

nitrogen fertilization of strawberries and soft fruit

Economic importance of soft fruit

Various types of soft fruit are grown in the Netherlands Area, auction market supply and price are indicated in the table below for 1960 and 1961 (Tuinbouwgids (Horticultural Guide), 1962, according to Roelofsen):

Table 1 — Area and auction market supply of soft fruit in 1960 and 1961

	<i>ha</i>		<i>auction market supply × 1000 kg</i>		<i>auction market supply, millions of guilders</i>	
	1960	1961	1960	1961	1960	1961
strawberries	4883 ¹⁾	4579	25591	27000	26.1	27.0
red and white currants	1574	1691	5741	8040	4.2	4.8
black currants	1438	1615	3972	5330	8.5	5.6
gooseberries	196	193	853	1230	0.5	0.6
raspberries	1319	1086	8147	6000	5.4	4.8
blackberries	190 ²⁾	110	1572	1720	1.3	1.3

¹⁾ 1016 ha of this is as yet not in production. Full data for 1961 not yet available.

²⁾ This also includes all soft fruit that has not been mentioned.

Fertilizer trials with soft fruit

The number of fertilizer trials that have been carried out with soft fruit in the Netherlands up to the present time is quite small. For some time there has been much interest in red currants in relation to potassium deficiency, which causes necrosis of the leaf margins and has led to quite a number of experiments with potassium. Most trials have been carried out on strawberries.

In practice fertilization is carried out accord-

ing to experience, supported by the results of fertilizer trials in the Netherlands and abroad. There is a suspicion, however, that these experiments have provided an inadequate basis, especially with regard to fertilizer recommendations on nitrogen.

General demands of soft fruit on soil and fertilization

Soft fruit crops in general show the most vigorous development on light sandy clay soil

or sandy soils rich in humus. Excess water in winter is disastrous. The land needs to be properly drained. On clay soils a profile which becomes lighter with increasing depth is desirable. There should not be any impervious layers. The soils should retain sufficient moisture during summer. In view of this a reasonable humus content is required; otherwise, the fruits of strawberries, raspberries, etc. will not develop properly. The more superficially the crop roots due to impervious layers or a high water level in winter, the worse will be the damage occasioned by summer drought. Manuring with organic materials is very popular in soft fruit growing. Nitrogen application has a considerable influence on the yield. The size of the nitrogen dressing is usually limited owing to deterioration in quality of the harvested product. A well-adjusted nitrogen application will not give the maximum quantity of product, but it does give the maximum quantity of a first class product. A heavy nitrogen dressing may cause vigorous vegetative development at the expense of flowering and production.

STRAWBERRIES

Fertilization experiments with strawberries have yielded extremely variable results. This has been due to soil type, fertility, preceding crop and weather.

Nutrient requirement as related to growth stage

LONG and MURNEEK (1937) investigated the nitrogen and carbohydrate content of strawberry plants throughout the season. As soon as the roots of young runners become functional the total amount of nitrogen and the percentage of nitrogen in all parts of the plant increases rapidly, until a maximum is reached at the end of October. Eighty per cent of the nitrogen is then to be found in the leaves. Afterwards the nitrogen content in the leaves decreases rapidly from 2.5 to below 1 per cent. At the same time the amount of nitrogen in stem and root — the storage or-

gans — increases rapidly as a result of translocation from the leaves. In spring when fresh leaves, flowers and fruit are formed the nitrogen from the storage organs is used, and these organs have the lowest nitrogen content in May-June. Carbohydrates follow roughly the same pattern. At the end of October 50-70 per cent of the sugars are in the leaves. Afterwards insoluble carbohydrates are stored in stem and root and are used again in spring. Three periods can be distinguished in the nutrient requirement of strawberry plants: After picking, vigorous vegetative growth sets in and involves the leaves and crowns as well as the runners. Somewhat later, new roots are also formed. Cropping has exhausted the plant and for fresh growth nutrients are required.

From the end of August until the beginning of October the formation of flower buds takes place. It is necessary that at that moment the plant has sufficient nitrogen and carbohydrates available. The formation of the latter requires healthy and well-developed foliage. A low nitrogen content leads to insufficient flower bud formation, and a high one to satisfactory flower bud formation, especially if sufficient carbohydrates are present (LOREE, 1925). A low nitrogen content and limited carbohydrates may lead to poor development of stamens (GARDNER, 1923). An excess of vegetative growth may induce a shortage of carbohydrates, which may endanger flower bud formation. According to American investigations the fertilizer treatment just before the period of flower bud formation in September is the most important one. LONG (1940) demonstrated that nitrogen fertilization on 15 September, two weeks before the formation of flower buds from 25 September until 4 October, could bring flower bud formation almost up to the level of continuously fertilized plants. The dressing on 1 October was too late. Fruit setting was insufficient with late fertilization and also with fertilizer treatment starting on 15 September (table 2).

The period of development in spring which

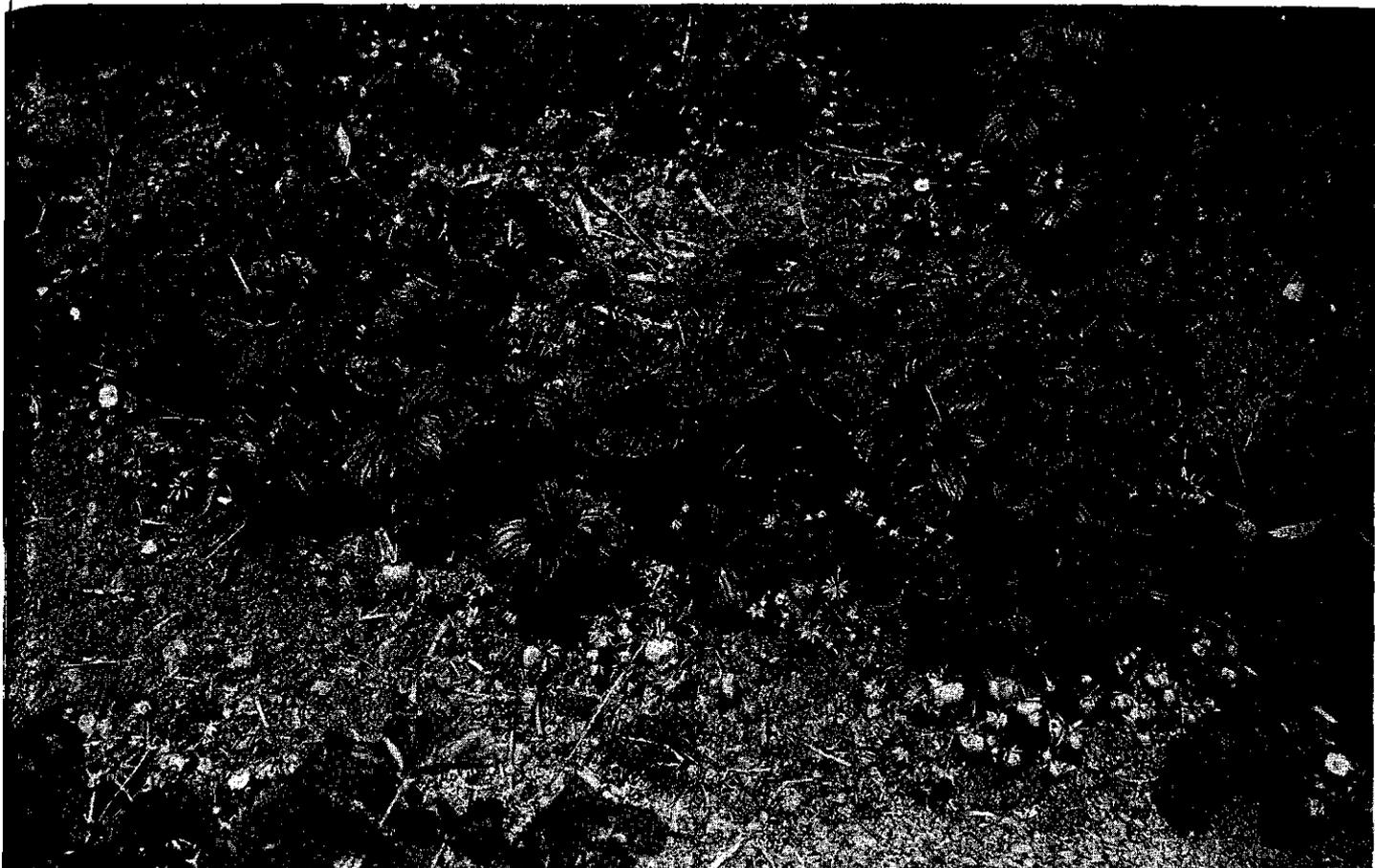


Table 2 — Withholding nitrogen fertilization until a specified moment before flower bud formation occurring between 25 September and 4 October. Late fertilization from 15 September onwards still has a favourable effect on the number of flowers, whereas that on 1 October has not

	<i>number of flowers</i>	<i>number of fruits</i>
continuously fertilized	900	683
nitrogen applied from		
1 July onwards	981	404
1 August "	825	554
1 September "	1026	639
15 September "	871	360
1 October "	604	360

follows winter dormancy may be considered a third period of great nutrient requirement. Fresh leaves, inflorescences, flowers and fruit require nutrients, which are partly drawn from the storage tissues in stem and root. Fertilizer trials have proved that treatment in spring in general does not increase the number of inflorescences. It does increase fruit setting and size of fruit to a slight extent. If the formation of flower buds has suffered owing to lack of nutrients in autumn, however, a well-timed spring dressing may increase the number of inflorescences, so that a reasonable harvest may yet be obtained

(DAVIS and HILL, 1928). It may be that formation continues until spring, or else weak flower buds start developing due to the spring dressing. Nitrogen fertilization in spring, however, may also be harmful because excessive development of leaves may occur at the expense of fruit yield. Too much foliage will favour the development of fruit rot in a wet harvest period. Ripening is delayed. In a dry harvest period strawberry plants with too much foliage will suffer most. Early fertilization also has the disadvantage that the formation of runners is stimulated more than with a summer dressing.

It is difficult to bridge these three above-mentioned periods by one treatment, especially on light soils and with plants with a poor nutrient status. The most favourable time of application seems to be after harvesting, if necessary supplemented at the moment of flower bud formation in September. In spring a fertilizer dressing is necessary only if the stand is rather thin. Experiments carried out in America on applications at various times, however, gave somewhat conflicting results. A summer dressing in general was more favourable, that in spring quite often gave excessive leaf development and decreased yields.

The amount of nitrogen required

In practice strawberries generally have a high nitrogen response, a somewhat lower potassium response and little response to phosphate. In sand culture trials carried out by WALLACE (1921-1923) the untreated plants and those without nitrogen were smallest and those without phosphate next smallest. Without nitrogen the plants showed very weak growth, the leaves were very small and yellowish-green, and early in the season they displayed red discolorations beginning at the petiole and at the base of the midrib. The fruit was vividly coloured. Excess of nitrogen causes uneven ripening of the fruit, which is soft and has a poor taste. With increasing nitrogen supply the contents of sugars and

acids in the fruit decrease (KNIGHT and WALLACE, 1932). Although the firmness of the fruit decreases at high levels of nitrogen this decrease in quality is not of economic importance under practical conditions (WALLACE, 1956).

Strawberries need a moderate amount of nitrogen. Plants free from virus need less nitrogen, as their growth is more vigorous (BOULD, 1961). This also holds for vigorously growing varieties. Strawberries under glass should also receive less nitrogen as too much foliage will in this case lead more quickly to insufficient fruit setting.

In a few fertilizer trials the yield from untreated plots has been as high as from those fertilized with nitrogen. This was even the case in an experiment in which nitrogen had not been applied for 10 to 20 years (HENDRIKSEN, 1960). On the central fertilization experimental field at Bruchem strawberries gave a clear nitrogen response only in the 6th experimental year (DE Vos, 1955, 1956). On sea clay at Numansdorp the lowest nitrogen level of 300 kg nitrolime per ha gave the highest yield (BARENDRECHT ADVISORY DISTRICT, 1957). However, omitting nitrogen alone may also be harmful. WAGNER (1931) obtained the poorest yield by fertilizing with phosphate and potassium only and the highest production by applying N, P and K or withholding fertilizer altogether.

The highest yield is obtained from plants which appear to have too little foliage, owing to nitrogen deficiency (BOULD, 1961). The nitrogen content in the physiologically active, mature leaves should be 2.7-2.8 per cent (of the dry matter) at the moment of ripening of fruit. Variations in the rate of nitrogen treatments are most clearly perceptible in the nitrogen content of the leaves at that stage. A nitrogen content of below 2 per cent indicates serious nitrogen deficiency, a content of over 3 per cent an excessive uptake. During flowering the optimal content is 3.2 per cent, after picking 2.4 per cent. Just as in other fruit crops the nitrogen content of

the leaves decreases as the season progresses. German investigators consider lower nitrogen contents already optimal, according to GRUPPE (1961) 2.4 per cent at the beginning of flowering, according to NAUMANN (1961) 1.8-2.0 per cent after harvest.

Dressing with farmyard-manure

A dressing of farmyard-manure is extremely desirable in strawberry growing. In the autumn of the year preceding strawberry planting farmyard-manure is worked into the soil. When strawberries are planted in summer this farmyard-manure will also be profitable to the preceding crop, for instance early potatoes. The variety Jucunda on sandy soil at Zundert responded favourably to a farmyard-manure dressing of 40-60 tons per ha (VAN DER BOON, 1960). The nitrogen contained in farmyard-manure is liberated gradually. Well-decomposed farmyard-manure may liberate 50 to 125 kg nitrogen per ha in the first two years depending on the condition of the soil. According to BOULD (1961) 50 tons of farmyard-manure per ha, ploughed in before planting in autumn, gave the highest yields on most sandy clay soils and moreover supplied enough nutrients for three years. KNIGHT AND WALLACE (1932) obtained the best results with 12.5 tons of farmyard-manure per ha before planting and an annual fertilization of 25 kg N, 170 kg P₂O₅ and 55 kg K₂O in spring. Next best was a treatment of 50 tons of farmyard-manure per ha without additional fertilizer. The first treatment gave an increase of 16 per cent, the second one of 7 per cent compared with those given artificial fertilizer only. LATIMER (1933) obtained varying results with nitrogen in experiments lasting 10 years. Compared with untreated plots, plots fertilized solely with nitrogen on average gave negative results. Nitrogen in combination with phosphate, however, increased the yield by an average of 5 per cent. Farmyard-manure gave best results, with an average yield increase of 20 per cent compared with untreated plants. To sum up it can be said that farmyard-

manure increases the yield of strawberries. When farmyard-manure has been applied, only a moderate dressing of fertilizer nitrogen is necessary, and nitrogen may even be omitted. In any case excessive leaf development should be avoided.

Sensitivity of the root system to excessive salinity

A complication in fertilizing a strawberry crop is the sensitivity of the roots to excessive soil salinity. Root scorching may quickly develop. For this reason fertilizer should be withheld from shortly before planting until 5-6 weeks after planting, when the roots have started to grow properly. Incorporation of farmyard-manure in spring may also hamper the initial growth of plants in continuous dry weather, owing to high salinity and a decreased capillary rise of moisture in the profile (BARENDRECHT ADVISORY DISTRICT, 1957). The negative effect of a nitrogen application may also be partly due to root scorching. It is not advisable to apply large quantities of fertilizer at any one time. This is especially important in a dry spring (DE Vos, 1956). On the central fertilization experimental field at Bruchem applying fertilizer exclusively in the (dry) spring was considerably worse than dividing the application into a spring and an autumn dressing ($\frac{2}{3}$ in autumn and $\frac{1}{3}$ in spring). Fertilizer should as far as possible be applied when rain is to be expected. A top-dressing in summer should not be applied too close to the centres of the plants, but always between the rows. The top dressing is best applied as compound fertilizers which in view of the requirements of strawberries should contain little nitrogen and a high proportion of potassium, e.g. with an N : K₂O-ratio 1 : 2 or 3. Dense stands in particular should receive proportionally more potassium than nitrogen.

Practical standards for the fertilization

It is difficult to give any practical standards for the fertilization of a strawberry crop without prior knowledge of the soil type, the

nitrogen supplying capacity of the soil, the rate of farmyard-manure and the fertility of the soil. A heavy application of farmyard-manure considerably decreases the necessity for application of nitrogen fertilizer. Depending on the growth of the crop only 15-40 kg of nitrogen per ha is necessary after a farmyard-manure dressing of 80-100 tons (BRUYSTENS, 1960). Strawberries on light sandy soil and peat soil grow more vigorously and should, therefore, receive less nitrogen than those on sandy clay and clay soil. A vigorously growing crop demands much care in nitrogen fertilization. A first-year stand needs more nitrogen, for the development of sufficient foliage, than an older one. The nitrogen requirement of strawberries under glass is smaller. 400-500 kg of a compound fertilizer 9 + 10 + 23 or 6 + 18 + 30 is recommended.

GERRITSEN (KRONENBERG, 1949) advises 120 kg of nitrogen per ha per year, to be divided into 200 kg of calcium nitrate after planting in summer before the end of September, when the strawberries are already growing well, carefully scattered between the rows and 450 kg of nitrolime in February or March in which scattering fertilizer over the plants should be avoided as well. In the second year part of the nitrogen is applied immediately after harvesting and part in spring. On the South-Holland islands 60 kg of nitrogen is applied in winter and 40 kg of nitrogen after picking. If the stand seems rather light after flowering a top-dressing of 200-300 kg of nitrolime per ha is applied as soon as rain is expected (BARENDRECHT ADVISORY DISTRICT, 1957). According to OELE and DE WILDE (1958) the best time for fertilization is in autumn when 80 kg N should be applied, while a light top-dressing of 30-40 kg of nitrogen as calcium nitrate is applied in spring. The top-dressing after harvest is easier to apply on the more moisture-retaining soils. On lighter soils rainy weather should be awaited, which often means postponing until August or September. This is to prevent root scorching.

CURRENTS AND GOOSEBERRIES

In this group black currants have the greatest requirement for nitrogen. The usual drawback that with heavy nitrogen application the yield increases at the expense of quality holds to a much less extent for black currants. Red currants have a high potassium requirement. If potassium deficiency occurs in a plant it is not very easy to remedy this at short notice by means of potassium fertilization. Gooseberries may suffer severely from potassium deficiency as well. Black currants are least susceptible.

Currants demand an ample supply of organic manures, black currants most of all. Red currants need less and withstand drought better on light soils rich in humus than black currants. An annual application of 20 tons of farmyard-manure per ha is very beneficial to the crop, especially on the lighter soils.

BLACK CURRANTS

In an experiment lasting 14 years WAGNER (1931) obtained the lowest yields of black currants on the untreated plot and on a plot without nitrogen fertilization; the yields were 57 and 70 per cent of the completely fertilized plots respectively. Without nitrogen growth was poorest, the leaves pale green and the currants smaller. Omitting the potassium fertilization had a slight negative effect, while omitting the phosphate fertilization had no influence at all. WAGNER found that the annual uptake of black currants was 63 kg N, 25 kg P₂O₅ and 34 kg K₂O.

WALLACE (1936) describes the results of an English investigation with black currants. Farmyard-manure gave the best results and these could not be equalled by fertilizer application. Potassium was the most important nutrient, while the adverse effect of withholding nitrogen was clear here as well (table 3).

In experiments by WALLACE (CHILDERS, 1954) the growth of shoots and the development of leaves and flowers was considerably decreased by withholding nitrogen. Leaf fall was

Table 3 — Influence of farmyard-manure and of withholding nitrogen and potassium on the yield of black currants, compared with bushes receiving complete fertilizer (= 100 per cent)

	<i>Woburn</i>		<i>Hadlow</i>	<i>Long Ashton</i>	<i>Cannington</i>
<i>farmyard-manure/ha</i>	<i>30 tons</i>	<i>75 tons</i>	<i>65 tons</i>	<i>25 tons</i>	
farmyard-manure	138%	91%	166%	106%	117%
artificial fertilizer: N, P, K	100%	100%	100%	100%	100%
ditto: P, K (no N)	—	—	—	89%	88%
ditto: N, P (no K)	—	—	74%	64%	83%

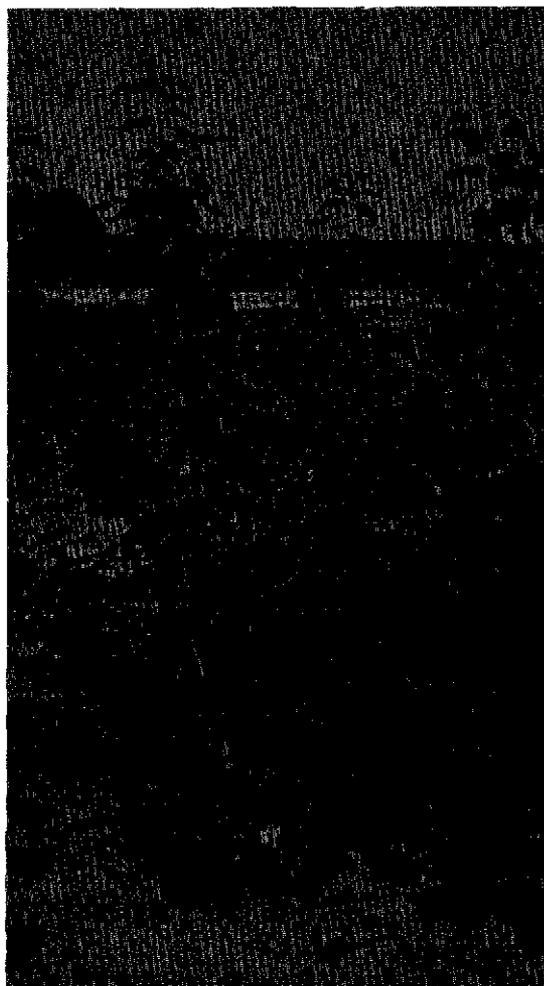
hastened. The leaves were small, pale green with red tinges in the last week of July. The next year the tops of the shoots had only very small leaves. There was an indication that the leaf-drop symptom was more severe in the bushes without nitrogen. Fewer and smaller fruits were formed (WALLACE 1921-1923).

The highest yield was obtained with a nitrogen content of 2.8-2.9 per cent in the leaves as sampled before the ripening of the fruit. A content of 2.3-2.5 per cent of nitrogen indicated nitrogen deficiency, one of over 3 per cent nitrogen excess (BOULD, 1960). A favourable response to nitrogen was obtained only after water shortage had been remedied by overhead irrigation (BOULD, 1959).

BLOOD and HEPPELL (1959) obtained a strong response to nitrogen in black currants; the maximum yield had not yet been reached at 250 kg of nitrogen per ha. There was no advantage in dividing this fertilization into a spring and autumn dressing; spring treatment gave the highest yield.

The content of vitamin C in the currants may decrease due to nitrogen fertilization, but owing to the increased yield the total production of vitamin-C per unit area is higher (CHILDERS, 1954).

Based on an experiment lasting 2 years with bud graftings of the variety Goliath, RIETSEMA (VAN DER BOON, 1952) found that black currants required 125 kg N, 69 kg P₂O₅ and 187 kg K₂O per ha.



Red currants

Practical standards for the fertilization of black currants

In practice too the favourable effect of farmyard-manure and nitrogen is well-known. Black currants, which have a superficial root system, are susceptible to water shortage, especially during fruit development and ripening. The soil is kept clean-cultivated. Organic manure is also applied to maintain the soil structure. As the black currant bush is subjected to vigorous pruning for rejuvenation purposes every year, its nitrogen requirement is high. Most currants come from vigorous long shoots formed the previous year. Before planting a dressing of 50-60 tons of farmyard-manure is applied and during cropping 50 tons are added and lightly worked into the soil every 3 years. The optimal nitrogen fertilization is between 160-200 kg nitrogen per ha (VAN GILS). The fertilizer application may also be divided, the greater part early in spring and the remainder in the form of calcium-nitrate after flowering, but only if the fruit is well pollinated and a fairly good yield is to be expected. The fertilizer should

be applied carefully as leaf scorching can easily occur. A fertilizer dressing that is too late and too heavy, however, hampers the maturation of the wood at the proper time.

RED CURRANTS

Red currants require more potassium and less nitrogen than black currants. WAGNER (1931) found in an experiment lasting for 14 years that withholding nitrogen gave a yield of 83 per cent of that obtained from completely fertilized plots and when potassium was withheld one of 68 per cent. Withholding nitrogen appeared to be more harmful in the first years of the experiment than later on. The more adverse effect of omitting potassium is in agreement with the results obtained at the horticultural experimental farm at Utrecht (LIJSTEN, 1942). In 1919 experimental fields with differential fertilizer levels were laid over 50 per cent clay fraction). In 1929 red currants of the variety "Hoornse Geelsteel" were planted. During the trial years up till 1942 the plot without nitrogen did not lag much behind in terms of development. The



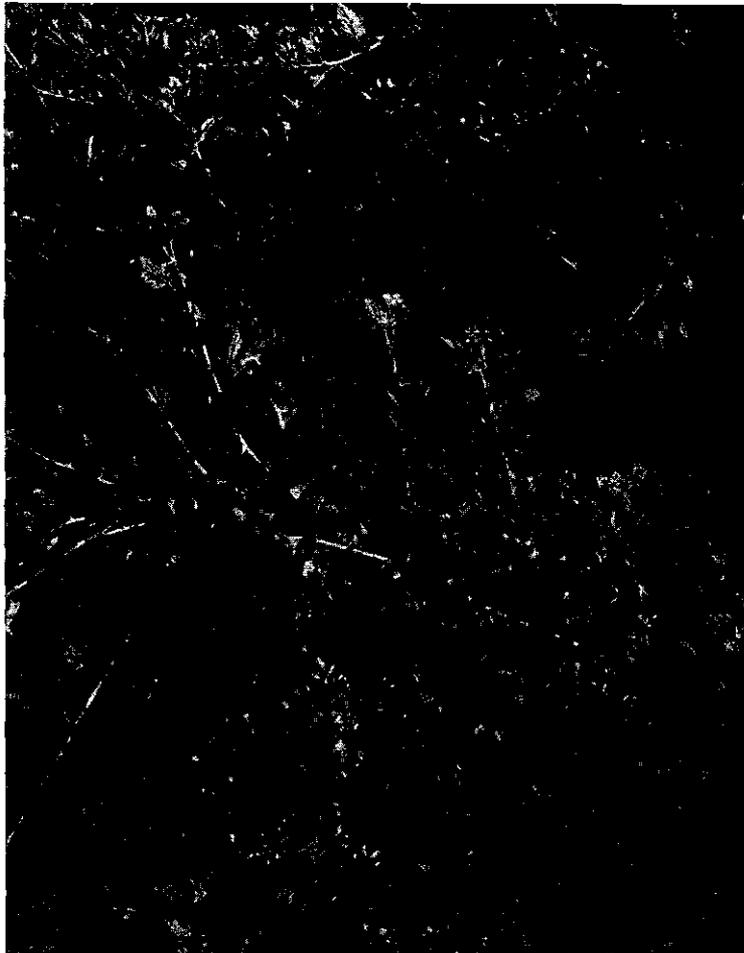
bushes showed on almost normal growth. The leaves were certainly somewhat lighter in colour and leaf fall began earlier. There was hardly any growth when potassium was omitted. Quite early in summer, when the bushes on the other plots were still in full growth, those on the plots without potassium had shed their leaves and terminated their growing period. Plots without nitrogen gave a decrease in yield from 1931 onwards. Omitting potassium did not result in a yield loss until the third harvest year (1933). In subsequent years the plots without nitrogen and potassium fell further and further behind, while from the fourth year onwards the plot without potassium also yielded less than that without nitrogen. Yields from plots with and without phosphate were almost the same; a dressing of lime had a slight unfavourable effect (table 4).

Table 4 — Response of red currants growing on medium heavy river clay soil to fertilization with nitrogen, phosphate, potassium and lime

	soil analysis 1937		yield as a percentage of completely fertilized
	untreated	fertilized	
compl. fert.	—	—	100 %
without N	—	—	73 %
without P	P-value	4	7
	P-citric-acid	90	146
without K	K-HCl %	0.027	0.063
without Ca	pH	6.1	6.7
			53 %
			103 %

During the experiment the nitrogen application was increased from 80 to 160 kg per ha, because growth appeared to be insufficient. This increase in nitrogen seemed profitable in an adjoining experiment with red currant bushes 6 years old. The yield increase over 8 years amounted to 550 grams per bush. With 2800 bushes per ha this means an increase of 1550 kg red currants per year.

DALBRO and DULLUM (1957) obtained a continuously increasing yield on clay soil with increasing applications of calcium nitrate.



With 900 kg calcium-nitrate (140 kg nitrogen) per ha the maximum had as yet not been reached. Fruit setting was stimulated by nitrogen; the number of currants per cluster as well as the length and weight of the cluster increased. Without nitrogen the cluster was short and the currants small. If nitrogen was applied the currants were larger. If more nitrogen was applied there was a tendency towards smaller currants. Lower yields were obtained with farmyard-manure, ploughed in or spread immediately after application. It was calculated that 40 per cent of the nitrogen in farmyard-manure was active when it was ploughed in; still more was lost when it was spread and only 25 per cent of the nitrogen was active.

Other fertilization experiments in the Netherlands, however, did not show a favourable effect of high nitrogen applications on red

currants compared with moderate applications, e.g. in an experiment of 2 years' standing at Ammerzoden with 50 kg, a trial of 6 years' standing at Driel with 150 kg and an experiment of 7 years' duration with 50 kg nitrogen per ha at the "Lange Ossekampen" at Wageningen.

In a 4-year pot trial with red currants (variety Versailles) in quartz sand RIETSEMA found that an N:P₂O₅:K₂O-ratio of 6:3:4 was optimal for red currants. From the results of the pot experiments he found by conversion a requirement for 100 kg nitrogen per ha (VAN DER BOON, 1952).

Practical standards for fertilization of red currants

In practice the use of farmyard-manure in red currant growing is recommended, though its advantageous effect is not as great as with black currants. Farmyard-manure has not only a favourable effect on soil structure, but also on the potassium supply to red currants. It is recommended to apply 50 tons of farmyard-manure before planting and 10 to 20 tons during cropping, supplemented by 80 to 100 kg nitrogen per ha (KESTEREN ADVISORY DISTRICT, 1951). DE BAKKER (1948) advises 120 kg of nitrogen if no farmyard-manure has been used. There are varietal differences; "Duitse Zure" and "Erstling aus Vierlanden" require more nitrogen than "Correction" and "Fay's Prolific". The variety "Jonkheer van Tets" should receive a moderate nitrogen dressing in the first few years (DIJKSTERHUIS, 1958).

GOOSEBERRIES

Gooseberries grew indifferently in the experiments of WAGNER (1931). Withholding nitrogen did not have any unfavourable effect. The author estimates the annual uptake at 79 kg N, 40 kg P₂O₅ and 123 kg K₂O per ha.

Growth of gooseberries in the sand culture trials of WALLACE (1921-1923) was poorest

without any fertilization and without nitrogen application. Withholding phosphate was obviously unfavourable from the second year onwards. Serious margin necrosis occurred when potassium was withheld. The fruit was small in the untreated pots and in those without nitrogen and without phosphate. The great requirement for potassium became evident in field experiments. 30 and 75 tons of farmyard-manure per ha had a considerably more favourable effect on heavy soil at Woburn than fertilizer treatment. Farmyard-manure sometimes needs additional potassium. There is evident danger in excessive nitrogen dressing in gooseberry growing; too vigorous growth is associated with lower production. Branches break easily. Infection with mildew increases. In a few experiments, therefore, the yield on the plots without nitrogen was highest. In relation to the danger of nitrogen excess the potassium fertilization should be liberal (WALLACE, 1936).

In a fertilization experiment with gooseberries on light sandy clay soil at Alnarp in Sweden (JOHANSSON, 1957) growth was retarded where potassium was deficient. The yield loss amounted to 55 per cent at the end of the experiment. The yield decrease due to withholding nitrogen amounted to 22 per cent. A complete dressing with fertilizer was more satisfactory than 25 tons of farmyard-manure per ha.

Practical standards for the fertilization of gooseberries

In practice the nitrogen requirement of gooseberries is similar to that of red currants. Experiments, however, have shown that nitrogen excess is more dangerous for gooseberries than for red currants. DE BAKKER (1948) advises 120 kg nitrogen per ha as standard; in gooseberry growing for harvesting green less nitrogen need be applied than if they are harvested ripe. With abundant flowering and if fruit setting is expected to be good a top-dressing may be applied if necessary.

RASPBERRIES AND BLACKBERRIES

Both crops bear fruit on biennial shoots that die afterwards, and both crops have high requirements for water as well as for organic manuring.

RASPBERRIES

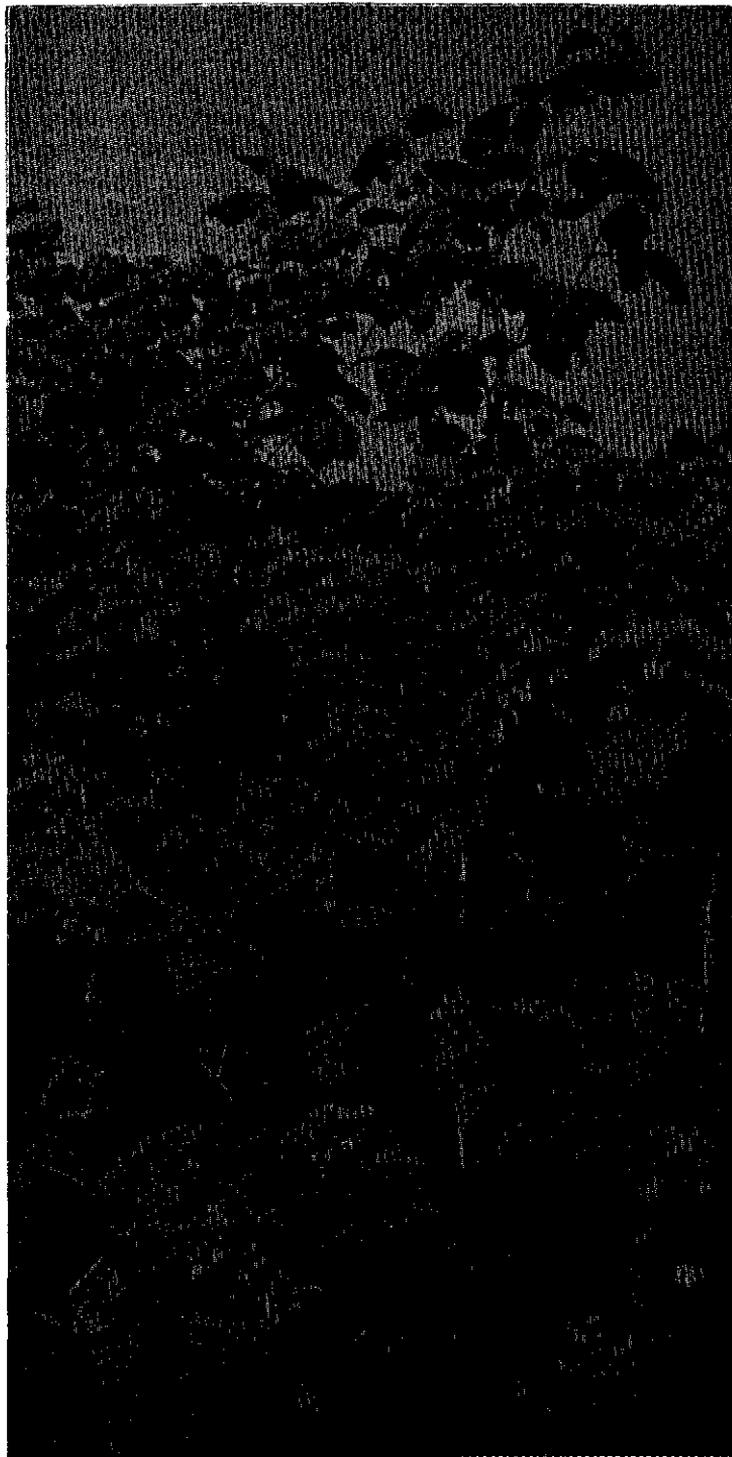
Withholding nitrogen fertilization decreased yield by 46 per cent in experiments by WALLACE (1931). Weight and length of the leafy shoots also decreased sharply. The nitrogen content in the leaves was 1.73 per cent and 2.13 per cent respectively for unfertilized plants and those fertilized with nitrogen. The fruit of plants without nitrogen contained more sugar and less acids in the juice.

In sand culture trials by WALLACE (1921-1923) omitting potassium initially gave the greatest retardation of growth, and after July this became worse due to nitrogen deficiency. Early in the season the leaves were yellowish-green to white with purple blotches and dropped earlier where nitrogen was deficient. The average length of the shoots was least in the pots without nitrogen, followed by those without potassium.

In field experiments potassium appeared to be the most important element. Nitrogen did increase the number of shoots, but a positive effect on the yield only occurred with a simultaneous liberal potassium dressing (HOBLYN, 1931).

Nitrogen increases the yield up to a certain limit. The number of shoots does increase, but the number of fruits per shoot decreases, partly due to insufficient light (CHILDERS, 1954). The crop is then easily affected by red spider mite. (NAUMANN, 1961).

Farmyard-manure had a very favourable effect on a heavier soil, while on a somewhat lighter soil 30 tons per ha appeared to be sufficient (WALLACE, 1936). For optimal growth and yield the nitrogen fertilization should be high enough for the nitrogen content in the leaves in the centre of the fresh shoots to be 2.9-3 per cent at the beginning of flowering (BOULD, 1960).



Practical standards for the fertilization of raspberries

A heavy application of farmyard-manure (50 tons per ha) is recommended in November or early in spring (KESTEREN ADVISORY DISTRICT, 1951). Sometimes this amount is applied only before planting and a further 10 to 20 tons per ha annually either against the rows of plants and covered with a layer of soil in winter, or else spread between the rows in May to decrease the rate of drying of the soil and to reduce soil compaction during the harvest period. To cover the nitrogen requirement an extra 25-40 kg nitrogen is applied (WALLACE, 1956). The amount of nitrogen needed is 100-140 kg per ha (DE BAKKER, 1948, VAN GILS, 1950, KESTEREN ADVISORY

DISTRICT, 1951). If necessary, a top-dressing of 100 kg calcium nitrate per ha may be applied near the time of flowering and at the beginning of harvesting (OELE AND DE WILDE, 1958). On calcareous soils sulphate of ammonia should be used to suppress as far as possible the occurrence of chlorosis in the crop due to iron and manganese deficiency.

BLACKBERRIES

Blackberries do not have such stringent soil requirements as raspberries. Here too, the moisture retaining capacity of the soil is the most important factor.

Farmyard-manure is considered indispensable, among other things to reduce compaction of the top-soil during harvest. In addition a



Black-berries

dressing of 140 kg nitrogen is desirable. The abundant foliage requires considerable amounts of nitrogen. Excess, however, makes the growing period unduly prolonged. The latest flower clusters never give a first class product. There is a risk that the young shoots will not mature sufficiently before winter and therefore suffer from frost damage (DE BAKKER, 1950). This danger is increased by one-sided nitrogen fertilization and too low a rate of potassium. In the KESTEREN HORTICULTURAL ADVISORY DISTRICT 200 kg nitrogen and 300 kg potash are recommended when farmyard manure has not been used. The nitrogen requirement of blackberries is somewhat higher than that of raspberries (OELE AND DE WILDE, 1958).

According to American investigations, too heavy fertilization may under certain conditions cause root scorching and damage (CHILDERS, 1954).

BILBERRIES

Bilberries belong to a separate group. The improved *Vaccinium corymbosum* grows 1 to 2 m high. Bilberries grow best on moisture retaining sandy soil rich in humus and on reclaimed peat sub-soil or acid peat. Moisture-retaining soils with a water table 60-75 cm below the surface are most satisfactory. The top-soil needs to be well-aerated. A pH-water of 4.5 is optimal; the most favourable pH-range is between 3.9 and 5 (ROELOFSEN, 1960). The roots have no root hairs, but have a symbiotic relationship with an endotrophic fungus (mycorrhiza). In all probability the fungus decomposes organic nitrogen compounds in the soil into substances available to the plant (CAIN, 1954). This supply, however, is inadequate as the bilberry responds favourably to fertilization (WASSCHER, 1947). As the fertilizer may easily leach out on light soils rich in humus, fertilization in multiple applications is essential. Moreover, the shallow root system is very sensitive to excessive salinity.

In sand culture the nitrogen requirement of bilberries was relatively high, that of phosphate and potassium rather low. According to American investigations it is most satisfactory in practice to apply a compound fertilizer in spring, when the buds begin to grow, viz. 500-700 kg 5-10-5 or 5-10-10 (GERITSEN, DE GROOT and others, 1951). In more recent years an N : P₂O₅ : K₂O-ratio of 1 : 1 : 1 has been considered more favourable (CAIN, 1954). Two-thirds of the nitrogen should be applied as ammonia and one-third as nitrate. Bilberries prefer ammonium fertilizers. If the soil has a pH above 5 the nitrogen should be applied only as the ammonium form. Six weeks after the spring dressing and often once more later in the season a top-dressing of 150 kg sulphate of ammonia per ha is applied. The plant will display a positive response to nitrogen, if the nitrogen content in the leaves is below 1.4-1.6 per cent (CAIN, 1954).

More information is gradually being obtained about the nitrogen requirement of bilberries under Dutch conditions. ROELOFSEN (1960) recommends an application of 300 kg sulphate of ammonia in March-April and in June, combined with 150 kg superphosphate and 150 kg sulphate of potassium. At the beginning of August a top-dressing of 150 kg sulphate of ammonia is applied, unless there is a danger of crop growth continuing too long as for instance on peat soils, resulting in the freezing of shoots due to insufficient maturation of the wood before winter. During periods of drought the application will have no effect and may even cause damage. The later fertilizer dressings are of importance for the following year's harvest as regards good development of shoots and formation of flower buds. Young plants should not be fertilized too heavily. The rate of fertilizer is increased as the plants become older. (WASSCHER, 1942). On soils with an insufficient moisture supply due to too low a humus content, too deep a water table or too high a clay content, it is recommended to apply a mulch layer of at

least 5 cm of sawdust. This requires an increase in the rate of nitrogen.

It is also possible to apply the top-dressing by means of spraying with a 1 per cent solution of urea. Further investigations are in progress to determine whether this method offers any advantages (GERRITSEN, 1959).

The use of farmyard-manure has not found acceptance. Root scorching may occur due to application of farmyard-manure (GERRITSEN, DE GROOT, and others, 1951).

SUMMARY

A literature survey is presented on experiments and practical standards for the fertilization of strawberries and soft fruit.

Most crops require a dressing of farmyard-manure: in decreasing order strawberries, black currants, raspberries, blackberries, gooseberries and red currants. Bilberries receive no organic manure.

The requirement for nitrogen under practical conditions decreases in the order: black currants, blackberries, raspberries, red currants, gooseberries, bilberries and strawberries. Some crops are sensitive to excessive fertilization and show root scorching owing to too high a salt concentration in the soil moisture: strawberries, bilberries and possibly blackberries.

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