and germination capacity declines sooner. Root growth is reasonable when seeds are germinated. Under field conditons deep sowing appears to be possible, though irregularities in stand will probably be more disadvantageous than in the hothouse. Therefore in trials under good humidity conditions (and in the absence of birds) chickpeas are best sown at a depth of 1 cm. For cultivation under good moisture conditions seeds should preferably be sown shallowly. But the seeds may also be sown deeper, which is especially necessary under dry conditions, provided the cultivar is suitable.

6.3. Light and photosynthesis

6.3.1. *Introduction*

The chickpea grows best in the Indian rabi (winter) period, during the dry seasons in Ethiopia, and during the spring and summer periods around the Mediterranean. In these periods the sky is clear or slightly clouded, except for occasional rain. With cloudy weather and rain, the high relative humidity is believed to reduce flowering and seed-setting percentages. In my trials these processes and the influence of light on the photosynthesis of the crop were studied.

Under controlled conditions, however, no differences in pollen production, germination of pollen, growth of pollen in the style and pod-setting were observed as a result of differences in relative humidity. Therefore the assumption was made that low light intensities alter the physiological behaviour of flowers, and add to the possible reasons for lower yields. The 'generative sink' then suffers at the cost of the 'vegetative' sink. The effects of various light intensities was studied in relation to fruit-setting.

6.3.2. *Literature and previous observations*

The germination of the chickpea normally takes place in darkness. VIGNOLI (1936) observed an increase in uptake of CO_2 and a more rapid utilization of reserve protein and carbohydrates when germination took place in the light. TIWARY (1932) noted that unripe seeds germinated if they were kept in darkness, while in the light those seeds failed to germinate. Normally unripe nonviviparous seeds need a resting-period during ripening in the pods. In chickpea pods, light can enter through the thin carpels. A depressive effect on the concentration of riboflavins in chickpea seedlings was reported by NAIK and NARAYANA (1963).

In my trials under controlled conditions, the chickpea reacted favourably to artificial light (HPL high pressure bulbs, fluorescent TL 55 tubes supplemented with bulbs). However, the plants did not grow as well as in natural light and a slight etiolation took place due to the lower light intensities, despite a constant energy flow throughout the photoperiod.

A crop of *Cicer* may be expected to utilize light energy economically. The leaflets have a planophile distribution (see Section 6.3.4.). The imparipinnate leaves cast less shadow on the lower leaves than is with the crop like soya bean, which has larger leaflets. No interception of light can harm fruit-setting because the flowers appear on the last few nodes of every branch. Eventual tertiary branches produce few flowers that constitute a small part of the total amount of flowers, and they may be shaded.

No reports are available yet on the photosynthesis of the chickpea.

6.3.3. *Photosynthesis*

Treatments and design

A comparison of actual photosynthesis with the yields of chickpea is an interesting subject. Potential yields can be calculated from data on photosynthetic acitvity (DE WIT, 1965). Because of the difficulty to measure leaf area, the chickpea is not normally chosen for routine trials, which are confined to a small number of crops like maize, wheat and beans (*Phaseolus vulgaris* L.) In the course of my experiments photosynthesis measurements could be taken. In two experiments the photosynthetic activity and the respiration of the leaves of chickpea were determined with the laboratory equipment of the Institute for Biological and Chemical Research of Field Crops and Herbage at Wageningen. The assembly of equipment has been described in detail by LOUWERSE and AN OORSCHOT (1969).

In one trial nine cultivars were studied, on the other the difference in photosynthesic activity between leaves of different age of two cultivars. Both trials included two temperatures and measurements were in duplicate.

Material and methods

The plant material was grown in pot of 5 l filled with a mixture of light sandy soil and leaf mould in the proportion of 2:1. The pots were placed in the greenhouse under natural daylength (13 h 37′ to 11 h 46′ during September for the study of nine cultivars and 10 h 52′ to 15 h 08′ from March to May 5th for the study of leaves of different age). For the other conditions see Section 6.2.3.

The selected leaves were placed in perspex leaf chambers. The leaves were kept as horizontal as possible between two rackets prepared from nylon strings. The temperature and the relative humidity of the air was controlled and measured by thermocouples. The rate of CO_2 exchange was determined with infra-red gas analysers. The light intensity was measured with photocells; the light source consisted of four 400 HPL lamps. The light intensity was adjusted with metal screens. All data were recorded on two recorders. Calculations were carried out with the available FORTRAN programme on an IBM Computer Model 1620.

For screening nine cultivars of chickpea, the topmost 5 or 6 (sometimes 4) leaves of one-month-old plants were placed in the leaf chambers. The cultivars used are mentioned in Graphs 6–14. The temperatures in the chambers were 18 °C and 26 °C. A range of light intensities was included to obtain data at 0; 15; 30; 50; 70 and 100 %, e.g. 0.0; 0.6; 0.12; 0.20; 0.28 and 0.40 cal cm^{-2} min^{-1}. These values are approximate since the strength of the current and the lamp age were not constant. The leaf area was measured by planimetry from a photostatic copy of the leaves. The dry weight of the examined parts was found after drying at 105 °C for 24 hours.

To compare leaves of different age, plants were sown at weekly intervals. When the routine measurements were taken, plants of 6, 5, 4, and 3 weeks old were used. Usually the 6th up to the 10th leaf could be placed in the leaf chambers. The age of the measured leaves was approximately 10–12 days less than the age of the oldest parts of the plant, consequently the leaves were approximately 4, 3, 2, and 1 week old. The total number of leaves is given in Table 15. Of the youngest plants the very last 4–5 leaves were used. The temperatures were 19 °C and 28 °C. Two cultivars, 'Vilmorin' and 'C 727' from Lyallpur were included in this trial. The range of light intensities was the same as for the preceding trial.

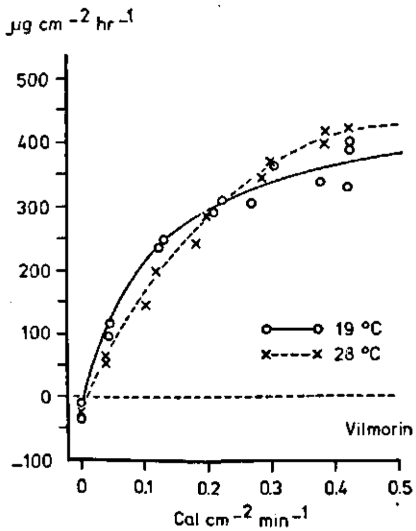
TABLE 15. Total number of leaves on the main axis, present on chickpea plants of different age, taken for photosynthesis measurement at two temperatures

Cultivar	Age	Number of leaves											
Vilmorin	6 weeks	18 °C	14	16		15	15	26 °C	14		12	17	
	5 weeks		14	13		14	15		13	16	12	15	
	4 weeks		10	13		12	13		8	11	14	15	
	3 weeks		13	14		7	12		10	10	12	13	
C 727	6 weeks		16	16		12	15		17	16	16	17	
	5 weeks		13	14		12	14		14	14	11	13	15
	4 weeks		11	13		11	12		11	12	11	12	
	3 weeks		8	10	11	8	11		8	8	10	10	

Results of the studies on photosynthetic activity of nine cultivars of chickpea

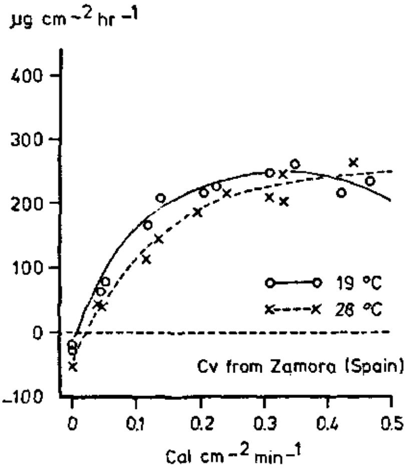
The results are plotted in Graphs 6–14. The graphs illustrate that the cultivars differ in net photosynthetic rate. The cultivars 'Vilmorin', 'C 107' (a 'kabuli' type of chickpea), 'Greece', 'Gibridnyj 27' and 'A 64–7–A' and to a lesser degree '1007' from Madrid had a higher rate of photosynthesis than the cultivars 'Green grain', no JM 522 B from Alemaya and 'DZ 10–2' also from Ethiopia. The first group reached values of 250–400 μg CO_2 $cm^{-2}h^{-1}$ while the others only reached 200 μg $CO_2{}^{-2}h^{-1}$, although 'DZ 10–2' reached up to 280 μg CO_2 cm^{-2} h^{-1} at a light intensity of 0.4–0.5 cal $cm^{-2}min^{-1}$. The cultivars from Greece and USSR showed a large difference between the two temperatures. At 28 °C the rate of photosynthesis was higher in other cultivars but the differences are small. As the perimeter of the composed leaves is fairly high while the leaflets are small, the leaf area measurements may be inaccurate. Moreover the plant mass in the rooms was relatively small, so that the leaf area was smaller than usually in this type of chambers. This may explain the differences between the duplicates.

It is remarkable that the light saturation point was not the same for the nine cultivars and for both temperatures. At the high temperature the saturation was reached at higher light intensity. Several cultivars already reached their maximum photosynthesis rate at light intensity near 0.5 cal $cm^{-2}min^{-1}$ and slightly higher rates could be expected at higher light intensities.

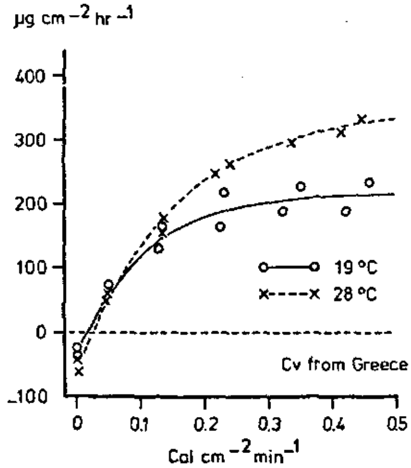


GRAPH 6.

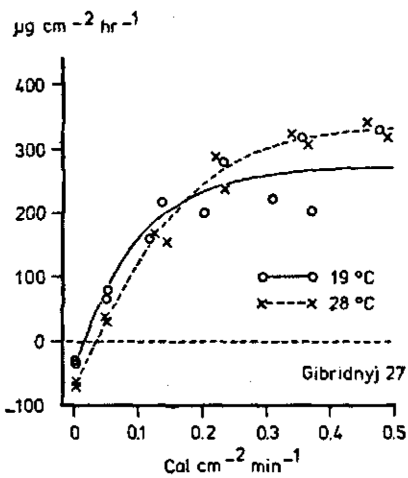
GRAPHS 6–14. Photosynthesis rate of nine cultivars of chickpea at two temperatures (18 °C and 26 °C)



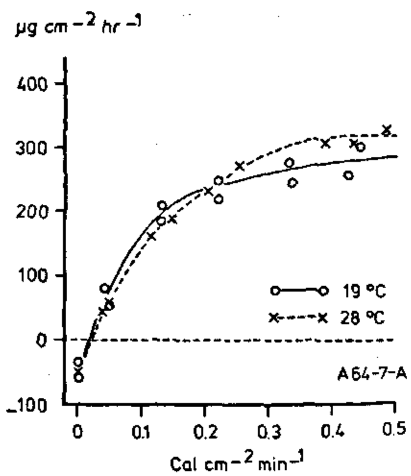
GRAPH 7.



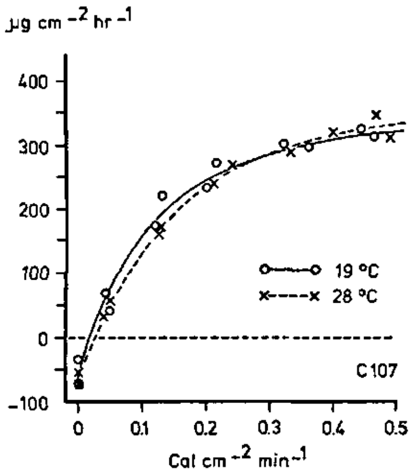
GRAPH 8.



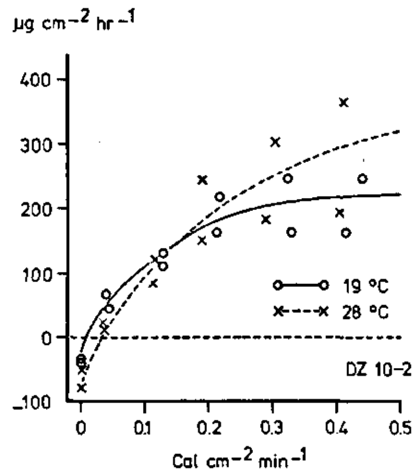
GRAPH 9.



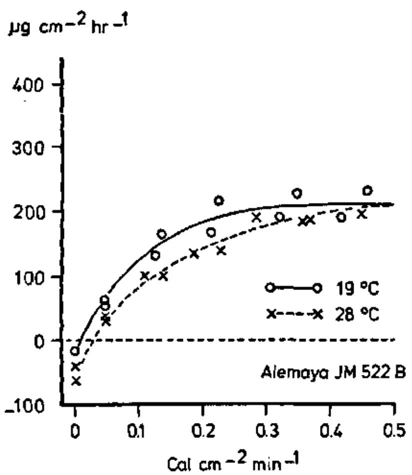
GRAPH 10.



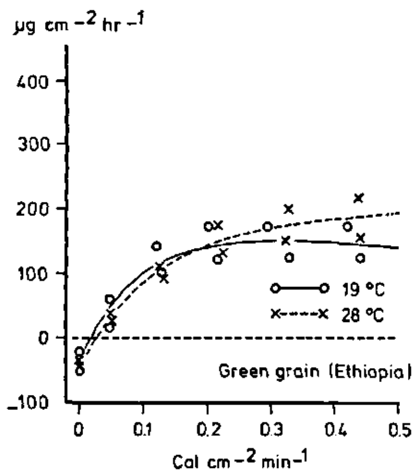
GRAPH 11.



GRAPH 12.



GRAPH 13.



GRAPH 14.

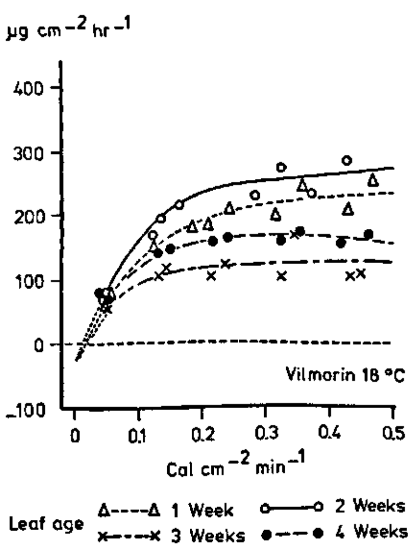
Results of the study on the difference in photosynthetic activity between leaves of different age

The photosynthetic rate of leaves different in age is given in Table 16 and Graphs 15–18. The highest rate of photosynthesis was measured from leaves of about two weeks old. The youngest leaves of one week, also comprising the unfolding top leaf, did not reach maximum activity. The leaves of three and four weeks did not differ much in activity, which is appreciably lower than that of younger leaves. In 'Vilmorin' at 18 °C, three-week-old plants showed a lower CO_2 uptake than the four-week-old leaves. This may be due to discrepancies between the duplicates. In 'C 727' at 26 °C the difference between the duplicates is very large for the three-week-old leaves. The average of these two values produce a graph similar to that of the four-week-old leaves.

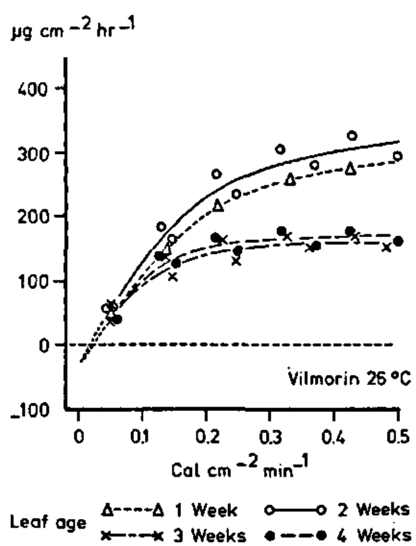
TABLE 16. CO_2 uptake at a light intensity of 0.5 cal $cm^{-2}min^{-1}$ and the corresponding CH_2O production of chickpea plants of different age at two temperatures (mean between 2 duplicates)

Cultivar	Age		CO_2 uptake	CH_2O production		CO_2 uptake	CH_2O production
			in mg	$cm^{-2}h^{-1}$		in mg	$cm^{-2}h^{-1}$
Vilmorin	6 weeks	18 °C	184.7	126.5	26 °C	182.2	124.8
	5 weeks		119.5	81.9		170.1	116.6
	4 weeks		326.5	223.7		334.6	229.2
	3 weeks		257.9	176.7		310.4*	212.6
C 727	6 weeks		136.6	93.6		161.2	110.2
	5 weeks		143.1	98.0		148.8	102.0
	4 weeks		371.2	254.3		395.4	270.9
	3 weeks		318.1	217.9		385.1**	263.8

* based on 1 measurement only
** based on 3 measurements.

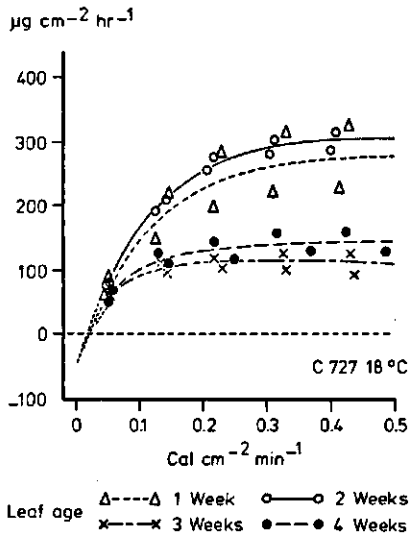


GRAPH 15.

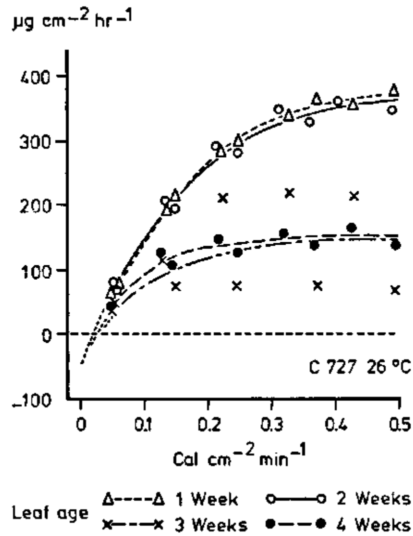


GRAPH 16.

GRAPHS 15-18. Influence of leaf age on the photosynthesis rate of 'Vilmorin' and 'C 727' at two temperatures (18 °C and 26 °C)



GRAPH 17.



GRAPH 18.

Discussion and conclusions

A comparison with the photosynthesic rate of other crops show that the highest rates from the screened collection of chickpea cultivars are equal to some of the lower values for maize at about 26 °C (HESKETH et al, 1963; LOUWERSE, ALBERDA 1971, pers. commun.). The values are much better than those of dry beans and red clover (*Trifolium pratense* L.), see Table 17. Since light saturation was reached chickpeas are not as ideal as maize. Chickpeas appear to be comparable to wheat.

At the low temperatures (18–19 °C) the leaves remain vigorous for a longer period and subsequently the lower photosynthesis rate is maintained for a

TABLE 17. Photosynthesis rate for a number of crops

Crop	Rate of photosynthesis in µg CO_2cm^{-2}h^{-1}			
	Light intensity	Hesketh and Moss	Light intensity	IBS
Zea mays	0.28–0.56 cal cm^{-2}	360–480	~ 0.5 cal cm^{-2}	490–590
Triticum vulgare	min^{-1}		~ 0.5 min^{-1}	320–410
Cicer arietinum			~ 0.45	250–400
Phaseolus vulgaris	0.28–0.56	120	~ 0.5	155
Trifolium pratense	0.28–0.56	195–200		

Light intensity is expressed in visible light, 400–700 mµ.

longer period, so the differences between the two temperatures probably have less influence on the yields than would seem apparent (see Section 6.5).

Field measurements will be necessary to establish direct relations with yields, in order to screen material on high photosynthesis rate.

6.3.4. *Potential Production*

Screening cultivars and local strains

The maximum yield in practice is about 4800 kg of grain per hectare. This corresponds with about 9600–10800 kg of dry matter since according to several authors straw yield amounts to 100–125% of the grain yield. This high yield was attained in a preliminary yield test at Karaj (Iran) from strains originating from Ardabil (REGIONAL PULSE IMPROVEMENT PROJECT, 1968). Also with careful cultivation, a white-seeded strain from Shahpour yielded 4200 kg in a preliminary trial (RPIP, 1969). An advanced yield test produced 3900 kg from another strain. The absolute maximum for India (Uttar Pradesh) was 2700 kg per ha in a co-ordinated yield trial. The cultivars Radhey and Type 3 (hybrid) have been recently released with a yield potential of 2500–3000 kg per ha. Actual average yields range from 600 to 1600 kg of grains (1350–3600 kg of dry matter) per hectare.

Thus when cultivation practices are optimum and suitable cultivars are chosen, yields can be greatly improved, although the suitability of chickpea to poor conditions acts against these record yields.

Theoretical estimation

Design

When several averaged conditions are included, the maximum production can be calculated with the established values for photosynthetic activity. The methods of DE WIT (1965) were used. PENNING DE VRIES inserted the author's data into the available ELCROS computer programme of the Department for Theoretical Production Ecology and the Institute for Biological and Chemical Research on Field Crops and Herbage at Wageningen. The programme was somewhat simplified. The model of the simulated crop growth and the programming were described by DE WIT, BROUWER and PENNING DE VRIES (1970).

Crop production was calculated from average values of the amount of light, the light distribution, the leaf area, the temperature and the measured photosynthetic rate. Leaf ageing and respiration were taken into account. The calculations assume plenty of soil water and adequate fertility. Because no actual field data of the conditions were available, monthly averages of weather were used. The leaf area was estimated. The calculations were carried out for two cultivars in suitable areas. It is stressed here, that the values used for the calculations are merely a choice since no field data were available.

Material and methods

The data used for the calculations are given in Table 18. The Leaf Area Index was calculated from the highest yields in the hothouses, where fertility

TABLE 18. Ecological data at Madrid and New Delhi as taken for the calculation of potential chickpea production

Location	Madrid			New Delhi			
Latitude	± 40°N			± 28°30'N			
Temperature (monthly average)	Max. °C	Min. °C	Light cal $cm^{-2}day^{-1}$	Temperature	Max. °C	Min. °C	Light cal $cm^{-2}day^{-1}$
March	13.9	4.4	260	October	33.9	18.3	270
April	17.8	6.7	339	November	28.9	11.1	210
May	21.7	10.0	396	December	22.8	7.8	179
June	26.7	13.9	422	January	21.1	6.7	191
July	30.6	16.7	413	February	23.8	9.4	245
August	30.0	16.7	369	March	30.6	14.4	303
				April	36.1	20.0	363
Cultivar	'Vilmorin'					'C 109'	
Leaf Area Index	3.5					4.0	
Sowing date	March, 1st.					October, 1st.	

was adequate and plenty of soil water was available. The planimetric measurements were taken after establishing the photosynthetic activity. The average leaf area per g of dry matter was 33 cm^2g^{-1} for 'Vilmorin' and 38 $cm^{-2}g^{-1}$ for 'C 107'. Therefore LAI was estimated as follows.

'Vilmorin': 125 g $plant^{-1}$ × 33 cm^2g^{-1} = 4125 cm^2plant^{-1}. A spacing of 30 × 40 cm: = 83300 plants ha^{-1}, equivalent to 83300 × 4125 cm^2ha^{-1} = 343.10^8 cm^2ha^{-1}. LAI: 3.5.

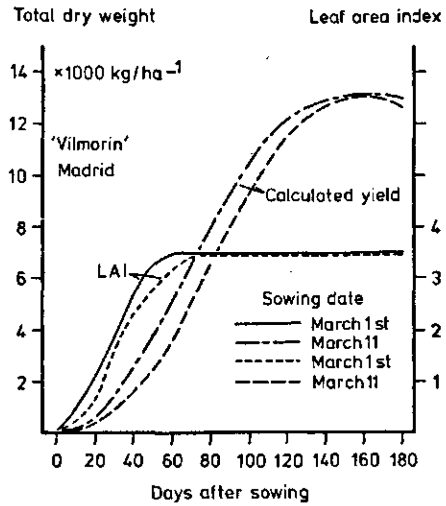
'C 107': 58 g $plant^{-1}$ × 38 cm^2g^{-1} = 2200 cm^2plant^{-1}. A spacing of 30 × 20 cm: 167000 plants ha^{-1}, equivalent to 167000 × 2200 $cm^{-2}ha^{-1}$ = 368.10^8 cm^2ha^{-1}. LAI: 3.7. A spacing of 30 × 15 cm: 450 cm^2plant^{-1}, equivalent to a LAI: 4.8.

For the cv. Vilmorin a LAI of 3.5 was used for the calculation, for cv. C 107 a LAI of 4.0 was chosen.

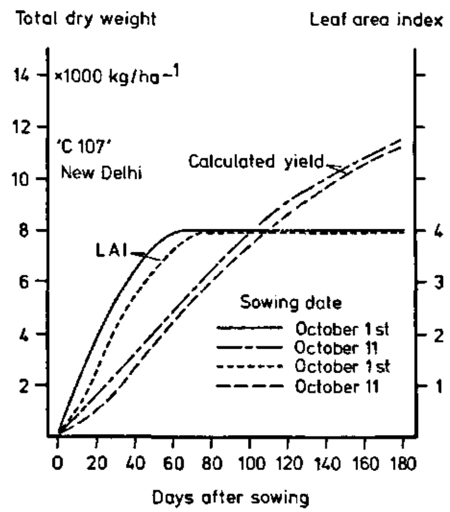
The leaf distribution function was calculated from the measurements of 500 leaves of both cultivars. The rounded-off cumulative frequencies over the classes 0–10°, 10–20°, ..., 80–90° were 0.35; 0.61; 0.80; 0.95; 0.96; 0.97; 0.98; 0.99; 1.00 respectively. These quantify the planophile leaf distribution of the chickpea. However, the leaflets direct themselves more or less perpendicularly to the direction of the light, which reaction has a positive influence on the interception of the light.

Results

The results of the calculation are shown in Graphs 19 and 20. After a growth period of 180 days, the theoretically estimated dry matter yields are the following. 'Vilmorin' at Madrid produces 13155 kg dry matter ha^{-1} per season,



GRAPH 19. Calculated potential production of 'Vilmorin', for Madrid



GRAPH 20. Calculated potential production of 'C 107', for New Delhi

equivalent to a maximum gross photosynthesis of 360 kg CH_2O ha^{-1} day^{-1} in June. The values calculated for 'C 107' at New Delhi are 11202 kg dry matter ha^{-1} per season, with a maximum of 210 kg $CH_2O ha^{-1}$ day^{-1} in early December and 280 kg at the end of March.

When sowing was carried out ten days later, the yield of 'Vilmorin' was lower, 13141 kg and the yield of 'C 107' was 11388 kg. Moreover 'Vilmorin' reached optimum yield after 150 days, while 'C 107' increased in weight until the last day of the assumed growth period of 180 days.

For comparison the simulated gross photosyntheseis of maize reaches 20 tons ha^{-1} (LAI 4, California, Iowa, 70–90 days) and 400 kg CH_2O ha^{-1} day^{-1} (controlled conditions, temperature 20 °C).

Discussion and conclusions

From the abovementioned values it is clear that the chickpea produces much less than its calculated potential. The calculated yields of about 11000–13000 kg ha^{-1} under current conditions of New Delhi and Madrid respectively are very similar to the maximum yields obtained at Karaj! A certain discrepancy between these calculations and the drought-resistant characteristics of the chickpea exist. Exactly for this reason the crop is cultivated under less optimum soil conditions. And when the soil conditions are very favourable, the production remains mainly vegetative. To assume that available water is plentiful and fertility adequate is at present difficult, since the chickpea requires less optimum conditions than is usual for a crop. The yields from small plots indicate the first goal towards which chickpea improvement should be directed, and subsequently the calculated values should be aimed at.

The effect of a delay in sowing of ten days is not very pronounced. An extended delay or advance in sowing may sow larger differences. When calculations of the LAI give other values or when measurements replace my estimations, the calculated yields will be altered accordingly.

6.3.5. *Influence of light intensity on flowering and fruit-setting*

Treatments and design

It was established that fruit-setting is independent of relative humidity (6.6). With low light intensities vegetative growth seems to be relatively favoured, so that fruit-setting is indirectly influenced. (PENNING DE VRIES and others, 1971, pers. commun.) Flowering is sometimes influenced by the light intensity level (SALISBURY, 1963).

In a screened plot the total yield is expected to be lower than in a plot without screens. How much seed yields decrease was a most interesting topic to study and therefore the ratio between seed and shoot yield was investigated.

In two compartments of the hothouses, a replication was laid of four three-row plots consisting of a cultivar each, and two-row border plots. Three levels of light intensity were applied perpendicular to the rows. The two replicates were situated at the same site in the two compartments under the same ecological conditions.

Material and methods

The blocks measured 5 × 6 m, including four three-row plots and two two-row border plots of 6 m each. Each cultivar ('Vilmorin', 'Pb 7', 'Beladi' and 'DZ 10–2') was allotted to a plot per block and to one of the four border rows.

Each row consisted of 30 plants, spaced at 20 cm within the row, at 25 cm between the rows and at 50 cm between the plots. Chickpeas were sown in small pots and planted in the soil after two weeks. Only a few plants had to be replaced.

The light intensity was as follows. The control was unscreened (100% available light in the greenhouses) and two shaded treatments (75% and 25% available light) were installed. These intensities corresponded to 5×10^5; 3.75×10^5 and 1.25×10^5 erg $cm^{-2}sec^{-1}$ (0.72; 0.54 and 0.18 cal cm^{-2} min^{-1}) against 6.75×10^5 erg $cm^{-2}sec^{-1}$ outside the greenhouses, as measured at plant level on days with a slightly overcast sky. Screens, adjusted to a level of one meter above the soil, lowered the light intensities to the indicated values when the plants started to flower.

The daily maximum temperature was kept as closely as possible at 25 °C but rose frequently to 30 °C in sunny periods for a few hours. The night temperature was kept at 15 °C. The relative humidity varied between 50% and 80%. The trial was submitted to the natural daylength in the spring at Wageningen.

The temperature and the relative humidity did not differ much between the screened and the controlled plots. Only under the heavy shade did the humidity remain at an increased level longer than the other treatments. This increase occurred after watering, which was carried out twice a week only. Weekly observations were carried out and the data, taken at harvest, were the pod production per plant (mean of 10 plants), the number of seeds, the weight of pods and seeds, the 100-seed weight and the dry matter production. The cultivars 'Pb 7', 'Beladi' and 'DZ 10-2' were harvested 64 days after sowing. 'Vilmorin' was harvested 14 days later. The data on number of pods, was statistically analysed.

Results

Table 19 shows the results from the trial. The lowest light intensity was discarded for the statistical analysis, since growth was greatly reduced and consequently pod production was very low. Decreasing light intensities suppressed flowering in a few observation plants to different extents according to the cultivar (Table 20) and pod setting was affected even more severely. De-

TABLE 19. Mean yield data of two replicates of the trial on light intensities

Cultivar	Vilmorin	Punjab 7	Beladi	DZ 10-2
Light intensity	Number of pods per plant (rows in centre of 3-row plots)			
25%	0.7	0.1	3.0	0.1
75%	28.0	47.8	37.2	62.2
100%	57.1	76.1	60.5	77.2
	Number of pods per plant (total average)			
25%	0.4	4.0	3.0	11.0
75%	21.6	39.1	32.4	69.7
100%	42.7	59.0	53.5	92.9
	Dry matter yield of shoots (incl. border plots)			
25%	3.1	2.2	1.8	2.3
75%	14.7	7.2	6.4	7.8
100%	18.7	8.5	7.8	8.3
	Dry matter yield of pods (incl. border plots)			
25%	0.1	0.3	0.3	1.1
75%	10.1	5.7	6.0	13.6
100%	21.3	11.0	10.8	19.9
	Dry matter yield of seeds (incl. border plots)			
25%	0.1	0.2	0.2	0.9
75%	7.1	4.2	4.6	9.8
100%	16.6	7.8	8.1	15.6
	Number of seeds per pod (incl. border plots)			
25%	0.67	0.71	0.69	0.45
75%	0.94	1.12	1.07	1.75
100%	0.94	1.18	1.07	2.41
	100-seed weight (incl. border plots)			
25%	28.9	7.9	11.1	8.4
75%	34.9	9.6	13.4	10.0
100%	41.2	11.2	14.2	11.1

TABLE 20. Number of flowers and pods produced by one representative plant per cultivar and per light treatment (mean between two replicates)

Cultivar	Vilmorin	Punjab 7	Beladi	DZ 10-2
Light intensity		Number of flowers per plant		
25%	13	27	7	38.5
75%	71	137	47.5	175
100%	141.5	142.5	87.5	132
		Number of pods per plant		
25%	1	17	2.5	23.5
75%	24	89.5	38	103
100%	82	94	76.5	95

TABLE 21. Coefficients of dry matter production of pods/shoots and seeds/shoots (border plots included)

Cultivar	Vilmorin	Punjab 7	Beladi	DZ 10-2
Light intensity				
		pods/shoots		
25%	0.03	0.15	0.17	0.45
75%	0.69	0.79	0.94	1.75
100%	1.14	1.30	1.38	2.41
		seeds/shoots		
25%	0.02	0.10	0.12	0.36
75%	0.48	0.58	0.73	1.26
100%	0.89	0.91	1.04	1.89

creasing light intensities caused a decrease of the dry weights of shoot production and pod production, the number of seeds per pod and the 100-seed weight. Because pod production decreased at a higher rate than the shoot production, the pod/shoot and seed/shoot (Table 21) coefficients equally decrease with decreasing light intensities. The influence of the light intensity on the number of pods per plant was statistically very significant ($P < 0.025$). Between cultivars significant differences ($P < 0.05$) occurred.

Conclusions

The seed yield decreased under low light intensities more than the shoot yield. In the extremely heavily shaded plots, growth was seriously affected and the pod yield was very low. A decrease of light intensity of 25% throughout the entire flowering period caused a 42% decrease in the ratio between pods and shoots of all cultivars. The weight of 100 seeds was appreciably lowered by the shade treatments. It is likely, therefore, that cloudy days cause a decrease in seed production because of the lower light intensities and not because of the increase of the relative air humidity. It may be expected that cloudy days are especially harmful to seed yield and quality when the crop is in full flower. This is found in practice although it has been always attributed to the increased air humidity (6.6.2). Thus, fertilization of the ovules is not a problem, but the development of the fruit.

6.4. Photoperiodism

6.4.1. *Introduction*

When we consider the latitudes and the growing seasons of *Cicer* in its cultivation areas, a large range of photoperiodic situations is found. In the following Table (22) these factors have been arranged for some centres in the most important regions of cultivation.

For instance around the Mediterranean, *Cicer* is cultivated under increasing photoperiods, which are short during the first months of the growing season. In India and Pakistan the crop is cultivated during the cool dry winter period under decreasing daylengths. Only in March, when most of the crop is ripening or has been harvested already, does the daylength surpass 12 h. In Ethiopia, the photoperiod does not differ much. *Cicer* may be seen on the fields nearly the whole year, although mainly form September to January.

Photoperiodism of *Cicer arietinum* has been studied several times. The experiments were carried out in pots or on field plots under natural daylight. The short-day treatments were obtained by screening the objects, the long-day treatments by additional illumination with electric bulbs or tubes.

Pal and Murty (1941) found a more rapid flowering under a long day (LD) situation while in short days (SD) the plants remained vegetative for a longer period, produced larger plants, and flowering was retarded, but the plants were expected to produce higher yields. Bhardwaj (1955) applied photoperiods of 16 h and 8 h for two weeks only, four weeks after emergence of the seedlings.

Table 22. Latitude, time of sowing and photoperiod at time of sowing of some centres of chickpea cultivation

Country	Latitude	Centre	Latitude	Time of sowing	Photoperiod at time of sowing
Spain	35–43°N	Madrid	40°25′	March	11.17–12.40 h
Turkey	37–42°N	Ankara	39°55′	March	11.18–12.39 h
Tunisia	29–35°N	Beja	36°43′	Jan.–April	9.41–13.41 h
Iran	30–37°N	Teheran	35°41′	Jan.–March	9.47–12.33 h
Pakistan	25–38°N	D. I. Khan	31°51′	mid. Sept.–mid. Oct.	12.24–11.28 h
India	15–37°N	New Delhi	28°70′	Oct.–Nov.	11.54–10.37 h
		Nagpur	21°10′	mid. Sept.–Nov.	12.50–11.00 h
Mexico	15–30°N	Monterrey	25°40′	Oct.–Dec.	11.55–10.36 h
Ethiopia	5–15°N	Dire Dawa	9°02′	Sept.–Nov.	12.18–12.02 h
				April	12.14–12.27 h
Argentine	20–33°S	Cordoba	31°22′	June–July	10.56–10.07 h

Shortening the day had no effect, LD delayed the flowering in the cultivar 'NP 28' for 5 to 8 days. For another cultivar 'NP 58' SD advanced the flowering by 10.5 days and LD retarded flowering by 10 days compared with the control. These cultivars tended to be SD plants. A promotive effect of SD on flowering has never been reported elsewhere and no other cultivars were studied by BHARDWAJ. NANDA and CHINOY (1960) put forward a theoretical system of phasic development periods for *Cicer*. In the vegetative period, the relation between photoquantums and thermoquantums (respectively sums of received amounts of light and temperature) was strongly inversely correlated. The vegetative growth was advanced by LD, even in periods of 24 h, but branching was inhibited. Under SD conditions the plants grew over a longer period. These authors thus described *Cicer* as a LD plant.

SINGH (1958) gave the following formulation of the photoperiodical characteristics of *Cicer arietinum*: a LD indeterminate plant. In his experiments, the natural day of the Indian winter period was found to be optimum for root growth, leaf number, nodule infection and nodular development. LD (16, 20, 24 h) decreased the vegetative period by 20, 23 and 29 days, respectively compared with the natural day. With periods of 16 h, the ratio of shoot to root growth was found to be a maximum. MATEO BOX (1961) mentioned the chickpea as a day neutral plant. MOURSI et al. (1963) determined the chickpea as a LD plant. Flowering was earliest in 16 h days, while in 14 h days the dry matter output was the highest. Equal amounts of energy, however, were not applied throughout the treatments.

ESHEL (1967) found in his field trials with different sowing dates a pronounced response to the photoperiod. One Mediterranean cultivar and one from Bulgaria flowered sooner but yielded less under increasing photoperiods. In his opinion the influence of the daylength was even more important than the temperature. MATHON (1969) classified the chickpea tentatively as reacting in favour of long days (16, 24 h). His experiments were carried out under controlled conditions.

SANDHU and HODGES (1971) found maximum and earliest flowering, highest number of seeds per plant and most vigorous vegetative growth at 16 h days, 22.5° C and high light intensities. In 8 h SD inhibition of flowering took place.

From these data I concluded that the reaction to the photoperiod as such had not been fully investigated. The effect of lengthening the day with artificial light would give better conclusions than shortening the day, which deprives the plant of energy. In the latter case later flowering than in the control has to be expected. Therefore a series of experiments was initiated, in which all plants received the same amount of energy. Supplementary light treatments were very weak and will produce only photoperiodic effects.

6.4.2. *Investigation on daylength 1.*

Treatments and design

In order to establish the optimum or maximum photoperiod for growth and flowering in chickpeas, a series of eight daylengths was applied (1969). The daylengths were kept constant throughout the experiment. The longest photoperiod was 16 h, as under natural conditions daylengths of 16 h are only exceeded at latitudes of 50°. A randomized block experiment was designed. The daylengths were allotted to the containers at random. Only one repetition could be obtained, but within each treatment five identical pots offered the possibility to harvest three times. Two cultivars were included, so the total experiment included 80 pots.

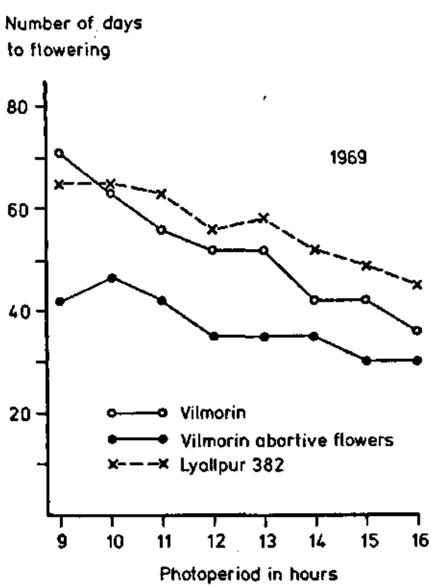
Material and methods

The eight applied daylengths were 9, 10, 11, 12, 13, 14, 15 and 16 h, corresponding to 9 h of natural daylight and 0, 1, 2, 3, 4, 5, 6 and 7 h of supplementary light, respectively. The cultivars 'Vilmorin' and '382' from Lyallpur were used. The plants were grown in garden soil (6.2.3). Data on growth were taken from two representative plants per pot. Harvesting was carried out three times: 51 days after sowing (2 pots per treatment), 61 days after sowing (1 pot) and 71 days after sowing (2 pots).

Results

Number of days to flowering

It may be seen (Graph 21) that there is a tendency that LD (14–16 h) advance flowering of the chickpea. The cv. Vilmorin flowered 35 days earlier in 16 h-days compared with 9 h-days. In the cv. '382' this difference was 20 days. The formation of pseudo- (abortive) flowers in the cv. Vilmorin started 7 days sooner in 16 h-days compared with the 9 h-days. Both cultivars flowered in all daylengths.



GRAPH 21. Number of days to flowering in a series of 8 photoperiod treatments

Dry matter yield

The analysis of variance, carried out on the Control Data 3200 computer of the Agricultural University, revealed that the third and the total of all three harvests differed significantly due to the photoperiod ($0.05 < P < 0.1$). The two earliest harvests did not differ statistically. Earliness, expressed as the difference of the third and the first harvest (H_3–H_1) or the quotient of the third and the first harvest (H_3/H_1) showed no statistically significant difference. Dry matter yield was decreased in short day conditions. The difference between cultivars was large (Graph 25).

Number of leaves

The 1969 data on the number of leaves taken at four dates after sowing showed an increase up to 57 days, and a loss of (lower) leaves up to 67 days. Due to a premature leaf fall the data were rather inconclusive and therefore not given. They were also taken as total number of present leaves and not as total number of produced leaves. Ultimately the premature leaffall influenced the dry matter yield negatively to a small degree, although the effects of photoperiodicity were not disturbed.

Plant length

The length of the plant was recorded three times; 25, 38 and 46 days after sowing. The length of the primary stem was taken from the soil to the top. The photoperiod appeared to have an influence in all experiments. LD promote an increase in length (Table 23).

6.4.3. *Investigation on daylength 2.*

Treatments and design

In 1970, in order to obtain better growth, a series of photoperiods was applied to chickpeas grown in sand with nutrive solution. Additional treatments were the application of supplementary light at different times (6.4.6) and the clipping of shoots (6.9). The treatments were laid in a balanced imcomplete block design without replications. Four photoperiods, three different periods of supplementary light, four cultivars and two clipping treatments were investigated.

TABLE 23. Plant length in cm taken at three dates after sowing, as influenced by photoperiodical treatments

Daylength in hours		9	10	11	12	13	14	15	16
Vilmorin	25 days after sowing	17	17	18	19	18	20	21	21
	38 days after sowing	22	21	22	24	26	26	30	32
	46 days after sowing	25	26	26	29	30	30	33	35
382	25 days after sowing	8	8	8	8	8	8	8	8
	38 days after sowing	12	12	14	12	14	15	15	19
	46 days after sowing	14	17	17	18	18	19	22	28

Material and methods

The four photoperiods were 10, 12, 14 and 16 h, the four cultivars were 'Vilmorin', '382' from Lyallpur (as in the first experiment), 'Beladi' and 'Kitanicka 199'. Data on growth were taken from representative plant per pot. The number of leaves, number of nodes to flowering and the plant length were noted. One final harvest was taken 77 days after sowing. The vegetative data were compared statistically. Although these data were taken every week, only those taken four weeks and eight weeks after sowing were used in the statistical analysis.

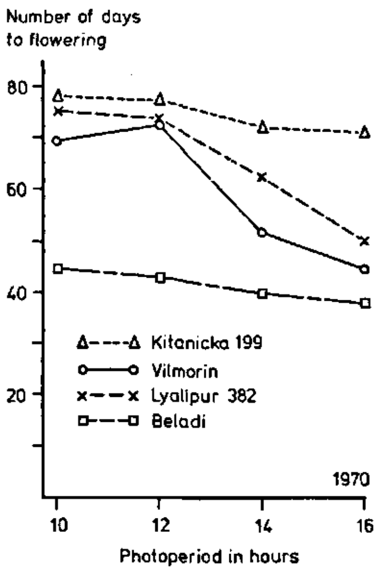
Results

Number of days to flowering

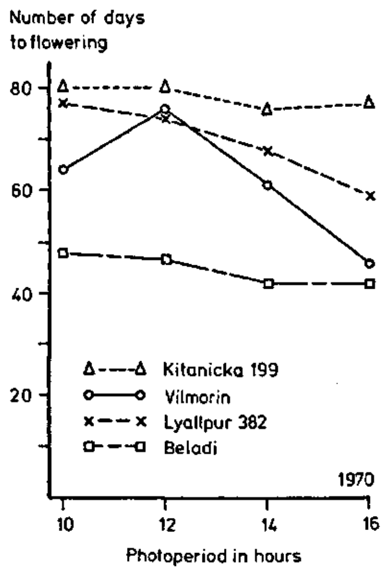
The 1969 data were confirmed. Over-all flowering was delayed in 1970 by about one week probably because of better growing conditions. The interactions of daylength and cultivar, expressed in number of days to pseudo-flowering, to flowering and the number of days between these data, were statistically significant ($P < 0.05$; $P < 0.001$ and $P < 0.05$, respectively). Although not immediately interpretable, the values for flowering show a tendency to be lower in LD (Graph 23).

Number of nodes before flowering

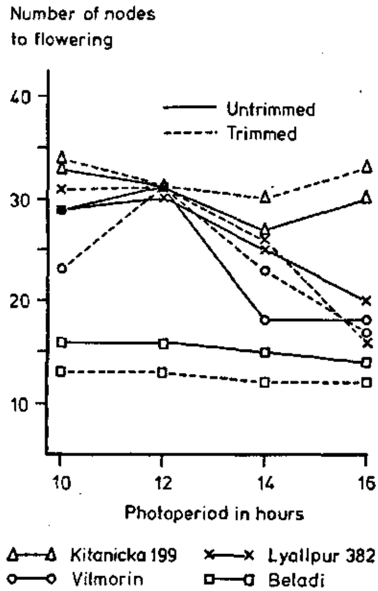
The number of completely vegetative nodes contributes in a negative sense to the yield of the plant. The lower the first pod, the higher the yield which may



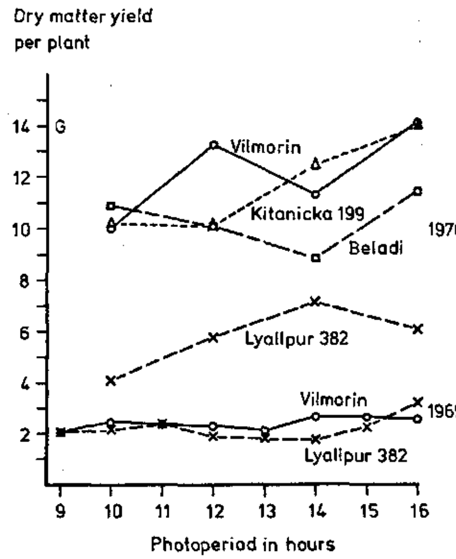
GRAPH 22. Number of days to flowering of non-trimmed plants, second daylength investigation



GRAPH 23. Number of days to flowering of trimmed plants, second daylength investigation



GRAPH 24. Number of nodes developed before flowering, second daylength investigation



GRAPH 25. Influence of photoperiod on dry matter production, investigations on daylength 1 and 2

be expected. The number of the first generative node is quite characteristic for a cultivar. Interaction daylength × cultivar was very significant ($P < 0.025$) 'Beladi' and 'Kitanicka 199' showed more indifference towards daylength in this respect (Graph 24). Except in 'Kitanicka 199' LD decreased the number of nodes produced until the appearance of flowers.

Dry matter yield

In 1970 the effect of the photoperiod on dry matter was more clearly expressed than the previour year, mainly in favour of long day (statistical significance $0.05 < P < 0.10$) Lyallpur '382' already reached its maximum at a daylength of 14 h, in 'Vilmorin' the values were irregular but the maximum was obtained at 16 h-days. In 'Beladi' the dry matter yield was lower at 12 h and 14 h-days than at 10 and 16 h, but the maximum was reached at 16 h-days.

Number of leaves

After 8 weeks the linear interaction between cultivar and daylength was statistically significant ($P < 0.01$). The photoperiod tended to affect both leaf numbers after 4 and 8 weeks ($P < 0.25$). The increase in number of leaves between those dates similarly showed a significant interaction ($P < 0.025$) between cv. and daylength (Table 24). 'Beladi' had a maximum number of leaves at a photoperiod of 14 h (4 weeks) and 12 h (8 weeks) (Table 25).

Table 24. Number of leaves at 4 and 8 weeks after sowing as influenced by the photoperiod

Weeks after sowing		4				8			
Photoperiod		10	12	14	16	10	12	14	16
Cultivar	'Vilmorin'	8.2	8.3	8.3	9.8	24.8	25.0	25.7	25.8
	'382' (Lyallpur)	6.0	5.8	6.3	7.3	21.5	22.5	22.8	25.8
	'Beladi'	7.0	7.7	9.2	7.7	24.3	25.0	23.5	22.7
	'Kitanicka 199'	7.3	8.2	8.5	7.8	23.3	24.7	25.7	27.0

Table 25. Plant length in cm at 4 and 8 weeks after sowing as influenced by the photoperiod

Weeks after sowing		4				8			
Photoperiod		10	12	14	16	10	12	14	16
Cultivar	'Vilmorin'	15.8	17.3	17.8	19.5	52.0	56.8	60.5	59.3
	'382' (Lyallpur)	7.2	6.5	7.8	10.2	37.2	40.5	41.0	45.5
	'Beladi'	19.5	18.7	24.0	23.5	65.2	59.8	62.5	59.7
	'Kitanicka 199'	12.0	14.3	16.0	16.2	44.7	50.7	55.8	63.0

Plant length

The LD treatments induced longer plants (Table 25). After 4 weeks the data differed significantly, after 8 weeks the interactions between daylength and cultivar were significant ($P < 0.01$). The increase in length between the fourth week and the eighth week gave a similar picture with the same interaction and tendency. A long photoperiod does not increase plant length of 'Beladi' ultimately, but after 4 weeks the promotive effect of both 14 h and 16 h days is noticeable.

Branching

Although no detailed data on branching of the chickpea were collected, the branching does not seem to be fixed or related to the potoperiod. Per cultivar the way of branching is very typical. A number of 5–9 primary branches was oberved, but no regularity could be found.

6.4.4. *Photoperiodic effect of the sowing date 1*

Treatments and design

This experiment (as well as 6.4.5.) was set up to evaluate the effects of treatments simulating the course of natural daylength. Four sowing dates were established in such a way, that the plants grew simultaneously under equal conditions. The only variable treatment was the photoperiod at a latitude of 30 °N. This was achieved by exposing all trolleys to nine hours of natural daylength (equal energetic conditions) and the supplement was given by fluorescent tubes. Eight trolleys with ten pots each constituted a randomized block design with two replications, two cultivars and five identical pots per treatment. Three harvests were carried out.

TABLE 26. Sequence of applied daylengths in the sowing date trials

	Simulated sowing dates			
Week no.	March 21	June 21	Sept. 21	Dec. 21
1	12 h. 09 min.	14 h. 05 min.	12 h. 10 min.	10 h. 12 min.
2	12 h. 20 min.	14 h. 04 min.	12 h. 00 min.	10 h. 14 min.
3	12 h. 33 min.	14 h. 01 min.	11 h. 46 min.	10 h. 17 min.
4	12 h. 45 min.	13 h. 56 min.	11 h. 34 min.	10 h. 23 min.
5	12 h. 57 min.	13 h. 50 min.	11 h. 21 min.	10 h. 28 min.
6	13 h. 08 min.	13 h. 41 min.	11 h. 13 min.	10 h. 39 min.
7	13 h. 19 min.	13 h. 31 min.	10 h. 57 min.	10 h. 48 min.
8	13 h. 28 min.	13 h. 21 min.	10 h. 48 min.	10 h. 59 min.
9	13 h. 38 min.	13 h. 11 min.	10 h. 39 min.	11 h. 07 min.
10	13 h. 47 min.	12 h. 59 min.	10 h. 31 min.	11 h. 15 min.
11	13 h. 54 min.	12 h. 45 min.	10 h. 23 min.	11 h. 27 min.
12	13 h. 58 min.	12 h. 32 min.	10 h. 17 min.	11 h. 40 min.
13	14 h. 03 min.	12 h. 20 min.	10 h. 14 min.	11 h. 52 min.

Material and methods

The simulated sowing dates were realized by adjusting the electric switches once a week to follow the natural course of the daylength. The sowing dates were March 21, June 21, September 21 and December 21 and the photoperiods given in each treatment are shown in Table 26. The cultivars chosen were 'Vilmorin' and 'DZ 10–12'. Growth medium was garden soil. Data on vegetative growth were taken weekly from one representative plant per pot. The harvests were 38, 53 and 65 days after sowing.

Results

Dry matter production

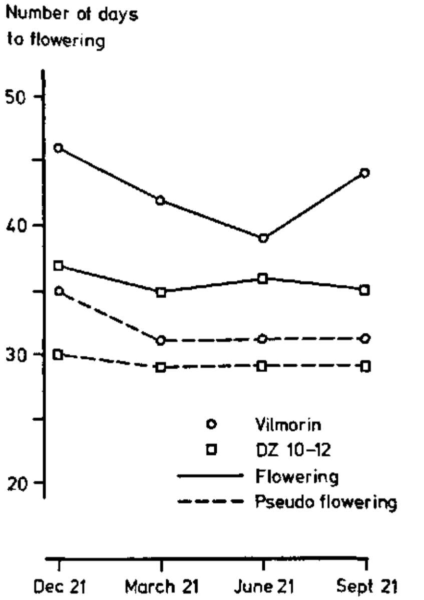
The plants of 'Vilmorin' sown on June 21 yielded slightly better than those of the other treatments, although the difference was not statistically significant (last harvests see Table 27).

Number of days to flowering

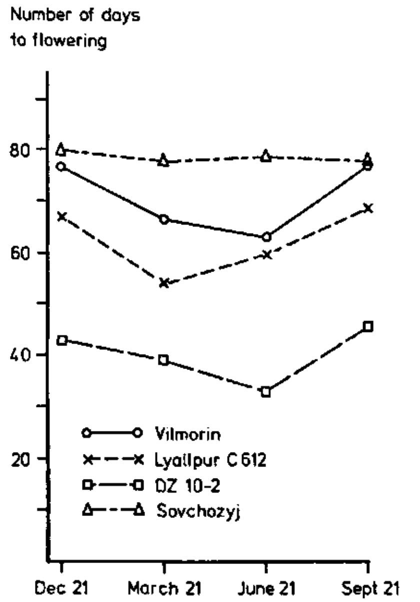
The treatments had no effect on the first appearance of abortive flowers, except for a delay of four days in 'Vilmorin' in the plants sown in December. Differences in real flowering are small for 'Vilmorin': the plants sown in June flowered 6 days sooner than those sown in December. Fruit setting was observed to commence 45 days after sowing except in the December treatment, where it commended on the 50th day (Graph 26).

Vegetative growth

No conspicious differences in the number of leaves and plant length were observed.



GRAPH 26. Influence of photoperiodic effect of simulated sowing days on flowering (Section 6.4.4)



GRAPH 27. Influence of photoperiodic effect of simulated sowing days on flowering (Section 6.4.5)

TABLE 27. Influence of simulated sowing dates on dry matter yield in g per plant

Cultivar	Year	Sowing date	March 21	June 21	Sept. 21	Dec. 21
Vilmorin	1969		1.71	1.86	1.46	1.56
DZ 10–2	1969		1.33	1.44	1.28	1.37
Vilmorin	1970		12.23	12.14	11.25	14.63
DZ 10–2	1970		7.54	6.40	5.91	7.04
C 612	1970		5.44	6.34	7.04	5.80
Sovchoznyj 14	1970		15.05	16.94	12.88	18.13

6.4.5. *Photoperiodic effect of the sowing date 2*

Treatments and design

To obtain better growth and more pronounced data, a second series of sowing-date simulation treatments was set up. The treatments were similar to those in Section 6.4.4., but the plants were grown in sand with nutritive solution. An additional treatment was the inoculation with *Rhizobium* bacteria (see Section 6.7). The experiment was a replicated block trial with 8 blocks of 16 pots each. Two replicates and four sowing dates were alotted at random to the 8 cisterns. Four cultivars were investigated. Per cultivar 2 pots were inoculated and two remained uninoculated within a block.

Material and methods

The daylength was adjusted every week as in 1969 (Section 6.4.4.). The cultivars were 'Vilmorin', 'C 612', 'DZ 10–2' and 'Sovchoznyj 14'. There was only one harvest 79 days after sowing.

Results

Dry matter yield

The second year, the influence of the photoperiod on the dry matter yield was also statistically insignificant. The 1970 data suggested that the sowing date treatments of March 21 and December 21 had a slight effect. Between cultivars large differences in yield were observed (Table 27). The December treatment was favourable for 'Vilmorin' and 'Sovchoznyj 14', the March treatments favoured growth in 'Sovchoznyj 14' and 'C 612' to a lower extent, while DZ 10–12 grew best in the September treatment. The June treatment was the second best for 'Sovchoznyj 14'.

Number of days to flowering

The difference between the number of days to flowering and the number of days from pseudo-flowering to flowering was statistically significant ($P < 0.025$). The March and June sowing date treatments advanced flowering in comparison with the September and December treatments.

Vegetative growth

The data on number of leaves and plant length, both after four and after eight weeks, did not differ statistically.

Discussion and conclusions

The data on dry matter and vegetative growth appear to differ, although the difference is not enough to determine a significant effect of photoperiod on dry matter yield. The photoperiods apparently were not sufficiently distinct to produce clear differences. In general, the cultivars reacted slightly favourably to increasing length of photoperiod (December, March) while 'Vilmorin', 'DZ 10–2' and 'Sovchoznyj 14' produced hardly less in the June treatment. The flowering was promoted in the initial long photoperiods (June) and with an initial photoperiod of 12 h 09' increasing to 14 h 03' (March 21). This is in agreement with the favourable effect of LD on the shortening of the vegetative period (6.4.2., 6.4.3.).

6.4.6. *Influence of timing of application of supplementary light in the daily photoperiodic regime*

Treatments and design

The question arose wether the period of the day during which supplementary light was applied, had some influence on the effectiveness of the photoperiod with regard to the chickpea. For practical reasons, 50% of this light was distributed before the natural day, and 50% after the natural day. For all treatments except 9 h-days, a kind of dawn was created and an abrupt transition from light to dark and vice versa was avoided.

In several plant species (*Pharbitis nil* Chois., *Perilla frutescens* (L.) Britt., *Glycine max* (L.) Merr. 'Biloxi' cf. TAKIMOTO and IKEDA, 1960; *Oryza sativa* L. cf. BEST, 1961), the light intensity needed to terminate the effective nyctoperiod is much lower before the natural day (dawn) than the minimum light intensity sufficient to initiate the nyctoperiod (dusk). In the morning the plant is physiologically more sensitive for light than at dusk. In the Experiment 6.4.3 three ways of applying supplementary light were investigated. If the treatments were not statistically different, they could be regarded as replicates within the experiment on the length of the photoperiod.

Supplementary light was given *a* before the natural day, *b* after the natural day, *c* in equal parts before and after the natural day. The photoperiods were 10, 12, 14 and 16 h.

Results

Dry matter yield

The effect of the different times of application of the supplementary light was not statistically significant. Table 28 shows that the reaction is small and not consistent for all cultivars.

Number of days to flowering

The vegetative growth period expressed in number of days was not significantly influenced. Only a tendency ($0.10 < P < 0.25$) could be noticed both before abortive and complete flowering. The maximum mean retardation in flowering date of the treatments *b* and *c* over treatment *a* over all cultivars was 3.4 and 5.6 days respectively. The number of nodes before flowering, was similarly influenced where the retardation amounted to 2.0 and 2.5 nodes, respectively.

TABLE 28. Data on the influence of the time, at which supplementary light was applied (*a* before natural day, *b* after natural day, *c* before + after natural day)

Data	Treatment	Cultivar 'Vilmorin'	'382'	'Beladi'	'Kitanicka 199'
Dry matter yield in g	a	11.9	5.7	11.2	11.6
	c	11.7	6.1	9.2	13.6
	b	13.8	5.7	10.8	9.8
Number of days to pseudo-flowering	a	36.1	51.4	35.0	58.0
	c	33.9	55.0	34.3	62.0
	b	34.5	53.5	36.1	65.0
Number of days to flowering	a	52.4	63.5	41.4	73.4
	c	64.3	68.0	41.6	76.9
	b	63.8	64.8	42.1	74.9

Only the cv. Vilmorin flowered much earlier when only light before natural day was given. (Table 28). In 'Kitanicka 199' pseudo-flowering was influenced by the treatments, but real flowering reacted less consistently. Since flowering in '382' was very simultaneous within each pot, the effect could be seen between blocks.

Discussion and conclusions

The time of application of the supplementary light has no statistically significant influence in this experiment, but there were differences in both directions. Thus the photoperiod experiment may be regarded as having three repetitions. The effects within various cultivars as given in Table 28 lead to the conclusion that a longer artificial dawn has a small promotive effect on flowering, though not all cultivars react similarly. During the dawn the chickpea appears to be slightly more susceptible to the influence of light. The method of giving supplementary light both before and after the natural day was satisfactory.

Observation

The leaves of the chickpea show a dormant position in the dark, as could be observed when the plants were withdrawn from the dark sheds when no supplementary light was given (nyctoperiod 15 h, photoperiod 9 h). The leaflets drooped from the rachis. The normal, planophile situation was recovered after about 20 to 40 min. In *Leguminosae* this is a rather common phenomenon (nyctinasty).

6.4.7. *General conclusions*

The chickpea is a species which reacts favourable to long photoperiods of 16 h. Differences between cultivars exist, but in general the chickpea may be defined as a plant with a moderate sensitivity to photoperiod. The vegetative period is shortened in LD, but SD (9 h) do not prevent flowering.

Because the differences in length of the photoperiod in the sowing date experiments are not large the influence of the photoperiod subsequently is moderate. In conclusion the shortening effect of LD on the length of the vegetative period and the stimulation of vegetative growth is quantitative.

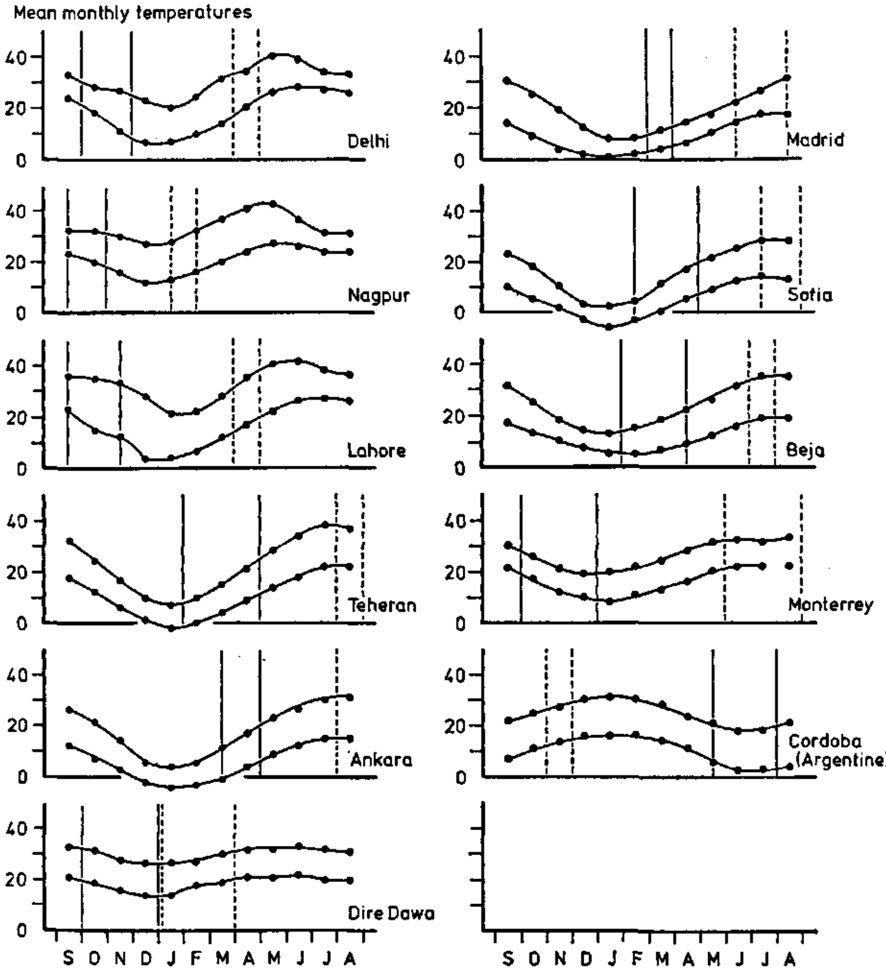
6.5. TEMPERATURE

6.5.1. *Introduction*

The effect of temperature on chickpea growth is in general only known empirically from cultivation. Data for the limits for survival and for growth have been collected from chickpeas grown under various conditions in different places. The minimum temperature tolerated depends on the cultivar. IVANOV (1933) remarked that some cultivars withstood −8 °C. KOINOV (1968) reported some lines that resisted −29 °C with a 5 cm layer of snow on the field, and −12.9 °C when no snow was present. Only recently germinated chickpeas showed this tolerance. Under a snow cover, temperatures are much higher than in the air.

In areas with occasional frostly nights, frost-resistant lines may be selected for use in breeding programmes. Frost damage is sometimes troublesome in Eastern Europe, the USSR and here and there in Northern India. POPOVA (1937) reported some frost-resistant groups and FAO (1959) tabulated three degrees of frost-resistance (resistant, moderately resistant and susceptible) for a number of cultivars.

Graph 28 shows the average montly temperature for a number of places of cultivation. The chickpea is grown as a winter crop in India, where temperature generally drop to 5°C at night (Delhi) or even lower and rise to 15–20°C



GRAPH 28. Mean monthly minimum and maximum temperatures in some important areas of chickpea-cultivation, with the average sowing period (continuous lines) and the average harvest period (dotted lines)

during the day in the vegetative period, although at sowing and germination (October, November) temperatures are higher. During flowering, the average minimum temperatures are 10–14 °C and average maximum temperatures rise to 25–31 °C. During ripening (March, April) night temperatures do not drop below 14 °C and maximum day temperatures may rise to 35 °C. In the Indian summer (May, June), beofre the monsoon rains, the chickpea fails to flower, even when under irrigated conditions a certain growth is achieved. Flowering is very poor or absent in humid tropical zones and fruit-setting in humid temperate zones is poor. PAPADAKIS (1966) classified the chickpea as a winter legume, supporting an average minimum temperature of the coldest month of −2.5 °C to −7 °C and growing at an average temperature of the coldest month between 8 °C (minimum) and 22 °C (maximum). According to ESHEL (1967) the combined data on temperature and daylength are negatively correlated with the length of the vegetative and generative periods. When sown in June (average daily temperature of 25 °C), the chickpea did not flower in Israel. In our greenhouses, the temperature for the experiments did not drop below 18 °C at night and growth was satisfactory. The influence of temperature on branching was investigated by HUGON (1967). Basal branching was stimulated at temperatures of 18 °C (day) to 14 °C (night) or at a constant temperature of 10 °C. Low temperature suppress branching in darkness, high temperatures (26 °C) suppress branching in the light.

The most common way to manipulate the temperature in an arable crop is to alter the sowing date. Most authors (KOINOV 1968, BRYSSINE 1955, SEN 1964, for further references see 5.3.3) have recommended to sow early so that the vegetative period was long. Sometimes it was better to delay sowing to prevent diseases. The pre-winter sowing in Bulgaria offered no advantage over early sowing in spring. Average daily temperatures over 22 °C seemed less favourable.

Artificial vernalization of seeds is rarely applied on a large scale to meet the low temperature requirements of field crops such as wheat. This is only feasible in highly developed areas with organised agriculture. The reaction of the chickpea to vernalization was investigated in India, where this crop is normally associated with wheat.

KAR (1940) found no effect on flowering when vernalization treatments were carried out before sowing. PAL and MURTY (1941) reported earlier flowering in two out of four cultivars. Under Indian summer conditions vernalization hastened flower bud formation. PILLAY's investigations (1944) suggested that vernalization may advance flowering of chickpea by two to three days, after storing germinated seeds at 0–2 °C for two weeks. No difference in dry matter output was observed. CHAKRAVARTI (1958) also found a slight advancing effect on flowering after vernalization. His more recent studies (1964) revealed a more pronounced effect. The first flower appeared about four nodes earlier than in the control. CHAKRAVARTI postulated the presence of two groups of substances; one for the control of growth and one for the control of flowering and yield. A better growth during the first six weeks was followed by a declining growth and lower final dry matter yield than in the unvernalized control plants.

After vernalization NANDA and CHINOY (1969) found an advance in the formation of flowers buds and in the growth of the branches, especially under SD, while the number of branches was reduced. MATHON (1969) classified the species as not needing cold for its development. It may be concluded that a definite influence of vernalization on production and earliness has not yet been proven. Only small effects, both positive and negative, have been found, Artificial vernalization is at the moment too expensive and too delicate for most regions cultivated with chickpeas. Low temperatures during early growth in Iranian and Mediterranean spring indicate that chickpea withstands cold. Apparently vernalization is not indispensable.

In order to define optimum temperatures for certain stages of development in chickpea several investigations were carried out.

6.5.2. *Optimum temperature for germination*

Treatments and design

The INTERNATIONAL RULES FOR SEED TESTING (1966) gave a constant temperature of 20°C or a daily amplitude of 20–30°C as optimum for seed germination of *Cicer arietinum*. A germination test was carried out at the Government Seed Testing Station at Wageningen. Ten temperatures, seven constant ones and three with a daily amplitude were studied for verification. A cultivar of Mediterranean origin was used. The seeds were similar to those of 'Vilmorin': large, wrinkled, and creamy white. Per temperature four replicates of 25 seeds were tested.

Materials and methods

The seeds were germinated between filter paper of 2 mm thickness on the Copenhagen germination tables of the Seed Testing Station. Each replicate was placed in a zinc rack. Strips of filter paper hanging in thermostatically controlled water baths on the germination tables provided sufficient moisture. The investigated temperatures are given in Table 29. Each day counts were made on normal and abnormal seedlings. The 5th and 8th day after the beginning of the experiments were considered as the limits for a good germination. Germination was considered as normal when healthy roots of 15–20 mm were produced. The top layer of paper was removed after reasonable germination.

Results

The results are given in Table 29. It is shown that the cultivar has a reasonable germination within a range of 15°C to 30°C. The optimum temperature for germination was a constant of 20°C (identical to the data given by the Rules) or an intermittant one of 15°C to 25°C (the Rules give an amplitude of 20°C to 30°C).

Discussion and conclusions

A fairly wide range of temperatures is suitable for germination of the chickpea. Optimum temperatures, as found in my investigations, are fairly well met in

TABLE 29. Data on the germination of chickpeas at different temperatures: percentage of germinated seeds removed daily

Temp.	Days after the start of the experiment								
	3	4	5	6	7	8	9	10	total
10°C	–	–	–	1	–	1	14	–	16
15	–	–	–	48	27	12	8	–	95
20	–	–	–	90	8	1	–	–	99
15–25	–	–	–	90	4	5	–	–	99
25	–	12	–	80	–	–	–	–	92
20–30	2	–	30	33	16	8	–	–	89
30	–	3	–	80	6	6	–	–	95
25–35	–	–	30	17	20	13	–	–	80
35	3	15	–	45	8	11	2	–	84
45	–	3	–	12	–	2	2	–	19

India, but not in Iran, Ethiopia and the Mediterranean growing area. In regions with night temperatures lower than 15°C, the emergence of plantlets will last proportionately longer, although soil temperatures do not generally reach temperatures as low as the minimum air temperature. Under a layer of snow the germination is arrested and recommences after arise in temperature. When soil temperatures reach 35°C, which occurs during daytime only, germination of chickpeas is less favourable but still reasonable. Differences in the optimum temperature range for germination may exist between cultivars.

6.5.3. *Influence of daily temperature amplitudes*

Treatments and design

Chickpeas, like most plants are subject to and grow better under conditions with a certain daily temperature amplitude. An investigation was carried out to study to which extent of the amplitude is important. Chickpeas were grown together with three other *Leguminosae* in two Latin square designs. Two controlled growth rooms contained a Latin square each. A different amplitude was applied in each room. Since tropical *Leguminosae* were also studied, the mean temperature was relatively high for chickpeas.

Material and methods

The amplitudes chosen were 6° and 12° around a daily mean temperature of 26°C, so that the temperature treatments were 23–29°C and 20–32°C. The rooms were conditioned to a 'square' climate, e.g. the temperature was kept constant for 12 hours and subsequently switched over to the other temperature. The photoperiod coincided with the thermoperiod and was maintained for 12 h. Relative air humidity was kept at 75%. The light source consisted of 16 luminescent tubes per growth room, at about 60 cm above the plants. The plants (Mediterranean type of chickpea as in section 6.5.2.) were grown in sand and nutritive solution, except 10% china clay was added to the medium. There was one harvest 36 days after sowing.

Results

The dry matter yield differed statistically between the two treatments ($P < 0.05$). The dry weight per plant was 0.68–0.81 g (mean 0.74 g) for the small amplitude, while the dry weight at the large amplitude varied between 0.67–0.70 g (mean 0.69).

Discussion and conclusions

The differences were small and overlapped between the treatments, so that the chickpea can be considered slightly affected by the extent of the amplitude. The amplitudes in the 'square' climate account for much higher amplitudes under natural conditions (WENT, 1957). Under natural conditions the daily amplitude can be high (see Graph 28). From my experiments it was concluded that a small amplitude was more favourable than a large one, consequently the small one was chosen. However, for easier adjustment and a clear difference, amplitudes of 8 °C were maintained throughout the temperature experiments.

6.5.4. *Initial investigation on the effects of temperature*

Treatments and design

To obtain initial data on the effect of two temperatures in the vegetative period a trial was carried out in the growth rooms. Eight weekly harvests were taken to establish plant length, number of leaves and dry weight. In each growth room, two cultivars were placed in a Latin square of 4 × 4 pots, with duplicate treatments inside the square. After the first harvests the pots were resown for the supplementary growth period. Each harvest was taken from two pots.

Material and methods

The temperature ranges were 18 °C (night) to 26 °C (day) and 20–32 °C. Relative humidity was 50%, the photoperiod 12 h. The cultivars 'Vilmorin' and 'DZ 10–5' were used. After the subsequent harvest of the 5, 6, 7 and 8 week-old plants, the pots were resown to obtain plants growing for a period of 4, 3, 2 and 1 week, respectively, with the purpose to save time and space.

Results

The data are shown in the Graphs 29 and 30 and Table 30. At the low temperature range (18–26 °C), both cultivars produced more dry matter, more leaves and a larger leaf area. The plants were more vigorous. The Net Assimilation Rate was calculated in mg cm^{-2} based on the mean leaf area from samples taken at the final harvest, which consisted of branches with about 25 leaves each. After 7 weeks the NAR fell in 'Vilmorin', but not for 'DZ 10–5'. The Ethiopian cultivar produced more vegetative material with the same leaf area. Pseudo-flowering started after 3 weeks (DZ 10–5) and 5 weeks (Vilmorin) for both temperatures. No real flowering took place in 'Vilmorin' before the last harvest. Flowering in 'DZ 10–5' was hastened by one week at the low temperature and started 6 weeks after sowing.

Discussion and conclusions

At the same light intensity, the low temperature range appeared more favourable for growth and flowering. The development of the leaf area was strikingly larger at low temperatures. The cv. Vilmorin appeared to draw from the reserves in the seeds even after two weeks. The data on the cv. DZ 10–5 (brown seeded) are not in agreement with the lower photosynthetic activity of 'DZ 10–2' (a black-seeded cultivar from the same habitat) when compared with 'Vilmorin' (see Section 6.3.3). In the present trial, the Ethiopian cultivar produced more dry matter with the same leaf area.

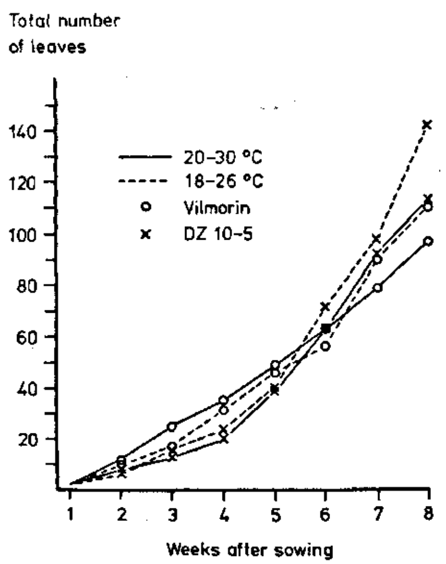
6.5.5. *Effects of 6 temperature ranges on early growth*

Treatments and design

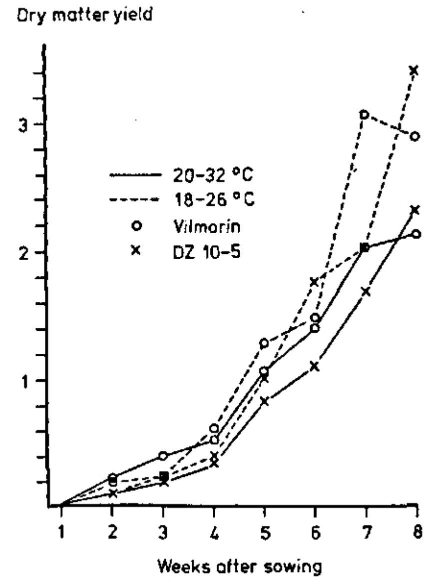
To obtain reliable comparative data on growth and flowering, the trials in Sections 6.5.5. and 6.5.6. were set up. The object was to find optimum temperatures for development under controlled conditions, this trial had not been carried out before. Six temperatures were applied to one cultivar and two lines out of a landrace-sample. Each of the six growth cabinets contained four pots.

Material and methods

With intervals of 3 °C between the mean temperatures, six temperature ranges were applied in the growth cabinets (relative humidity 50%, daylength 14 h, given by 12 h of HPL light, and 2 h of low-intensive light). The lowest range



GRAPH 29. Growth curves for 'Vilmorin' and 'DZ 10–5' at two temperature amplitudes: number of leaves



GRAPH 30. Growth curves for 'Vilmorin' and 'DZ 10–5' at two temperature amplitudes: dry matter yield

TABLE 30. Quantitative data of plants harvested 2–8 weeks after sowing, average of 2 pots with 4 plants each leaf, area calculated from samples taken at the last harvest

Cv.	Vilmorin								DZ 10–5							
Temperature Mean area per leaf	18–26 °C 6.5 cm²				22–30 °C 5.3 cm²				18–26 °C 4.4 cm²				22–30 °C 3.8 cm²			
Age in weeks	Nr of leaves	leaf area cm²	dry matter p. plant (mg)	NAR mg cm⁻²	Nr of leaves	leaf area (cm²)	dry matter p. plant (mg)	NAR mg cm⁻²	Nr of leaves	leaf area (cm²)	dry matter p. plant (mg)	NAR mg cm⁻²	Nr of leaves	leaf area (cm²)	dry matter p. plant (mg)	NAR mg cm⁻²
2	6	39.0	190	4.87	7	37.1	220	5.93	7	30.8	100	3.24	8	30.4	100	3.28
3	17	110.5	230	2.08	25	132.5	390	2.94	16	70.4	230	3.26	13	49.4	190	3.85
4	31	201.5	600	2.98	35	185.5	510	2.75	24	105.6	390	3.71	20	76.0	330	4.34
5	46	299.0	1260	4.21	48	254.4	1040	4.09	40	176.0	980	5.57	39	148.2	810	5.47
6	56	364.0	1470	4.04	63	333.9	1380	4.13	71	312.4	1750	5.61	63	239.4	1080	4.52
7	90	585.0	3060	5.23	79	418.7	2010	4.80	98	431.2	2000	4.64	92	349.6	1670	4.78
8	110	715.0	2890	4.04	97	514.1	2120	4.12	142	628.4	3400	5.25	113	429.4	2300	5.36

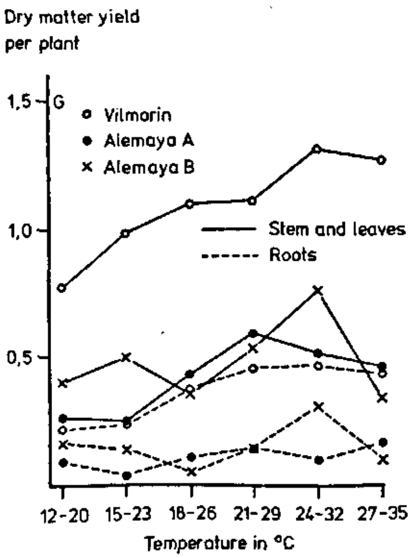
TABLE 31. Mean number of branches developed at different temperatures

Trial	6.5.5. 37 days after sowing				6.5.6. 85 days after sowing	
Type of branch	Primary		Secondary and small primary		All developed branches	
Cultivar Temperature range	Vilmorin	Alemaya	Vilmorin	Alemaya	Vilmorin	C 727
12–20°C	2.8	0.4	0.1	0.0	11	13
15–23°C	3.4	1.0	1.3	1.4	10	13
18–26°C	2.8	0.7	1.3	1.3	11	8
21–29°C	2.7	0.4	0.7	1.4	9	8
24–32°C	2.0	0.5	0.5	1.5	12	18
27–35°C	1.5	0.0	0.9	1.2	9	11

was 12°C (night) to 20°C (day), the highest one 27–35°C. Each temperature was constant for 12 h per 24 h. The cv. Vilmorin was used, and two morphologically slightly different seed types of Alemaya, Ethiopia.

Results

The harvest, 37 days after sowing, showed that the number of leaves increased with temperature. All cultivars produced 13–14 leaves on the main axis at 12–20°C, while 19–22 leaves were developed with a temperature range of 27–35°C. The stems were weaker at the high temperatures, and less primary branches developed (Table 31). Medium temperatures promoted branching. In the Ethio-



GRAPH 31. Influence of temperature on early growth, plants harvested 37 days after sowing

pian 'Alemaya', both the high and the low temperatures delayed branching. Where dry matter is concerned, both cultivars grew best at the high temperatures (21–29 °C and 24–32 °C). Values for root dry matter indicated the same trend. The differences in temperature response between the two lines of 'Alemaya' were so small that the average dry matter yield could be calculated. 'Alemaya' formed buds at the three highest temperatures even after 21 days, although real flowers appeared after 37 days in the medium temperature ranges. The lower ranges would have flowered a few days later as inspection of the then present flower buds showed.

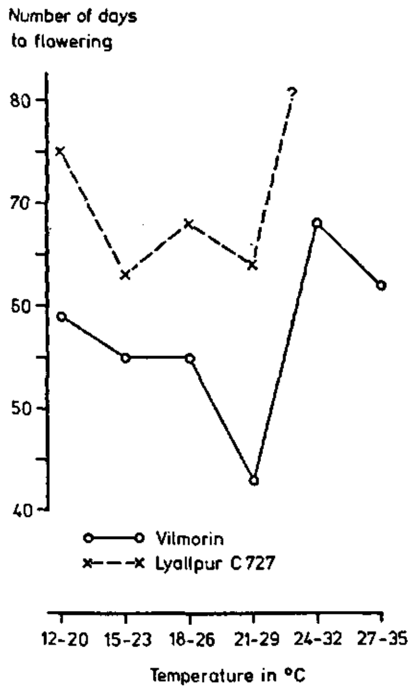
6.5.6. *Effects of 6 temperature ranges on growth and flowering*

Treatments and design

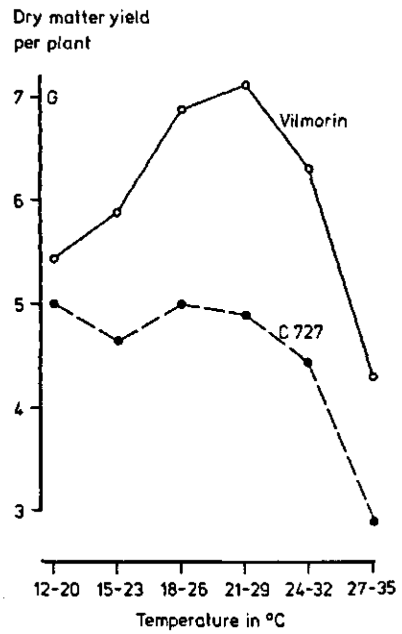
To evaluate the effect of the temperature on the stages after the vegetative growth, the trial in Section 6.5.5. was repeated under the same conditions, but harvests were taken after the first pods became ripe.

Material and methods

Except for the choice of 'C 727' instead of 'Alemaya' the conditons of the trial were identical to 6.5.5. The harvest took place 85 days after sowing.



GRAPH 32. Influence of temperature on flowering (Section 6.5.6)



GRAPH 33. Influence of temperature on dry matter yield, plants harvested 85 days after sowing (Section 6.5.6)

Results

Dry matter output differed significantly between the temperatures ($P < 0.05$). 'Vilmorin' yielded best at 21–29 °C, while the four lowest temperatures produced equally good yields in 'C 727' (Graph 33). The total number of leaves obtained at 21–29 °C and 23–32 °C were 122 and 123 leaves for 'Vilmorin' respectively, and 117 and 152 leaves for 'C 727'. At the highest temperature 'C 727' produced 150 leaves. The number of branches was somewhat irregular. (Table 31).

For flowering 21–29 °C was the most favourable range for 'Vilmorin'; for 'C 727' the ranges of 15–23 °C, 18–26 °C and 21–29 °C had a similar affect on flowering. 'C 727' did not flower at all at the highest temperatures, and flowering of 'Vilmorin' was much retarded (Graph 32). 'C 727' showed no abortive flowering. At the high temperatures the axillary buds did not even develop into flower buds and turned yellow; except for a few normal flowers, 'Vilmorin' produced mostly abortive (pseudo) flowers.

Discussion and conclusions

Although temperatures higher than 26 °C (average) induced better growth quantitatively, plant habit and flowering were negatively affected. The optimum temperature range for Vilmorin was 18–26 °C, for Alemaya 21–29 °C and for 'C 727' 15–23 °C and 18–26 °C, when all data were considered. These temperatures are higher than those during most stages of growth, especially during sowing (Ethiopia, Mediterranean) and early growth (India). An optimum temperature throughout the growth period should be lower than those mentioned, when fruit-setting is taken into consideration. This experiment showed that optimum temperatures for growth and flower development differ between cultivars and do not always coincide within the same cultivar. The fast growth at the higher temperatures is suboptimum, and weak plants are the result.

6.6. Relative humidity and other factors affecting flowering

6.6.1. *Introduction*

Cicer arietinum can grow without rain, provided soil moisture is sufficient. An excess of rain can be harmful. It is generally thought that rain and high humidity are unfavourable during flowering. Apart from poor soil aeration, which has depressive effects, flowering and especially fruit-setting are thought to suffer from rain. Irrigation and light rain can be favourable during the vegetative growth, depending on the soil conditions.

The humidity of the air is linked with the cloudiness of the sky. Rain is necessarily accompanied by clouds. The influence of air humidity, therefore, could be correlated with the amount of light. It has never been established whether the humidity of the air and the amount of light have independent effects on the flowering and fruit-setting of chickpea.

6.6.2. *Air humidity*

HOWARD et al. (1915) were the first to correlate humidity and cloudiness with low setting of seeds in chickpeas. Before this time it was general knowledge that humidity had bad effects. Since then this correlation has been generally accepted. Labelling of flowers which develop during cloudy weather revealed a low setting percentage of 0–41% compared with setting during bright weather. In rainy weather a setting of 5–45% was observed. When glass tubes were placed around flowering branches, lower setting occurred even in bright weather. It seems rather improbable, however, that only increased air humidity affected the setting process, because the temperature of the air within the glass tube may have increased considerably. Moreover mechanical damage is not excluded. KADAM (1938) reported that flowering proceeded slower in clouded weather than under sunny conditions. SEN et al. (1961) reported optimum setting when the minimum relative air humidity varied between 21% and 41%. A lower humidity, due to delayed sowing in an advanced season, resulted in poor setting. According to AZIZ et al. (1960) seed-setting on cloudy days is four to eight times lower than usual in bright weather. The optimum time for flowering at Lyallpur, where they conducted their investigations, is March. The mean relative humidity is 72%, the mean minimum temperature 8.9°C and the mean maximum temperature 24.3°C. The mean relative humidity is 90% in February and 54% in April. A similar course of humidity prevails in many chickpea areas.

The pollen collected on cloudy days appeared to be quite normal. Germination in vitro was good in a 20% sucrose solution at 25°C, but not at variable room temperatures of 10°–25°C. Germination on detached stigmas was also sufficient. AZIZ et al. (l.c.) concluded that high humidity and low temperature, as well as low humidity and high temperature, adversely affect seed-setting. It is evident that high air humidity is favourable for the development of diseases which affect the production of pods.

ESHEL (1968) established that pollen is more viable in half-open flowers than in fully open flowers. No differences in viability of pollen produced at the beginning and at the end of the flowering period were observed, so the degree of pollen viability is not related to the rate of fruit-setting during the flowering season. Pollen growth in vitro only reached 1.4 mm after 24 hours, whereas the style was about 7 mm long. In vitro some substances produced in the style are apparently lacking.

6.6.3. *Other factors in relation to seed-setting*

Several other factors in relation to the problem of low seed-setting are mentioned in literature. Self-incompatibility can cause low setting of seeds (PAL and RAO, 1940) by a failure of the ovules to develop. Chickpeas may have 2–4 ovules per ovary. When 3–4 ovules are present, rarely all ovules develop. The two ovules close to the style have more chance to develop, since the pollen tubes meet them first. Consequently two seeds are usually produced. Breeding for a higher number of seeds per pod eliminates this source of low seed-setting.

CHANDRASEKHARAN and PARTHASARATHY (1948, 1960) stated cleistogamy as a reason for failure of fruit-setting in chickpea. In cleistogamous flowers, however, pollination and fertilization take place in the closed flowers. In chickpea cleistogamy is the rule, since pollination takes place during the hooded-bud stage. On the other hand, PARTHASARATHY's concept of cleistogamy in chickpea may be understood as the appearance of abnormal undeveloped flowers. These may appear before normal flowering or under unfavourable circumstances. These abortive flowers are called 'pseudo-flowers' by AZIZ et al. (1960). Another explanation of this concept of cleistogamy may be that the non-opening of the flowers is one of the abberations that accompany partial sterility. This sterility may be of phsyiological or genetical nature. In my opinion the term cleistogamy should not be used for this kind of defects in seed-setting.

Remedial measures, tried out by AZIZ, had mostly no or negative effects. Only early sowing and fertilizer application at low rate (30 kg N/ha) increased the setting percentage. Larger rates had even a negative effect.

6.6.4. *Relative humidity and vegetative growth*

Treatments and design

To investigate whether relative air humidity alone could effect the vegetative growth, chickpeas were grown under different humidities in six growth cabinets. To assess the influence of temperature two temperature ranges were chosen. Duplicate treatments of two cultivars accounted for pots per cabinet.

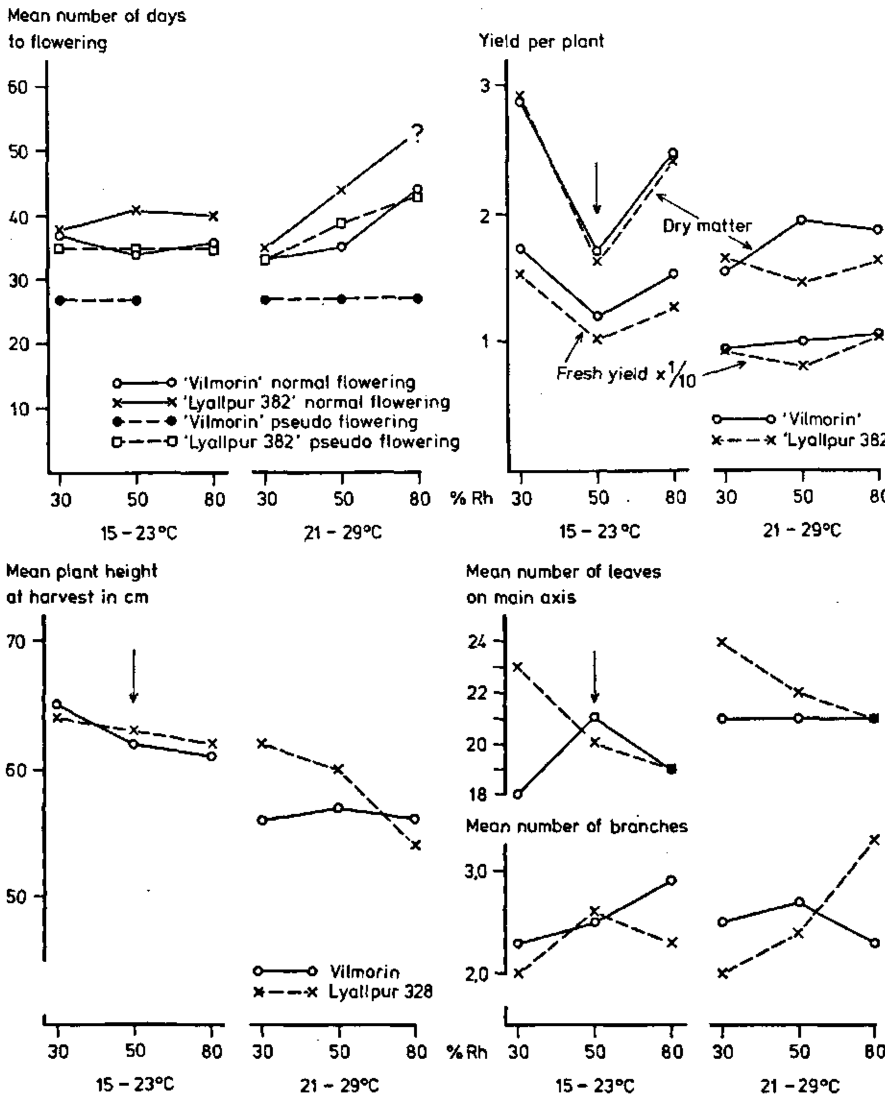
Material and methods

The relative humidities (RH) throughout the trial were 30, 50 and 80%. The temperature ranges were 23–15°C and 29–21°C. The thermoperiod was 12 h per day, the photoperiod was 16 h; 12 h of 1000 W HPL per cabinet, supplemented with 2 h of four 25W electric bulbs both before and after the day. 'Vilmorin' and '382' from Lyallpur were sown in pots with sand and nutritive solution. Observations were weekly and one final harvest took place 46 days after sowing.

Results

The data on vegetative growth and yield of fresh and dry matter showed a small promotive effect of low humidity. At 50% RH and 15–23°C the yield must have been low because of a default in light supply in the growth cabinet. 'Vilmorin' had a higher water content than '382' (dry matter contents 16.9% and 17.5% of fresh weight, respectively). The temperature effect was clear, the lower amplitude being more favourable. The high temperature range produced more leaves and more branches, except at the high RH for 'Vilmorin'. Plants tended to be longer with a low RH, but the effect was small.

Flowering was delayed at high RH, at high temperatures only. Pseudo-flowering in 'Vilmorin' was not affected, real flowering was retarded by 11 days in 80% RH compared with 30% RH, but at 15–23°C the differences were insignificant. Lyallpur '382' did not flower at harvest in the high temperature range and 80% RH (Graph 32).



GRAPH 34. Influence of relative humidity on early growth. Flowering and yield data of plants harvested 46 days after sowing (Section 6.6.4)

6.6.5. *Relative humidity, flowering and fruit-setting 1*

Treatments and design

Flowering and fruit-setting were compared in a series with the same conditions as in Section 6.6.6. Different relative humidities were applied after the flower initiation period only, to obtain plants as uniform as possible within each temperature range. The plants were harvested after ripening of the seeds.

Material and methods

In each cabinet one pot was sown with 'Vilmorin', one with 'Alemaya' type B (see 7.5.) and two with 'Alemaya' type D. RH was 50% before first flowering, 26 days after sowing. At this date the 'Alemaya' types flowered under the high temperature conditions. Observations were made on the progress of flowering, the germination of pollen in vitro, the growth of the pollen tubes in the style and the pod and seed yields.

For flowering observations one plant was chosen per pot. The flowers were labelled at the main stem just above the flower peduncle. Dates of appearance of the corolla, the opening and the fading of the flower (stages B, C and E cf. ESHEL, 1968, see Table 32) were noted.

The germination and the growth of pollen tubes were observed on object glasses with a thin layer of an agar medium, consisting of 8% sucrose, 50 ppm H_3BO_3 and 1% agar (DE BEER, 1963). A drop of warm liquid agar was put on the object glass and smeared out by another glass. The pollen was distributed on the agar by tapping gently with the staminal tube. The glasses were stored at room temperature (20°C) for 90 min. or sometimes at 30°C too, in Petri dishes with moistened filter paper. To facilitate and synchronize the counts, all pollen grains were killed after germination in the damp of formaldehyde. In some cases, when germination lasted longer, the tubes were allowed to grow for four or six hours. The germination percentage was recorded initially as a mean of five areas at a microscope magnification of 125. After the initial precise countings, only estimations were made, since no large differences were found. Only a limited number of flowers could be observed (from one observation plant per pot) to support the data at harvest.

The penetration of the pollen tubes in the style was followed with a simple colour technique. In the styles and ovaries of the flowers dissected for pollen observation the callose of the penetrated pollen tubes coloured with a drop of a resorcine blue and Martius' yellow mixture (GERLACH, 1969). The pistils were pressed between cover glass and object glass, and the examination could be carried out after five minutes. The callose pellets were stained light blue and could be distinguished easily in the whitish or greenish tissue. Flowers were collected from 9.00 to 10.00 h in the morning.

At harvest the number of pods, filled pods and seeds were recorded.

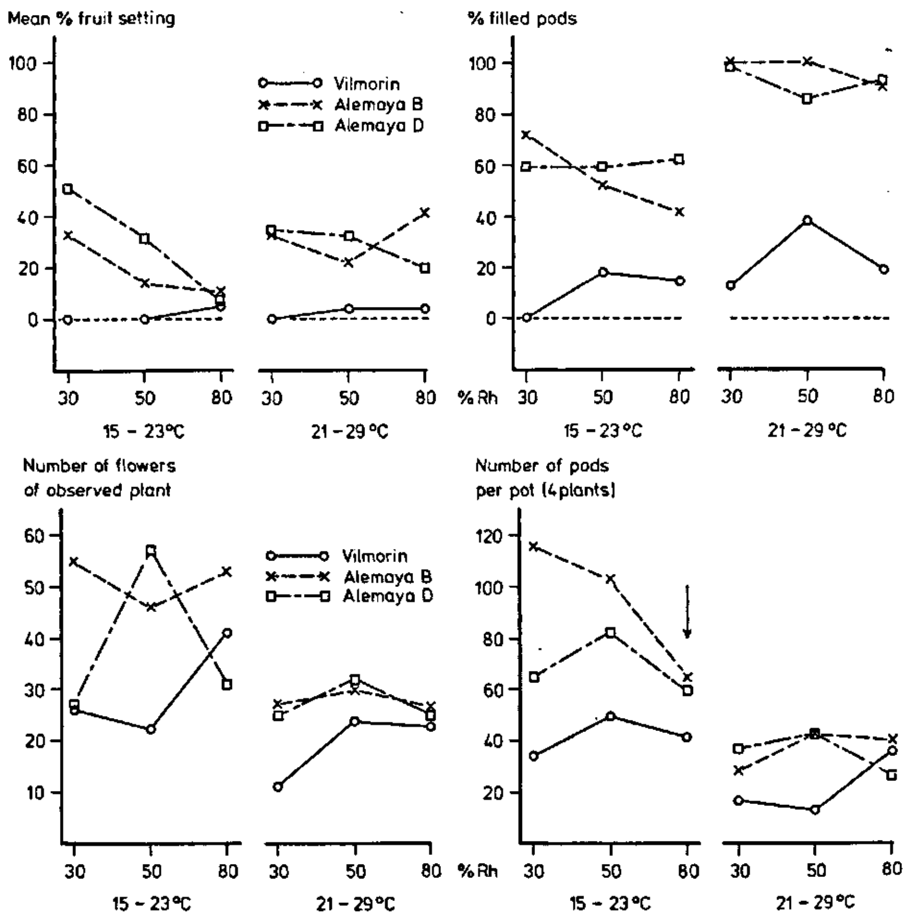
TABLE 32. Stages of flower development cf. Eshel, 1968

A	Bud closed, corolla nearly visible, stigma immature, anthers at the base of the bud
B	Bud hooded, corolla clearly showing, stigma receptive, anthers at about half the height of the style
C	Flower half-open, flag unfolded, anthers at the same height as the stigma, anthers dehisce
D	Flower fully open, corolla fully expanded, anthers shriveled
E	Flower fading, ovary starts to elongate.

Results

The results on the number of pods and seeds are shown in Graph 35. The effects of 80% RH at 15°C–23°C have been obscured by a default in the illumination. The number of flowers in 80% RH was lower than at 50% RH for 'Alemaya D'. In other treatments, 80% RH was not disadvantageous except for fruit setting in 'Alemaya D' in 80% RH at 21–29°C. Both advantageous effects of 30% RH on pod production ('Alemaya B') and disadvantageous effects were recorded ('Vilmorin', 'Alemaya D') in the low temperature range.

The results of the observations on germination of pollen in vitro and the penetration of the pollen tubes is given in Table 33. The diameter of the mature, tricoplate-formed pollen grains was about 30 μm. The pollen tubes germinated on agar had an average diameter about 25μm. During the first 90 min., the length of the pollen tubes varied between 100 and 720 μm. Depending on the flowering



GRAPH 35. Influence of relative humidity on flowering, fruit-setting and yield of plants harvested 93 days after sowing (Section 6.6.5)

phase, the germination of the pollen grains varied between 70% and 80%, except for the pollen grains taken from young anthers (bud stage, A) or fading flowers (stage E) with greyish white pollen.

A temperature influence on the germination of pollen was clear. At 30 °C the germination percentage was often better and the pollen tubes were always longer (up to 410 μm after 2 h, 500 μm after 6 h) than at room temperature of 20 °C (up to 290 μm after 2 h, sometimes only 40–80 μm). At both 20 °C and 30 °C pollen viability was satisfactory, independent of RH and temperature treatments in the growth cabinets.

The staining methods revealed that the growth of pollen tubes in the style is dependent upon temperature and flowering stage. At 15–23 °C the growth in the pistil is slower than at 21–29 °C. At stage B (hooded bud) no growth was observed, at stage C (just opened flower) no penetration had taken place further than the middle of the style, and at stage D (fully open flower) the callose pellets were seen throughout the pistil near the ovules. At 80% RH no penetration was observed in two cases, but in other cases good penetration was seen. Fading flowers (stage E) showed penetration of pollen tubes in almost every case.

The appearance of the pollen was not clearly different between RH treatments. No yellowish, watery substance was seen, as reported by HOWARD et al. (1915). The development of the flowers was completed in 3–4 days at 21–29 °C, at 15–23 °C in about 6 days.

6.6.6. *Relative humidity, flowering and fruit-setting 2*

Treatments and design

Since manipulation with the labels might have damaged the flowers to some extent, the trial in Section 6.6.5. was repeated. Only one temperature range was chosen, to obtain a replicate. Six cabinets contained two replicates of three humidities. In each cabinet four cultivars occupied a pot. Treatments were only carried out after all pots had been received a uniform treatment in a growth room in order to increase uniformity.

Material and methods

The cultivars chosen were 'Vilmorin', 'Punjab 7', 'Beladi' and 'DZ 10–2'. During the pretreatment period all pots were placed in a growth room (18–26 °C, 60% RH). Fluorescent tubes provided the light source at 50 cm above the plants for 16 h a day.

One month after sowing the pots were placed in the growth cabinets under the same temperature regime, RH was set for 35%, 65% and 85%. Light was provided by a 1000 W HPL lamp at 60 cm above the plants for 16 h a day.

The flowers and pods were marked weekly with a small tip of oil paint on the stems just above the peduncle. The sequence of flowering, expressed as the number of flowers developed per week, was noted for each plant. The mean number of pods per plant, calculated from four plants per pot, was taken for statistical analysis. 'Beladi' was harvested 75 days after sowing, 'DZ 10–2' after 77 days, 'Pb-7' after 79 days and 'Vilmorin' after 85 days.

TABLE 33. Observations on germination of pollen in vitro and in the pistil

Temperature	Relative Humidity	Cultivar	Vilmorin				Alemaya B				Alemaya D			
		Flowering stage	B	C	D	E	B	C	D	E	B	C	D	E
							% Germination in vitro							
21–29°C	30%		–	–	–	30(1)	–	–	79(1)	–	90(1)	73(3)	85(2)	–
21–29°C	50%		–	80(1)	90(2)	0(1)	–	90(1)	–	–	–	74(2)	84(3)	–
21–29°C	80%		50(1)	60(1)	–	–	–	–	–	–	–	85(2)	82(3)	–
15–23°C	30%		–	85(3)	–	40–80(3)	100(1)	–	95(3) 15(2)	0(1)	–	–	89(3)	0(1)
15–23°C	50%		–	90(4)	–	–	–	–	–	–	–	30(2)	81(3)	–
15–23°C	80%		–	80(2)	90(2)	40(2)	95(2)	–	–	–	–	–	–	–
							Penetration in the style							
21–29°C	30%		–	–	–	3(1)	–	–	2(1)	–	0(1)	–	1(1) 2(3)	–
21–29°C	50%		–	–	–	0(1)	–	–	–	–	–	0(1) 1(1)	2(2)	–
21–29°C	80%		0(1)	–	–	–	–	–	0(1)	–	0(1)	1(1)	0(1) 2(3)	–
15–23°C	30%		–	3(1)	–	3(1)	0(1)	0(1)	0(2) 2(2)	2(1)	–	–	2(2)	2(1)
15–23°C	50%		–	0(1) 2(1)	–	–	–	–	0(1)	–		0(3)	0(3)	–
15–23°C	80%		–	3(1)	–	3(2)	2(1)	–	–	–	–	–	–	–

0 = no penetration, 1 = penetration halfway the style, 2 = penetration throughout the style, 3 = pollen tubes in the ovarium (between brackets: number of flowers examined).

Note: Flowers of cv. Punjab 7, stage D, grown at 18–26°C (Section 6.6.6)) were observed to have pollen with a germination percentage of 41% (30% RH); 50% (65% RH) and 31% (80% RH). Penetration in the style was observed as 2(4); 2(4) and 2(3) for the 3 relative humidities resp.

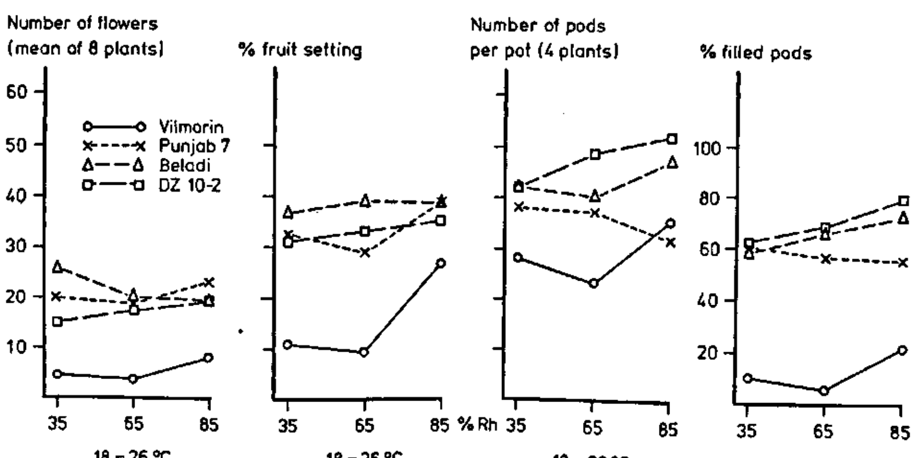
Results

The data on flowering, number of pods and fruit setting are given in Graph 36. The interaction between relative humidity and cultivars was not statistically significant. The relative humidity caused no significant differences between the number of pods per plant from different treatments. Differences between cultivars were large and statistically significant. The repetitions did not differ statistically. The highest humidity of 85% did not lower the pod-setting, from the graphs it seven seems favourable except for 'Pb 7'. The formation of flowers in 'Pb 7' tended to be lowered but the fruitsetting was not affected.

Conclusions

Low or high relative air humidities as such do not harm vegetative growth. In relation with high temperatures high RH seems to delay flowering. The last experiment showed that 'Pb 7' produced less flowers at high RH, but the percentage of fruit-setting was not affected. High RH at temperature range of 15–23°C; 18–26°C and 21–29°C are therefore not disadvantageous for fruit-setting. Various cultivars may have an optimum temperature for growth and development of flowers and these processes may be influenced by relative humidity to a smaller extent than the temperature. In 'Vilmorin', as the least drought-resistant cultivar, flowering and fruit-setting appeared to be favoured at 50% and 80% RH. Pollination and fertilization were not markedly influenced by RH. My results on pollen viability in different flowering stages agree with those of Eshel, who studied the process of pollen germination in vitro in more detail.

Therefore it is assumed that under field conditions the relative humidity of the air as such is not the cause of low setting. Low humidities in presence of suboptimum soil humidity will affect flowering by drought. However, when



GRAPH 36. Influence of relative humidity on flowering, fruit-setting and yield of plants harvested 75–85 days after sowing (Section 6.6.6)

water supply is plenty, seed-setting in the closed flower is not affected. The development of the fruits at high humidity are not affected, when soil aeration and water supply are right, and temperatures are favourable.

It remains to be seen, whether rain as such can lower fertilization. This could be investigated by spraying water on a flowering crop growing under optimum conditions. The spraying should be carried out on clear days, because the main cause of low seed-setting was found to be low light intensity, as is shown in 6.3.5. Rain may cause a temporary asphyxiation of the roots and mechanical damage to the fragile peduncles and pedicels. Damage by hailstorms and heavy rains is well known and much feared.

6.7. Soils and nutrients

6.7.1. *Soils*

Cicer arietinum is grown on a wide range of soil types. This is reflected in various plant habits. The same cultivar varies a great deal when grown on different soils. On dry, light soils the plant remains short, few branches are developed and flowering and fruiting take place within about four months. On more humid, water retaining and heavier soils the vegetative growth is abundant, a larger number of branches is produced and flowering and fruiting is retarded. On too fertile soils fruit-setting is poor, as when soil humidity is too high.

The different soil factors will be discussed separately.

Types and texture of soil

In northern India, chickpeas are generally grown on moderately heavy, grey and brown alluvial soils of the upper Gangetic Basin, preferably on the somewhat elevated parts. In Maharashtra and on the Deccan Plateau, black cotton soils are used as well as some red soils (vertisols) (Wealth of India, 1950). On the recently reclaimed foot-hill swampy soils of the Tarai Region (Pantnagar, U.P.) where fertility is good and the organic matter percentage is high, vegetative growth is too abundant. In the western part of the Punjab, Haryana and Rajasthan lighter soils, mostly sandy loams, are used successfully. Raychaudhury (1958) quoted that a range from sandy loams to clay loams is suitable for most 'grams'.

In Ethiopia, chickpeas are grown preferably on black, rather heavy soils with a good water-retention capacity (vertisols). Red soils (latosols) are cultivated in the Yerer-Kereyu Highlands.

In the Aege an region of Turkey, chickpeas are grown on vertisols or vertic soils, rich in calcium, which are situated near foor slopes of the hills, providing both good moisture and good drainage. Red and black steppe soils (vertisols) are used in Central and East Anatolia.

Structure of soil

Very little exact data are available on the soil structure requirements of *Cicer arietinum*. The crop seems to thrive well on one ot several times ploughed soils and even on unploughed soil. DATTA and KATHAVATE (1969) did some experiments to establish the effect of compaction on a sandy loam from Delhi. A bulk density of 1.60 $g.cm^{-3}$, produced by a hydraulic press resulted in the highest yield. This corresponds with a capillary colume of 40%, which is normal for sandy soils.

Soils with more or less the same solid-phase composition can be very different with regard to the rate of percolation, as reported by KANITKAR et al. (1960) from Rohtak in Haryana. If lower soil layers are compacted, resulting in defective aeration, leguminous crops grow poorly after a good germination.

Some data on the structure were given by KANITKAR et al. (l.c.). The best seed yields were attained when the plants were grown in soils with 47% aggregates of more than 2 mm diameter, 28% between 1 and 2 mm and 25% less than 1 mm. Straw yield was as good or slightly better on soils with both lower and higher content of aggragates below 1 mm and the lowest content (2%) of aggregates between 8 and 10 mm. The different proportions of soil aggregates obtained from various sites were compared in small seedbeds.

No detailed reports have been made on the influence of the physical phase distribution. Only incidental data are given about the soil on which a certain experiment was carried out. As long as no soil water surplus (anaerobic situation) exists, a wide range of soil phase distributions is suitable.

The chickpea is a deep-rooting plant. Two metres is not exceptional. Therefore soil water is extracted from a deep layer, in contrast with wheat which uses water available in the top 50 cm. For this reason mixtures can be grown together (BAINS, 1968). The power to extract soil water was measured by KENESARINA (1966). Sometimes this power is considered as unfavourable, for example, when the soil becomes too dry for the next crop. In pot trials, wilting occurred for millet, sorghum, wheat and chickpeas nearly simultaneously at the same water content of the soil (AFZAL, 1962). It may be concluded, that shallow rooting renders the chickpea less resistant to drought. Deep-rooting is apparently the main base of its drought resistance. The chickpea escapes drought. When grown in light soils, AFZAL found a lower plant-water content for chickpea in comparison with wheat. This also renders *Cicer* suitable for dry conditions.

NIJKAWAN and DHINGRA (1946) stated that yield is correlated with soil moisture content before sowing. They studied water uptake during the growing season and found the following sequence:

- first month: moisture percentage drops in the 1 m layer, most in the top 30 cm.
- Later on: water losses are minimum (colder period).
- middle January: the 0.6–1 m layer becomes drier.
- after beginning of February/March: water losses smaller again.
- at the end of the growing season another maximum in water use was recorded, especially in the top layer, resulting in a very dry surface layer of 15 cm and a second layer of 15 cm at the wilting point.

These results point to an initial need for water and higher evapotranspiration during the flowering period and at the end of the ripening. The statement sometimes made that winter rains do not influence the yield of chickpeas, is improbable.

pH

The early work on fertilizers and manures by FAULKNER in 1921, indicated that lime can increase the yield of chickpea. This suggested a favourable influence of increasing the pH of the used Lyallpur soils, but no data of the acidity of the soils were given. For 'grams' in general a pH of 6.5 to 8.0 is considered suitable (RAYCHAUDHARI 1958).

A low pH of 4.6 is most favourable for the development of *Fusarium* wilt, and less for plant growth (CHAUHAN, 1962). PALIWAL et al. (1967) established that chickpeas were fairly tolerant to high pH (8.6 to 9). At a higher alkalinity the crop suffered. DHAWAN (1951) reported correlations between the yield of chickpeas and several soil characteristics but the pH only ranged from 7.95 to 8.84. Differences in pH had no significant influence on yield. Germination and early seedling growth was not affected at a pH of 8.5, but growth of 4-week-old plants retarded (BHARDWAJ 1960a). It may be concluded that a pH of 6–9 is favourable for the yield of chickpeas, but a liberal availability of calcium adversely affects the cooking quality (BRYSSINE, 1955). There are no indications available for the lowest pH limits.

Alkalinity, salinity

Many soils or soil patches in India have alkalinity and salinity problems. Chickpeas grew quite well up to a conductivity value of 1.2 mmhos cm^{-1}, fairly well up to 1.5 and worth at a value of 5.2 in cultivation fields (PALIWAL et al., 1967). The crop is tolerant to salinity up to a sodium absorption rate of 2 (good growth) or 4.5 (moderate growth). BHARDWAJ and SARIN investigated this matter for wheat and gram and concluded that gram was not as tolerant as wheat for saline and alkaline soils. This was found empirically, but no correlations had been made previously between the reaction of seedlings in the fields and in the laboratory.

Influence on germination

Germination was not retarded when 0.05% NaCl or Na_2SO_4 based on air-dry soil was added (BHARDWAJ, 1955; 1960a) to the medium. The soil-water content is important (WAHHAB, 1959). At 15% of field capacity, chickpeas did not germinate; when the field capacity was at 75%, chickpeas tolerated a salt concentration up to 0.3% NaCl.

Germination within 15 days only took place when the soils contained little soluble salts and had a low alkalinity. A 0.6% NaCl or 0.2% Na_2CO_3 solution promoted root growth during the first 3 days (BHARDWAJ, 1964).

Influence on growth

Under moist conditions SO_4^{2-} had a more adverse effect on growth than Cl^-, especially on the number of leaves and branches. Cl^- was worse under dry conditions and suppressed plant elongation (BHARDWAJ and RAO, 1955).

Flowering was retarded by 6 days (by Na_2SO_4) and by 2–5days (by NaCl). In fields, 20 plants were selected at random from saline patches and compared with those taken from normal places in the same fields (BHARDWAJ, 1960a). The dry weight of shoot (straw) and the seed yield, seemed to be related with the pH of the 0–15 cm layer of the soil. An increase of pH gave lower yield, and growth was suppressed after 4 weeks. The percentage CO_3^{2-} was negatively correlated with the growth and yield. HCO_3^- and Cl^- also badly influenced the straw yield.

When in alkaline soils exchangeable Na^+ ions exceeded 15%, even in the absence of soluble salts, germination and growth were retarded. With a high pH, growth was affected after four weeks but not entirely arrested. There was regrowth after 4 weeks.

Influence on early seedling growth

When germinating seeds of chickpea were placed in glass tubes in the dark, 0.2% Na_2SO_4 solution suppressed root growth significantly. This salinity occures for instance in patches near Kamal (Punjab). Root length was reduced to 33% and shoot length to 49% compared with the control. These effects were more severe than for wheat (SARIN and RAO, 1956). The same was reported again in 1961, suggesting a rapid method for screening crops for resistance against salinity.

Influence on respiration

BHARDWAJ and RAO (1960b) stated that both NaCl and Na_2CO_3 caused lower oxygen-uptake. SARIN (1961) measured CO_2 production in Warburg flasks. Metabolism was retarded by 0.6% Na_2SO_4 up to 67% at 60 h after incubation began.

Influence on chemical composition

SARIN (1960) investigated chickpea seedlings grown in a 0.6% Na_2SO_4 solution. The salt solution disturbed the relative quantities of the ions present in the seedlings, suggesting the abnormalities that may occur in saline and alkaline soils. These included a toxic effect of SO_4^{2-}.

BHARDWAJ (1962) studied the reactions of carbohydrates and nitrogen in seedlings grown in a 0.2% solution of $NaCO_3$. The content of reducing sugars was lowered, total nitrogen increased but protein content was lowered. Non-reducing sugars reacted in various ways according to the cultivar. The accumulation process of protein-nitrogen and reducing sugars was thus disturbed. NaCl in a 0.6% solution in the same type of test (BHARDWAJ, 1963a) increased non-reducing sugars. Cl^- caused a decrease of water absorption of the roots, a higher ash content, and a conspicuous reduction in reducing sugars and protein-nitrogen, which may be related to the negative influence on growth.

Influence on enzymatic activity

Some enzymes have also been the subject of experiments. When germinating in Na_2CO_3 solution, polyphenoloxydase activity, a terminal oxidase in metabolism, did not increase as in control seedlings (SARIN 1961b).

NaCl raised the catalase activity measured in Warburg flasks (BHARDWAJ, 1964) whilst Na_2CO_3 lowered it.

Influence on cultivars

Differences between cultivars with regard to their tolerance for saline or alkaline soils are evident. BHARDWAJ (1960b, 1963b) noted that precocious cultivars of *C. arietinum* are more tolerant than later ones. I think this is because precocious cultivars escape the salt concentration occurring later in the season. Some of the cultivars differed in tolerance: 'NP 58' was more tolerant than 'NP 28' (SARIN 12, 1961). WAHHAB (1959) found cv. 12/34 more tolerant than 'Pb 7.'

From all the data it is rather difficult to draw a general conclusion. Suboptimum growth and yield may be partly explained by abnormal contents of inorganic and organic substances. Drought resistance in *Cicer* is not correlated with salt resistance. Wheat is more hardy in the last respects. Within *C. arietinum* differences exist in salt tolerance.

6.7.2. *Mineral nutrients and fertility*

In Section 5.6 it has been said that *Cicer arietinum* L. does not need fertile soils and does not usually respond favourably to fertilizing. Numerous experiments have been carried out in India and elsewhere in the world. In some cases fertilization improved yields, in most cases only low doses were economical. In practice, a very small acreage under chickpeas is fertilized. The general idea that chickpea need not to be fertilized, however, is untenable. Although a non-exacting crop, it is evident that chickpea removes mineral nutrients from the soil. RPIP (1969) reported for Hyderabad that 136 kg N, 31 kg P_2O_5 and 82 kg K_2O was withdrawn with a yield of 2300 kg seed, and about the same amount of straw per ha and small portions of the roots. Very little potassium will be removed if the straw remains on the field. A crude average of minerals present in a 1000 kg seed harvest is 40 kg N, 12.5 kg P_2O_5 and 2 kg Ca (see Section 10.3.1).

Nitrogen

The chickpea, as a leguminous plant, absorps aerial nitrogen by way of its root nodules (for symbiosis see Section 6.7.3.) and therefore nitrogen fertilizers cannot be expected to have much effect. Large doses of 60–100 kg per ha can even damage the crop. Vegetative growth is promoted solely at the cost of fruitsetting, although HOWARD (1923) reported no effect in this respect. Non-damaging but insignificant responses to high nitrogen application are reported by RPIP (1969). MOOLANI (1966) found a good response in West Bengal in combination with phosphorus, MORACHAN (1968), WAMANAN and DAS (1968) obtained small effects from rates of 50 kg per ha. A nitrogen deficiency shows leaves of a lighter green than usual.

Phosphorus

When phosphorus was added considerable increase of yield of chickpea was reported by ABAD (1948), ABRAHAM (1968), BALLAL and NARU (1961), PANIKKAR (1961), PARR and BOSE (1947), RAHEJA (1958), RAYCHOUDHURY (1960), SEN and JANA (1959), SEN and KAVITKAR (1960), SHARMA et al. (1962), SHUKLA (1964), SINGH (1963), VERMA (1968). Basic fertilizing of chickpea in Pantnagar and other stations where there are chickpea trials, is done mainly to maintain the existing fertility. In general rates of 30–40 kg N per ha are optimum. Economically, however, hardly any application rate seems to be paying yet, if the immediate grain yield of Bengal gram is only taken into consideration. With the present fall of the area cultivated with chickpeas in India, fertilizing may give better returns in the near future. It is a wise policy to return the phosphorus extracted from the soil annually, rather than only when cash crops are grown. The system of fertilizing cereals or cotton by fertilizing a previously grown leguminous crop is often practised, but with chickpeas not really economical. For berseem (*Trifolium alexandrinum* L.), this policy is justified if fertilizers are in short supply.

The world sollection of chickpeas at Hissar (RPIP) is now being screened on its response to high P fertilization. Most lines hardly survive a dressing of 200 kg P_2O_5 per ha. As this amount is nearly twice the maximum rates used in W. Europe it is not surprising. Lower dressings gave better results.

No effect of phosphorus fertilizers is reported by FAULKNER (1921), SEN et al. (1962), RPIP (1969) for Kanpur, Varanasi, Hissar. Adverse effects of rates higher than 50 kg per ha also occurred in Hyderabad. In Iran (Karaj) effects of P were insignificant.

Potassium

In India, response to potassium dressing has been rarely reported. It is assumed that the potassium status of the soils is fairly good. The advice of RAYCHOUHURY (cf. WAMANAN, 1960) to apply a quantity of 180–240 kg K_2O and its validity for the whole of India is questionable. SEN and KAVITKAR (1960) calculated that 122 kg K_2O per ha was available in Pusa soils, explaining the insignificant response of potassium fertilizers. SHARMA et al. (1962) and WAMANAN (1968) obtained negative effects when they applied K in their trials. The Regional Pulse Improvement Project (RPIP) (1969) quoted a negative response of K when applied with N in Hyderabad, where the availability of K amounted to 366 kg K_2O per ha. PK increased the yield with 100–200 kg. In Kanpur good effects of NK treatments were found. Local conditions make general recommendations rather unreliable.

In Mexico no fertilization with potassium is needed (CHENA, 1967), because availability is good, The advice to give potassium as chloride seems questionable, since chlorides can damage the crop (BRYSSINE, 1955). In Morocco, important quantities of potassium seem to be extracted, as is found by CALZECCHI (1953) for Italy. In Algeria, 0–50 kg K_2O was recommended by GOLUSIC (1971).

Calcium

Liming was recommended to improve yields (FAULKNER, 1921) in India. Presumably this advice concerned a rectification of the pH, which may be high (up to 9) for chickpeas. The seed coat of the chickpea, however, becomes firmer when much calcium is available, and then a longer time is needed for cooking. For a good market price, chickpeas should pieferably be grown on soils which are not rich in available calcium.

Trace elements

Several experiments to investigate the need for trace elements had only moderate success. In chickpeas, no specific symptom of shortage of any nutrient is known. JAIN and MEHTA (1965) reported the non-significant effect of giving trace elements in Sriganganagar (Rajasthan). Low organic matter of the soil was supposed to restrict microbial activity in the sandy loam and thus insufficiently convert the elements applied (MATHUR et al. 1959). Under Indian conditions, RAHEJA et al. (1959) recommended spraying instead of broadcasting the micronutrients on the field.

Boron

B uptake in chickpea plants was correlated with the water-soluble B-content of many soils in Rajasthan (BASER and SAXENA, 1967) while increasing soil-organic matter promoted B uptake. Goradu Soil (fine sandy loam) was capable of supplying an adequate quantity of Boron, 0.3–0.5 ppm. Leaf analysis showed 95 ppm B (GHANDI and MEHTA, 1960).

Manganese

Under Delhi conditions the chickpea responded to Mn, if given together with NPK, Mg, Zn and B, but on richer soils a Mn application alone resulted in a top yield. (Ghosh et al., 1964).

Zinc

In Kota (Rajasthan) MATHUR et al. reported a 14% increase in yield when 10–20 kg Zn/ha was given by broadcasting $ZnSO_4$.

Selenium

ZALKIND et al. (1968) reported a fairly high Se content (2.91 ppm) of chickpeas, grown in the main producing areas of India. In the Ukraine this value was only 0.25 ppm. Se-content is related to the disease lathyrism but except in *Lathyrus sativus* L. no difficulties have arisen. RUDRA (1952) gave other data: in *Cicer* 5.0 ppm, in *Lathyrus* 22.9 ppm.

Organic matter and manure

On the desirability of the organic matter content few reports exist. If available, stable manure is used on fields (and in pot trials). HOWARD (1923) found that leaf mould did not influence seed yield, but only vegetative growth. *Cicer* grows well on the sandy loams of Rajasthan and Western Punjab and Haryana, indicating that a low organic matter percentage does not obstruct growth of *Cicer*. The role of storing water however is very important, as droughts can be fatal in these regions.

6.7.3. *Symbiosis, introduction*

The chickpea, being a Leguminous plant, bears nitrogen-fixing root-nodules as is usually the case particularly in *Papilionaceae*. These root nodules are well known, but their effect on growth and chickpea yields is not very clear. Inoculation rarely induces much better yields.

RASUMOWSKAYA (1933) reported an increase of yield on land planted with seed inoculated with symbiotic bacteria, especially in the second year after inoculation. The chickpea-*Rhizobium* was found to be specific. In 1934, RASUMOWSKAYA established more properties of this *Rhizobium* species. Other nodule bacteria from vetches, clover and peas could not form nodules on *Cicer*. Plants and seeds had higher protein contents after inoculation and final yields were higher. IVANOV (1933) found that the percentages of protein in the seeds varied from 12.6% to 31.2% within the same cultivar. He ascribed this difference to the fact that the crop was new to many stations in the USSR with non-inoculated soils. In 1934, KONOKOTINA described the morphology and life cycle of the *Rhizobium*. Only on artificial media did the bacteria develop into rods and branched rods. In the nodules of different ages, the size and habit of the coccoid bacteriods differed; sometimes chaines of coccoids were seen.

In 1948, MARCILLA ARRAZOLA et al. reported on trials in Spain on the influence of a commercial inoculum. After inoculation the root nodules were better developed but the yields were not improved. It is likely, however, that the soil already contained the specific strain of *Rhizobium*. BRYSSINE (1955) also failed to obtain better results, most probably for the same reason.

With inoculated seed, MOODIE (1943) obtained normal plants on a nitrogen-free sand culture. Yields of grain were 37 and 74% higher, respectively on narmal and clay phases of a silt loam. Protein content of the seeds increased by 5.4% in a field trial. Immature plants increased in N content (from an average of 1.4% to 2.0%) and the roots increased in N content (from 0.8–1.0% to 3.1–3.5%). Chickpeas were considered more efficient in fixing atmospherical nitrogen than field peas and were recommended for intercropping or rotation with wheat in the USA (Washington State).

SANLIER-LAMARCK (1965) investigated how to inoculate sterile cultures most successfully. The *Rhizobium* bacteria easily formed nodules if they were administered to the seeds in a suspension of talcum powder in water. The specific strain could also form nodules on roots of lentils and alfalfa, which is in contradiction with earlier communications.

GUPTA and SEN (1962) reported on the efficiency of 12 isolates of *Rhizobium*-strains from chickpeas on the protein content of the plants. By inoculation with a suspension in sterilizes soil the protein content could be raised with percentages varying from 0.9 to 70.9% depending on the strain. Hence the different characteristics of various strains could be shown. Morphologically little difference was observed, but in vitro characteristic physiological differences were noted.

XANDRI et al. (1965) reported on the non-effectiveness of the commercial Spanish and American preparations such as Cepas Seccion (liquid) and Nitragin (*Rhizobium leguminosarum* Frank) on the yield and the protein content of chickpeas in Spain. The soil must have contained *Rhizobium* of *C. arietinum*. Some earliness in flowering and ripening seemed to be present after inoculation. The nodules of inoculated plants were poorer in nitrogen than those of non-inoculated plants, so that a slower transport of nitrogen that induces earliness, is suggested.

SEN (1966) established, that the local strains, present in the soil, were best suited to similar conditions elsewhere. When seeds were treated with imported strains, the N contents of the whole plant could even decrease. The best strain doubled the N content in six-week-old plants compared with the control. A suitable strain increased the yield of grains by 16% in one case, but no effects were detected in their N content.

CHOPRA (1967) investigated the relationship between the bacteroid-leghaemoglobin and N content of the root nodules. These were positively correlated, increasing from the 50th to the 138th day. When flowering was underway, the bacteroids and leghaemoglobin content decreased, whilst the N content remained constant.

TABLE 34. Results of inoculation trials (from literature)

Author	Experiment	Seed yield		Seed protein-content		Plant protein-content	
		more	less or same	more	less or same	more	less or same
RASUMOWSKAYA (1933–34)	field	×		×		×	
IVANOV (1933)	field			×		×	
MOODIE (1943)	pot						
	field	×		×		×	
MARCILLA ARRAZOLA (1948)	field		×				
GUPTA and SEN (1962)	pot					×	
XANDRI TAGÜENA (1965)	field		×		×		×
SEN (1966)	pot					×	
	field					×	
KATTI (1968)	field local strain	×		×		×	
	exotic strain		×		×		×
REWARI (1970)	field	×					

KATTI (1968) studied the effect of inoculation of chickpeas under various conditions, and found that non-inoculation combined with a rate of 22.4 kg of N per ha gave a higher number of flowers on red sandy loam, while alluvial clay loam produced better plants when inoculation was combined with a rate of 44.8 kg of N per ha.

GUPTA and KAUR, 1969, found abnormally large, functional nodules when *Cicer* was grown on virgin land. Their diameter was 3–4 cm. REWARI (1970) reported a 60% increase on farmers' field in Mysore. Probably no bacteria were present previously, since chickpea cultivation in this state is less important. A survey of results of inculation trials is given in Table 34.

6.7.4. *Symbiosis, systematic classification of the specific Rhizobium*

It is difficult to classify systematically the *Rhizobium* bacteria specific to *Cicer arietinum*. In *Rhizobium*, FRED et al. (1932) described six species, covering the six main cross-inoculation groups within 16 of the most important crop plants. A *Rhizobium* strain of one cross-inoculation group can form nodules on any legume species of the group, but not on others. The chickpea-*Rhizobium* was tentatively placed in the pea-group, *Rh. leguminosarum* Frank, but a foot-note revealed that the chickpea bacteria do not belong in this group. RAJU (1936) tested many strains of nodule bacteria and leguminous plants, and he came to the conclusion that the symbiotic bacteria of the chickpea belong in a separate group, the *Cicer*-group. No cross-inoculation was found, which agrees with the results of RASUMOWSKAYA (1934), but not with those of SANLIER-LAMARCK (1965).

Up to now, the *Rhizobium* strains of chickpea have not been raised to the rank of a species, although the invalidly published name *Rh. cicerii* (nomen nudum) occurs in the publication of MARCILLA ARRAZOLA et al. (1948).

6.7.5. *Symbiosis, own observations*

First observations

In the summer period of 1969, root nodules were collected from roots of cv. Vilmorin, grown on river sand with a Nutrifol solution. The sand was not sterilized and could not have contained specific *Rhizobium* bacteria. Consequently unintentional inoculation must have taken place by way of the seeds. Probably bacteria were present on or in the seed coat after threshing. The nodules were cut open and showed only a light pinkish colour, so that it may be supposed that they were effective to some extent. On the other cultivar of chickpea in this trial, 'C 612' from Pakistan, no nodules could be found. These seeds had been fumigated.

Treatments and design

Isolation and an increase of nodules on plants was initiated before inoculation as an additional treatment in the second trial on the photoperiodical influence of the sowing date (Section 6.4.5.). One half of the pots (2 replicates of 16 pots per sowing date) was sown with inoculated seeds.

Material and methods

Disintegrating root-nodules collected from roots of 'Vilmorin' were deposited in the top soil layer of four plastic pots, containing garden soil with leaf mould. Four cultivars, 'Vilmorin', 'Sovchoznyj 14', 'Pb 7' and 'Green Grain', were sown separately. Four control pots were not inoculated.

Isolations were carried out in Petri dishes with a medium of *Rhizobium*-agar (a yeast-mannitol agar) and grown at 28 °C. After inoculation on tubes these were stored in a refrigerator at 4 °C. In trial 6.4.5. the surface of all seeds of four cultivars, 'Vilmorin', 'C 612', 'DZ 10–2' and 'Sovchoznyj 14' were disinfected with a 3 % H_2O_2 solutions for 10 min. Agar plates were inoculated with bacteria, incubated for three days at 28 °C, and suspended in distilled water. Some talcum powder was added. The seeds were inoculated by keeping them in the suspension for 1 h 30 min. The control was treated in the same way without Rhizobia. Seeds were sown at a depth of 2 cm in the sand culture. After harvest of the shoots the top 6–7 cm layer was inspected by spraying water on top of the inclined pots.

Results

The disintegrated nodules applied in garden soil with leaf mould, induced prolific nodulation even when applied at some distance of the seeds. The control plants formed no root nodules. Because of the small number of pots no yields were recorded. On agar the isolated bacteria grew well. After storage for 6 months regrowth was sufficient. Morphologically the bacteria appeared to be of a coccoid nature, when taken from agar cultures. From young nodules ovate forms were derived.

The differences in flowering and vegetative growth between inoculated and control plants in the sand culture were not statistically significant. The roots of 2 outof 8 containers with 16 pots each, were inspected. Plants grown from the non-inoculated seeds also showed nodules (Table 35). The root nodules were similarly abundant and were restricted to the central part of the root system. Their colour was at most light pinkish, but mainly whitish.

Re-inoculation of the available *Rhizobium*-strain probably failed twice in my other experiments, because of the dry conditions of the upper 10–15 cm layer of the sand cultures in single pots. When continuously humidified from below, as took place in the containers, inoculation was successful.

TABLE 35. Occurrence of root nodules in sand-culture (own observations)

Cultivar	Control	Inoculated
Vilmorin	+ + + +	+ ± — —
C 612	+ + + —	+ + + +
DZ 10–2	+ — — —	+ + — —
Sovchoznyj 14	+ + — —	+ + + ±

+ : 3–4 nodules per plant; ± : few nodules; —:no nodules

Discussion and conclusions

Inoculation by placing nodules near germinating seeds proved to be successful. Because control plants also possessed nodules, the *Rhizobium* cells or spores most probably were spread from one pot to another through the water. It is not surprising, therefore, that no statistically significant differences could be detected between inoculated and control plants with regard to flowering and vegetative data. Moreover low effectiveness was possible because of the whitish colour and the sufficient nitrogen supply. The whitish colour of the observed nodules make a low effectiveness possible and the nitrogen supply was ample.

When inoculation is applied in the field or in pots, care must be taken that the top soil is moist. In fields this will normally be so, as the seeds would fail to germinate in dry soil.

In general it may be concluded that the *Rhizobium* strains of chickpea are highly specific. Most soils cultivated with chickpeas contain the bacteria and infection may even occur by way of the seeds. In the second and third year of cultivation in a newly occupied area, larger yields and higher protein contents may be expected than the first year. Inoculation promotes the formation of root-nodules, but its direct influences on seed yields is mostly not clear in areas where chickpeas are a common crop. When the strain is adapted to the cultivar, climate and soil, higher protein-contents can be induced. Although this is very important, the farmer cannot be expected to inoculate the seeds when no striking difference in yield between treatment and control can be shown, as with soya beans. Even when the inoculative is distributed free of charge, it might be difficult to have it used.

6.8. Effects of phytohormones

Most of the investigations on the effect of growth hormones on the chickpea have been of a pure physiological nature, in which the chickpea happened to be chosen as a test plant. The research of Hugon (1960, 1961, 1965, 1969, 1970) and Mange (1962, 1966, 1969b) concerned the effect of various substances on growth and branching. The other publications of these authors give data on chemical changes in the metabolism of the chickpea.

Phytohormones were applied by putting crystals or drops of solution on the buds, or by injection. Kinetin (0.01–0.1 ppm), adenin (0.5 ppm) and several vitamins (a.o. thiamine) lowered the degree of correlation between the reaction of cotyledonous buds or the buds of the scale leaves after removal of the primary stem. Apical dominance of the longest branch is thus inhibited by non-specific growth substances.

Gibberellic acid (GA) provoked a release of apical dominance at rates of 50 ppm only, presumably because of the inhibition of the top bud. At rates of 10–50 ppm, applied on lateral buds, the growth of the stems is accelerated without difference between lateral and primary stem. The acropetally transported 6-benzylaminopurine and kinetin in etiolated plants were more active in the removal of the apical dominance, when the apex was kept at about 1 °C for 16 h, while the rest of the plant remained at 22 °C. Basipetal transport was observed if the substances were applied near the top in the cold treatment.

Growth as such was accelerated by GA at 100 ppm. The movements of the top of the branches, as influenced by the rapid growth and the exaggerated elongation of the internodes, were faster than the control with a much larger amplitude. Apart from the elongation (in one trial 90 cm and 25 internodes against 60 cm and 21 internodes for the control), the leaf area was reduced, and the anatomy of the leaf showed a reduction of secondary elements. The reduced leaves resembled tendrils because of their incurved appearance.

Application of GA (100 ppm) increased the total sugar content, especially in the stems, slightly increased amino acid contents, and decreased total nitrogen. After treatment organic acids were more abundant in leaves and less in the stem compared with the control. It seemed probable that GA prolonged the active growth phases by an accelerated photosynthesis, since in the dark elongation was only expressed by an increase in water content and fresh weight.

RODRIGUEZ LOPEZ (1953) established that 2,4-dichlorophenoxyacetic acid depressed seed germination when the seeds were soaked for 4 h in a 2–20 ppm aqueous solution. Similar treatments with 2–5 ppm β-naphtylacetic acid and α-naphtylacetamide stimulated shoot growth. Only the cultivar 'anguloso blanco' grown for 30 days in the field after germination for 11 days, showed an increased weight especially after treatment with β-indolylacetic acid. Cultivars with coloured seeds suffered more from phytohormone treatments.

SIRCAR and KUNDI (1960) found that a root extract of water hyacinth (*Eichhornia* sp.) inhibited root growth to some extent, but produced more roots and increased plant length of the shoots of young seedlings. GA (100 ppm) was found to have no accelerative effect. However, later SIRCAR and CHAKRAVERTY (1962) showed that by spraying GA or water hyacinth extract on 40-day old plants at weekly intervals up to flowering, height was increased. GA killed the apical meristem and decreased the formation of lateral branches. Maximum earliness in flowering was obtained with GA.

Six weekly foliar sprays in the early stages of growth were investigated in pot trials by UPRETY (1968), GA_3 (100 ppm) increased height in the dwarf 'NP 58' and the tall 'NP 28' but reduced flowering, nitrogen percentage and both seed and total yield. B 995, N-dimethyl-aminosuccinamic acid, a growth retardant, reduced plant height considerably, but increased the number of branches. Especially in 'NP 28' the yield increased. Thus B 995 might be used in practice after further assessment.

6.9. REGENERATION AFTER MUTILATION

6.9.1. *Introduction on the practice of topping*

A few sources (DUTHIE, 1890; WEALTH OF INDIA, 1950) refer to the age-old practice of clipping shoot tips from *Cicer arietinum*, both for use as a vegetable and to induce better branching. SINGH, A. (1958) compared clipping with normal treatments in a field trial. Moderate clipping appeared to be beneficial for growth and seed yield, while heavy clippings induce a better root growth and nodulation. DESMUKH (1959) found no adverse effect of topping. Some cultivars ('Warangal', 'Dacca') produced a higher seed-yield, others ('D 8', 'EB 28') gave lower yields of seed and dry matter. Moreover the output of green matter is beneficial to the farmers. The control plants were higher than the topped ones.

Sometimes goats (and perhaps other livestock) are purposely allowed in the young *Cicer* crop. They nibble at the tips of the shoots and care is taken that severe mutilation is avoided. Of course this kind of grazing sometimes occurs unintentionally. Where grazing is practised the risks are usually well understood. When rainfall is likely to be scanty, clipping is not carried out. It is difficult to assess to what extent this practise still exists. I have never witnessed topping during my visit to India, and have no personal information on this matter.

In order to quantify the effects of trimming the shoots of *Cicer*, two experiments were set up. Not only clipping, but any loss of vegetative matter caused by pests, diseases or hail was simulated to assess to what extent *Cicer* is able to regenerate from these injuries.

The branching of the chickpea has been elaborately studied by CHAMPAGNAT (1952a and b) and HUGON (1967). Although the material they used was not been specified, it may be concluded from illustrations that a Mediterranean type of chickpea was used (race *mediterraneum*) with large, white, wrinkled seeds similar to those of cv. Vilmorin. The abovementioned authors distinguished a basal branching (arising from about 6 lowest nodes), and a median zone of branching, separated by about 6 nodes with inhibited buds. These types of branching are inhibited or stimulated despending on many factors such as temperature, growth energy as influenced by growth medium and light, and the influence of growth hormones.

Various types of branching exist in chickpea. It may be supposed that types different from the Mediterranean one possess other optima for stimulation and inhibition of certain types of branching.

6.9.2. *Topping Trial 1*

Treatments and design

Five treatments of clipping at different heights at different times were investigated in four replicates with two cultivars. In each pot there were four plants. The neighbouring trials were taken as control.

Material and methods

In 1969, cv. Vilmorin and cv. DZ 10–2 were sown in pots with garden soil in a hothouse. Daylength treatment consisted of 9 h of natural day and 7 h of supplementary light. Early clipping was carried out 2 weeks after emergence, medium clipping at 4 weeks after emergence and late clipping 6 weeks after emergence. Emergence took place two days after sowing. Light clipping consisted of removing the shoot above the youngest complete unfolded leaf, medium clipping consisted in halving the shoot and in the heavy treatment the shoot was removed above the second leaf (fourth node above the cotyledons). The clipping combinations are given in Table 36.

Results

Both light and heavy trimming, if carried out early, give good regrowth. The medium trimming 4 weeks after emergence, gave reasonable regrowth under greenhouse conditions and a light trimming after 6 weeks had little influence. Later heavy trimming had a very depressive effect. At harvest, 26 days after the treatment, from 'Vilmorin' only 21 % of the dry matter yield of the control was obtained and from 'DZ 10–2' only 28 %.

The number of primary branches was clearly decreased. Especially with the late heavy trimming, branching was affected. Secondary branching was promoted in 'Vilmorin' by all treatments.

The flowering in 'Vilmorin' was retarded but for late trimmings, which took place after initiation of the flowering period. In 'DZ 10–2' flowering was not retarded much. The weight of the fruits may indicate the delay in production. The regrowth after the late heavy clipping had not yet produced fruits.

6.9.3. *Topping Trial 2*

Treatments and design

To gain more precise data on the effect of the clipping of shoots in chickpea, a

TABLE 36. Data on Topping Trial 1, 70 days after sowing (average of 4 replications of 4 plants)

Treatment Cultivar	Early-light	Early-heavy	Medium	Late-light	Late-heavy	Control
		Total dry matter				
Vilmorin	2.49	2.19	1.67	1.85	0.53	2.63
DZ 10–2	1.90	1.63	1.42	0.67	0.51	(1.80)
		Dry weight of pods				
Vilmorin	0.14	0.21	0.15	0.17	0.00	0.45
DZ 10–2	1.14	1.04	0.67	0.38	0.00	(0.98)
		Mean number of days until 'pseudo-flowering'				
Vilmorin	37	41	42	32	34	29
DZ 10–2	35	35	27	27	27	
		Mean number of days until flowering				
Vilmorin	40	50	55	40	42	31
DZ 10–2	37	37	37	34	34	
		Mean number of branches (primary vs secondary and tertiairy)				
Vilmorin	2.6 5.6	2.6 5.6	3.8 6.4	3.2 6.5	2.1 2.5	4.0 2.0
DZ 10–2	4.4 2.6	3.0 4.3	3.9 4.3	5.0 2.1	2.2 1.8	

subtreatment was carried out in the constant daylength trial of 1970 (6.4.3). One treatment was carried out. The sand medium with nutrient solution was chosen to provide better conditions.

Material and methods

Over all daylength treatments, half of the pots were trimmed a fortnight after sowing. Depending on the cultivar the number of leaves on the main axis was reduced from 8–25 to 2–10. One harvest was taken 77 days after sowing. The data were analysed statistically. Since the plants were still fragile and hardly branched at the time of the clipping treatment, a shadowing effect of the control plants was absent.

Results

As may be seen from Table 37 the severe mutilation had its influence on the number ofleaves after 4 and 3 weeks, on the length of the shoot which replaced the primary shoots and ultimately on the dry matter yield at harvest. These data proved to differ statistically ($P < 0.001$). Clipping and daylength treatments tended to interact ($0.10 < P < 0.25$). After a clipping treatment amounting to 3.1 leaves and 4.4 cm, the difference in average plant length, 12.2 cm, after 4 weeks decreased to 7.8 cm after 8 weeks. Although the plants did not recuperate entirely after 56 days or 77 days, good regrowth was apparent.

The start of the generative phase was also influenced (Graphs 23, 24). The mean retardation caused by trimming was 6.1 and 5.7 days for abortive and normal flowering, respectively. The first flowers occurred on the same node of the replacing shoots as on the original ones of the control plants. The mean number of days between pseudo-flowering and normal flowering in 'Vilmorin' and '382' was retarded by 3.0 and 3.4 days, respectively, while for 'Beladi' and 'Kitanicka 199' normal flowering was advanced by 5.6 and 2.5 days, respectively. The number of nodes developed between pseudo-flowering and flowering followed the same trend. The mean number of nodes did not differ, and the number separated per cultivar differed insignificantly but with the same tendency.

Discussion and conclusions

As shown by the decreasing differences in length and leaf production, growth was promoted by topping. Flowering was retarded or advanced depending on the cultivar. Although good regrowth was present, a final effect on seed harvests can only be assessed under normal growing conditions over a couple of years. Since in practice both promotive and harmful effects have been found, the conclusion that the chickpea can regenerate under favourable growth conditions cannot be backed with more evidence. Mechanical damage in early stages can be overcome to some extent. Unlike cereals with only one terminal inflorescence, the chickpea can regenerate the productive parts by the secondary branching. Apical dominance is broken. On which node the branching will be re-initiated is a characteristic of plant type in chickpea. Also the cotyledonous buds may develop even when this branching does not normally happen.

TABLE 37. Data on Topping Trial 2 at different dates after sowing (average of 24 pots with 4 plants)

	Dry matter yielding		Plant length				Growth	
	77 days after sowing		4 weeks after sowing		8 weeks after sowing		4th–8th week	
Cultivar	topped	control	topped	control	topped	control	topped	control
Vilmorin	9.94	15.00	10.2	25.1	53.1	61.3	42.9	36.2
382	5.50	6.12	5.2	10.7	42.0	40.1	36.8	29.4
Beladi	8.84	11.87	12.7	30.2	49.9	73.7	37.3	43.5
Kitanicka 199	9.86	13.45	9.2	20.3	52.8	54.3	43.7	34.0
standard error	2.4		2.9		7.0		6.7	

	Number of leaves				Growth	
	4 weeks after sowing		8 weeks after sowing		4th–8th week	
Cultivar	topped	control	topped	control	topped	control
Vilmorin	4.8	12.6	23.4	27.3	18.7	14.7
382	3.5	9.3	22.5	23.8	19.0	14.6
Beladi	3.8	12.0	19.4	28.3	15.7	16.3
Kitanicka 199	4.0	11.9	23.5	26.8	19.5	14.9
standard error	2.1		2.1		3.1	

	Number of days to flowering				Days between flowering dates	
	Pseudo-flowering		Normal flowering			
Cultivar	topped	control	topped	control	topped	control
Vilmorin	35.2	34.5	62.0	58.3	26.8	23.8
382	54.5	52.1	68.3	62.5	13.8	10.4
Beladi	41.1	29.2	44.8	38.6	3.8	9.4
Kitanicka 199	66.3	57.0	78.3	71.4	11.9	14.4
standard error	5.6		6.7		8.4	

	Number of nodes before flowering				Nodes between flowering types	
	Pseudo-flowering		Normal flowering			
Cultivar	topped	control	topped	control	topped	control
Vilmorin	10.7	12.9	23.5	24.3	12.8	11.3
382	19.9	20.5	26.9	25.3	7.0	4.8
Beladi	11.3	11.5	12.4	14.8	1.1	3.3
Kitanicka 199	26.9	24.2	32.1	30.3	5.2	6.1
standard error	3.0		4.0		4.2	

6.10. Concluding remarks

Summarizing the data from the chapters on ecology and cultivation the following remarks can be made.

The chickpea needs high solar radiation and is clearly a quantitative LD plant. Only moderately high temperatures are needed. A daily temperature fluctuation is recommendable, but the temperature amplitude should not be too large. High relative air humidity is not harmful, but the soil should definitely not be too wet. Such a combination of ecological factors is usually found in summer at high altitudes both north and south of the equator and should therefore be considered the ecological optimum. It seems that the chickpea has not evolved to grow in conditions very different from its original habitat, or from the area of distribution of its wild relatives.

The present cultivars of the chickpea are adapted to soils of only moderate fertility. All evidence points to the chickpea being a relatively neglected crop. No cultivars have yet been selected on response to less optimum ecological conditions; the present adaption in several areas is only moderate.

The many failures of chickpea to respond to fertilizers in India are supposedly because of cultivation under suboptimum conditions (temperature). Moreover, the present cultivars are not selected for response to fertilizers.

Since breeding programmes are underway, better adapted cultivars should eventually become available. One or more reaction patterns (e.g. response to daylength, and fertilizer) in chickpea should be changed. Perhaps some achievements could be obtained in the plant type. A 'green revolution' is still far away for chickpea. It only seems to be possible by breeding locally adapted cultivars. The Russian cultivars, for instance, are relatively insensitive to the photoperiod. They are adapted to the environments of high degrees of latitude, and less sensitive to a large fluctuation in daylength. However, Ethiopian cultivars are more sensitive to the photoperiod under the temperature conditions of my trials. A generally adapted cultivar, as is the case with e.g. the IR rice cultivars seems highly improbable at present.

It thus appears that for cultivation northern India's cool winter season is only optimum for solar insolation, but not for daylength, as the radiation does not last long enough. Night temperatures in December, January and even February remain too low. However, the influence of cold nights on the physiologically effective length of the nyctoperiod has not yet been established. Afghanistan, Central Asia, Iran, Turkey and the Caucasus apparently are among the areas where the highest yields can be obtained. Proofs of this statement are the record yields obtained at Karaj, Iran. Ethiopia is suitable with a possible exception for the photoperiod, when tested under medium temperatures. The Mediterranean countries have suitable periods, but the optimum periods may be short. In general also, short-growing chickpea cultivars are needed in order to leave sufficient time for subsequent crops.

7. BREEDING

7.1. INTRODUCTION

Much of the research on the chickpea, *Cicer arietinum* L., up to the present time has been devoted to the breeding of the crop. Better cultivars may increase the yield per hectare, so that, for instance, in densely populated areas more space becomes available to expand the cultivation of this and other crops. Attention has been paid especially to breeding aspects such as collectioning, screening on yield and resistance against diseases, evaluation of pedigrees and of making new combinations. Despite these efforts, apparent from the large number of publications on the aforementioned aspects of breeding, the yields of the main producing areas have not been improved to a large extent.

Despite the alarmingly low (average) yields per hectare of 650–700 kg only, yields of 3000 kg and more have been reported on small trial plots. The highest yield recorded, 4800 kg of grains per ha, was obtained in Iran. This yield was converted from yields on a plot of 5 m^2 only (RPIP 1968). However, there is still a long way to go, before a maximum average yield of 3–4000 kg ha is reached.

Earlier research on genetics in chickpea concerned inheritance of several characteristics, that unfortunately are not of immediate use to the plant breeders (POEHLMAN and BORTHAKUR, 1969). In chickpea the qualitative characteristics, leaf type, flower colour and pod colour, are not of much economic value. Such characteristics are merely suitable for describing well a particular cultivar. On the other hand, seed characteristics are very important for the market value. The study of inheritance of quantitative characteristics, such as yield, is more complicated than that of qualitative characteristics and has been studied only recently.

7.2. GENETICS

7.2.1. *Cytogenetics, polyploidy and aneuploidy*

A good amount of work has been performed on the cytology and, especially on the basic number of chromosomes and the levels of ploidy of the chickpea. A few wild species of *Cicer* were studied, but many were not investigated for lack of fresh material in most research centres. There is not yet unanimity about the exact number of chromosomes in chickpea. In both early and recent publications the indicated numbers are 14 and 16. More recently a chromosome number of 16 has been established several times.

DOMBROVSKY-SLUDSKY (1927) and RAO (1929) found 2n = 14. DIXIT (1932a) counted 2n = 14 chromosomes for the 'desi' types of chickpea (small, brown seeds), and 2n = 16 for the 'kabuli' types (large, white seeds). In a following publication (DIXIT 1932b) a gigas mutation found in a 'desi' type population was investigated and observed to have 2n = 16 chromosomes. These gigas plants were characterized by a larger size, thicker and larger leaflets, larger flowers and pods than the normal plants. MILOVIDOV (1932), quoted in TISCHLER's list, 1937) found n = 8 and reported also 2n = 32 in tissues with both diploid and tetraploid cells.

AVDULOV (1937) and CHEKHOV (1938) reported 2n = 16 for *C. arietinum L.* and *C. pinnatifidum* Jaub. et Spach.

IYENGAR (1939) scrutinized the behaviour of *C. arietinum* and '*C. songaricum* Steph.' in somatic divisions and in meiosis.

Thirty cultivars of *C. arietinum* L. showed 16 chromosomes; '*C. songaricum*' is reported to have 14. IYENGAR compared his results with a great number of reports on cytological research in other genera of plants. He concluded that *Cicer* is an allotetraploid with a basic number of 4, and discussed evolutionary processes in this context.

AHMAD et al. (1952) investigated two local and two exotic gram types and their F 1. The chromosome number was 16 in each case. No differences in shape of the karyotype could be found with respect to the blight-resistant character of the exotic (french) cultivars. OKE (1955) reported the counting of chromosomes in endomitotic polyploid parts of the roots, (2n = 4 x = 32). In some seedlings, however, 33 chromosomes were observed.

SEN and JANA (1956) counted 32 chromosomes in a spontaneous autotetraploid *C. arietinum* with gigas characteristics.

FRAHM-LELIVELD (1957) observed the chromosome number of an Ethiopian black-seeded cultivar of *C. arietinum* and counted 14 chromosomes. Earlier, DOMBROWSKY-SLUDSKY (l.c.) reported one pair of satellites within diploid material (2n = 14). IYENGAR (1939) found 2 satellited pairs within a set of 16.

During the last decade, MEENAKSHI and SUBRAMANIAM (1960, 1962, 1963, 1966, 1967) carried out a series of investigations on mitosis of *Cicer* chromosomes, both morphologically and with respect to different staining methods. They counted 16 chromosomes, of which one pair had satellites. In rare cases these were in a tandem condition, i.e. with two satellites attached to the same chromosome, separated from each other by a constriction.

The interesting phenomenon of tandem satellites may throw new light on different opinions about chromosome numbers. The nucleoli were reported to persist during diakinesis. A case of triploidy was published with more information about the specific reactions in somatic divisions. Their most recent publication described tetrasomaty in roots of gram: tetraploid cells within diploid root (1967). Detection was easiest when the chromosome set was checked on the number of satellited chromosomes.

COBLEY (1956, 1965, following DIXIT, 1932) regarded the 'kabuli' gram as a probable different species. According to them '*C. kabulium*' (*nomen nudum*) has 8 chromosomes in haploid condition, as compared to 7 in ordinary *C. arietinum*. Counts by the other investigators mentioned do not corroborate this view. Apparently both chromosome numbers occur in both Mediterranean and Kabuli types, and Indian or 'desi' types.

RAMANUJAM and JOSHI (1941) produced the first artificial tetraploids (2n = 4x = 32 chromosomes) of *Cicer arietinum* with colchicine. Optimum survival and production of tetraploids were obtained by soaking the seeds in a 0.25% solution for 30 min. AKHTAR et al. (1954) found a 0.1% solution for 24 h more suitable. The plumule can also be treated by application of a colchicine solution on a piece of cotton wool fixed around the plumule of the emerging plant. The 4x plants showed gigas characteristics, and their growth was retarded. In the C3 generation, the initial pollen sterility of 40–80% decreased and the strains became more fertile. In some cultivars fertility even reached an acceptable level. SRIVASTAVA (1955) described several tetraploid cultivars. The 4x lines, compared with the original 2x lines, showed slower growth, larger and thicker, darker green leaflets, larger accessory cells of the stomata, and larger flower buds, flowers, pollen grains, pods and seeds.

DE et al. (1957, 1962) studied the chemical influences of colchicine treatments. The activity of several enzymes such as phosphatases, phosphorylases and dehydrogenases (increasing during germination of diploid and tetraploid lines) was lower for tetraploids.

SEN and JANA (1956) counted 2n = 32 chromosomes in a spontaneous autotetraploid with gigas characteristics.

Induced aneuploidy has been reported by THOMBRE et al. (1968). They found 2n = 17 chromosomes in one plant of the M_2 generation of a chickpea collection subjected to gamma-irradiation. In root tips only, aneuploid chromosome numbers of 18, 20 and 24 were found in cv. N 68 in addition to the number of 16 and 32 regularly found. These phenomena were called polysomaty (PHADNIS et al., 1968).

From a review of the data there seems little doubt that two numbers of chromosomes exist, which, however, are not correlated to the region of origin. This was previously considered to obstruct crossability between Indian and Mediterranean or Kabuli types, but this is not likely because of the better results obtained in the past two decades.

Recently (PODLECH and DIETERLE, 1969) the somatic number of chromosomes of *C. chorassanicum* was found to be 16. Unfortunately only a few geneticists mentioned or deposited reference material in a herbarium so that much work has a limited value only.

In tabel 38 the chromosome numbers found for the genus *Cicer* are summa-

TABLE 38. Chromosome numbers reported in the genus *Cicer* L.

C. arietinum L.	2n = 14, 16; n = 7, 8
C. chorassanicum (Bge) M. Pop.	2n = 16
C. pinnatifidum Jaub. et Spach	2n = 16
C. songaricum Steph.	2n = 14

Note: Since material from the last species originated from Kashmir, it must be referred to *C. microphyllum* Benth.

TABLE 39. Chromosome counts of recently obtained seed material of *Cicer* spp.

Species	2n	Origin	Collector	Herbarium
C. anatolicum Alef.	14,16	Erzurum, Turkey	Walther	WAG
C. bijugum K. H. Rech.	16	Turkey, no location	–	ANK, WAG
C. cuneatum Hochst.	16	Aksum, Ethiopia	Seegeler 157	WAG
C. incisum (Willd.) K. Maly	16	J. es Sheikh, Lebanon	Shaukat A. Chaudhari	WAG
C. judaicum Boiss.	16	Jerusalem, Israel	Ladiszinsky	WAG
C. montbretii Jaub. et Spach	16,24	Kaz Dağ Turkey	Baytop	ISTF, WAG
C. pungens Boiss.	14	Panjao, Afghanistan	Rechinger 18720	W

rized, in Table 39 the results of own observations are given. Countings were carried out with acetocarmine smears of root tips, and with root tips, cut in paraffin with crystal violet stain. Herbarium material of the mentioned species is deposited in the Herbarium Vadense (WAG) or other indicated herbaria.

7.2.2. *Genetic factors*

Research on the genetics of the chickpea started in 1911 at the Imperial Agricultural Research Institute at Pusa, and later, when the premises of the institute were demolished by earthquakes in 1934, transferred to Delhi. In the thirties, the chickpea was used in India in many genetic studies for detecting Mendelian segregations.

In Table 40 a summary of all genetic factors discussed in literature is given. Most crosses are handmade, often using natural or induced mutants as one of the parents. Most mutations went from dominant to recessive.

BALASUBRAHMANYAN (1951) reported 10 out of 13 mutants found by him were mutations in the dominant direction. Several characters have been investigated more than once, with sometimes different results. As mentioned previously, may characters involved have little economic value. Some additional comments on purple colours in the plant, caused by anthocyanins, follow.

I also observed that the colour of leaves and stem is mostly associated with petal colour. Purplish shades of various intensities in stem, leaflets, pedicels and ripe pods often coincide with purple flowers. Deep purple colours of the plant make some accessions in the germ plasm collections very conspicuous. There have not yet been reports the inheritance of the anthocyanin content. The nature of these colours was established by CHAUDHURI et al. (1958). The bronze mutant has a higher red and lower yellow anthocyanine content, more carotenoids and more chlorophyll than the normal green plant.

7.2.3. *Correlations and heritability*

In order to obtain higher yields one has to try to improve any characteristic which makes the chickpea more suited than before for the desired or present conditions. In 1915, HOWARD et al. listed important components that define

TABLE 40. Summary of reported genetic factors

Characters and characteristics	Allele symbol	Author
Plant habit		
– erect/prostrate	Hg/hg	Argikar, 1963
– normal/bunching mutant (erect)	Bu/bu	Singh, D., 1959
– normal/bushy	Bu/bu	Athwal and Brar, 1964
– basal branched/umbrella type	dom./rec.	Ramanatha Ayyar, 1937
– basal branched/umbrella (linked to position of leaflets Al al)	U/u	Bhat, 1951
– branching/non branching	Br/br	Ramanatha Ayyar and Argikar, 1963
– gigantism	recessive	Dixit, 1932
– one-side branching	recessive	Patil, 1959a
Stem		
– normal/giant and flat stem mutant	Fs/Gs	Singh, B., 1963
– purplish green/yellowish green	B/b	Argikar, 1963; Athwal 1964
– (pleiotropic, see flower colour)		
Leaves		
– filicoid leaf	recessive	Alam, 1935; Argikar 1952a
– tiny leaf	tlv	Ekbote, 1937, 1942; Vachani, 1942; Argikar, 1958, 1959; Singh, H. B., 1963; Athwal, 1964
– tiny leaved–2	tlv–2	Singh, D., 1959
– alternifolia	avl	Argikar, 1952c, 1958
– opposite leaflets (linked to U) (alternate leaflets (linked to u)	Al/al	Bhat, 1951
– simple leaf	slv	Ekbote, 1937, 1942; Argikar, 1959
	Slv tlv or slv tlv	Vachani, 1942
	st	Athwal, 1964
– simple leaved–2	Silv	Singh, B., 1962
	recessive	Pathak, 1964
– narrow leaf	nlv	Ramanujam, 1945; Argikar, 1959
	recessive	Pathak, 1964
(pleiotropic)	nlv	Singh, H. B., 1953
– hastate leaflets (arrowshaped)	recessive	Singh, B., 1963
– fasciculifolia	recessive	Chaudari, 1957
– normal, lanceolate leaflet/obovate (bunchy mutant)	BU/bu	Singh, D., 1959
– trifoliate (sterile)	recessive	Pathak, 1964
– quinquifoliolate	recessive	Pathak, 1964
– close leaflets	recessive	Pathak, 1964
– form of upper scale leaf monogenic		Pimplikar, 1943; Pavlova, 1959; Bhide, 1964
Colour of leaves		
– normal/bluish green	Gr/gr	Argikar, 1962
– green/pale yellowish green	Lg/lg	Balasubramanyan, 1937
– normal/bronze	Blv/blv	Bhapkar, 1962, 1963
– bronze	–	Chaudari et al., 1958

Inflorescence		
– normal single/double flower	S/s	Khan and Akhtar, 1934
– normal/double flower	Df/df	Athwal, 1964
– double flower	recessive	Nazir Ahmad, 1964
Flower colour		
– in general	C, B, P	Ramanatha Ayyar, 1936
– blue	B	Khan and Akhtar, 1934
pink (purple)	P+B	
white	P+bb or ppbb	
– normal standard/green standard	W/w	
– pink (purple)/bluish	P/p	Bhapkar, 1963
– white	recessive	Patil, 1964
– blue (sometimes associated with ovule sterility)	recessive	Singh, D., 1959
– blue	recessive	Patil, 1967
– pink (purple)/white (linked to pp)	P/p	Athwal, 1967
– pink	Sco+Bco	More et al., 1970
– salmon pink	Sco	
– blue	Bco	
– white	Sco bco	
– purple/white	dom./rec.	Khosh-khui et al., 1971
– phyllodeous flower	recessive	Singh, B., 1963
Ovule		
– ovule sterility	recessive	Singh, D., 1959
Pod shape		
– small mutant	recessive	Chaudari, 1956
– long pod/round pod	Rp/rp	Athwal, 1964
Pod disposition		
– pendant habit	Pnfl	Patil, 1967
– horizontal mutant	pdfr	Patil, 1967
– prostrate lying pods	recessive	Singh, B., 1963
Seed shape		
– irregular, granulated surface linked with yellowish-brown and reddish brown seed-coat	A+P or B+P	Singh, H., 1936
– round, smooth surface linked with bluish-brown seed-coat	A or B	
Seed coat colour	A or B	Singh, H., 1936
– bluish brown		
– A + R interaction		
– yellowish brown	P modifies A or B	
– dark reddish	A + P + D or B + P + D	
– black dots/no black dots	B/b	
– green	recessive	Argikar, 1956
– brown	Gr	Argikar, 1962
– black	$Tb_a + Tb_b$ complementary, epistatic to Gr	Argikar, 1962

– pinkish-buff/olive-buff-dark	P/p	Bhapkar, 1962
(pleiotropic)	B	Ramanatha Ayyar, 1936
– buffy brown	$F^r + T^r$ (compl.)	Bhapkar, 1963
– brown/yellow	Br/br	More et al., 1970
Cotyledon colour		
– yellow	dominant	Phadnis, 1946
– green yellow	dominant	Argikar, 1952b
– yellow/green	Gr/gr	Argikar, 1962
Seed measure		
– pleiotropic factors	B and P	Balasubramanyan, 1950
– large/small	RP, bP or bp/Bp	
– small	recessive	Chaudari, 1956
– small 12–15 factors	partially dominant	Athwal, 1967
Seed coat surface		
– rough/smooth	R/r	Balasubramanyan, 1937
– rough/smooth	Rs/rs	More et al., 1970
Disease resistance to blight	dominant	Hafiz, 1953
Sterility		
– abnormal flowers	recessive	Jagannatha Rao, 1934

the yield potential of *Cicer arietinum*, as plant habit, number of flowers setting percentage of seeds, the time of flowering and development of the root system. Weight of plants, number of seeds, size of seeds and number of primary branches were correlated with seed yield (KHAN, 1949). MIRZA (1964) concluded that for blight resistance (and therefore high yield), intense hairiness, relatively few leaflets, large pods and seeds, sparse branching and medium or early maturity were required. These characters are apparently connected with a better aeration in the leaf canopy that prevents a rapid spread of the disease. SINGH, S. (1968) confirmed a negative correlation of seed yield and leaf area and furthermore reported also on a negative correlation of seed yield and flower width. Apparently broad-shaped flowers will have larger ovaria and thus large pods, which can be disadvantageous for the seed development, as more reserves go into the pods.

BALUCH and SOOMRO (1968) investigated nine cultivars and they confirmed statistically the positive correlation between seed yield and plant height at flower initiation, number of pods per plant and seed size. A negative correlation would be expected between yield and the height of the first pods or at least the number of nodes before the first pod. Apparently a good vegative development led to the first correlation mentioned. Plant height was simply correlated with the internode length and the vegetative period was correlated with the number of nodes up to flower initiation.

The double-podded character may increase yields, but failed to do so because of a lower number of seeds per pod (NAZIR AHMAD, 1964). There was no linkage with yield components, such as branching.

In general it can be stated that early or late maturity done does not define high yields. Laumont and CHEVASSUS (1956) directed selection to low plant types with short internodes, stiff stems, quick maturity and high ratio seed: pod. The desired type was further defined by ROHEWAL et al. (1966) who postalated an increased photosynthesis by early secondary branching. In general rapid covering of the soil is important. ROHEWAL et al. measured ideographically several levels of branching, pod bearing etc. SIDDIQUE (1964) considered plant type and seed size as good parameters for yield.

SHARMA (1969) reported significant genotypic correlations of the previously mentioned characteristics, as well as the number of seeds per pod and pod length. Pod width was not significantly correlated with yield (compare the data of SINGH, l.c.).

ATHWAL and SANDHA (1967) found negative correlation between seed size and number of seeds per pod. They suggested that selection for high number of seeds per pod will counteract a high yield of large seeds. The number of seeds per pod, an important yield character in many *Leguminosae*, seems not to be positively correlated always to seed yield of chickpea.

Since rearrangement of genetical factors may occur, interpretation of correlations should be handled with care.

Hertitability of quantitative characters in chickpea has been reported in the last decade only. ATHWAL and GILL (1964) reported moderate heritability for five characters studies in three crosses (yield, 100-seed weight, branch length, number of seeds per pod and pod size). Heritability (in a broad sense) was reported by CHANDRA (1968) for setting percentage (80-85%), days to flowering (73–75%), duration of flowering (79–81%), plant height (68–73%) and primary branching (68–75%) over 4 generations.

For the number of pods per plant a high genetic advance of 31–46% was obtained in 4 generations. The environment especially influenced the variation of plant height, the secondary branching and the number of pods per plant (CHANDRA 1968). Later slightly better heritability was reported for the number of primary and secondary branching and setting percentage, which influence the number of flowers and fruits. (SANDHA and CHANDRA, 1969). However, the total yield had only a low narrow sense heritability (due to the additive effect of genes) of 20% and the expected genetic advance was about 30%. Single plant selections for branching and yield were recommended for selection progress.

SINGH (1970) concluded that the number of days to flowering and fruiting were not consistently associated with yield. The pod number, the number of seeds per pod, the seed size and the number of primary branches were the most important quantitative traits recommended for all pulses. However, he reported the unpublished results of CHANDRA (1960), who found the number of days to flowering to be one of the main yield contributing characters.

7.3. FLOWERING AND CROSSING TECHNIQUES

The chickpea has small papilionaceous flowers, the flag of which rarely exceeds a length of 1 cm. The stamens are diadelphous, nine stamens have fused filaments and are placed ventrally around the ovary, leaving the tenth stamen free, situated dorsally above the ovary. In the growth of the flower bud (see Section 6.6.) the filaments extend and the anthers deposit the pollen on the pistil when they have grown past the style. The pistil and anthers usually remain in the keel, which is frontally adnate and adherent to the dorsal margin.

Detailed data on anthesis and pollination were given by RAMANATHA AYYAR and BALASUBRAMANYAN (1935) and ESHEL (1968). Self-pollination takes place in the bud stage one to two days before the opening of the flowers, which thus are called cleistogamous. The flowers of the chickpea open on two successive days. The first day they open from about 9.00 to 15.00 h, and close at about 18.00 h. The second day they open earlier and also close sooner. They subsequently fade. Purplish flowers then turn blue.

The chickpea is a strict self-fertilizing species. Evidence for occasional cross-fertilization is very scanty. In landraces, which are mostly of a mixed nature sometimes aberrant types occur. A balanced selection pressure seems to maintain these mixtures. In the interesting Ethiopian mixed chickpea crops population studies have never been carried out. (see Section 5.11.). ESHEL (1968) obtained a 100% self-fertilization, when he grew alternative rows of different cultivars in the presence of several beehives.

Honey bees (*Apis* spp.) visit the flowers of the chickpea rather frequently. Only open flowers attract them. Flower buds are hardly suitable for bees to feed on. In India the behaviour of bees has been observed at many places, although RAMANATHA AYYAR et al. (1935) claimed that no bees were present on the crop in Coimbatore. According to these authors few or no cross-fertilizations occur in nature. Bumble bees (*Bombus* spp.) also visit chickpea flowers to collect honey and pollen. In my collection they only stayed about four seconds on the flowers. Only fully opened flowers were visited, irrespective of colour. Since self-pollination is finished in the bud stage, no effect on fertilization is possible. Therefore this easy self-pollination is an effective barrier against cross-fertilization. Even possible effects of certation of pollen from other chickpeas are unlikely because of the time-lapse of about one day. No measures are needed for geographical isolation of different lines.

The results of the artificial hybridizations are rather poor on the whole, because of the fragility of the flowers. All laborious efforts yield not more than one seed per pod and over-all setting is estimated at 15–25% only. Although sterility occurs in some mutants (SINGH, D. 1959) this is mainly a partial ovule sterility, or both male and female sterility. Curiously enough no clues on the occurrence of male sterility have been reported.

Several data are available on hybridization in chickpea. KHAN (1932) stressed the difficulties in crossing and warned against wilting if the petals were damaged. The first successful hybridizations were carried out by KHAN and AKHTAR

(1934). In India emasculation takes usually place by removing all petals and stamens with a fine pair of forceps. When the anthers open during the treatment, the flower must be discarded and the forceps 'disinfected' in alcohol.

The pollination is easily done with the staminal tube of the male parent after removal of the petals. The pollen should by yellow, somewhat sticky, but not too wet, nor greyish or creamy nor of a dry, powdery consistency. The flowers of the (hooded) bud stage have to be carefully chosen for emasculation. The manipulation is preferably carried out in the evening previous to pollination on the next morning, although emasculation can also be carried out in the afternoon. This is done at Hissar, for instance (S. CHANDRA, pers. commun.). Pollination should be carried out in clear weather. Immediate pollination is also practiced, which is customary at Nagpur (B. A. PHADNIS and M. V. THOMBRE, pers. commun.). In Israel, best results were obtained with emasculation between 6.00 and 8.00 h, immediately followed by pollination (KHOSH-KHUI and NIKNEJAD, 1971). The best stage of bud development appeared to be the hooded-bud stage, as described by ESHEL (1968). The petals have just protruded from the calyx, and the anthers are at about half the height of the style, the anthers are yellow but the pollen is not yet shed. Young buds (petals invisible and anthers green) or older and larger buds (closed buds, petals just visible, anthers at the base of the bud, turning to yellow) yielded no fruits after pollination. Apparently the pistil is not yet ripe in these stages. When pollination of buds, in a good stage, was postponed until 24 of 48 h after emasculation, no seed-set was observed. Pollen collected from fully expanded flowers (ESHEL's stage of half-open flowers) in which pollen dehiscence had taken place was most fruitful. Emasculation and pollination between 10.00 and 11.00 h or 16.00 and 17.00 h resulted in low seed-sets of 15% and 5%, respectively. When the treatments were carried out in the easy morning setting (97,5%) was successful. However non-emasculated flowers had been removed, so that there was no competition and very vigorous buds had been selected for crossing.

Normally petals are removed when buds are emasculated but KHOSH-KHUI et al. left the petals of the hooded buds intact. RETIG (1971) crossed chickpea flowers without emasculation by pollination of the hooded-bud stage of flowers. Two thirds of the seeds obtained after a setting percentage of 35, which is about the natural rate (AZIZ et al. 1960), were hybrids. As a marker, purple pigmentation (anthocyanin) was used, blight resistance was also recommended as a marker. This technique enables the breeder to increase the number of crosses per day.

Since the pedicels are very weak, the marking of the crosses is done with threads or small labels attached to the main stem. Neither muslin bags nor paper bags were considered useful, since other flowers are no longer within easy reach. Insect pollination is less probable when the petals are absent, and the pollen is not air-borne. At Nagpur and in Israel paper bags are used. KHOSH-KHUI et al. (1971) protected the flowers from sunshine by cheese-cloth screens.

More than one generation per year can be obtained by transport of material to mountanous areas or other countries, where the growth seasons differ from those in the original area. In summer, when chickpeas are not cultivated in the plains of India and Pakistan, they can be grown in hill stations or in Iran or Turkey. The use of stored, deep frozen pollen may be applicable to speed up the breeding programmes. This practice is not yet carried out and no data are available on the reaction of the pollen to storage.

Crossing at species level is in its initial stage only, and has not yet produced results at Hissar, Nagpur, Lyallpur and Jerusalem (pers. commun. S. CHANDRA, M. V. THOMBRE, A. O. SHAW and G. LADISZINSKY resp.). It is difficult to grow perennial species of *Cicer*, and wild annual species also may offer difficulties such as dormancy. For easy germination the seed coat should be removed partially (*C. anatolium*, *C. incisum*, *C. bijugum*, *C. montbretii*, *C. pungens*). *Cicer judaicum* and *C. pinnatifidum* germinate without incision provided the seed has been stored for several months. *Cicer bijugum* and *C. montbretii* seeds of the previous season react favourably after the swollen seeds had been stored in a refrigerator at 4°C for one and three weeks, respectively.

Moreover, the species related to the chickpea are scarce except for *C. pinnatifidum* (2.3.6). As 38 related species do exist in nature, it must be concluded that contact between collectors and breeders has not been good. Even in the Soviet Union, where wild species were collected during the Vavilov expeditions, no inter-specific crosses have been reported. The genetic material within *C. arietinum* might have been sufficiently rich to improve cultivars.

The hybridization at species level should be done in mountain stations, especially for species from a certain altitude. Here a collection of perennial species is more likely to survive than in the plains, or even in greenhouses, where results are poor (pers. obs., div. pers. commun.). Moreover, in India and Iran the greenhouses have to be cooled in the summer at considerable cost. The wild species may be used most conveniently as male parents. The pollen has to be collected in summer and applied to chickpea flowers of the current season or, after storage, in the next growth season.

7.4. BREEDING METHODS

7.4.1. *Present breeding research*

Nearly all research on breeding chickpeas is carried out by governmental institutions. Compared with plantation and temperate vegetable crops, this crop has been of little interest to private breeding enterprise. Occasionally a good cultivar is listed in catalogues of commercial seed-growers, e.g. the french firm Vilmorin.

The Indian Agricultural Research Institute and co-operating Agricultural Services, as well as the Pakistani Agricultural Universities produced several improved cultivars. However, none of these became very popular, as no striking differences in yield could be shown from farmers' fields, although there was some increase in yield, disease resistance and quality.

All previous work has been done on a local base. Material has been exchanged to a limited extent and results have been regularly published, but an integrated attempt to solve the problems has only recently been undertaken. The Regional Pulse Improvement Project, now at Karaj (Iran), can be considered the first extensive project to co-ordinate work on cultivars, their agricultural characteristics and breeding value in order to produce better ones. The related agricultural problems such as diseases, pests and cultivation practices are simultaneously being tackled. The RPIP previously covered Iran and India only, but extensive and useful contacts have been made with a view to improve exchange of ideas and material with other countries. The project moved to Iran in 1970. In India, the entire project is continued in the All India Co-ordinated Pulse Improvement Project, by the Indian Agricultural Research Institute together with many state agricultural departments and university agricultural faculties.

Breeding work is carried out in the following countries: most extensively in India end West Pakistan, also in Iran, and to a limited extent in Mexico. In former French North Africa breeders did good work. No priority is given to renewed efforts in breeding work, since the Mediterranean types of *Cicer* are fairly ideal in seed shape and quality. If cultivated on well fertilized plots yield up to 2,000 kg can be ontained in that region.

In the Indian subcontinent reasonably adapted cultivars have been developed so far, by hybridization (SWAMINATHAN et al. 1970). Simple line-selection of the best available cultures is no longer sufficient for paucity of resistance against diseases, but it is still an important technique when good cultivars are introduced from abroad. It is neccesary to evaluate them, and to maintain them as breeding for crossing.

Although good cultivars are available at research stations at present, even those only moderately improved are not yet extensively cultivated. Probably the increases in yield of these improved cultivars are not sufficiently obvious to persuade the farmers to buy the seeds. As in the Punjab and Uttar Pradesh the area under irrigated improved wheat is expanding rapidly, improved chickpea cultivars adapted to rainfed conditions also deserve attention.

Results of research on pulses in the USSR weie given by IVANOV et al. (1969). From more than 22 thousand accessions, collected on expeditions of VAVILOV and his collegues, some 70 improved cultivars have been released. Among these several *Cicer* cultivars are now widely used.

7.4.2 *Breeding criteria*

High yield

The first and most important objective of breeding is high yield, a complex character. For high yield many of the following characters must be combined into the most suitable cultivar for the conditions of a particular climatological zone or farmtype in relation with the cultivation methods. Introductions and progenies of crosses are screened in preliminary and advanced yield trials.

Regional adaptability

Cultivars to be grown in a certain region must be adapted to the specific climatological and edaphic factors of the habitat. Chickpeas that grow during the cool season in India and those that grow elsewhere during the summer are definitely not suited to direct cultivation in the other season and/or in another region. Within a region, cultivars are bred for irrigated cultivation and adequate rainfall conditions, while others have to be adapted to insufficiently or irregularly rainfed areas. For more humid or mountainous regions other cultivars will be necessary. Characteristics such as adaptability to drought or cold and the length of growing period are of much importance. A cultivar with a wide geographical adaptability, although it does not yet exist, would give a more uniform product over large areas. However, it is improbable that such a cultivar can be created. Moreover, when such a cultivar is cultivated over a large area, the chance of epidemics of pests and diseases is much greater than when several cultivars are cultivated.

Plant type

The chickpea may be classified in three plant types: the erect type, the semi-erect type and the prostrate type. Further classification into intermediate types is feasible. The prostrate cultivars, of which the stems are runners, are not suitable for good yields. They make less use of the space available for a canopy and are more subjected to moulds than the other types. In India the semi-erect types are best liked, because of their good coverage of the soil. Their stems and branches are ascendant but spreading. A more erect type (vertical branches) is preferred for mixed cropping. In the USSR and Bulgaria, erect types are among the most recently developed. These types are especially suited to mechanization. In Spain and Mexico, the use of erect cultivars has not yet been reported. Popova (1937) also remarked on the possibilities for mechanical harvesting in several of her botanical proles. The main source of erect habit is the subrace (= proles) *bohemicum*.

Disease resistance

In connection with regional and climatological adaptability much emphasis has been laid on disease resistance. There are no reports about the nature of the resistance (horizontal or vertical). Most of the work is still at the stage of studying the nature of pathogens (see Chapter 9). As yet completely resistant lines against wilt, *Fusarium orthoceras* App. et Wr. var. *cicerii* Padwick and blight, *Ascochyta rabiei* (Pass.) Labr., are very scarce. Table 41 summarizes the resistant cultivars and lines, most recently reported. Blight resistance is based on a dominant factor (Hafiz, 1953).

Out of 2000 entries less than 25 lines were initially resistant against wilt or blight, or against both diseases. In Delhi, even these were susceptible when inoculated severely (Jeswani, pers. commun.). At Karaj, Iran, some lines were promising against blight. Koinov (1968) claimed that cv. Plovdiv 19 was blight resistant for more than 15 years.

TABLE 41. Recently published disease-resistant cultivars and lines

	degree of resistance	reference
Blight-resistant		
Spanish, Greek, Mexican	tolerant	PUERTA ROMERO, 1964
C 235	tolerant	ATHWAL and BAJWA, 1965
VIR 32, K 273	resistant	VEDYSEVA, 1966b
Dobrudzhanski 6, Plovdiv 19	resistant	KOINOV, 1968
lines 1528, 6625, EC 26435	moderately resistant	GREWAL and PAL, 1970
E-100, De Russia 199	resistant	RETIG, 1971
Wilt-resistant		
102	resistant	MATHUR and KUREEL, 1965
G 24	resistant	ATHWAL and BAJWA, 1965
S 26	tolerant	do
C 214	tolerant	CHANDRA, pers. commun.

Screening methods are not yet uniform, and often only natural attacks of diseases are incorporated in investigations. The installation of wilt-infested plots and the use of pathogens, grown on synthetic media in the laboratory, are improving screening. The occurrence of new races of pathogens hamper the research, and environmental factors play an important role. Horizontal (polygene) resistance should be introduced by crossing from all avialable sources, although vertical resistance to one or more pathogen races may be more adequate.

Resistance to insects

Initial attempts have been made to study resistance to pests of chickpea, such as pod borers (*Heliothis* spp.) and aphids. Out if the germ plasm collection at Delhi, 50 numbers were probably resistant to pod borers, and seven were possible sources of resistance to both cutworms (*Agrotis* sp.) and aphids. The line 'C 109-1' appeared to avert bruchids (*Bruchus* spp., *Callosobruchus* spp.) from oviposition in storage by nature of the seed coat (RPIP, 1969; SAXENA et al. 1970). For further references see Chapter 9.

Quality

The nutritive value of the chickpea is an important factor by which quality is determined. The protein content, however, does not influence the market value. Determinations of the protein content and amino acid compositions (RPIP, 1969; CHANDRA and ARORA, 1968) in general are time consuming and have only recently been included in screening work. New techniques, such as DBC (dye-binding capacity, ref. in MUNCK, 1970) and colorimetry (AMIRSHAHI and TAVAKOLI, 1970) are available and may simplify the investigations. High protein contents of 29.8% are reported (CHANDRA et al. l.c.) for cv's Algeria 2444, Frontier 8, Gaddag S2 and Gram Cross A.

Characters directly influencing the market value are grain size (the larger, the better), cooking quality (a shorter cooking time requires less fuel), and colour of the seed coat (white, cream and green seeds are preferred to brown and black). For split chickpeas the colour is not so important, since the cotyledons of most types are yellow.

Other selection criteria

The photosynthesis rate varies between cultivars and therefore the most efficient cultivars could be selected. However, fixed relations between yields and photosynthesis rates are not established, and the elaborate installation needed for measurement of photosynthesis oppose direct application at this moment. Simple yield trials remain the most direct method to select superior lines, but the photosynthestic efficiency may partly explain the superiority.

The position of the leaflets in chickpea is almost ideal. The leaflets are situated horizontally, but direct themselves more or less perpendicularly to the solar radiation. A form with erect, straight leaf stalks may absorb more of the available energy of the entire canopy. The canopy, although planophile, is rather open, permitting good penetration of light.

In addition to the breeding of chickpea cultivars that mature early or late, attention should be paid to the ageing of individual leaves, especially the lowest ones. Ideal cultivars should possess leaflets, which are not shed too soon from the lowest nodes and remain productive as long as is required.

7.4.3. *Breeding systems*

Since crossing in chickpea is done by hand and is difficult, elaborate breeding systems are not easily set up. After crossing between material of two or more desirable sources, selection is often carried out on a single-plant basis in F_2 and next generations. Improvement of established cultivars is achieved by means of a system of backcrossing with material containing desirable characteristic. The methods are mass selection in the initial stage, and then line selection. Families and lines are tested in yield trials and others in F_3 to F_7. Since new genetic combinations are formed different types may occur before homozygosis is complete in the population. Thus, selection must be practised continuously and is also needed in sowing-seed production fields. Nevertheless pure chickpea-material is not difficult to obtain.

7.4.4. *Introduction of new cultivars*

According to several estimates, about 75% of the chickpeas in the main producing areas are grown from unselected local cultivars. New cultivars which yield more or have other agreeable characters, will be readily be accepted for cultivation, if only a sensible increase can be shown. The farmer does not bother to obtain sowing seed of an improved cultivar, if the advantages over the old cultivar are not very clear. Fear of failure under suboptimum conditions promotes an attachment to traditional plant material.

Although the results obtained with the present improved cultivars are less striking than those with the new creal cultivars, extension services should

PLATE 3. Ripening chickpea plants near Medina del Campo, Prov. Valladolid, Spain

encourage common farmers to use them and so ensure better yield. The agricultural services should take care of the multiplication.

In the Mediterranean and Mexico, more use is made of selected lines. Chickpeas are a comparatively new crop in several Soviet republics, and are only grown from selections and as hybrids. In Ethiopia, very recently some selections became available, and cultivars have been tested. Ethiopian peasants even grow mixtures of different seed shapes and deliver them to the market unseparated. The consumers do not care for particular types of seed.

In Spain, Morocco, Israel and Mexico cultivars are investigated for yield. In other countries such as Turkey, Tunisia and Algeria, the yields and seed types are considered as reasonable and cultivars are not screened at present. Centres for testing cultivars and local landraces are situated in India, Pakistan and Iran.

In Chapter 2 taxonomical classification was discussed in detail so that only a few remarks are made here. Cultivars can be classified in any proposed system, depending on the purpose. Many systems have been set up (SOOMRO and BALUCH, 1968). In breeding work a simple, 'special purpose' artificial classification for general use is most suited to distinguish between cultivars (HAWKES, 1970). Time is often too limited to apply the available taxonomical classifications. Unfortunately many breeding stations either use no classification at all or one of their own. New cultivars are usually released with a short description, but a complete record of all characters related to herbarium material should be de-

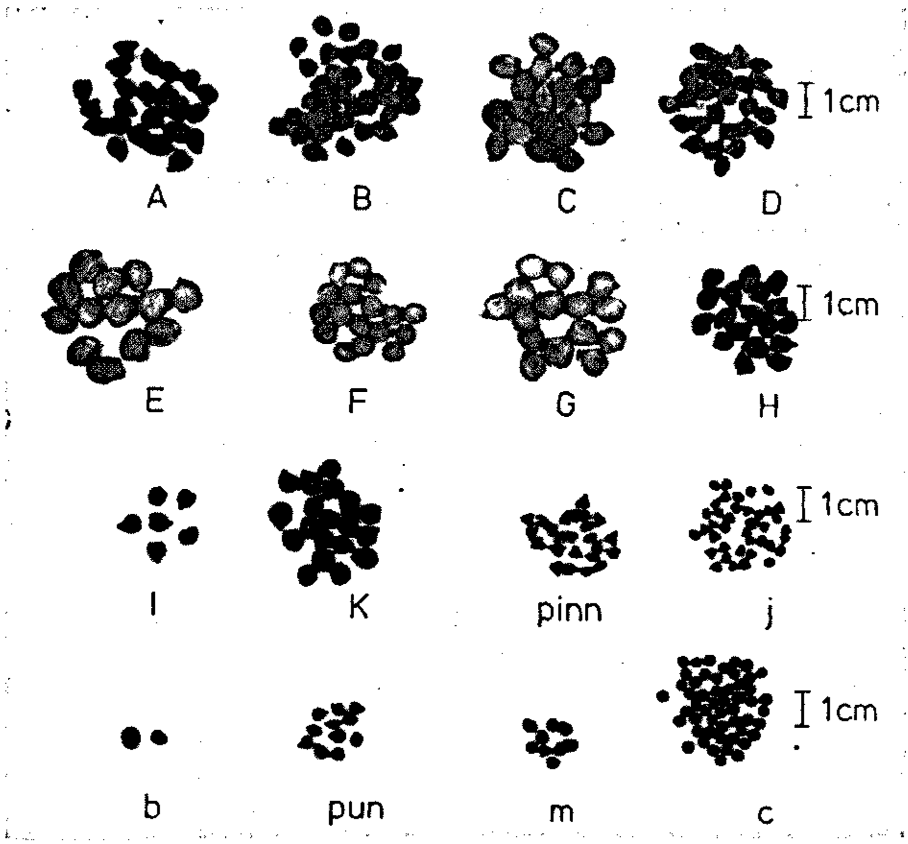


PLATE 4. Shape and dimension of some *Cicer* seeds, A-K groups of *C. arietinum* as mentioned in Table 41, A: DZ 10-2 (Ethiopia), B: JM 522 B (Ethiopia), C: DZ 10-10 (Ethiopia), D: Pb 7 (India, Pakistan), E: INRAT T 19-37-D (Tunis), F: Gibridnyj 27(USSR), G: INRA 57 (Morocco), H: Green Grain (India), I: JM 522 I (Ethiopia), K: CIC 41/64, Gatersleben, from E. Europe?, pinn: *C. pinnatifidum*, j: *C. judaicum*, b: *C. bijugum*, pun: *C. pungens*, m: *C. montbretii*, c: *C. cuneatum*

posited. Since much effort is expended on exchange of collections, the registration of origin, characters and breeding treatments should be done properly.

The entire scene of classification has been obscured by ancient and recent exchange of material and hybridization in chickpea. A geographical classification no longer offers a clear system, because many intermediate forms have been created. The cultivars of *Cicer arietinum* may be artificially arranged into the following 'types', which are based on seed characters (Table 42).

TABLE 42. Classification of chickpea on account of seed characteristics

Type	seed shape	seed size	colour of seed coat
A	irregular, angular or not	large, mostly small	black
B	irregular, not angular	small	brown
C	irregular, not angular	large	cream to dark brown
D	irregular, angular	small	brown
E	irregular, strongly grooved (brainlike)	large	cream to light orange
F	rounded	small	cream, yellow or orange brown
G	rounded	large	cream, brown or light orange
H	irregular, strongly grooved	small	green
I	irregular, lightly grooved	small	brown with mosaic patches
K	rounded	small	red brown to dark brown

Small: under 25 g per 100 seeds. E and G are referable to the 'Kabuli' types in India, E is the typical Mediterranean type. A, B, C and D are the 'desi' types in India, though mainly B and D. The difference between B and D is the presence of sharp edges in D in fully mature seeds.

The surface (smooth, rough or tuberculated) and the presence of minute black dots are not taken into account. For a more detailed classification of the seeds and other characters see HOWARD et al. (1915); SHAW et al. (1931); LAUMONT et al. (1956) and SOOMRO et al. (1968).

8 PESTS OF THE CHICKPEA

8.1. Introduction

The chickpea is not severely attached by many insect species, probably because of its rather repulsive glandular secretion. In the field the major pest is the gram caterpillar (*Heliothis* spp.); in stores beetles (*Callosobruchus* spp.) can damage the pulses. This chapter gives a short account of insect, nematode and other animal pests of the cultivated chickpea.

Pest can be controlled in the field by insecticides, but chemical control is often uneconomical. Research on resistant plant varieties and on integrated methods of control is therefore most important. Pulses in storage rooms can be fumigated.

8.2. Insect pests

8.2.1. *Gram caterpillar, gram podborer, old world bollworm etc.*

Heliothis armigera (Hübner) = *H. obsoleta* F. (*Lep.–Noctuidae*) is a cosmopolitan polyphagous insect, living on cotton, maize, tomato, cowpea, chickpea and several other plants.

Damage to chickpea varies from year to year and from area to area. In Iran up to 90% of the crop can be destroyed. In the Punjab the insect is considered of minor importance. In Delhi it is described as quite troublesome. A crop damage of 20% is not uncommon. The pest is reported to reduce yield by about 10% in France (Fagniez, 1946). It is also known in Bulgaria (Koinov, 1968a). Arellano (1965) reported *H. virescens* (F.) in Peru.

Other *Heliothis* (= *Chloridea*) species occurring on *Cicer* are *H. virescens* (F.) and *H. dipsocea*.

Life cycle

During the growth of the chickpea, the yellowish-brown *Heliothis armigera* moth lays its eggs on tender parts of the plants or on the soil. The small green caterpillars with longitudinal streaks feed on the young leaves. When they are about 2 cm long, they penetrate into the developing pods and destroy the young seeds. A hole of about 2 mm marks the entrance of the caterpillar. The attacked pod remains empty. Larval life takes 2–3 weeks. Pupation usually occurs in the soil. When it takes place in the pod, the imago remains trapped. During unfavourable seasons the pupae enter a stage of diapause. *H. virescens* and *H. dipsocea* have similar life histories, but are of less importance. They have only been reported occasionally on chickpea.

Several parasites have been reared from gram caterpillars. In Madhya Pradesh one third of the *H. armigera* caterpillars were parasited by *Campoletus perdistinctus* Vier. (*Hym., Ichneumonidae*). The female wasp deposits one egg in 2–4 day old instar larvae. Larval development takes 2 weeks. In January-February at Jabalpur the life cycle lasts 17–23 days, in March only 14 days. The adults live 7–12 days (GANGRADE, 1964). Hyperparasites, such as *Euritoma browni Crawford* (*Hym.-Euritomidae*) and *Brachymeria* sp. (*Hym.-Chaldididae*) exist.

TIKAR and THAKARE (1961) reported the parasite *Horogenes fenestralis* (*Hym.-Ichneumonidae*), apparently later listed as *Diadegma* (= *Angitia*) *fenestralis* Holmgren (THAKARE and LANDE, 1966).

Control by farming methods

To check the podborer fields should be ploughed in autumn. In areas with cold winters (Bulgaria, Turkey, Iran) the pupae are then better exposed to low temperatures. In India ploughing in the summer (May) exposes the pupae to high temperatures so that the population of pod borers is reduced in the kharif (hot rainy season) crops and the succeeding rabi (cool dry season) crops.

Chemical control

Insecticides should be applied at an early stage of attack when severe infestation is suspected. Otherwise application is uneconomical. The following insecticides have proved effective: sprays of Methylparathion and DDT at 0.1%, Malathion, Endrin at 0.02%, Mevinfos, Sevin and dusts of DDT (5%) or BHC (5%) at a rate of 2.5 kg/ha, Carbaryl at a rate of 1.3 kg/ha, Endosulfan at 700 g/ha and Supracid at 600 g/ha.

When the straw is for cattle feed, only Carbaryl and Thiodan (Endosulfan) can be used to prevent residue problems. Chlorinated hydrocarbons should not be applied.

Resistant varieties

At the Indian Agricultural Research Institute (RPIP 1968, 1969) strains of chickpeas were screened for tolerance and resistance to *Heliothis* and 50 lines were selected. These lines showed than less 5% damage of pods. Only natural infestation took place. Further screening is needed. The potassium and phosphorus levels of the plant, resulting from various rates of fertilizers, did not alter the incidence of the pod borer. Apparently the pod borer does not prefer a particular inorganic content of the plant (SAXENA, 1970).

8.2.2. *Red gram plume moth*

The moth, *Exelastis atomosa* Wlsm. (*Lep.-Pterophoridae*), which normally lays its minute solitary eggs on *Cajanus cajan*, may occasionally oviposit on chickpea. The greenish brown caterpillars feed on the pods and seeds and can be controlled in a similar way to that described for *Heliothis*.

8.2.3. *Gram cutworm, greasy cutworm*

In India these cutworms, *Agrotis ypsilon* Hufn. and *A. flammatra* (Schiff.) (*Lep.-Noctuidae*), can cause considerable damage. The moth lays its eggs on the soil around the stem base or on the lower leaves. Young larvae feed on the epidermis of the leaves, which are touching the soil. Older larvae cut the plants at ground level level and carry vegetative parts into their burrows. Pupation takes place in the soil, inside an earthen cell. This pest occurs early in the season (October) and can complete two generations during the cool period.

Control

The gram cutworm can be controlled with persistent insecticides either applied to the soil as bait or sprayed on the plants. E.g. a 5% dust of DDT, Heptachlor, Chlordane or Aldrin at 15–20 kg/ha can be used.

Resistant cultivars

In the germplasm collection at the Indian Agricultural Research Institute, New Delhi, screening yielded seven lines in the collection tolerant for *Aphis craccivora* Koch, which were free of cutworm damage in 1967–68. Verification screenings are now being carried out.

8.2.4. *Gram or pea semilooper*

The semilooper, *Plusia orichalcea* (*Lep.-Arctiidae*), is reported from pea and chickpea in India. Oviposition takes place on the plant. Pupation occurs in the soil or on the plant. The green-coloured caterpillars can defoliate the chickpea plant completely. Young pods are also eaten. DDT and Endrin give a good control (PRADHAN, 1963).

8.2.5. *Chickpea leaf-miner flies*

Liriomyza (= *Agromyza*) *cicerina* Rond. (*Diptera-Agromyzidae*), the leaf-miner fly, occurs in Bulgaria (KOINOV, 1968a), the USSR (BADULIN and BALASHOV, 1967), Spain (DEL CANIZO, 1947), and Turkey (KARMAN et al., 1970). In Israel the insect has recently become a serious pest.

The fly may lay up to about 35 eggs on the young leaves. The small larvae of the 1.5 mm long fly mine in *Cicer* leaves. Leaves and pods of *Ononis* spp. and other wild *Leguminosae* can also be infested. From Tadzhikistan losses of 10–40% were reported (cf. KOINOV, l.c.). Three to four generations may develop in one season.

Control

Agrotechnical methods like deep ploughing (25–30 cm) reduce the number of affected plants (Bulgaria).

Effective control can be obtained by spraying Thiofos 0.1%, Lebacid 50% emulsion at 66 cl/ha, or Carbaryl 50% wettable powder at 2 kg/ha. DDT 5% dust at 3–4 kg/ha, HCH 12% dust at 1.8–2 kg/ha or Parathion, Phosphamidon, or Lebacid 3% dust at 20–25 kg/ha is also advised.

KOINOV (1968) referred to the parasite *Opius cicerini*, found in Tadzhikistan, as a possible biological control.

Liriomyza obtusa M. is listed from India (ICAR, 1969). The gram podfly lays it minute eggs in the valvae of the pods. The larvae feed on the growing seeds. In the early stages of growth of the chickpea the leaves are sometimes mined. The pest can be controlled with 0.05% nicotine sulphate or with 0.25 DDT on mined leaves. Clean cultivation is also recommended.

Liriomyza trifolii was found as a leafminer on chickpeas in Iran (KAMALI, 1969).

Liriomyza congesta is another leaf miner species reported from Iran, where it causes up to 30% crop damage. Control with Metasystox 0.15% was satisfactory (MOJTEHEDI, 1969).

8.2.6. *Pulse beetles*

These seed beetles or bruchids; *Callosobruchus* (formerly *Bruchus*) *chinensis* L., *C. maculatus* (F.) (= *B. quadrimaculatus* F.) and *C. analis* F. (*Col.–Bruchidae* = *Lariidae*) may seriously infest stored chickpeas. Peas, pigeon-peas, cowpeas and beans can also be damaged by these beetles both quantitatively and qualitatively. In India a considerable part of the 15% loss by insects was estimated to be due to bruchids (PARPIA, 1968). Depending on storage facilities similar losses occur in other countries.

The Indian Agricultural Research Institute and the Regional Pulse Improvement Project are investigating the *Callosobruchus* species and their methods of control.

The initial chickpea-infestation occurs in the field. Here the female bruchid deposits its eggs on the pulses. The young larvae gnaw a hole in the seed coat and feed on the cotyledons. Up to three larvae can develop in one seed. In seeds in which one beetle has developed the germination potential varies from 16–43%; seeds giving rise to 3 beetles have no germination capacity. Unless the chickpea crop is harvested, the beetles of the new generation will attack it. After threshing a number of pulse beetles may be transferred from the field to the stores where further bruchid generations will develop.

PINGALE (1956) substantiated the effect of bruchid infestation on stored chickpeas. Beside the loss of weight, the precentage of free fatty acids increases, and the thiamine (vitamin B 1) content decreases. With an increase in percentage loss, the taste of the split seeds (dhal), prepared from the chickpeas, becomes more and more insipid, and also rancid and bitter. When 40–60% is damaged, the seeds are no longer edible.

CHATTERJI (1953) reported that broken (split) pulses without skin (dhal) were less affected in storage than whole pulses with or without skin; the losses in weight were 7.75%, 25.50% and 18.25% respectively. The lower humidity level of the broken pulse and the reduced space for pupation in the separate cotyledons could account for the loss in weight.

Control

In the field the incipient bruchid-population should be controlled. RPIP (1969) obtained good results with sprays of Thiodan or Dieldrin at 0.5 kg/ha. DDT, Diazinon, Dimecron and BHC also proved effective. RIVNAY (1962) preferred Rotenone 0.75% dust to DDT to avoid killing pollinating insects.

Seeds should be treated just before or in storage, but no treatment is necessary when no initial population is present and the store is free of bruchids. Untreated seed is always to be preferred for human use.

When control is unavoidable, the following methods are recommended. If the stock is mixed with hydrated lime, pyrethrum or derris powder there will be no further damage. But large quantities of dust are needed, 1 part dust to 4 parts seed. After washing the pulses can be used for food. Fumigation with methyl bromide and treatment with DDT 5% dust will kill all bruchids. This method is only applicable when the seed is seriously infested and is to be used for sowing.

Recently 1 ppm of lindane kept stocks free from *Callosobruchus* for over two months (NISA and AHMED, 1970). This rate is well below the safety limits of WHO and FAO, but the period of control is too short. Other insecticides were not appropriate within health safety limits.

DDT and gammexane did not depress germination and sometimes even stimulated the process (FLAMINI, 1950). An antiparasitic agent containing copper depressed germination.

The old practice to store chickpeas mixed with chilli (*Capsicum*) powder, as reported in WEALTH OF INDIA (1950), should be investigated to establish a possible repelling effect of the chillies against beetles.

Normal drying of the seeds represses bruchid growth, but is not sufficiently safe since the beetles are adapted to dry conditions.

Heat treatments are sufficiently protective. RIVNAY (1962) recommended that seeds be kept at 57°C for 3–4 h. In my opinion a slightly higher temperature can be used, when the seeds are for consumption.

Eradication with male-sterile techniques could be possible (RAINA, 1970).

In the screening programme of the Regional Pulse Improvement Project a chickpea strain was detected, which was not preferred for oviposition (SAXENA and RAINA, 1970). *Callosobruchus maculatus, C. chinensis* and *C. analis* preferred well-filled seeds with a smooth seed-coat. The roughness of the seed coat of the cultivar 'G 109-1' can explain the relative difficulties for oviposition, when the eggs are to be glued on the seed coat. Especially the large species *C. maculatus* did not lay eggs on this cultivar at all. This is an elegant, harmless base of resistance and can easily be introduced into other cultivars by crossing. However, the effect has also to be studied under storage conditions, where the pulse beetles have no alternatives.

Another base for breeding resistant plants is reported by APPLEBAUM et al. (1969), who extracted saponins from several legumes. If these saponins, whose part in plant life is not yet clear, are present in higher concentrations, larval development in *Callosobruchus chinensis* stopped. Only pure saponins affected the development. In crude or mixed preparations the effect seemed to be neutralized.

I am indebted to Mr. H. C. BURGER, Plant Protection Service, Wageningen, for determining some bruchids, which were imported unintentionally with my seed collections. The following bruchid species were present, as far as could be ascertained from the material. *Callosobruchus analis* (F.) was found on *C. arietinum* L. 'Green Grain' from Bombay, India; *Callosobruchus maculatus* (F.) (most probably) on chickpea 'white, bold' from Shiraz, Iran; *Callosobruchus maculatus* (F.) on chickpea 'Beladi' from Khartoum, Sudan. Moreover some *Bruchus* spp. were present in herbarium material of *C. acanthopyllum*, PODLECH 12394 from Anjuman, Afghanistan; *C. oxyodon*, BORNMÜLLER 6635 from Lur, Iran; and *C. pungens*, RECHINGER 18720 from Panjao, Afghanistan.

Apparently the well-known bruchid species occurred in the seeds of Asian and African origin. The beetles also attack the wild *Cicer* species, the seeds of which most probably have a composition similar to chickpea seeds.

8.2.7. *Other insects reported to feed on chickpea*

In Delhi *Bruchidius* spp. (*Col.-Bruchidae*) were collected from chickpeas but high populations only occurred on lentils.

Tuberculobruchus sp. was also found, but it is probably not a pest (Regional Pulse Improvement Project, 1969).

Pseudopachymerus quadrimaculatus (*Col.-Bruchidae*), introduced from Brazil, appeared to be a pest of chickpeas in Italy (BINAGHI, 1947).

From Iran the cosmopolitan and polyphagous aphid, *Aphis craccivora* Koch (*Hemiptera-Aphididae*), is reported as a possible vector of Pea Leaf Roll Virus in chickpeas. The presence of a certain preference to some lines was also noticed. The aphid is also found on chickpeas in Egypt and Israel. Diazinon and Metasystox may successfully check the aphid population.

In Iran *Acyrthosiphon pisum* Harris appeared to be the vector of BYMV in chickpea and other crops. Here, *A. sesbaniae* David was detected as the vector of CMV in chickpea (KAISER and DANESH, 1971a).

Sitona crinitus Herbst (*Coleoptera-Curculionidae*) affects lentils, chickpeas, lucerne and vetch in Turkey (East and Southeast Anatolia). A 10% DDT or BHC dust at 20–25 kg/ha was reported to control the insect if applied before oviposition in early March. (KILIÇ et al., 1968). The larvae feed on the roots, but do not cause severe damage. The weevils attack leaf buds, leaves and stems (METCALF and FLINT, 1962).

The polyphagous *Laphygma exigua* Hbn. (*Lep.-Noctuidae*), known as the lucerne caterpillar or the beet army worm, also feed on chickpeas (INDIAN COUNCIL OF AGRICULTURAL RESEARCH, 1969). The dark-brown moth lays its eggs in clusters on the lower parts of young chickpea-plants. The young caterpillars feed at daytime; the older also at night. Pupation takes place in the soil. As a method of control eggs and larvae can be collected. The same insecticides as used against *Heliothis* are applicable.

Cosmolyce (*Polyommatus*) *boeticus* L. (*Lep.-Lycaenidae*), the blue butterfly of *Vigna unguiculata* (L.) Walp., *Phaseolus aureus* Roxb. and *Ph. mungo* L., also appear on *Cicer arietinum* L. The short flat, pale green caterpillars can be controlled by spraying 0.16% DDT or by hand picking (ICAR, 1969).

Caliothrips impurus (*Thys.-Thrypidae*) was observed on chickpeas in Iran (MOJTEHEDI, 1969). Metasystox at a rate of 0.15% gave sufficient control.

8.3. NEMATODES

So far extensive damage by nematodes has not been reported, except for an initial statement by SESHADRI (1970). *Meloidogyne incognita*, the root-knot nematode, has been detected on chickpea. MATHUR et al. (1969) reported chickpea as a host plant for *Meloidogyne javanica*. Chickpea may also become infested by *Tylenchorhynchus dubius*, a phytophagous nematode of West European soils, as was found by SHARMA (1968) in Wageningen. In these conditions there was hardly any multiplication.

The chessboard type of crop rotation experiment now being carried out in India will reveal whether or not nematodes are a problem to *Cicer*. Rotation systems should be followed to prevent an increase in nematode population that would be economically damaging.

Rare occurrence of *Tylenchus* spp., *Aphelenchoides* spp. and medium occurrence of *Aphelenchus* spp. and *Scutellonema* spp. on chickpeas was listed by EL TIGANI et al. (1970) from the Sudan. OMIDVAR (1969) indicated that all pulse crops in Iran are infected by one or more phytophagous nematode species. *Meloidogyne* root knot nematodes have been isolated as well as a *Paratylenchus* species.

8.4. OTHER ANIMAL PESTS

Like any staple crop, chickpeas are attacked by mice and rats. Traps and baits are remedies but hygienic conditions such as clean, tightly closed silos will prevent serious loss. All storage buildings must be properly constructed.

Birds may feed on the filled pulses, and chickens should be kept away from drying floors. During threshing and transport birds are not troublesome because of the presence of humans, but birds may enter the pulse stores.

8.5. PLANT PARASITE

Although BRYSSINE (1955) noted chickpea for its complete resistance against the parasite *Orobanche*, recent observations in Morocco reveal that sometimes attacks have been observed (pers. commun., BENNER, after BRYSSINE). It is possible that one or some strains of *Orobanche* have adapted to *Cicer*. Varietal differences between cultivars may exist and care must be taken not to export the parasite.

9. DISEASES OF THE CHICKPEA

9.1. INTRODUCTION

Like almost any cultivated plant, *Cicer arietinum* has its specific diseases. These jeopardize the cultivation of chickpea in several regions. In general the crop is attacked by relatively few diseases, the two most important being wilt and blight. The other diseases have had little economic effect so far, as they only occur incidentally. However, when new varieties are screened it should be remembered that these minor pathogens may become more virulent or more widely spread.

9.2. WILT DISEASE

Wilt, chickpea wilt disease, gram wilt (E.), la rabia del garbanzo (Mex.), ukhera or soka (Punjab).

It is difficult to trace the origin of wilt disease of chickpea. In 1915 a physiological deficiency was considered to induce wilt. After more research it was decided that the causes were both pathogenic and physiologic. In 1939 the fungus *Fusarium orthoceras* was isolated as one of the main causes of this disease. Even now opinions still differ whether *Fusarium* is a primary infestation or not or whether physiological conditions and poor soil conditions, are solely responsible. Many scientists believe the disease is a combination of both factors.

After initial work by MCRAE (1924), MITRA (1925), NARASINHAN (1929), UPPAL et al. (1935), PRASAD and WATTS PADWICK (1939), WATTS PADWICK (1940) declared that *Fusarium orthoceras* App. et Wr. var. *ciceri* Padwick (*Fungi Imperfecti*) was the fungus attacking the chickpea plant. Research on gram wilt and all *Fusarium* wilts in India was founded by WATTS PADWICK and PRASAD with their extensive publications. The nomenclature of the pathogen is disputed by ERWIN (1958a). DASTUR (1935) based the disease on physiological factors only, since all re-inoculations with the *Fusarium* he found, failed.

The fungus

The fungus has a whitish mycelium; in some isolations the plectenchymatous layer is pigmented. Ovoid or spindle-shaped conidia with or without a septum are formed in the aerial mycelium. Sometimes terminal and intercalary single 1–2 celled chlamydospores occur.

The first symptoms can be observed at the age of about one month. The disease occurs in patches in the fields, because it is soilborne. The wilting symptoms can be divided into several patterns (PRASAD and WATTS PADWICK, 1939, ERWIN, 1957, ERWIN and SNYDER, 1958). CHAUHAN (1962b) who paid much attention to this disease (1950–1965), distinguished four types of wilting:

1. wilting of the whole plant in an early stage (age one month)
2. wilting of the whole plant after flowering
3. a part of the plant whithers, the rest flowers and forms pods normally
4. a part of the plant whithers after flowering while the rest remains intact.

These types are a refinement of the general known 'early' and 'late' wilt (RAHEJA and DAS, 1957).

The first visible symptoms of wilting is a drooping of the younger leaves followed by the older ones. The veins clear, after which the leaves become yellow and then brown, from the margin of the leaflets inwards. The symptoms of acute outbreaks of wilt are similar to those caused by the yellowing virus, but the discolouration is not as bright. The leaves do not fall. The roots discolour to brown and black, while the xylem vascular bundles contain the mycelium. In later stages the xylem becomes brown and filled with the fungus hyphae. Even in the stem this appears and thus wilting is caused by blocking of the vascular bundles (comparable to physiological drought). The toxin production of *Fusarium orthoceras* var. *ciceri*, however, is already active during wilting (CHAUHAN, 1961). The complete blocking by the hyphae occurs sometime after the first wilting symptoms become visible. Ultimately the dead plants dry up and become brown or black and are conspicuous amongst the healthy or only partially wilted plants.

Infection

Fusarium is a soil fungus. When no chickpea is grown, the mycelium remains in the soil. Conidia and chlamydospores may reach the seed coat at harvest and remain there to infect the next crop. The seeds are not infested. The fungus grows from the seed coat or the soil on the growing seedlings and may penetrate into non-damaged tissues. The development is strongly influenced by temperature. In vitro, 20–25°C is optimum for its growth. Below 15°C fungus growth stops. At 35°C the fungus hardly grows and chlamydospores are formed. In cultivation the development of *Fusarium orthoceras* var. *ciceri* is influenced by soil type, pH, organic matter content, soil humidity and soil temperature.

Type of soil

CHAUHAN (1962) compared five types of soil to study the effect of soil type on the development of wilting disease. The severest incidence of wilt occurred on sandy soils, the least on clayey loam. These facts suggest physiological drought. Under field conditions a low pH reduced fungus growth, while at a pH higher than 7.2 *Fusarium* incidence was higher. However in sand cultures or sterilized garden soil the reverse was found. In an acidic medium the disease was more serious.

Organic matter of the soil influences the fungus growth. The development of the disease was negatively correlated with the organic matter content (CHAUHAN, 1962).

Soil humidity levels were compared (CHAUHAN, 1963a) and a high humidity

(25% of the dry soil weight) aggravated the disease. With lower humidity levels the death percentages of chickpea plants decreased. The influence of poor aeration of the root zone should not be neglected.

Soil temperature

Just as in vitro, temperatures below 15° are too low for fungus growth under field conditions. Therefore during the coolest period of the Indian winters, *Fusarium* has less chance to cause wilting of chickpeas, which accounts for the gap between early and late wilt. The optimum temperature is 25°C; at 35° the growth is very slow (CHAUHAN, 1963b). At germination, however, soil temperatures in India are favourable for infection.

CHAUHAN (1965) compared combinations of soil and environmental factors. Acidic soils, with high humidity and low organic matter content, gave almost 100% plant mortality. Other combinations with acidic soils were less promotive to the disease. Acidic soils with a low moisture and a low organic matter content gave the least mortality.

Artificial inoculation has encountered some difficulties. Several authors did not succeed in inoculation with propagated fungal material. PRASAD and WATTS PADWICK (1939) were able to isolate the *Fusarium* on oatmeal agar. The portions of roots and stems carrying the disease were previously disinfected in 0.1% $AgNO_3$ (2 min.) and 1% NaCl to remove the $AgNO_3$ and washed several times in sterilized water. Inoculum was prepared from the fungus grown on moistened autoclaved unhusked rice in flasks. The content of one flask was used to inoculate one pot.

In the field inoculation can hardly be standarized. Wilt-sick plots for screening of chickpea-cultivars are prepared by taking several cubic meters of soil from a field, which has severe wilt incidence every year, to the trial plot. In these plots, *Cicer arietinum* is grown every year, so that the disease is intensified by excluding crop rotation. The use of laboratory inoculum is a safe method to obtain heavy infestation.

Geographical distribution

Fusarium orthoceras var. *ciceri* is a widely distributed disease of chickpeas. In Northern India and Pakistan (Punjab), 15% of the crop is infected annually, so that losses are considerable. In some years even a loss of 30–70% may occur (GREWAL and PAL, 1970). In Spain and Mexico the damage is also extensive (CHENA et al., 1967; CIAS, 1969). Therefore more research on wilt control is justified.

Control of wilt

Cultural practices can influence the incidence of wilt. The sowing date, the sowing method, and the time of irrigation affect soil-plant interaction. From trials on sowing date (WATTS PADWICK, 1943; RAHEJA and DAS, 1949, 1957) it seems that in India retarded sowing usually lowers fungal attack. Seed yields, however, are lower when sowing is carried out later in the season. Often late sowing cannot be carried out because of the soil moisture content which has dropped below optimum level. At Hissar (Haryana, India) the fields during the 1969–1970 season, showed that sowing in early November was more favourable than the earlier sowings. Almost no plants sown in November were lost, while the September-sown plots showed many wilted plants.

Sowing in rows is preferable to broadcasting the seed (ATHWAL and BAJWA, 1965). Deep sowing (12.5 cm) gave higher susceptibility to late wilt at flowering (RAHEJA and DAS, l.c.).

The time of irrigation may influence wilting, in flowering and fruit-setting stages. Watering the soil may improve living conditions for *Fusarium* and affect the aeration of the soil. In vegetative stages irrigation should be applied when necessary. Flooding the fields, as for Panama disease in banana (*Fusarium oxysporum* Schl. var. *cubense* G. F. Sm.) could perhaps eradicate the disease during fallow.

Intercultivation has never been studied in relation to wilt. By aerating the soil, crop growth is improved, fungal growth not so much, and soil moisture conservation is adversely affected. However, plants, susceptible to late wilt, were found to have had a better initial growth.

With certain soil characteristics it is difficult to grow a good crop of healthy chickpeas. Heavier soils are preferable to sandy soils, apparently when drought is playing a role, the physiological part of wilt becomes prevailent. The pH should not be altered by calcium dressing since the data are not yet conclusive, and because disease incidence is related to several other soil factors simple recommendations cannot be made.

Soil humidity should not be too low, as physiological drought may occur. Even the chickpea cannot withstand severe drought. The organic matter content of the soil can be improved. CHAUHAN (1962b, 1963c, 1965) found that the use of groundnut and mustard cakes had a very favourable influence on the survival of chickpeas on wilt-sick land.

Deep tillage during the wet season lowers the disease incidence (ATHWAL and BAJWA, 1965, NN, 1956).

KOINOV (1968) recommended a waiting period of four to five years, before chickpeas are planted again in the same field.

Disease resistance

It is evident that the degree of susceptibility to wilt varies between cultivars of *Cicer arietinum*. Many isolations have been made and tested on different cultivars. Early resistant material was reported by DASTUR (1928). AYYAR and IYER (1936) found a single genetic factor governing the inheritance of resistance to wilt. The possession of a thick layer of suberin (cork, in several layers between the epidermis and the cortex in older roots) could account for the resistance. Complete resistance, however, is very rare. Strains reported as resistant (nr. 106 from Bihar cf. MATHUR et al., 1964) often became susceptible later (MATHUR et al., 1965). Most probably physiological strains do exist.

Only a few strains from those samples recently introduced by RPIP/AICPIP into the germplasm collections now available in Iran and India, were initially found to have promising resistance characteristics. Whether these strains will be useful in practice remains to be seen. The Delhi trials showed that they succumb to heavy artificial inoculation. However they have a good future in breeding, if the resistance level suffices against normal natural attacks of wilt.

In view of this rather depressing situation in some areas, interspecific crosses are being considered. This work has hardly begun because of the lack of seed material of wild species of *Cicer*. The initial failure of crossing *C. arietinum* L. with *C. pinnatifidum* Jaub. et Spach, from which species are readily obtainable, must not discourage new attempts. This cross has not succeeded in Israel, nor have crosses with '*C. songaricum* Steph. ex DC.'. The only economical solution is the development of resistant cultivars especially against the soilborne *F. orthoceras* var. *ciceri* (HUITRON, 1968).

9.3. OTHER FUSARIUM WILT DISEASES

Fusarium lateritium Nees emend. Snyd. et Hans f. *ciceri* (Padwick) Erwin was reported to damage chickpeas in California (ERWIN, 1957, 1958). The forma does not differ much from *F. orthoceras* var. *ciceri*. ERWIN compared his isolates with one Indian *Fusarium* accession and therefore proposed the older name, so that *F. orthoceras* var. *ciceri* would by synonymous with *F. lateritium* f. *ciceri*. A Californian and some Ethiopian cultivars possessed considerable resistance to both Californian and Indian *Fusarium* strains.

ECHANDI (1970) reported *F. oxysporum* as the incitant of chickpea wilt-disease in Peru. Differences in susceptibility existed between cultivars.

9.4. BLIGHT DISEASE

Blight of chickpea, gram blight (E.); l'anthracnose du pois chiche (F.); la rabia del garbanzo, el anthracnosis del garbanzo; picado, aquasol, acentellado (Sp.); la rabbia del cece, antracnosi del cece (It.); chandni, bulla, hawa (Punjab).

This disease is caused by *Ascochyta rabiei* (Pass.) Labr. (= *Phyllosticta rabiei* (Pass.) Trott.), in the generative stage *Mycosphaerella rabiei* Kovacevski (*Ascomycetes, Sphaeropsidales*).

The fungus was first described by TROTTER (1918) as *Phyllosticta rabiei* (Pass.) Trott. LABROUSSE (1930, 1931) studied the disease, which caused much damage in Morocco. He decided that the fungus fitted better in *Ascochyta* because of a low percentage of two-celled conidia (2–4%). In literature however the name *Phyllosticta* is still being used.

LUTHRA (1932, 1935) investigated the disease in India for the first time. KOVACHEVSKI (1936) found perithecia on the pods and therefore identified the perfect stage as *Mycosphaerella*.

Symptoms

All subsoil parts of the plant are blighted. Brown to black spots appear on stem, leaves, flowers or pods. Oval patches occur on stem and flowers, those on leaflets and pods are round, 3–10 mm in diameter. The pycnidia, lying in concentric circles, form the patches. The stem is often cut by the diseased patches and especially the younger parts are attacked.

In a plantation, initial attack is difficult to see. Later on in parts of the field, the upper parts of several plants appear brown and dried. From these centres of infection the disease can rapidly spread over the field and adjoining areas. The plants usually dry out to a certain extent, sometimes completely. The seeds produced on a partially diseased plot can harbour the fungus with or without symptoms, especially when the attack breaks out in the last stages of growth.

The Ascomycetous fungus has hyaline to brown septated hyphae. The

PLATE 5. Symptoms of blight disease, caused by *Ascochyta rabiei* (Pass.) Labr. near Medina del Campo, Prov. Valladolid, Spain

pycnidia, forming the diseased spots, are pear-shaped. The conidia emerge from short conidiophores, embedded in stromatic tissue. When the pycnidia are wetted, the stroma swells and the spores come free. These spores are oval to oblong, about 10–14 μm and mostly unicellular. If they are formed in dry weather, only 2% is bicellular; in humid weather this amounts to 5–10%. Minimum, optimum and maximum temperatures are 10°, 20°, and 32.5°C, respectively (LUTHRA et al., 1935). The spores remain viable in freezing temperatures.

Infection is caused by diseased sowing-seed, by infected tissue not separated from the sowing seed, or by diseased plant remains from the fields. From the seeds harvested from a blighted chickpea field, fungi grow readily on the shrivelled and partially blackened seeds of which only a low percentage germinates. Isolation on agar is easiest from these seeds. Symptomless, apparently healthy carriers can germinate, and the disease may strike only some weeks later or at flowering. When seeds are not sufficiently winnowed, diseased particles of pods, stems etc. remain in the sowing seed and thus cause infection.

Ascochyta rabiei can remain alive for two years on dry plant-debris. If all debris are not burnt or buried after harvest, the parts carrying the fungus remain on the field or on threshing places in the vicinity of the fields. Dry material can be blown by the wind over quite long distances. In summer (India) or cold winter (S. Europe) growth is absent, but the inoculum becomes active after the first rains or in spring. Thus the new crop can become infected.

Whether or not there is an epidemic depends on humidity, temperature, wind and cultivation method.

Humidity can both promote and reduce blight. During the monsoon rains the resting pycnidia eject spores and these land on the soil. Because no chickpeas are available, these spores die. The amount of inoculum is thus decreased. On the other hand during the winter season, especially in the flowering and fruit-setting stages, the disease can attack very severely, when rainfall exceeds 200 mm. The blight then becomes epidemic. Regions receiving less rain have less or no damage from chickpea blight. When less than 150 mm is received, the disease is not important (SATTAR, 1933). Distribution of rain, however, is more important than its total amount.

Infection is promoted by the secretion of malic acid of the leaves and stems. Laboratory experiments showed that a better germination of spores took place in the presence of this acid. During the flowering stage and afterwards secretion reaches a maximum (N/50–N/25, 1.3%, pH 2.5). These higher concentrations of, mainly, malic acid presumably favour the growth of *Ascochyta*.

The effect of temperature, if separated from humidity, is difficult to assess. In general the disease will not spread at temperatures above 32.5° and below 12.5°C. In the Punjab little infestation will take place in December and January. In the subsequent months, however (flowering and fruit-setting), meteorological conditions are favourable for the development of blight.

The wind is important for spreading the disease. Although the spores are not of an airborne type, dried parts of infested plants with pycnidia can be blown several hundreds of metres and thus form a severe source of secondary infection. This dispersal can occur both in dry and wet weather. When humidity is favourable infection can take place.

Less infestation occurs in *Cicer arietinum* when it is sown as a mixed crop. Cereals and oilseeds are mentioned as successful interceptor. A certain dilution effect by these non-susceptible species is considered to oppose the development of blight. Areas with most fields under *Cicer* are rather vulnerable as the disease can spread continuously. Here mixed cropping is an insurance against blight.

If a turning plough is used every year after the first summer rains (or in spring), whether the field is kept fallow or not, blight will be reduced, because debris will be buried.

Artificial inoculation

Inoculatives can be prepared by making suspensions of the spores, harvested from oatmeal-agar cultures. These can be sprayed on the plants at intervals of some 10 days. (HAFIZ, 1952; ASHRAF, 1953). Under field conditions the crop can be inoculated by broadcasting diseased plant debris (SATTAR et al., 1951). No cross-references are given on this easy though rather crude method. Dried mycelial mats can be applied to the soil (AUJLA, 1964).

Geographical distribution

Chickpea blight is more widely spread than wilt. It has been reported from India and Pakistan, the USSR, Italy, Spain, Morocco, Israel, Bulgaria and E. Africa. Total economic effect is extremely difficult to estimate, but an individual farmer can lose his entire crop.

Control of blight by agricultural methods

Against blight of chickpeas the use of healthy sowing-seed, sanitary measures and the practice of mixed cropping are recommended. Resistant cultivars are not yet widely in use or are not yet adapted to a wide area.

Healthy seeds for sowing should be used in blight-vulnerable areas. These can be imported from blight-free regions. This primary source of infection is then avoided, but considerable input of capital and transport costs make this measure unpopular. The presence of the fungus in the seeds can be checked in the laboratory; hyphal growth after 7–10 days from disinfected seeds on agar plates shows the internal presence of the fungus. Sanitary measures include uprooting, by hand or with harvesting machines and cutting the roots below soil level.

Small parts of the plant, which could be a source of infection, will remain on the soil surface. The straw should be buried, burnt or fed to cattle. Cleaning the threshing flour, which often is situated in the field, is equally important. In fact the winnowing of a more or less diseased crop may spread the disease, even though ploughing for the next crop eliminates a large portion of this danger. A fully diseased crop should not be left on the field, but be collected and burnt, or preferably buried. Ploughing the soil helps to combat the fungus.

The ploughing should preferable be carried out after the first rains or after irrigation, because humidity is needed to deliver the spores.

Chemical control

Although breeding resistant cultivars has always been considered more practical, LABROUSSE (1930) advised the use of Bordeaux mixture, which should be applied twice. SOLEL et al. (1964) proved that Zineb (3 kg in 1200 l per ha) controlled the disease if applied six times. Thus better yields as well as better 100 seed weights were obtained in Israel. One preventive spraying was not effective. LUKASHEVICH (1958, 1964, after KOINOV, 1968) applied a Bordeaux mixture of 1–2% with success. Reasonable control was obtained with a TMTD emulsion in water of 2–3% (KOINOV, 1968). A warning system by radio broadcast when the weather is favourable for the development of the disease, can direct the farmer to spray when necessary. In this way the warnings against *Venturia* apple scab and *Phythophthora* potato blight are given in the Netherlands. Chemical control, however, is still too expensive in most chickpea-cultivating areas.

KHACHATRYAN (1961) used TMTD for seed treatment successfully. Disinfection of seeds for sowing, probably only when infection was not severe, gave good control in Turkey. KARAHAN (1968) used TMTD at 300 g per 100 kg of sowing seed after moistening. Germination was not affected. KOINOV (1968) found no results from seed disinfections.

The fungus is located inside the cotyledons, so a penetrating agent is needed. SATTAR (1933) and ZACHOS (1952) did not obtain sufficient control with hot water treatments or the use of formaldehyde and malachite green.

Resistance

There are not many sources of resistance against blight. Breeding work is made more difficult by the many physiological strains of *Ascochyta rabiei*.

Six forms of *Ascochyta* were first studied by LUTHRA and SATTAR (1939). Cultural and morphological characters were quite different. Even a non-pathogenic form was obtained, which was judged not to belong in *Ascochyta rabiei*.

The strains F8 and F10 were imported from France (AHMAD, 1952; HAFIZ, 1952). They were resistant at first but have since become susceptible. Associated with the early resistance was a large number of hairs per unit surface area on the stem and leaves, and more acid secretion than the susceptible cultivars. HAFIZ (1952) postulated that the greater secretion of the larger number of hairs would be harmful for germination of spores. This postulate is not substantiated by the findings of SATTAR (1933), who found a stimulative effect in vitro. An optimum range of concentrations of the malic acid is feasible. In early stages of growth, when production of malic acid is low, differences in susceptibility were absent.

A higher number of stomata (114–136 per (most probable) mm^2) than the susceptible cultivar Pb 7 (66–96 per mm^2) (HAFIZ, 1952) as a base for resistance by suppressing penetration of hyphae, which enter by way of the epidermis, seems no longer meaningful since more pathogenic strains were isolated. Leaves with thicker cuticles are not longer expected to be more resistant.

Different cultivars of chickpeas and isolates of *Ascochyta* were further studied by AUJLA (1964, 1967), BEDI (1969), BUSHKOVA (1960), HAFIZ and ASHRAF (1953), PUERTO ROMERO (1952), SOLEL et al. (1964), VEDYSEVA (1966).

Cvs 'C 12/34' and 'C 612' from Pakistan and India possess resistance (NAQVI and AZIZ, 1963). ATHWAL and BAJWA (1915) recommended 'C 235' as blight-resistant. With a collection of fifteen cultivars AUJLA established that none was resistant against all eleven strains of the fungus. One very virulent isolate even attacked all cultivars severely. PUERTO ROMERO found a few Spanish, Greek and Mexican cultivars possessing moderate tolerance. VEDYSEVA reported 'VIR 32' and 'K 279' from the USSR as highly resistant hybrids. SOLEL et al. found that the cv. Bulgarian was not attacked. Cv. Plovdiv 19 from Bulgaria proved to be blight-resistant for over 15 years (KOINOV, 1968a).

Exchange of this material may offer, at least temporarely, a solution for the local scarcety of resistant germplasm. Especially in the Punjab and Haryana research on blight has been intensified by new projects.

9.5. STEM ROT

Sclerotinia sclerotiorum (Lib.) de Bary (*Ascomycetes*) affects the stems and branches of the chickpea plant. The roots are generally not attacked. The mycelium, causing the rotting, forms sclerotia inside and outside the stems. The sclerotia inside are elongated while the others are globular. These bodies remain dormant in the soil until the next growing season.

Symptoms

At first brown patches appear on the stems, normally at soil level. The white fungus threads spread over all parts of the plant as a cottony growth. The plant becomes yellow and brown, then succumbs to rot or drought. Primary infestation usually takes place at the stem base. In young stages the plants rot away completely.

The fungus growth is favoured by temperatures between 15° and 20°C and humid soil conditions. The sclerotia can survive in the soil during summer, when temperatures are high. The disease can spread by the sclerotia infesting the plants near the diseased one or next season's chickpea crop on the same field. Other fields may become infested when sclerotia are mixed with the sowing seed. Several other crops are also susceptible, such as berseem and tomato.

Control of stem rot

Sclerotinia can be controlled by cultivation, sanitary measures and seed disinfection. Only seeds free from sclerotia must be used, so that inspection is advisable. Diseased plants or crops must be collected and burnt, fed or used as compost for non-susceptible crops (cereals).

Deep ploughing or flooding kills the sclerotia, but just leaving the land fallow is not effective, since they resist heat. During growth irrigation or rain water should not be allowed to stagnate. Rotation with non-susceptible plants reduces the incidence of the disease. Other *Sclerotinia* species causing diseases of chickpea are *S. minor* Jagger, reported by MARRAS (1961) from Sardinia, and *S. rolfsii* Sacc. that causes root rot of *Cyamopsis* and wilt of *Cicer* (MATHUR, 1962).

9.6. FOOT ROT

Operculella padwickii Khes. (*Ascomycetes-Sphaeropsidaceae*), the fungal agent of another type of wilting, was described by KHESWALLA in 1941. The monotypic genus was founded to include the peculiar characteristics of the fungus. The mycelium is broad and granular, both inter- and intracellular. Non-stromatic pycnidia are only found in cultures on agar plates or on infected debris in the soil. The spores are irregularly shaped, hyaline, yellowish-white and first emerge through the ostiole, but ultimately force open the upper spherical part, leaving a lid attached to one side.

The wilting symptoms are as follows. The infected plants show drying from the top downwards. The leaves become pale green, then yellowish and ultimately drop off. The base of the stem discolours to dark brown and rots away. The leaves themselves do not host the fungus.

9.7. RUST

Gram rust, rust of chickpea (E.), la rouille (F.), el chahuixtle (Sp.) is caused by *Uromyces ciceris-arietini* (Grogn.) Jacz. (*Basidiomycetes*). This rust was first detected and described in France, Soane on Loire, in 1863 as *Uredo ciceris-arietini*. BOYER and JACZEVSKI found the telial stage in 1893 (MEHTA and MUNDKUR, 1946).

Symptoms

Five days after inoculation, the first symptoms are visible consisting of whitish patches on the leaflets. After 10–14 days brown pustules appear, when the sori burst through the epidermis. The small, round or oval pustules tend to flow together. In severe cases, petioles and stems may also bear the sori. Later the leaves discolourate to yellow or brown, sometimes even to red or purple. Defoliation ultimately affects yield, although pods are not attacked.

The fungus

The uredia with 4–8 spores and the telia with 1 spore form the visible sori. Teliospores are darker brown than uredospores (MEHTA and MUNDKUR, 1946). The spores are liberated in abundance and several generations are formed in one season on the same field. The wind easily spreads the spores. The optimum germination temperature is 26 °C. Spores can be refrigerated at 6 °C for almost one year, but in the soil when the temperature is above 30 °C, they do not survive. At room temperatures viability is lost within a month. At 20–24 °C the appearance of uredia on the plant lasted 11–13 days only, while at 8 °C it took 24 days.

Perpetuation of the disease to other seasons by uredial stages on other plants was found by SAKSENA (1955) and has been confirmed by PAYAK (1962). *Trigonella polycerata* L. hosted the fungus in the Indian dry and wet summer periods. Thus is explained the heavier attack in the cooler states bordering the Himalaya mountains, where the weed occurs in the foothills.

LEON (1962, 1963) based the outbreak of the disease in Mexico, where damage is now appreciable, on infestation with seeds. The spores must have been carried on the seed coats. Since pods do not bear the fungus, threshing and winnowing caused this spread.

Artificial inoculation can take place with the stored spores, harvested together with the leaflets, so natural outbreaks of the disease are not required for screening. The spores can be used after the germination percentage has been assessed in a drop of water or on moistened cellophane strips. Germination of the teliospores was not successfull.

The spores are made into a suspension and sprayed on the plants, or on detached leaves floating in a 5% sugar solution. A concentration of 0.05% malic acid promotes germination better than lower or higher concentrations.

Control

Losses were estimated by DALELA (1962) with a sample of 100 plants taken at random from a mature crop. The proportion of diseased leaves was established for individual plants. Chemical control was insufficient. The search for resistant cultivars is therefore the most appropriate and economical way to overcome the disease. MEHTA and MUNDKUR (1946) reported different extents of attack in various cultivars, many showing no rust. In Mexico the disease prohibited chickpea cultivation and therefore rust-free areas are recommended to avoid the rust. Inspection of sowing seed is also suggested.

Geographical distribution

Chickpea rust is reported from most Mediterranean areas: France, (KUHNHOLTZ-LORDAT, 1941), Cyrenaica (KRANZ, 1962) and in Bulgaria (ATANASOV and KOVACEVSKI, 1928), India, Afghanistan (GATTANI, 1964; SHAH SAMIN, 1969) and Mexico (LEON, 1962, 1963).

9.8. VERTICILLIUM WILT DISEASE

In California *Verticillium albo-atrum* Reinke et Berth. causes wilt of chickpeas in addition to its normal host range (ERWIN, 1958). Economically the disease is not very important. Diseased plants have yellowing leaves and many die. The xylem is discoloured to light brown, so some blocking effect may be supposed. The fungus is soilborne and can be isolated from the plant base.

9.9. Rhizoctonia wilt disease

Rhizoctonia bataticola (Taub.) Butl. was first reported on chickpeas by Dastur (1935) who reported an outbreak in Central India in December 1933. The leaves of some branches became bronzed and stiff, and the branches wilted. The young parts did not droop as for normal wilt. The leaves fell. Black or brown terminal parts of the roots contained the fungus. However, sclerotia were only observed in isolations on artificial media. Re-inoculation only succeeded partially. High temperatures seemed to vavour infection. More recent information on this disease is not available, so its danger appears to remain negligible.

9.10. Leaf spot disease

Stemphylium sarcinaeforme (Cav.) Wiltsh. was described first by Das and Sen Gupta (1961) and more information on specific nutritional needs were reported by the same authors (Sen Gupta and Das, 1964). Earlier another *Stemphylium* species, *S. botryosum* Wallr. on *C. arietinum* was reported by Zachos (1952).

S. sarcinaeforme causes oval necrotic patches measuring up to 3–6 mm on the leaflets. The spots have a dark centre and are ash-coloured at the margin. Re-inoculation by spraying a suspension of conidia or mycelium produced leaf spots within four days. Other leguminous species, described as the host range of the original *Stemphylium* could not be artificially infected. The *S. sarcinaeforme* on chickpeas is therefore considered to be a new form.

S. botryosum has a large host range and parasitizes in the seeds. Seed disinfection has no influence on the fungus, present in the cotyledons. The seeds never germinate. Perithecia of the generative form *Pleospora herbarum* (Pers. ex Fr.) Rabenh. are formed under suitable conditions. Infected seeds have violet, brown or blackish patches. They are smaller than healthy seeds. The life cycle, though not yet reported, appeares to take place in the living plant.

9.11. Phytophthora diseases

Phytophthora cryptogaea causes seed decay, seedling blight and root rot (Bhelwa, 1962). Jinks (1963) cultivated *Ph. infestans* (Mont.) de Bary on chickpea-agar in tubes. *Phytophthora megasperma* was tentatively determined by Stamps as the causal agent of blight (Suryanarayana and Pathak, 1968) which resulted in 15–20% loss of plants at Ludhiana (Punjab). The disease occurs in patches. Symptoms are poor root development, chlorotic dessicating leaves and a blighted dark foor region. Blighted basal regions contain large numbers of oöspores. Inoculation on cv. Pb 7 provoked symptoms after six weeks.

9.12. Other fungal diseases

Further reports describe certain fungi of little economic importance to growers of chickpea. Many of these reports are the first written on a particular disease.

Klinkovski (1947) stated that *Cicer arietinum* can act as a host for *Collectotrichum trifolii* Bain et Essary (*Fungi Imperfecti*) causing a type of blight.

Mystrosporium sp. (Mitra, 1935) caused another blight on chickpeas. Roundish spots up to 4 mm diameter on the leaflets are yellowish-brown with a pale reddish ring. Conidiophores appear in the centre as a blackish spot. The fungus is seedborne and can be treated by seed disinfection (formaline 0.5%). Only one cultivar of chickpeas appeared susceptible. A leaf-spot disease caused by *Nigrospora* sp. damaged early sown chickpeas under rainy conditions in West Bengal (Sen et al., 1964).

Rhizoctonia napi West grows on *C. arietinum*, but this fungus is not specialized and is hosted by many other plants (Shaw and Ajrekar, 1915).

Carranza (1967) reported an incidental wilt due to *Botrytis cinerea* Pers. from Argentine. Especially early sown chickpeas were attacked. This polyphageous fungus caused dark-brown lesions in the lower part of the stems, which may break down. Xylem necrosis apparently causes the wilting. *B. cinerea* can be multiplied by spore suspensious sprayed on the plant and added to the soil. Deep ploughing and rotations are recommended. I think that very early sowing should be avoided. In the Netherlands chickpeas grown outside were also attacked by, most probably, *Botrytis*. Conditions were too humid and the collections therefore contained *Botrytis*. Few or no seeds were harvested.

Izadpanah (1969) found a late season powdery mildew on all serial parts of the chickpea plant in Fars Province of Iran. The fungus *Leviellula taurica* was determined as the causal agent.

9.13. Bacterial disease

Rangaswami and Prasad (1959) described a bacterial disease, caused by *Xanthomonas cassiae* Kulkarni et al. The seedlings rot after emergence. The colonies on agar culture are smooth, shining, dull yellow and spherical. Inoculation of the gram-negative, short, rod-shaped bacteria caused a blight reaction on the leaves. *Cassia occidentalis* is another host, but its seeds were not damaged.

9.14. Virus diseases

These are very few diseases of chickpea caused by viruses. The Yellowing Virus disease has symptoms similar to those of *Fusarium*. Its causal agent is most probably the Bean Yellow Mosaic Virus, perhaps in combination with Alfalfa Mosaic and/or Pea Enation Virus. Inner symptoms are discolouration and necrosis of the phloem bundle (*Fusarium* causes these alterations in the xylem). Yellowing virus is aphid-born (Erwin and Snyder, 1958).

Another virus disease causes phyllody, abnormal non-functional green flowers (Venkatamaran, 1959).

The symptoms of narrow leaves, described by Sattar and Hafiz for the Pakistan Punjab, may have been caused by a virus. It is reproduced by juice inoculation (1952).

In Iran several cases of virus attack were reported by Danesh et al. (1969). Field inoculations reduced single-plant yields by 64–100%. Natural infection is by aphids or mechanically, but percentages of diseased plants are low. The chickpea is only one of the hosts of all four viruses, so no virus is specific to chickpeas. More detailed results on the damage and nature of AMV, BYMV, CMV (Cucumber Mosaic Virus) and PLRV (Pea Leaf Roll Virus), were published recently by Kaiser and Danesh (1971a, b). PLRV infects leguminous plants but is of little importance to chickpeas in Iran. The plants with the disease are chlorotic and stunted, the axillary buds proliferous and the phloem bundles are discoloured.

After artificial inoculation only, the Pea Enation Mosaic Virus PEMV could propagate on chickpeas.

Although most diseases are insignificant, they still deserve attention. With the spread of improved cultivars of chickpea, outbreaks of disease could be serious to large areas.

10. USES

10.1 Introduction

In the main growing areas, the chickpea is chiefly used for human consumption. Almost every day it is a part of the diet in the Indian subcontinent; in the other producing countries many people use it at least once a week. Although chickpea is very suitable for cattle fodder, it is not used as such because pulses, seeds and food grains in general are scarce. Hay is of considerable importance for cattle food.

10.2 Human food

The main advantage of the chickpea as a pulse is its high protein content and the good quality of its protein. In spite of different attitudes towards the chickpea through the ages ('a poor man's diet of gram' in India, 'he is counting his garbanzos' for a penniless person in Spain, are two characteristic expressions), its contribution to diet has always been very important in several areas. Pulses as a group constitute a large part of protein nutrition, especially in India.

In normal years the daily food intake of adults is reasonably balanced, but often the diet of children is not. At present over 300 million children suffer from retarded physical growth and some percentage has defective mental development. The main cause is an insufficient protein intake. Further pregnant women or weaning mothers are victims of protein malnutrition. Low protein consumption is not necessarily restricted to the poorer classes. For children the daily protein requirements are estimated at 1.5 g per kg of body-weight, for adults 0.6, which amounts to a (crude) average of 30 g of protein.

Proteins are mainly vegetable in origin, either because of religious or traditional customs, or because of poverty. FAO (1970) reported that 70% of the total protein consumption was from vegetable source. Cereals contribute 50%, pulses, oilseeds and nuts 12% and fruits and tubers both 4%. This points to the importance of improving both the protein content of cereals and the amount of pulses in the diet.

In certain regions, vegetable protein is even more important. In India 88% of the protein is derived from vegetable sources (1968–69) of which 20% is contributed by pulses and nuts. This amounts to a consumption of 64 g pulses per person per day (1957–59) against 7–17 g in W. Europe and Australia, 23 g in Israel and USA, 29 g in Egypt and 38 g in Turkey. In W. Europe and USA more nuts are consumed. Data for 1969 are not yet available for all countries, but net consumption is stable or rises except for India, where 49 g was available. The consumption of grain legumes, and their contribution to the protein con-

TABLE 43. Consumption of cereals and pulses and their contribution to the vegetable protein supply (After Jalil and Tahir, 1970, FAO data 1968)

Region	Cereal consumption		protein supply %	pulse consumption		protein supply %
	kg per capita per year	g per capita per day		kg per capita per year	g per capita per day	
Europe*	34.31	94.0	78.0	1.38	3.8	3.2
N. America*	97.08	266.0	62.1	52.76	144.5	33.8
Latin America	25.31	69.3	60.1	5.83	16.0	13.8
Near East	25.41	69.6	77.2	2.15	5.9	6.6
Far East	17.50	47.9	72.7	3.74	10.2	15.5
Africa	16.67	45.7	64.0	5.02	13.8	19.3
Oceania	111.29	304.9	86.2	1.08	3.0	0.8
USSR	65.04	178.2	74.1	7.74	21.2	8.8
China	19.37	53.1	62.3	7.54	20.7	24.3
World	29.50	80.8	–	7.79	21.3	–

* Cattle food included, in N. America and Europe of large importance.

sumption is given in Table 43. The production and the average availability of chickpeas in India and Pakistan have been compiled in Table 44. The protein supply has been calculated on a base of 20% after subtraction of a loss of 25% of the seed production.

TABLE 44. Consumption of chickpeas in India and Pakistan

		Population in thousands	production in 1000 tons	Production per capita in kg per year	Protein supply in g per day
India	1948–52	363,636	3989	10.97	4.51**
	1961–65	464,396	5537	11.92	4.90
	1965	486,650	5785	11.89	4.89
	1966	498,703	4205	8.43	3.46
	1967	511,125	3622	7.09	2.91
	1968	523,893	5972	11.40	4.68
	1969	536,983	4310	8.03	3.30
	1970	550,000*	5564	10.12	4.16
Pakistan	1948–52	74,954	658	8.78	3.61
	1961–65	106,900	675	6.31	2.59
	1965	113,300	709	6.26	2.57
	1966	116,700	583	5.00	2.05
	1967	120,200	578	4.81	1.98
	1968	123,800	528	4.26	1.75
	1969	127,500	583	4.57	1.88
	1970	132,000*	589	4.46	1.83

*estimated **25% losses subtracted, protein content at 20%

Since normally the protein requirements cannot be met from cereals only, pulses and other low-priced categories of protein-rich food products are of great value. In the vegetarian diet chickpeas, as the main Indian pulse, are an important ingredient. Locally, traditional habits and lack of knowledge about balanced diets or the necessity of a narrow cropping pattern oppose an improvement in pulse supply, and disproportional geographical distribution may cause quantitative shortages.

In the following sections the products of the chickpea are discussed.

10.2.1. *Acids*

The glandular hairs of the leaves, stems and pods of *Cicer arietinum* secrete an acid solution which contains 94.2% malic acid, 5.6% oxalic acid, 0.2% acetic acid (SAHARASRABUDDHE, 1914 cf. WEALTH OF INDIA, 1950; also complete reference in KOINOV, 1968).

The concentration varies between 0.36–1.30% and reaches its maximum at flowering. In the fruitening stage the concentration falls to 1%. Because of the acids the straw of chickpeas used to have a bad name for fodder consumption in Bengal, and some Western districts of the Punjab. Although it is advised to mix the straw with cereal waste, I have often observed cattle feeding on fresh plant remains. Further in mixed cropping and rotation, bad influences on the soil have been attributed here and there to the acid secretion. The organic acids, however, are oxidized rather easily.

The total contents of organic acids of the stems and leaves have been determined by MANGE (1965). The stems contained 3 meq g^{-1} of organic acids, the leaves 3.3 meq g^{-1}, consisting of malic acid (62 and 62% resp.), malonic acid (17 and 7% resp.) and citric acid (13 and 25% resp.). Oxalic acid, succinic acid and fumaric acid were present in small quantities.

The acids are used medicine or as a vinegar (see also Chapter 1).

Whether the acids are still extracted in India, is questionable. WATT (1883, 1908), WEALTH of INDIA (1950) mentioned the extraction of acids by clean thin white fabrics which were put on the crop before night or swept over the crop in the early morning. When the cloths were saturated with dew and acid solution, they were wrung out. This method may still be practised in some places, but I have never seen it or heard references to it.

10.2.2. *Fresh shoots*

WATT, (1890), WEALTH OF INDIA, (1950) and PURSEGLOVE (1968) referred to the use of fresh shoots as a vegetable in India (phalli). They are prepared like spinach. Phalli may be boiled in soups and curries, or fried with spices as a side dish. As a fresh vegetable, it will contribute some protein and vitamins.

The shoots consist of 60.6% water, 8.2% protein, 0.5% fat, 27.2% carbohydrates, 3.5% ash, 0.31% calcium, 0.21% phosphorus and 6700 IU per 100 g carotene. Iron certainly will be present, although no data on the quantities are available. KAUR and VIJAYARAGHAVAN (1961) isolated the crude proteins from fresh leaves: the methionine content was 2.6 g per 16 g N, so that leaves may be of supplementary value to the seeds. Fresh pods are also eaten (HUSSAIN and BHATTI, 1959) WATT (l.c.) reported production of a green dye from the leaves, a fact known by the Chinese. No cross-reference is known.

10.2.3. *Fresh seeds*

Fresh seeds are well liked in most countries that cultivate chickpeas. In India, Pakistan, Turkey and Ethiopia the uprooted plants with the pods containing the unripe, green seeds are sols on markets, in the streets and at railway stations. The seeds are eaten raw and relished as a snack. At the end of the flowering period a good price is fetched per unit area. Chickpeas are also removed from the pod, like shelled peas, and sold. Although investment in labour is great, because shelling is labourious, it is economic to sell fresh chickpeas when no fresh peas are available.

PLATE 6. Girls eating a snack of young seeds in a field of 'Bengal gram' near Bhopal, Madya Pradesh, India

PLATE 7. Shelling pods of chickpeas for sale of fresh seeds in Patna, Bihar, India

These seeds can be eaten like peas, or in soups, curries and rice dishes. Their taste differs slightly from that of peas. The content of nutrients is mostly lower than that of ripe seeds, but the water and Vitamin C content are higher. (see 10.4).

Parched fresh seeds are called 'hola' in India. Usually the entire plant is held in the fire for some moments, and then the parched seeds are eaten out of the pods. This is also done in Ethiopia.

10.2.4. *Ripe seeds*

Outside the India subcontinent are the majority of chickpeas consumed as whole ripe seeds. In India the large, white-seeded 'kabuli' types are mainly used whole. Green-seeded cultivars are also fancied and replace peas and dry peas to a certain extent.

After soaking for 18–24 hours the seeds are boiled for 45–90 mins and sometimes for 2 hrs. On the market small quantities of seeds already soaked, are sold to forgetful cooks (Spain, N. Africa). Cooking quality seems to depend on the calcium content in the seed coat. Pulses grown on calcareous soils have a poorer cooking quality (BRYSSINE, 1955). After soaking, chickpeas increase in weight considerably by 55–135%. Hors d'oeuvres are prepared from whole chickpeas, for instance 'hoummous' from Greece: mashed cooked seeds are mixed with oil and garlic and eaten with bread. This is a very substantial dish, which is also used as a side dish. The same preparation is known in Syria and Palestine as 'hommos', the usual arabic name for the crop.

Soups containing chickpeas, spiced or not, are 'harira' (especcially used during the Ramadan month), 'hlalim' and some preparations of 'chorba' (with meat, green wheat, parsley, celery, tomatoes and spices). For these dishes the grains remain entire, but they can also be mashed partly (Turkey) or completely.

Boiled seeds are well-known as an ingredient of the sauce for 'couscous', the national dish of Northern Africa. Couscous consists of small aggregates of coarsely ground durum wheat. The sauce contains, in addition to meat, chicken or fish; onions, capsicum, garlic and chickpeas. It is further varied by adding other vegetables.

'Tajin' is a preparation of meat with various fruits or chickpeas cooked in a special flat earthenware dish with a conical cover (Morocco) or in a normal pan. 'Tbikha' contains besides chickpeas, broadbeans and several vegetables. The ingredients are fried in olive oil and then water is added to form a kind of purée, in which the different ingredients can still be seen (Tunesia).

Several pulses are important ingredients of 'wot', the sauce to go with 'enjera' the flat pancake type of bread in Ethiopia, made of 'tef', *Eragrostis tef* (Zucc.) Trotter (= *E. abyssinica* Schrad.). Chickpeas of all types (brown, black, beige) are found in 'wot', as well as lentils, beans and peas and meat or chicken, if available. The cause is strongly spiced with capsicum.

The 'Kabuli chana' is a dish from North India, prepared from precooked chickpeas with fried onions, tomatoes, turmeric, chilli, cumin, ginger and other spices. The pulse can be dyed by putting tea leaves in a piece of muslin in the pan when boiling.

In Afghanistan cooked chickpeas 'nagut' are sold with a savoury sauce and sometimes some vegetables. As it is very nourishing it serves as a concentrated meal for people visiting markets, pilgrims and travellers. In Tunisia I saw a vendor selling simply cooked chickpeas at a religious festival. The Turks usually eat chickpeas ('nohut') in a sauce of tomatoes, onions, oil and meat, similar to their preparations of white beans. Rice or bread and salad complete the meal. In Spain a favourite 'garbanzo' preparation is the 'cocido', a kind of stew with potatoes, brown beans, onions and meat. Cooked with meat it provides a complete substantial meal.

In Bulgaria (ZLATAROV, 1913) a special bread, 'ssimitt' is made from wheat flour with a fermentative mixture, prepared from coarsely ground chickpeas stored for 8–15 h with tepid water at 32–35°C.

According to ZLATAROV (1922-23) *Bacillus macedonicus* Kjuljumov and *B. arietinus* Chodatti ex Zlatarov are involved in the fermentation and this process is also known in the orient. The same fermentation is used in the preparation of 'bosa', a light alcoholic beverage from *Panicum miliaceum* L.

EBINE (1966) mentioned the suitability of chickpeas for enzymic treatment with *Aspergillus oryzae*. The product is similar to 'miso', made from soya beans, and the proteins are more easily digested.

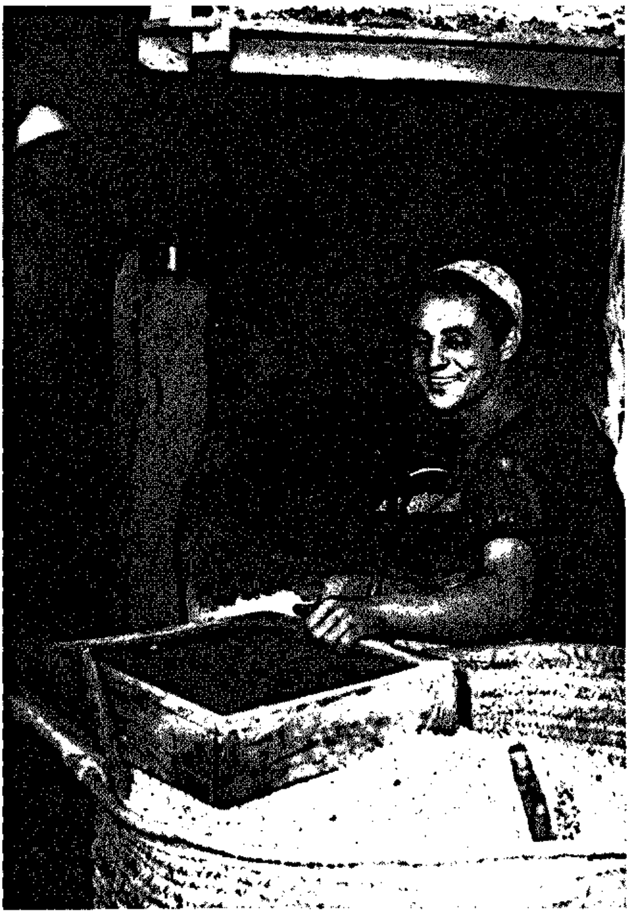


PLATE 8. Roasting of chickpeas in Marrakesh, Morocco

Seeds can be parched or roasted in large metal pans or hot sand and then eaten. Their taste is not as distinctive as the taste of peanuts. They are consumed with or without salt or with chilli powder and other spices and salt (India). Sometimes the seeds are mixed with fried potato-sticks or made into many other snacks or sweets. In Afghanistan, India, Iran, Turkey and Malaya the parched seeds are sold in the streets. In Malaya and Indonesia the chickpeas are known as 'katjang arab', the 'arabian peanut'.

In Turkey and Bulgaria 'leblebi' is prepared by frying chickpeas in a iron basket on a fire. After frying for half on hour whilst stirring continuously, the pulses are allowed to cool. They are kept for 1–2 days and their fried a second time. After one to two months the roast chickpeas are soaked for a night in so little water that it is all absorbed. In small quantities the swollen chickpeas are fried a third time for about 6 h. After polishing and dehusking the yellowish-grey 'leblebi' is ready for consumption. In Turkey a variation is known which has

PLATE 9. Sale of roast and spiced chickpeas in Delhi, India

PLATE 10. A hearty meal of boiled chickpeas with sauces and spices in Mazar-i-Shariff, Afghanistan

a thin white layer on the seed coat. According to ZLATAROV (1917) 'leblebii' is also used in oriental sweets as 'halwa' and 'rahat loukoum'. However, 'leblebi' is also the name for a soup with chickpeas in Tunis.

Parched seeds can be mixed with semolina, made from durum wheat, into a pastry: 'zhawiya' in Tunisia. A kind of chickpea butter, 'bsisa' is a speciality in Sfax, Tunisia, prepared from ground roast chickpeas with some durum wheat, horse beans and spiced with fenugrec and coriandre. It is eaten with water and oil and some dates or figs for breakfast from October to May.

In many countries the roast seeds are covered with pink or white sugar. 'Homsiya' is a sweet prepared from roast chickpeas in a thick sugar syrup, flavoured with lime. When it is to dry the product is cut into pieces. An Afghanistan sweet is 'kultsha', prepared from roast seeds with sugar and butter or oil (AITCHISON, 1891; VAVILOV, 1929). Furthermore the roast seeds can be made into flour, 'sattu', for special Indian preparations.

10.2.5. *Split seeds*

The split dehusked seed, consisting of the cotyledons only, is the main form in which *Cicer* is consumed in India. KURIEN (1968) reported that 75% of the pulses were milled. This 'dhal' is prepared by splitting large or medium seeds in a mill. After cleaning, the seeds are sprinkled with water and left overnight to facilitate the removal of the husk. After drying, the split chickpeas are milled and sieved to obtain uniform product. The dhal can be 'polished' with a suspension of turmeric powder and water, to obtain an attractive yellow colour. Most Indian cultivars have natured yellow cotyledons, except the kabuli forms. These are whiter, and are less often made into dhal. The extraction rate of dhal is about 80% of the weight of the whole gram.

The broken parts as well as the dhal can be ground into meal or flour. The separated husks (5–17% of the seed weight) and noncotyledonal parts of the embryo are used as cattle fodder. Dhal is further prepared into simple side dishes, often with turmeric, chilli, onions and tomatoes. It can be served as whole seed parts, as a mash or as thick soup. Any left-overs can be recooked into a mash. Dhal is also made from other pulses such as *Cajanus cajan* (L.) Millsp., *Phaseolus aureus* Roxb., *Lens culinaris* Medik. etc., and is a regular dish. Dhal can be made into chutneys. For 'chana poorees' the dough is prepared from dhal, that has been soaked and dried and subsequently fried and ground.

'Phutanas' is roast dhal, sometimes flavoured with turmeric, chilli and salt for use as a snack.

10.2.6. *Sprouted seeds*

Germinated chickpeas can cure vitamin deficiencies such as scurvy. Their Vitamin C content is about twice that of the dry seeds (BHAGVAT, 1942) especially after 30–48 h germination. The subsequent 3–4 days do not bring about a higher relative content. BUTT et al. (1965) reported an increase in Vitamin C content up to 7 days when the chickpeas are soaked in water or water with spores of iron sulphate. It is more common to germinate mung beans and soya beans. The method of preparation may vary from soups to the use as a vegetable with a suace. 'Kootu' is prepared in S. India and Ceylon from fried germinated seeds, spices and ground coconut.

10.2.7. *Meal and flour*

Chickpea meal or flour, in Hindi called 'baisin', 'besan' or 'sattu', is prepared from split seeds or from the broken parts ('chuni') that remain after the preparation of dhal. There are innumerable ways to use the flour. It is normally mixed whith wheat flour to prepare a special kind of 'chappati', the Indian flat bread made from unleavened dough. The chappati may also be filled with a mixture of gram flour and sugar. In protein-deficient areas of Turkey, a government order prescribes the use of 'nohut' meal in bread. Gram flour is used in salt pastries, as 'kofta', 'pakora', 'dhokla' or 'khaman' and 'pagodas'. The use in thick soups or omelets is well known in India. A sweet pastry containing gram flour is 'grayba hommes' (Tunisia). In India a popular sweet or sweet meat with gram flour is 'besan bari', 'laddu', 'pooran-poli' mostly consisting of fried or cooked dough with sugar, milk, butter or oil, raisins or nuts and flavouring. Several sweets are sold in syrup. Often the meal is roasted or puffed before the preparation of confectionary. The starch can also be used for textile sizing.

10.2.8. *Balanced food*

A modern application of chickpea flour is the balanced food. Especially prepared by industry, these foods are used in the diets of children, and expectant and nursing mothers. Easy preparation, high nutritive value and good storage qualities are some of their advantages.

Indian Multi-Purpose Food IMPF

Indian Multi-Purpose Food has been developed by the Central Food Technological Research Institute at Mysore (PARPIA and SUBRAHMANYAN, 1959; BHUTIANI, 1963). It is intended to supplement improperly balanced diets, containing too many carbohydrates, and can be used to cure kwashiorkor and other protein-deficiencies.

IMPF contains 42 g protein per 100 g and is prepared from specially processed chickpea flour and groundnut (*Arachis hypogaea* L.) meal in a proportion of 1:3. The proteins of both *Leguminosae* supplement each other: chickpeas are deficient in the amino acid methionine, and rich in lysine and threonine; groundnuts are deficient in lysine and threonine. However, the methionine content is somewhat too low (JOSEPH et al. 1958). Fortification with methionine-rich sesame (*Sesamum indicum*) could overcome the minimum and raise the biological value.

IMPF can be used, without altering food habits, in any dish in which different types of flour such as wheat flour or even normal chickpea flour are used. The spiced variant can be added as a chutney powder or cooked with rice dishes or dhal. Bread and stuffed bread preparations such as 'parathas', 'chapaties', 'dosai' and 'samosa' can be supplemented with the plain IMPF. In sweets the chickpea flour or dhal may be substituted partially by IMPF. In porridges it is a useful supplement.

A commercial plant has been established at Coimbatore. The Institute at Mysore has a smaller production unit and UNICEF has donated installations for groundnut-flour plants. In 1963 school children received the entire production in a Midday Feeding Programme. Government and International Foundations are supporting further development, distribution and even export. IMPF is very valuable for relief programmes. No information could be obtained, however, about the amounts of IMPF used in the normal diets today.

Superamine

Superamine is produced and developed in Algeria by nutrition specialists with UNICEF and FAO aid. Released in 1968 as a complete food for young children after weaning, it is for sale at a low (subsidized) price. It contains 20% of proteins, its composition is given in Table 45. Except for the skim milk powder, mostly indigenous materials are used. Its preparation is simple and similar to an instant porridge.

One factory at Blida of S.N. Sempac (Société Nationale des Semoules, Meuneries, Fabriques de Pâtes alimentaires et Couscous), a socialized organization, produces 1500–1800 tons a year. A second factory will be constructed.

TABLE 45. Composition of some balanced foods containing chickpeas

Composition of IMPF	
25% chickpea flour	
75% groundnut meal	
Nutrition value of IMPF	
calories per 100 g	352
protein	42.3 g
calcium	670.2 mg
phosphorus	825.4 mg
iron	5.3 mg
Vitamin A	3022.9 I.U.
Vitamin B_1	1.4 mg
Vitamin B_2	3.5 mg
Nicotin acid	14.1 mg
Vitamin D	250.4 I.U.
Composition of Superamine	
28% durum wheat flour	
38% chickpea flour	
19% lentil flour	
10% skim milk powder	
5% sugar	

Distribution is energetically tackled with government and UNICEF aid. A film is used for propaganda and the product was shown at the Fair of Alger. Further exports are made to the North African countries, Turkey, Iran and Nigeria (NN, Afric-Asia, 1971).

Other products

ALI et al. (1964) and HANIF et al. (1965) described for Pakistan the composition of a protein food developed from chickpea flour, *Cyamopsis tetragonoloba* (L.) Taub. flour and fish meal.

KRISHNAMURTY et al. (1958, 1959); TASKER et al., (1959, 1960b, c;) RAO, (1953) gave details on a low price protein food containing coconut, groundnut meal and chickpea flour.

Addition of calcium phosphate (1 g) and vitamins A (3000 I.U.), B (3.0 mg riboflavine and 0.8 thiamine) and D (300 I.U.) per 100 g proved adequate in most of the mixtures described. TASKER (1960a, 1961, 1962), described other mixtures with sunflower and sesame seeds and skim milk powder added and discussed their value as supplements to poor rice and tapioca diets.

DESIKACHAR et al. (1956) showed that soya beans, if they are autoclaved or made into flour, are only slightly better than chickpeas as a supplement to a protein- deficient rice diet.

Together chickpeas and soya beans have a high biological value, and an intake at 10–16% level would relieve much protein malnutrition. Chickpea products constitute about 25% of the above-mentioned mixtures.

10.3. CATTLE FEED

10.3.1. *Fresh Plants*

Young chickpea plants are suitable for feed, although the acid taste may discourage a large intake. In general the crop is of little interest for fodder, because many more productive plants are available. The crop should preferably be mixed with other fodders. Often goats and cows eat plants thrown on roads, after the plants have been sold for fresh consumption of the seeds. The composition of fresh plants is shown in Table 46.

WIRJOMIDJOJO (1956) referred to the possible use of *C. arietinum* as fodder in Indonesia, where it can produce up to 90 tons of green matter per ha per year (about 4500 kg dry matter per ha per growth season of 3 months). Since the seed has to be imported and other fodders are available, no prospects can be seen for this use in the tropics.

10.3.2. *Hay*

The hay of chickpea plants, about 100 to 125% of the harvested amount of seeds, is also valuable as cattle fodder. The organic acids are oxidized quickly, and should not be taken as a pretext to deny its value. Cattle in the Indian subcontinent are largely underfed and they eat 'everything under the sun'.

In India the hay is called 'bhusa'. The composition is given in Table 46. ENKEN (1957) referred to the chickpea as a forage crop in the USSR.

10.3.3. *Seeds*

In spite of its suitability for cattle feed, the seeds are mainly reserved for human food. The use of other feeds for cattle has been suggested in several publications (ABBAS, 1955; HOSSAIN, 1959) and mentioned may times elsewhere. The price of chickpeas has become prohibitive for the use as a fodder in the Asiatic parts of the area of cultivation. Moreover, the cheap feed cakes (remainders of mustard seeds, groundnuts, sesame seeds after oil extraction) have a high protein content (27–40% or more) and can fatten cattle even better than chickpeas alone. Seed husks are valuable for feed too.

In the USSR several data are published on the use of chickpeas as fodder (ARTIUKOV, 1959; CHEBOTAEV, 1960; ENKEN, 1953; JASINSKII, 1960; LIVANOV, 1960; MAKNEV, 1965). About 80% of the Mexican production consists of cultivars for fodder for pigs, horses and chickens.

The former exports of India to Britain, France and the Netherlands were mainly used as fodder for horses. The seeds are fed raw, or soaked, sometimes cooked, further milled ('atta' in Hindi, which stands also for dough) or as broken bits ('chuni'). Except for a suboptimum content of methionine, the composition is entirely suitable. Alse in chicken food chickpeas are very useful. For reports see PINO (1958, 1962). RAO (1966) investigated the addition of broken bits to chicken food, but this proved to be inferior to the conventional groundnut-cake and fishmeal rations. When only cereals are fed, chickpeas in some form will most probably improve the rations.

10.4. NUTRITIVE VALUE

10.4.1. *Chemical composition*

Research on chemical composition of chickpea started as early as the 19th century. To illustrate the wide variability in data, a table has been prepared (Table 46). Both location and cultivar have an influence on the composition (RPIP, 1969; KROBER, 1970). The data are recalculated to dry matter contents. The water content of stored seeds ranges from 8 to 13% (PLATT, 1965). The digestibility of the proteins ranges from 76% to 88% (Table 47).

The distribution of the nutrients over the different seed parts has been established by LAL et al. (1963). The embryo without the cotyledons (of cv. Pb 7) constitutes only 1.2% of the seed weight, cotyledons constitute 84.2% and the seed coat 14.6%. Proteins and fats are accumulated in the embryo, especially in the non-cotyledonal part. The seed coat has a high fibre and Ca content. The authors concluded that milling of the seeds does not appreciably lower the food value. This is not in agreement with earlier findings (NN, FOOD SCIENCE, 1959) that the cotyledons contain no carotene, no thiamine and no nicotinamide, which apparently are located in the plumule and radicle.

TABLE 46. Chemical composition of *Cicer arietinum* L. in % of dry matter (seeds, unless stated otherwise)

kcal per 100 g edible portion	proteins (crude)	fats (aether extr.)	carbohy- drates	fibres	ash	Ca	Fe	P	carotene provit.A
	% of dry matter					mg per 100 g			I.U.
	21.9–24.5	5.2–4.7	60.5–66.7	8.7–1.1	3.5–2.9				
	21.3–30.2	4.6–6.8	58.4–66.2	2.7–5.1	2.6–4.8	292	63	880–990	
	12.6–31.2								
	19.0	5.9	67.8	4.3	3.0	210		270	350
	22.4–31.6								
358	22.6	5.0				167	8.1		337
358	27.3	1.9	63.9	3.9	3.0	93.2	3.1	193.1	
	21.2–24.7	4.4–7.4	64.4–74.3	1.9–9.0	2.5–3.8				
	17.6–27.9								
361	18.6	5.8	67.1	4.3	3.0	210	10.7	260	364
	17.4–24.5				2.7–4.9	231–443	0.6–3.0	650–1363	
	21.1	4.7	62.57	8.9	2.7	200	5.6	272	
386	21.9	5.5	67.0	3.1		131	9.9		21.9
	18.4	4.6	53.4	14.5	3.7				
	24.7	9.2	50.4	9.7	3.0				
	24.0	10.3	52.8	5.0	3.1				
	25.0–27.6								
	18.4–29.8				4.1–4.7				
	15.8–20.2								
	19.5–30.6								
	10.8–11.3	2.1–2.2	44.9–48.0	27.2–33.1	9.1–11.4	1790–1980		520–570	
	12.9	1.5	38.1	36.3	11.2	2140		460	
	5.8–17.5	0.9–2.5	39.0–47.5	27.0–48.4	5.6–6.0				
	25.3	5.9	66.3	0.0	2.5	78	10.0	350	
392	19.7	4.1	73.3	0.0	2.9	82.4	6.2	45	
392	21.2	5.4	65.3	4.2	2.9	33	4.7	65.5	
402	23.6	4.6	67.0	0.0	4.7	149	7.3	131.8	
	25.4–27.8	5.5–7.5	59.9–63.1	1.7–3.4	2.1–3.7			982	
	25.3	5.9	66.3	0.0	2.5	210		340	
372	25.3	5.8	66.3	0.0	2.5	79	10.0	349	0.0

The cooking of the seeds is generally considered to raise the nutritive value (HIRWE and NAGAR, 1951; GAITONDE and SOHONIE, 1952), as does autoclaving (for instance 15–60 minutes at 0.7 kg cm^{-2}, BRAVO et al., 1968). Trypsine inhibitors, found by GAITONDE et al., were inactive after cooking. However, normal cooking did not alter the digestibility and nutritive value according to KANDÉ (1967).

The starch grains measure up to 30 µm and are oval-globular in shape with concentric layers and a simple centre (GASSNER, 1931). The composition of the carbohydrates (sugars and starch) has been referred to in WEALTH of INDIA (1950). TOLMASQUIM et al. (1965) and CORREA et al. (1965) studied the viscosity, the swelling power and the solubility of the starch.

The properties of the oil fractions are mentioned in WEALTH OF INDIA (l.c.). The oil content is higher than in other pulses (4–6%, more than 10% according to CHENA et al., 1967), so that parching should be easier. WOLFF and KWOLEK (in HARBORNE et al., 1971) listed the saturation of the oils as 11.8%. The bibliography on the biochemistry of the chickpea is a summary of the other

thiamine vit. B1	riboflavine vit. B	nicotin-amide	ascorbic acid, vit. C	remarks	reference
mg per 100 g					
				with and without seed coat	Watt, 1890
				minerals as oxides	Zlatarov et al., 1913, 1917
				not inoculated and inoculated resp.	Ivanov, 1932
			8 –19	higher vit. C content in germination	Bhagvat et al., 1942a
0.11				whole seeds	Wealth of India, 1950
					Milov, 1952
0.45	0.20	1.8	5.6		FAO, 1954
0.14–0.31				'desi' and 'kabuli' types respectively	Hashmi et al, 1954
				cv. Pb 7	Khan et al., 1955
				Turkish cultivars	Genckan, 1958
				effect of cv. and location included	Esh et al., 1959
0.33	0.56	2.9		whole seed	NN, Food Sci., 1959
				Ca, P and Fe as oxides	Hussain, 1959
				cv. Pb 7	Lal et al., 1963
	0.1	1.5			Platt, 1965
				'negro' (black type)	Chena et al., 1967
				'porquero'	Chena et al., 1967
				'blanco' (white type)	Chena et al., 1967
				22 named botanical varieties	Koinov, 1968
			2.1–6.0	40 named cultivars	Chandra et al., 1968
					RPIP, 1969
					Amirshahi, 1970
				green feed	Wealth of India, 1950
				dried hay	Wealth of India, 1950
				husks	Wealth of India, 1950
0.51	0.39	2.8		chickpea flour	Narayana Rao et al., 1959
				chickpea flour (basin)	Khan et al., 1955
				split chickpeas	Khan et al., 1955
				fried chickpeas	Khan et al., 1955
				fried chickpeas (leblebii) P as P_2O_5	Zlatarov et al., 1913
				fried chickpeas (without husk)	Wealth of India, 1950
0.0	0.43	0.0	0.0	chickpeas without husk	NN, Food Sci., 1959

products isolated from chickpea seeds, such as *biochanins*. Up-to-date detailed information on chemical composition is given in 'Chemotaxonomy of the Leguminosae', edited by HARBORNE et al. (1971). Very early work (1913–1923) was carried out by ZLATAROV.

In the ripening processes and during germination definite changes in chemical composition of the seeds were observed by several authors. Since chickpeas can be eaten fresh or germinated, these changes are of interest for the nutrition value. The riboflavine content decreases in maturing seeds (NAIK et al., 1963). The Vitamin C content increased in germinating seeds from a maximum of 40 to about 160 mg per 100 g (BUTT et al., 1965).

The data on the calories provided by chickpeas differ as a consequence of the age of the seeds, different analytical methods, different cultivars and origins. The range published by WAHEED KHAN et al. (1955) is interesting. Apparently roasting increases the caloric value, which is the highest (402) of all food grains in their list. The reliability of this value is questionable, however, since the amount of fats is listed as 4.5%, which is quite normal for chickpea, compared

TABLE 47. Digestibility and biological value of chickpeas

Level of intake	Digestibility 5%	10%	15%	Biological value 5%	10%	15%	Reference
		76			78		Niyogi et al. cf. Pal, 1939
		86			62		Swaminathan cf. Pal, 1939
		76			78		Nag and Banerjee, 1933–34
	85	88	88	60	52	46	Basu and Haldar cf. Wealth of India, 1950
			89				Kandé, 1967

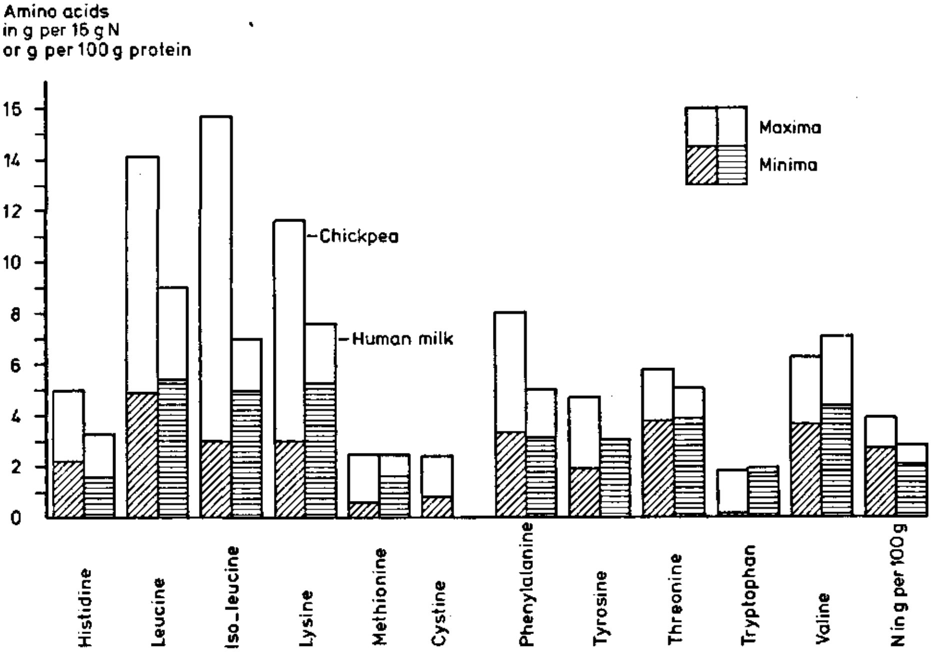
with the low rate of 1.2–1.7% for the other chickpeas investigated by the same authors. Split seeds contain 5.2% of fats. Whole seeds range from 332 ('Pb 7') to 389 ('C 12/34') in caloric value.

10.4.2. *Amino acid composition*

Many data were published on the composition of the proteins of chickpea seeds. HARVEY (1970) compiled his data from literature. A graphical representation of the essential amino acids is given in Graph 37. The data may be compared with all other foods, but only the amino acids of human milk are given for reference (FAO, 1968). The authors not quoted by HARVEY (RUDRA and CHOWDURI, 1950; TISI and GODOY, 1967; NARAYANA RAO, 1959) gave values well within the limits of the list. For both types of protein the maximum and the minimum content as published are given. Some amino acids, present in protein, have been more frequently investigated than others. The cystine, lysine, methionine and tryptophan contents have been studied most frequently for chickpea protein, as these amino acids are essential and are often present in low amounts in vegetable proteins.

Because of the wide range of the data, it remains difficult to compare chickpea with other pulses and other food crops. In relation to other pulses, the chickpea has a high content of most amino acids. Red gram (*Cajanus cajan* (L.) Millsp.) may be richer in histidine and methionine. Peas (*Pisum sativum* L.) may contain more valine, threonine and tryptophan. Peanuts (*Arachis hypogaea* L.) contain more phenylalanine and are sometimes richer in methionine. The contents of the non-essential amino acids (alanine, arginine, aspartic acids, glumatic acid, glycine, proline and serine) may vary.

Human milk has lower contents of most amino acids, except for proline, tryptophan and valine. Its methionine and tryptophan contents have a higher minimum than in chickpea-protein. Histidine is essential for children, and chickpea protein is superior in this respect to human milk. The cystine content of the chickpea protein is more than sufficient, and it can replace methionine to a certain extent. Phenylalanine and tyrosine, which can replace phenylalanine partially, are present in larger quantities than in human milk.



GRAPH 37. Contents of essential amino acids in chickpea protein

In conclusion it seems that the tryptophan content is a limiting factor, because the minimum published values are much lower than those in milk. The maximum value approaches that of human milk, and is about equivalent to the FAO requirement of 1 g per 16 g of nitrogen (1% of protein) (RPIP, 1969). KROBER (1968, and in RPIP, 1969) has criticised the analytical method used, however, because the usual method destroys tryptophan to a certain extent. Research is in progress.

It seems worthwile to investigate the possibilities of improving methionine and tryptophan contents by breeding and cultivation. In dietetics several combinations of foodstuffs to supplement chickpea proteins have been worked out. The proteins of groundnuts and sesame are very valuable in raising the biological value (JOSEPH et al., 1958; TASKER et al., 1959, 1960, 1961). KANDÉ (1967) found a large increase in efficiency of chickpea proteins when minerals and vitamins were added.

SUMMARY

1. The history of the chickpea or gram, *Cicer arietinum* L., has been described from Homer's time and the earliest finds, 5450 B.C. in Hacılar, Turkey, up to the present day. The crop was first domesticated in Asia Minor and was introduced in India either from Central Asia or Asia Minor, the two main centres of origin. Some forms were even introduced rather recently. Ethiopia is a secondary centre of domestication; connections with Egypt or Asia remain speculative. Several pieces of evidence oppose the opinion of DE CANDOLLE (1882) that the ancient Egyptians and Jews had only known the chickpea for two millenia.

Medical uses, no longer widely practised, are discussed. The spread to the present areas of cultivation is described and mapped.

2. The genus *Cicer* L. has been revised. POPOV (1929) accepted 22 species, now 39 species (8 annual, 31 perennial) are known. One species is described for the first time: *C. multijugum* from Afghanistan. A key to the species is prepared. The species, arranged alphabetically, are described and accompanied by detailed illustrations. The synonymy and typifications are given, as well as notes on geography, ecology and morphology. The geographical distribution of each species of the genus, occurring in Central Asia, Asia Minor and the Mediterranean, is presented in maps. It is stressed that the variability and geography of many species is not known sufficiently. The poor availability of fresh material of the wild species is a handicap to research.

The relation to the other genera in *Vicieae* is discussed. *Cicer* occupies a somewhat peculiar place with its glandular hairs, inflated fruits and seed shape. The infraspecific classification in the cultivated species is reviewed; an informal classification is presented on base of the work of POPOVA (1937) without rejecting the older varieties distinguished by JAUBERT and SPACH, and ALEFELD.

3. The importance of the chickpea as the third pulse crop in the world after beans and peas is presented in a map, graphs and tables. The crop ranks 15th among all crops in area occupied yearly. Yields, at present an average of about 700 kg per ha, are highest in Egypt (1670 kg) and Turkey (1220 kg). About 83% of the world production is in the Indian subcontinent.

The weather is the main reason for fluctuation in area. The partial recession in area, due to the expanding new cereal cultivars, will be met by higher yields per unit area and aided by higher prices.

4. Some anatomical particulars, e.g. the glandular hairs, are shortly reviewed.

5. The chickpea is generally cultivated in a traditional way. The resistance to drought (deep roots) and ability to grow in poor soils has not increased the care of the crop. However, with good soil preparation, proper sowing on rows, cultivation and fertilization the crop can yield reasonably. The sowing date is very important. Sowing early in the growth season is to be preferred, except in case of wilt disease. Plant density, sowing depth and sowing seed are

discussed. Irrigations, needed in some countries, should be practised with care so as not to induce soil anaeroby.

Often the chickpea is grown mixed with wheat or mustard, against crop failures and for utilization of different soil layers. In rotation the chickpea is a well esteemed crop. It has maintained soil fertility at a certain level for centuries in the densely populated areas of India. The plants are harvested mainly by hand. Threshing machines need good adjustment to prevent breakage of seeds. Storage is an important problem, since much loss may occur.

6. Ecological trials were carried out on light, daylength, temperature and relative humidity. The photosynthesis rate varied from 250–500 μg CO_2-uptake per cm^2 and per h at about 26 °C, but at 18 °C, the rate was not much less. Leaves of two-weeks old are the most effective in photosynthesis and may use twice as much CO_2 as the four-week old leaves. Estimated calculated production appeared to be 12–14 tons of total dry matter, or about 5–7 tons of grains, similar to the highest yield ever obtained on a small plot.

The chickpea is a quantitative LD plant. Under 16-h days the flowering was advanced by e.g. 20–35 days, if compared with 9-h days. Short days did not prevent flowering. Dry matter yield was improved in LD. The influence of the photoperiodic effect alone of the daylengths following different sowing dates on flowering and yield is small. Increasing photoperiods appeared to be more favourable than decreasing ones.

The optimum temperature for early vegetative growth ranges from 21–29 °C (night and day) to 24–32 °C for different cultivars. Over the entire growth period the optimum temperature is somewhat lower, 18–26 °C and 21–29 °C, which is also optimum for flowering.

The relative humidity was found to have little influence on fruit-setting. A decrease in light intensity of 25% of the available amount during May and June, however, was found to decrease the number of pods by 25–50%.

Data on soils and nutrients are summarized. As yet the chickpea does not respond to dressings of more than 10 kg N and 30 kg P_2O_5 per ha. Moderately heavy soils are preferred, but both heavy and light soils are used in some areas.

Growth substances usually have a negative influence on the growth of chickpeas. Scarcity of practical trials prohibits any recommendation.

Topping appears to be an old practice to stimulate branching. Regeneration, however, takes a long time and is only sufficient under optimum conditions and if applied at an early stage.

7. Breeding has not yet improved yields over large areas. A review on cytogenetics is given. Some new reports on the somatic number of chromosomes of some wild species are added. As crossing technique is a delicate operation, hybridization on a large scale is at present not possible, but pollination at an early stage without emasculation may be a solution. The introduction of new cultivars has not been very successful because they have not shown large differences with local cultivars.

8. The most important insect pests of the chickpea are the podborer and the pulse beetles, which are described in some detail. Geographical distribution

and way of control is given. All reported pests are mentioned. Nematode attacks seem to be underestimated at present. Rats may cause important damage in stores.

9. The diseases of the chickpea, their occurrence, possible way of control are described. Most damage is done by wilt, caused by both a soil fungus and by physiological drought, and blight. Several other diseases such as rust and foot rots are not yet serious over large areas. As for pests, chemical control is often uneconomic.

10. The chickpea is mainly used as human food, whether fresh, boiled, or roasted in many preparations. As a part of balanced foods it can form an important supplement to the protein nutrition of children. The proteins of chickpea constitute an important part of the protein intake in India. The chemical composition of the seeds (e.g. up to nearly 30% of protein) is given, as well as the amounts of essential amino acids.
Except sometimes for methionine and for tryptophan the chickpea appears to be an excellent source of amino acids.

SAMENVATTING

1. De geschiedenis van de keker, *Cicer arietinum* L., is beschreven vanaf Homerus en de vroegste vondsten, 5450 j.v.Chr. in Hacılar, Turkije. Het gewas werd vermoedelijk het eerst door de mens in gebruik genomen in Klein-Azië. In India werd de keker geïntroduceerd uit de oorsprongsgebieden Klein-Azië of Centraal Azië. Sommige vormen vonden er zelfs tamelijk recent (1700) hun domicilie. Ethiopië is een secundair genencentrum. Uitwisseling van genenmateriaal met Egypte en Azië blijft speculatief. De mening van DE CANDOLLE (1882) dat de Egyptenaren en de Joden de keker niet gekend hebben vóór onze jaartelling, kan met voldoende aanwijzingen worden weerlegd.

De medische toepassing is in onbruik geraakt, maar biedt interessante historische aspecten. De verspreiding naar de huidige teeltgebieden is beschreven en in kaart gebracht.

2. De taxonomie van het geslacht *Cicer* L. is aan een revisie onderworpen. POPOV (1929) accepteerde 22 soorten in zijn uitvoerige monografie; momenteel zijn 39 soorten bekend. Eén soort, *C. multijugum*, is voor het eerst beschreven. De soorten zijn in alfabetische volgorde behandeld en gaan vergezeld van een gedetailleerde tekening, voorzover materiaal voorhanden was. Van drie soorten kon geen materiaal verkregen worden, zodat hun status niet kritisch kon worden bezien. De synonomie en het typemateriaal zijn vermeld.

Gegevens over geografie en ecologie werden bijeengebracht en kaartjes geven de vindplaatsen van iedere soort aan. Het geslacht komt voor in Centraal Azië, Klein-Azië en rond de Middellandse Zee. Van veel soorten zijn verspreiding en ecologie onvoldoende bekend mede omdat vooral levend materiaal moeilijk is te verkrijgen.

De verwantschap van *Cicer* in de *Vicieae* is aangegeven. *Cicer* neemt een wat aparte plaats in door de klierharen, opgeblazen peulen en de vorm van de zaden. De onderverdeling van de geteelde soort, *C. arietinum*, wordt besproken. Een 'informele' classificatie wordt voorgesteld, zonder de oudere variëteiten, onderscheiden door JAUBERT en SPACH, en ALEFELD, te verwerpen. De classificatie is gebaseerd op de studie van POPOVA (1937).

3. De keker is een belangrijke peulvrucht, in produktie alleen overtroffen door bonen en erwten. Qua areaal neemt het gewas in produktie de 15e plaats in de wereld in. De opbrengsten zijn gemiddeld slechts 700 kg per ha, maar kunnen oplopen tot 1670 kg in Egypte en 1220 kg in Turkije. Ongeveer 83% van het gewas wordt op het Indische subcontinent verbouwd.

Het weer is de belangrijkste oorzaak van fluctuaties in de bebouwde oppervlakte. De gedeeltelijke teruggang van het areaal in India wordt veroorzaakt door de zich uitbreidende nieuwe graanrassen. Dit zal worden gecompenseerd door stijgende opbrengsten per ha en hogere prijzen van keker.

4. De anatomie van *Cicer* wordt geschetst. De droogteresistentie gaat gepaard met vele sklerenchymatische vezels in de stelen (HOLM, 1920). De afschei-

ding van organische zuren door de klierharen werd anatomisch onderzocht door SCHNEPF (1965).

5. De teelt van de keker wordt meestal nog op traditionele wijze bedreven. De droogteresistentie (diepgaand wortelstelsel) en de mogelijkheid het gewas op een arme grond te telen hebben de verzorging van het gewas niet verhoogd. Met goede grondbewerking, zaaien op uniforme afstand in rijen, onkruidbestrijding en enige bemesting kan het goede opbrengsten geven. De zaaidatum is van groot belang. Zaaien vroeg in het seizoen is het beste, maar niet wanneer verwelkingsziekten in het geding zijn.

Plantdichtheid, zaaidiepte en de kwaliteit van het zaaizaad worden besproken. Bevloeiïng is in sommige landen nodig en moet met zorg worden uitgevoerd om anaërobe omstandigheden van de grond te vermijden. Het tijdstip van aanwending ervan is belangrijk. Tijdens de bloei kan bevloeiïng beter achterwege blijven.

De keker wordt in India vaak in mengteelt verbouwd met tarwe en Indiase mosterd, om grotere oogstzekerheid voor de boeren te verkrijgen. De grond wordt beter benut doordat verschillende lagen worden beworteld. In de vruchtopvolging is keker een gewaardeerd gewas. Het hield eeuwenlang de bodemvruchtbaarheid in India nog op een zeker peil, al is dat laag. De boer bevroedt dit ook vaak.

De planten worden meestal met de hand opgetrokken bij de oogst. Dorsmachines moeten zorgvuldig worden afgesteld om het breken van zaden, bij traditionele dorsmethoden gering, te beperken. De wijze van bewaring is belangrijk, omdat vooral hier belangrijke verliezen kunnen optreden.

6. Ecologische proeven werden gericht op de invloed van het licht, de daglengte, temperatuur en relatieve luchtvochtigheid. De fotosynthesesnelheid varieerde van 250–400 μg CO_2 opname per cm^2 en per uur bij ongeveer 26°C, maar bij 18 °C was dat niet veel minder. Deze waarden zijn vergelijkbaar met die van tarwe. Bladeren van omstreeks twee weken hebben de hoogste fotosynthese-snelheid, en kunnen tot ongeveer twee maal zoveel koolzuur opnemen als bladeren van vier weken oud. De berekende potentiële produktie bedraagt 12 tot 14 ton droge stof per ha, wat ongeveer 5–7 ton zaden zou kunnen betekenen. Dit ligt niet veel boven de hoogste zaadopbrengst, ooit verkregen op een klein oppervlak in Iran.

De keker is een kwantitatieve langedag-plant. Bij een daglengte van 16 uur kon de bloei met bijv. 20–35 dagen worden versneld, ten opzichte van planten bij een daglengte van 9 uur. De drogestof-opbrengst werd in LD verhoogd voor alle onderzochte cultivars. De invloed van de daglengte corresponderende met verschillende zaaidata op een breedtegraad van 30° is klein. Toenemende daglengten lijken beter dan afnemende.

De optimale temperatuur voor de eerste vegetatieve groei varieert van 21–29°C (nacht- en dagtemperatuur) tot 24–32°C voor verschillende cultivars. Over de gehele groeiperiode gerekend is de optimale temperatuur wat lager, 18–26°C tot 21–29 °C, hetgeen ook optimaal is voor de bloei.

De relatieve luchtvochtigheid als zodanig had weinig invloed op de vruchtzetting. De oorzaak van slechte vruchtzetting werd hieraan vaak toegeschreven, maar een afname in lichtintensiteit had een grote invloed op bloei en vruchtzetting. Een afname van de lichtintensiteit met 25% van de in de kas beschikbare hoeveelheid in de maanden mei en juni over de bloeiperiode deed het aantal peulen met 25–50% dalen.

Gegevens over bodem en bodemvruchtbaarheid zijn bijeengebracht. De bestaande cultivars van de keker reageren nog niet positief op giften van meer dan 10 kg N en 30 kg P_2O_5 per ha. In ieder geval zijn hogere giften nog niet economisch verantwoord. Middelzware gronden zijn het beste, maar zowel zware als lichte gronden worden gebruikt. Een goede ontwatering is noodzakelijk.

Groeistoffen kunnen de groei van keker beïnvloeden, maar meestal is het gevolg negatief. Door gebrek aan praktijkproeven is het moeilijk aanbevelingen te doen.

Het toppen van de stengels van keker is een oud gebruik in India om vertakking te bevorderen. Hergroei neemt echter veel tijd en is slechts voldoende als het in een vroeg stadium onder goede groei-omstandigheden wordt uitgevoerd.

7. Met veredeling heeft men in het algemeen de opbrengsten van de keker nog niet kunnen verbeteren. De cytogenetica is behandeld. Van enige wilde *Cicer*-soorten zijn voor het eerst de chromosoomaantallen bepaald. Het kruisen in keker eist veel nauwkeurig handwerk en de lage slagingspercentages zijn een rem op het uitvoeren van uitgebreide kruisingsschema's. Mogelijk vormen methodieken, waarbij emasculatie overbodig is, een oplossing. Het invoeren in de praktijk van nieuwe cultivars is moeilijk, omdat vaak geen grote verbeteringen kunnen worden getoond ten opzichte van de traditionele landrassen.

8. De belangrijke insektenplagen van keker zijn de peulboorders en de zaadkevers. Deze zijn wat uitvoeriger behandeld. De andere insekten ooit vermeld als oorzaak van schade aan keker worden genoemd evenals hun verspreiding en bestrijding. Aantastingen door plantenaaltjes worden waarschijnlijk nog onderschat. Tijdens de bewaring van de zaadoogst is schade door ratten vaak groot.

9. De ziekten van de keker vormen de belangrijkste specifieke onzekerheid voor de teelt. Vooral verwelkingsziekte (*Fusarium* sp.) gepaard met fysiologische droogte, en bladvlekkenziekte (*Ascochyta* sp.) veroorzaken plaatselijk schade. Andere ziekten, zoals roest en voetrot zijn nog niet gevaarlijk over grotere gebieden. Chemische bestrijding is meestal nog niet economisch verantwoord.

10. De keker is hoofdzakelijk van belang voor de menselijke voeding. De zaden worden rauw, en vers gekookt gegeten, maar meestal gekookt of geroosterd nadat het gewas is afgerijpt en de zaden zijn gedroogd. Gebruikt in vele gerechten vormt keker een belangrijk aandeel in de eiwitvoorziening van miljoenen mensen, vooral in India. Als onderdeel van sommige uitgebalanceerde voedingspreparaten kan het bijdragen tot de verbetering van de eiwitvoeding van kinderen.

De samenstelling van het zaad (bijv. tot bijna 30% eiwit) en de bijprodukten is in een tabel bijeengevoegd, het gehalte aan essentiële aminozuren is afgebeeld in een grafiek. Alleen voor methionine en tryptophaan kunnen de zaden van keker een tekort vertonen.

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INDEX OF AUTHORS

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Synonyms are in *italics*. The number of the species is in **bold face**, followed by the page number of the principal entry. New synonyms are listed as syn. nov. Nomina nuda or corruptions, some of them not mentioned in the text, are put between '*quotation marks*'. Subspecific taxa in *C. arietinum* are not given (see Section 2.7).

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