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SOME INTRODUCTORY NOTES ON *TARAXACUM OFFICINALE* L. AS AN EXPERIMENTAL PLANT FOR MORPHOGENETIC AND PRODUCTION RESEARCH

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1. Introduction

Taraxacum officinale L. is a common weed in the vicinity of Wageningen. It grows along roads between the grass, in gardens, and also under shrubs in the more hilly localities. Normally, it has oblong, rather deeply dissected leaves. In shady localities, the leaves tend to show far less deep incisions. This was considered to be a useful property for morphogenetic investigations, especially in relation to light intensity, but probably also in relation to other properties of the environment.

Furthermore, already a superficial perusal of plants growing in the same environment reveals rather big differences in leaf shape between individual plants.

Another interesting property of *Taraxacum officinale* as an experimental plant arises from the circumstance that it produces seeds without normal fertilization, since in the embryo sack no meiosis appears to take place (see, e.g., 1). This property ensues that seed production, as far as genetic segregation is concerned, is comparable to vegetative propagation. This becomes immediately clear when, e.g., a large number of plants is grown from the seeds of a single mother plant. Even in the field, the seedlings obtained show a remarkable identity of size and shape (see, e.g., plate 1), rendering them extremely suitable for comparative physiological investigation.

It may be remarked in this connection, that, if, e.g., a first offspring generation from a single plant of, say, 100 plants is grown, a number of the order of 10^5 seeds, yielding identical plants may easily be collected herefrom already in the next season. This may be valuable for regional comparative research over large areas, as, e.g., envisaged under the International Biological Programme (I.B.P.). For some strains we, for example, would be able to provide such numbers of seeds during the next flowering season (1966).

Equally clear as the identity of the offspring of an single mother plant is the difference between offsprings of mother plants of different types. Comparative cultivation of several strains thus obtained in our experimental field maintains differences in character as observed between individual plants at a specific site in the free living state.

Taxonomists have since long discovered these differences within the *Taraxacum officinale* species and, probably owing to their constaney for the reason discussed above, have brought them together in an number of tribes and subspecies. J. L. VAN SOEST, in this country, carries out an extensive research in the taxonomic differences and features involved (see, e.g., 2). The reason for the existence of these subspecies and strains is not clear. The simplest hypothesis seems to be that, in the course of evolution, they may have arisen by mutation, and have thereafter remained constant.

Since the properties, discussed above – constancy per strain, differences between strains, easy and abundant propagation by seeds, and variable leaf shape – made these plants extremely attractive for morphogenetic types of research, some work in this field has been started in our laboratory in the past few years.

2. BUILDING UP A PLANT COLLECTION, AND COMMENTS ON DIVERSITY OF STRAINS

In the early summer of 1962 (mainly in June and July) several plants of *Taraxacum officinale* were collected at different sites in the neighbourhood of the laboratory. They were numbered from 1 to around 20, in the order of increasing dissection of the leaves as found at the moment of collecting, with no reference to possible effects of date and site. Later in the same season, more plants, considered of interest from some viewpoints, were added; strain numbers above 20 do not observe any regularity in the degree of leaf dissection. All plants were grown side by side on a small field in the laboratory grounds. From several of these plants, seeds were collected and sown in boxes in the greenhouse during the remainder of the 1962 season, and from these seedlings clones of various size, varying form a few to some 50 plants according to the number of seedlings available, were planted on a larger experimental field. Some of these strains which had a sufficient number of plants were used in 1963, in experiments to be described in section 3. During the summer of 1963, for a number of strains, larger clones were bult up, consisting of about 100 plants each. Finally, during 1964, we grew up to about 500 plants of some clones in view of the possibility to undertake experiments with more elaborate condition schemes in our newly arranged phytotron.

Detailed observations as to the behaviour of the various strains in the field during the seson are not yet available. The general impression is that the differences between various strains show up least in the winter season; most strains then develop deeply dissected leaves; abundant flowering occurs in late April and early May. Thereafter, new leaves develop which show much more characteristic variations in shape and degree of dissection than found in winter. Which influences are active here has not yet been studied; most likely they may be light (intensity and/or daylength), and/or temperature.

Neither have we gone into the taxonomical and cytological differences between the various strains so far. Therefore, we prefer to use the general term 'strains' for a collection of identical offspring of one plant, or their derivation, without any reference to their taxonomic value. So far, we use them simply as morphological entities with a reactivity towards the environmental factors which we are studying; as already remarked, our strains are defined by numbers.

We have recently made preliminary contacts with Professor VAN SOEST who already kindly supplied us with some preliminary taxonomical information on some of our strains. However, he pointed out that reliable information will have to wait until the appearance of the plants in spring can be studied. Therefore, we will not enter any further into this matter now. It seems, however, that semi-large scale cultivation of various tribes side by side under natural conditions may well be of value also for taxonomical questions, since the effects of differences in site can be far more easily evaluated than by considering single individual plants of which the relationship is quite unknown. Such cultures may also offer excellent material for comparative cytological and caryological studies, onto which we may well embark in due time.

It should be mentioned that *Taraxacum officinale* develops a big, rather branched root system which piles up reserve substances, and, both in absolute and in relative sense, increases during the growing season. Studies on the top/root relation are interesting, but its reaction to environment is, for the above reason, not strictly comparable to that of plant types that develop root systems without reserve organ properties (as, e.g., annuals; see als section 3).

This may be considered as a drawback for some types of work. Some other properties that may be considered less attractive in some respects are, e.g., the large number of leaves in the rosettes, and, most of all, the high light requirement which entails that most strains thrive badly under the lowest light intensity of our field series, viz. ca 12% of full daylight (see also section 3).

Plate 2 shows photographs of some strains from our collection, plate 3 shows leaves selected from these plants by picking them along one radius, going outside to inside.

Before concluding this section, I would like to mention a photograph that appeared in literature some years ago (ref. 3)*). The comment on this photograph reads:

> 'Mr. H. G. Schaffer sent us the photograph reproduced above. Finding his garden full of dandelions, Professor E. C. Wassink, director of Plant Physiological Research at Wageningen, Holland, decided to use them for studying the effect of light on leaf formation. The picture shows two of his experimental plots, with the moveable covers he designed to control light intensity'.

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*) Miss Dr. M. W. MENNENGA, of the Taxonomical Institute of the Utrecht University, kindly drew our attention to this photograph.

Unfortunately, neither the author who obviously took the photograph during a visit to our laboratory, nor the Editor of the Journal seem to have felt the need to consult us before publication. This has entailed that – apart from the fact that the photograph is not very suitable – the above few lines contain practically all errors that could possibly be made. First, our garden is only full of dandelions after we have deliberately introduced them for cultivation (some surely may have grown somewhere!) and the decision to use them for experiments was made before they were introduced. Secondly, we do not so much aim at studying leaf formation as well as development of leaf shape. Thirdly, the equipment shown is not the one designed for control of light intensity, but the one designed for control of day-length (described for the first time in ref. 4) as the reader will easily discover.

In the subsequent section, we will describe results of some preliminary field experiments, made in 1963. Results of similar experiments, preformed in 1964, will be described later. Recently, Mr. R. A. SANCHEZ in our laboratory studied some aspects of morphogenesis and growth in one of our strains under phytotron conditions; these studies will be discussed in a forthcoming paper.

3. SOME PRELIMINARY OBSERVATIONS ON THE EFFECT OF LIGHT INTENSITY ON GROWTH AND MORPHOGENESIS

A field experiment of the type designed earlier for similar studies in other plants (5, 6, 7) was laid out. Apart of full daylight intensity, gauze covers (5, 8) were applied, transmitting 75, 37, and 12 per cent of daylight respectively. The field (2 × 2 m) under each cover, and under full daylight was planted as indicated below, with 5 × 5 plants.

Harvest No. / Row	1	2	3	4	5
A	45	———	———	———	→
B	44	———	———	———	→
C	41	———	———	———	→
D	41	———	→	11	→
E	15	———	→	16	→

Figures in each row: strain numbers. Same for each light intensity. Field experiment 1963.

Four harvests were taken, at 29–V–1963 (No. 1, at the beginning of light intensity treatment; plants had been transferred to the experimental fields shortly before, and allowed to resume growth under full daylight), 31–VII–1963 (No. 2), 21–X–1963 (No. 3), 26–XI–1963 (No. 4); the 5th row of plants was left to hibernate.

As can be seen from the above scheme, the various rows were planted with plants of different strains, showing different appearance.

In the case of strain 41 we were able to plant more than one, but not fully two rows, and supplied a related strain for the last 2 places of the second row; with strain 15 no full row could be covered, and the related strain 16 was inserted in part.

This rather elaborate scheme served for obtaining a preliminary survey of the behaviour with respect to light intensity. It turned out that the plants all suffered rather much from the replanting in the experimental fields; moreover, practically all of them stood the lowest light intensity badly, and showed zero or low values for dry weight data recorded there (see below).

The procedure followed, moreover entails that each harvest contained only 1 plant per strain at each light intensity (2 of strain 41 in the first 3 harvests). Owing to the genetical identity of the plants, a rather reliable result could be obtained in this way. The degree of variation was somewhat different in different strains. The best growing strain, and that with the least divergence, probably was No. 45; the behaviour of the other strains was similar, in principle.

Dry weight and number of leaves

Text-figures 1 to 4 refer to strain 45, and represent successively: dry weight development of leaves, root system, and total plant, and number of leaves, under the various light intensities, and at the successive harvests.

The first harvest (29–V) shows the situation at the beginning of the treatment. Unfortunately, the items at light intensity IV (12% daylight) show the value zero at 31–VII and 21–X, indicating that the plants at these spots had not survived. The plant in the 4th vertical row of the scheme, given above, had survived

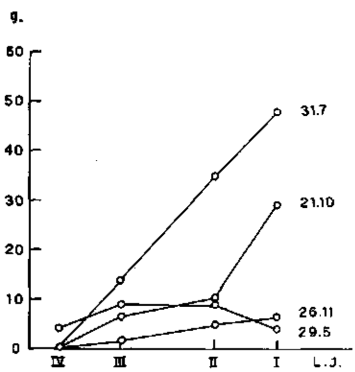

FIG. 1. Leaf dry weight (in g) at various light intensities and at successive harvest in *Taraxacum officinale* L. (Strain 45, field experiment 1963, light intensities 12, 37, 75 and 100% of full daylight; treatment started 29–V–1963, harvests at 31–VII, 21–X, 26–XI–1963.

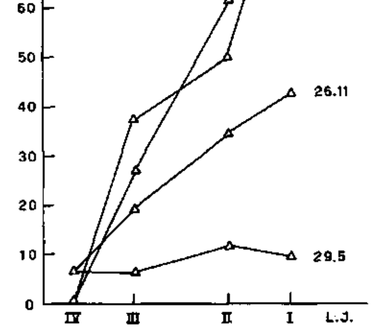

FIG. 2. Same as figure 1, for root dry weight (in g).

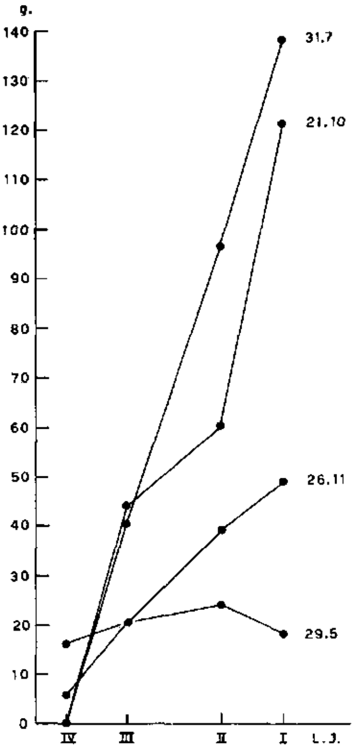

FIG. 3. Same as figure 1, for total dry weight (in g).

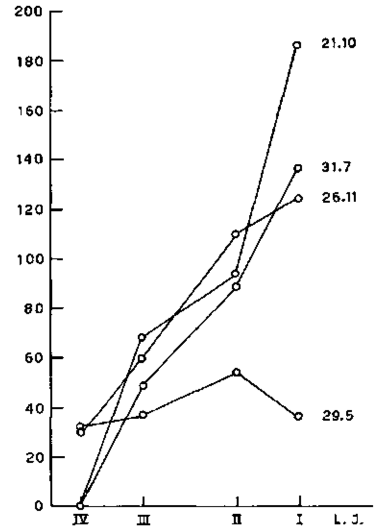

FIG. 4. Number of leaves (ordinate) in *Taraxacum officinale* L., see further legend figure 1.

at light intensity IV, and was harvested at 26–XI (simultaneously with those at the higher light intensities).

The values recorded for the various items, obviously, do not show a definite relation to light intensity at 29–V, at the beginning of the treatment.

The second harvest (31–VII) shows the clearest reaction to light intensity, which is not remarkable since this is in the middle of the growing season. Leaf dry weight, root dry weight, total dry weight, and number of leaves show a practically linear relation with light intensity, with a steep increase in most cases.

The same, in principle, is observed at the later harvests.

From 31–VII onward, leaf dry weight was found to decrease rather considerably at all light intensities. The same holds for other strains; Table 1 gives a compilation of data. The number of leaves, however, shows a far smaller decrease, if any.

Root dry weight during season shows a far smaller decline than was observed for the leaves. The main increase, especially at the higher light intensities, obviously was found between the harvests of 29–V and 31–VII. After that of 31–VII, hardly any increase has occurred, and, in most cases, even a decrease was found which may seem somewhat unexpected, especially at the higher light intensities, and for the period from 31–VII to 21–X. It remains certainly possible that some further increase has occurred for some time after 31–VII. The degree of decline between 31–VII and 21–X, and between 21–X and 26–XI was not very consistent in the different cases, certainly owing to the small number of plants available. The trend, however, is the same in all cases.

In all strains, at all light intensities, therefore, the root/leaf ratio (R/L) increases rather markedly during season. In strain 45, the values increase from ca. 1.9 at 31–VII to around 7 on 26–XI. (Table 1). The same trend is observed in other strains, with even higher figures (owing to further decrease of leaf dry weight) at 26–XI. Remarkably, there is no great difference between light intensities in this respect which means that root and leaf weight behave fairly proportionally. It has been noticed earlier that in several plants, the root–top ratio decreases markedly with decreasing light intensity (cf, e.g. 9, 10). The impression

TABLE 1. Development of dry weight of leaves and roots and of root/leaf ratio in strains of *Taraxacum officinale* L., used in 1963 light intensity series.

LI	I (100%)			II (75%)			III (37%)			IV (12%)		
Date	L	R	R/L	L	R	R/L	L	R	R/L	L	R	R/L
				Str. 45 (row A)								
31–VII	48	90	1.9	35	62	1.8	14	27	1.9	–	–	–
21–X	29	92	3.2	10	50	5.0	7	37	5.3	–	–	–
26–XI	6.5	42	6.5	5	34	6.8	2	19	9.5	–	–	–
				Str. 44 (row B)								
31–VII	49	112	2.3	29	53	1.8	14	34	2.4	0	0	–
21–X	10	40	4.0	11	33	3.0	5	33	6.6	2	9	4.5
26–XI	8	85	10.6	7	39	5.6	1.5	17	11.3	0	2	–
				Str. 41 (row C)								
31–VII	30	47.5	1.6	9.5	18	1.9	5.5	18	3.3	–	3	–
21–X	8	36	4.5	6.5	23.5	3.6	6	17	2.8	–	2	–
26–XI	3	43.5	14.5	1	23	23.0	1.5	29.5	19.7	–	10.5	–
				Str. 41/11 (row D)								
31–VII	20	40.0	2.0	7.5	9.5	1.3	3	2.5	0.8	0.5	3.0	6.0
21–X	13.5	47.5	3.5	5.5	32.5	5.9	1.5	16.5	11.0	1.5	7.0	4.7
(Str. 11) 26–XI	13.5	84.5	6.3	2.5	42	16.8	1.5	18.5	12.3	1.5	5.0	3.3
				Str. 15/16 (row E)								
31–VII	19.5	43	2.2	12.5	20.–	1.6	2.0	1.5	0.75	–	–	–
21–X	3.5	53	15.0	3.5	38.5	11.0	0.5	2.5	5.0	–	1.0	–
(Str. 16) 26–XI	5.0	47.5	8.6	2.5	39.5	15.7	0.5	2.5	5.0	–	1.0	–

LI = relative light intensity (natural daylight)
L = leaf dry weight per plant in g
R = root dry weight per plant in g
R/L = root/leaf ratio (g/g dry weight)

is that the latter is mainly so with root systems that have no reserve function, as is generally so in annuals. In root systems which, additionally, develop a clear reserve function, as in many perennials, root weight may be expected to be directly related to the output of photosynthesis.

Size and shape of leaves

Plate 3 shows representative leaves from the plants pictured on plate 2, at the same date (viz. 9–IV–1963). Plate 4 shows leaves from the same plants, at 28–V–1963. In the meantime, the plants had been left untouched under natural conditions. Leaf shape has changed considerably; several strains have developed leaves with a larger, less dissected terminal lobe. In most strains, as could be expected, the outer (oldest) leaves (left hand positions) show most resemblance with those on plate 3. Differences between strains now are much clearer than at the earlier sampling. Development of leaf shape during season under natural conditions still requires a thorough analysis.

Plates 5 and 6 refer to the light intensity series, discussed above. They show a complete record of leaf shape in strain 45 (row A), at different light intensities (I to IV) as far as leaves had developed, and at successive harvests (1 to 4).

Optimum leaf development clearly is at the second harvest, and the effect of light intensity on leaf shape is noticed most clearly there (simplification of leaf shape at decreasing light intensity). The decrease of leaf size later in the season is very marked, but the effect of light intensity on the degree of dissection of the lamina seems reduced.

Plates 7 and 8 shows the leaf shapes as recorded at harvest 2 (the stage of optimal leaf development) for the main strains used in the light intensity series (strains 45, 44, 41 and 15, designed by – row lettering – A, B, C, and E respectively). Clearly, all show the same trend, discussed above. Generally, the main simplification of leaf shape occurs between light intensities II and III (75 and 37 percent daylight respectively). Strain 41 (row C) was the only one showing a recordable leaf development at light intensity IV (12% daylight).

For the latter reason, it was thought advisable to present the whole record for strain 41 in plates 9 and 10 which is comparable to that for strain 45 on plates 5 and 6. The general trend of leaf size over the season is the same as discussed for strain 45. Also here the effect of light intensity is clearest at the second harvest, and the simplification of leaf shape especially at the lower two intensities is quite obvious. The difference, also for this strain, seems definitely less at the later harvests, as harvest 3 clearly shows. It may be presumed that this is an effect of decreasing temperature, but this still has to be established. Light intensity IV still shows the simplification, whereas at the last harvest, the difference in leaf shape between intensities III and IV is definitely smaller than in the preceding one.

Tables 2 to 5 included compile some information as to the relation between number of leaves and various dry weight data, for the light intensities I to III.

Table 2 contains data for the number of leaves per unit total dry weight and, conversely, for the total dry weight per leaf present. The latter generally decrea-

Table 2. Relation between total dry weight and leaf number in strains of *Taraxacum officinale* L., used in 1963 light intensity series.

LI	I (100%)				II (75%)				III (37%)			
Date	NL	TD	NL/TD	TD/NL	NL	TD	NL/TD	TD/NL	NL	TD	NL/TD	TD/NL
					Str. 45 (row A)							
31–VII	135	138	0.98	1.02	88	97	0.90	1.10	50	40	1.25	0.80
21–X	186	122	1.52	0.66	94	60	1.56	0.64	68	44	1.5	0.67
26–XI	124	48	2.58	0.39	110	39	2.80	0.36	60	21	2.9	0.35
					Str. 44 (row B)							
31–VII	110	160	0.69	1.45	83	82	1.01	0.99	57	48	1.18	0.85
21–X	122	50	2.43	0.41	100	45	2.23	0.45	48	39	1.23	0.81
26–XI	162	93	1.74	0.57	101	46	2.20	0.45	58	18.5	3.11	0.32
					Str. 41 (row C)							
31–VII	78	77.5	1.00	1.00	25	28	0.89	1.12	27	13	2.07	0.48
21–X	105	46	2.30	0.43	44	30	1.47	0.68	44	13	3.40	0.30
26–XI	111	46	2.41	0.41	49	24	2.05	0.49	75	31	2.42	0.41
					Str. 41/11 (row D)							
31–VII	70	60	1.16	0.86	30	17.5	1.71	0.59	13	6	2.17	0.46
21–X	116	61.5	1.90	0.53	66	38.5	1.71	0.59	32	19.5	1.64	0.61
(Str. 11) 26–XI	174	98	1.78	0.56	64	44.5	1.43	0.70	30	19.5	1.54	0.65
					Str. 15/16 (row E)							
31–VII	197	66	2.96	0.34	104	33.5	3.10	0.32	30	2.5	12.0	0.08
21–X	224	56	3.96	0.25	150	41.5	3.60	0.28	30	3.5	8.6	0.12
(Str. 16) 26–XI	205	54	3.80	0.26	155	41.5	3.73	0.27	15	3.5	4.3	0.23

LI = relative light intensity (natural daylight)
NL = number of leaves present per plant
TD = total dry weight per plant in g
NL/TD = number of leaves present per unit total dry weight (g)
TD/NL = total dry weight (g) per leaf present

ses during the season, especially between 31–VII and 21–X. At light intensity III this trend is less pronounced in most strains.

In general, there is a difinitely weaker trend in the direction of light intensity, especially at the later harvests. This indicates that the rather large differences in total dry weight between light intensities are paralleled by differences in leaf number of the same order of magnitude.

Table 3 contains similar data for root dry weight in relation to leaf number. Since root weight is by far the main portion of total dry weight, especially at the later harvests, the relations are much the same as discussed for table 2.

Table 4 relates total leaf dry weight to number of leaves, which leads to a 'size factor' per leaf, expressed in dry weight. This size factor (LD/NL) decreases

TABLE 3. Relation between root dry weight and leaf number in strains of *Taraxacum officinale* L., used in 1963 light intensity series.

LI	I (100%)				II (75%)				III (37%)			
Date	NL	RD	NL/RD	RD/NL	NL	RD	NL/RD	RD/NL	NL	RD	NL/RD	RD/NL
					Str. 45 (row A)							
31-VII	135	90	1.5	0.67	88	62	1.4	0.71	50	27	1.9	0.53
21-X	186	92	2.0	0.50	94	50	1.9	0.53	68	37	1.8	0.55
26-XI	124	42	3.0	0.33	110	34	3.2	0.31	60	19	3.2	0.31
					Str. 44 (row B)							
31-VII	110	112	1.0	1.0	83	53	1.6	0.62	57	34	1.7	0.59
21-X	122	40	3.0	0.33	100	33	3.0	0.33	48	33	1.5	0.67
26-XI	162	85	1.9	0.53	101	39	2.6	0.38	58	17	3.4	0.29
					Str. 41 (row C)							
31-VII	78	47.5	1.6	0.62	25	18	1.4	0.71	27	18	1.5	0.67
21-X	105	36.-	2.9	0.345	44	23.5	1.9	0.53	44	17	2.6	0.38
26-XI	111	43.5	2.5	0.4	49	23	2.1	0.48	75	29.5	2.5	0.4
					Str. 41/11 (row D)							
31-VII	70	40.0	1.75	0.57	30	9.5	3.15	0.315	13	2.5	5.2	0.19
21-X	116	47.5	2.45	0.41	66	32.5	2.0	0.5	32	16.5	1.9	0.53
(Str. 11) 26-XI	174	84.5	2.1	0.48	64	42	1.5	0.67	30	18.5	1.6	0.62
					Str. 15/16 (row E)							
31-VII	197	43	4.5	0.22	104	20.-	5.2	0.19	30	1.5	20	0.05
21-X	224	53	4.2	0.24	150	38.5	3.9	0.26	30	2.5	12	0.08
(Str. 16) 26-XI	205	47.5	4.3	0.23	155	39.5	3.9	0.26	15	2.5	6.0	0.17

LI = relative light intensity (natural daylight)
NL = number of leaves present per plant
RD = root dry weight per plant in g
NL/RD = number of leaves present per unit root dry weight (g)
RD/NL = root dry weight (g) per leaf present.

markedly during season, and far less over the light intensity range, as may also be seen from plates 5 end 6, and plates 9 and 10.

The average leaf weight at any harvest appears to depend only little on light intensity. This supplements the conclusion reached in relation to table 2. Also the number of leaves, and total leaf dry weight vary more or less parallelly. Since both vary strongly with light intensity, it is probably justified to conclude that the main action of light intensity is in affecting the number of leaves formed; probably the rate of formation of new leaves, or the lifetime of individual leaves, is affected by light intensity. Also this has to be studied in more detail. The

Table 4. Relation between leaf dry weight and leaf number in strains of *Taraxacum officinale* L., used in 1963 light intensity series.

LI	I (100%)				II (100%)				III (100%)			
Date	NL	LD	NL/LD	LD/NL	NL	LD	NL/LD	LD/NL	NL	LD	NL/LD	LD/NL
					Str. 45 (row A)							
31–VII	135	48	2.8	0.36	88	35	2.5	0.40	50	14	3.6	0.28
21–X	186	29	6.4	0.16	94	10	9.4	0.11	68	7	9.7	0.10
26–XI	124	6.5	19.0	0.05	110	5	22.0	0.05	60	2	30	0.03
					Str. 44 (row B)							
31–VII	110	49	2.25	0.44	83	29	2.9	0.34	57	14	4.1	0.24
21–X	122	10	12.2	0.08	100	11	9.1	0.11	48	5	9.6	0.10
26–XI	162	8	20.–	0.05	101	7	14.2	0.07	58	1.5	38.6	0.03
					Str. 41 (row C)							
31–VII	78	30	2.6	0.38	25	9.5	2.6	0.38	27	5.5	4.9	0.20
21–X	105	8	13.2	0.08	44	6.7	6.7	0.15	44	6	7.3	0.14
26–XI	111	3	37.–	0.03	49	1	49.–	0.02	75	1.5	50.–	0.02
					Str. 41/11 (row D)							
31–VII	70	20	3.5	0.29	30	7.5	4.0	0.25	13	3.	4.3	0.23
21–X	116	13.5	8.6	0.12	66	5.5	12.0	0.08	32	1.5	21.2	0.05
(Str. 11) 26–XI	174	13.5	12.8	0.08	64	2.5	25.5	0.04	30	1.5	20.–	0.05
					Str. 15/16 (row E)							
31–VII	197	19.5	10.1	0.10	104	12.5	8.4	0.12	30	2.0	15.0	0.07
21–X	224	3.5	49.8	0.02	150	3.5	42.8	0.02	30	0.5	60.–	0.016
(Str. 16) 26–XI	205	5.0	40.8	0.025	155	2.5	62.0	0.016	15	0.5	30.–	0.03

LI = relative light intensity (natural daylight)
NL = number of leaves present per plant
LD = leaf dry weight per plant in g
NL/LD = number of leaves per unit leaf dry weight (g)
LD/NL = average leaf dry weight ('size factor', SF, see also table 5).

figures in tables 4 and 2 seem to indicate that the activity of a unit of leaf material present is not greatly different in the range of light intensities I to III.

Table 5 relates total dry weight to leaf dry weight and leaf size. TD/SF expresses total dry weight per weight of average leaf present at the moment of harvest. Since the leaves become much smaller during season, this figure increases strongly during season, especially in the later stages. Since the size factor did not vary very much with light intensity (Table 4), TD/SF over the light intensity range, at each harvest follows mainly the total dry weight trend.

Of interest is also the figure for total dry weight per unit leaf (dry weight)

TABLE 5. Relation between total dry weight and leaf size in strains used in 1963 light intensity series.

LI	I (100%)					II (75%)					III (37%)				
Date	TD	LD	SF	TD/SF	TD/LD	TD	LD	SF	TD/SF	TD/LD	TD	LD	SF	TD/SF	TD/LD
						Str. 45 (row A)									
31–VII	138	48	0.36	380	2.85	97	35	0.40	240	2.75	40	14	0.28	143	2.85
21–X	122	29	0.16	760	4.2	60	10	0.11	550	6.0	44	7	0.10	440	6.2
26–XI	48	6.5	0.05	960	7.4	39	5	0.05	780	7.7	21	2	0.03	700	10.5
						Str. 44 (row B)									
31–VII	160	49	0.44	360	3.25	82	29	0.34	240	2.8	48	14	0.24	200	3.4
21–X	50	10	0.08	620	5.0	45	11	0.11	410	4.1	39	5	0.10	390	7.8
26–XI	93	8	0.05	1860	11.6	46	7	0.07	660	6.6	18.5	1.5	0.03	615	12.3
						Str. 41 (row C)									
31–VII	77.5	30	0.38	204	2.6	28	9.5	0.38	74	2.9	13	5.5	0.20	65	2.4
21–X	46	8	0.08	575	5.7	30	6.5	0.15	200	4.6	13	6	0.14	94	2.2
26–XI	46	3	0.03	1540	15.4	24	1	0.02	1200	24.–	31	1.5	0.02	1540	20.6
						Str. 41/11 (row D)									
31–VII	60	20	0.29	206	3.0	17.5	7.5	0.25	70	2.3	6	3	0.23	26	2.0
21–X	61.5	13.5	0.12	510	4.5	38.5	5.5	0.08	420	7.0	19.5	1.5	0.05	390	13.0
26–XI*)	98	13.5	0.08	1220	7.3	44.5	2.5	0.04	1100	17.8	19.5	1.5	0.05	390	13.0
						Str. 15/16 (row E)									
31–VII	66	19.5	0.10	660	3.4	33.5	12.5	0.12	304	2.2	2.5	2.0	0.07	36	1.2
21–X	56	3.5	0.02	2800	16.–	41.5	3.5	0.02	2050	11.8	3.5	0.5	0.016	220	7.0
26–XI**)	54	5.0	0.025	2160	10.8	41.5	2.5	0.016	2600	16.6	3.5	0.5	0.03	105	7.0

LI = relative light intensity (natural daylight)
TD = total dry weight
SF = leaf size factor (see table 4)
TD/SF = total dry weight per weight of average leaf present
TD/LD = total dry weight per unit leaf (dry weight) present
*) Str. 11. **) Str. 16

present, obtained from TD/LD. This shows an increase over the season, owing to the considerable reduction of leaf weight at all light intensities, and a remarkably indifferent behaviour towards light intensity. Again, this points to not greatly different activity of the leaves present in relation to light intensity. One would, however, suspect some difference to be present in order to initiate the following links of the chain, viz. lower number of leaves by differences in development or maintenance, and lower total dry weight production at lower light intensities. Even between light intensities I and II these differences are already considerable, as is shown in text figures 1 to 4. The apparent constancy of TD/LD in relation

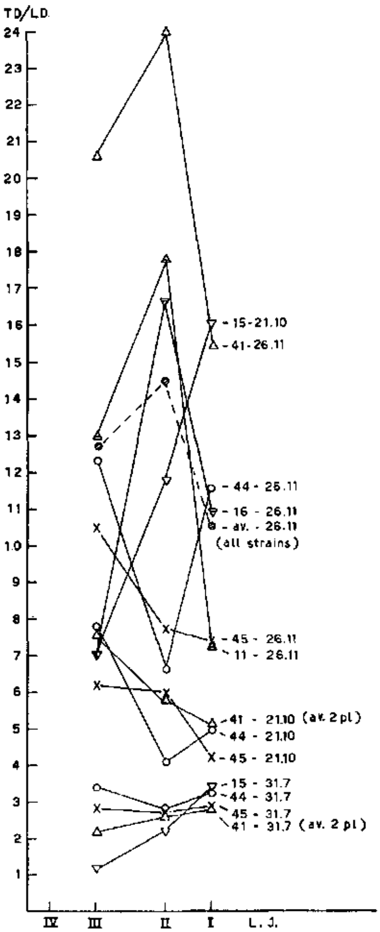

FIG. 5. Total dry weight of different strains of *Taraxacum officinale* L. per unit leaf (dry weight) present, at different light intensities, and different harvest. Data from table 5. Abscissa: light intensities.

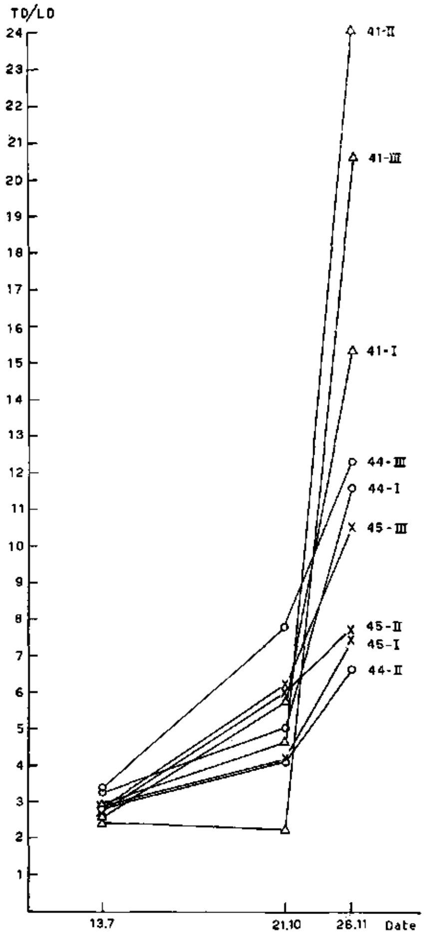

FIG. 6. Selection of data (rows A to C included) from figure 5, plotted against harvest date. (Rows D and E not well usable in this plot since containing different strain at last harvest).

to light intensity therefore seems rather remarkable; for a full discussion, however, data pertaining to larger numbers of plants have to be awaited.

Text figures 5 and 6 illustrate the above items, and also show the large variation at the last harvest (emphasized by the large ordinate scale deliberately used).

SUMMARY

Attention has been drawn to some useful properties of *Taraxacum officinale* L. with respect to research in morphogenesis. Seed formation does not include fertilization and segregation of genes, so that clones may be built up from seedlings. Leaf shape reacts to environment, e.g., with respect to degree of dissection, and strains and subspecies exist in nature, varying in leaf shape, so that their reactions can be comparatively studied. Owing to extensive seed production, large families of identical plants can be raised in a short time.

Some results of a preliminary field experiment, performed in the 1963 season, are presented in plates, figures, and tables, and briefly discussed.

Dry weight of leaves, roots, and total, as well as number of leaves show a definite, and almost linear relation to light intensity. Weights decrease, in general, in the later harvests. The same holds for leaf size, to a considerable degree.

The relation root dry weight / leaf dry weight increases markedly during season, mainly owing to the considerable decrease in leaf weight. The effect of light intensity on this relation is only small; this is at variance with what is normally observed with respect to root systems that have no obvious reserve organ function as in *Taraxacum*.

Optimum leaf development is at the second harvest (31–VII). The effect of light intensity on leaf shape then is most clear. Simplification of shape at decreasing light intensity occurs, most conspicuously between 75 and 37% of daylight. At the later harvests, the simplification of leaf shape at low light intensities is less, which may be a temperature effect, but has to be studied in a more definite way.

Relations between leaf number and various dry weight items (Tables 1–5) suggest that decreased light intensity primarily results in reduction in leaf number which leads to reduced dry weight data. Remarkably, hardly any definite effect of light intensity on dry weight production in relation to leaf dry weight present, was apparent. Some effect should probably exist, but requires a more extensive experiment to be brought out clearly.

The technical assistance of Miss J. Bos and Miss A. VENES is gratefully acknowledged.

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PLATE 1. Field view of a strain of *Taraxacum officinale* L (No. 10A, 2 rows), showing uniform appearance of seedlings from a single plant. Photographed 29-3-1965.

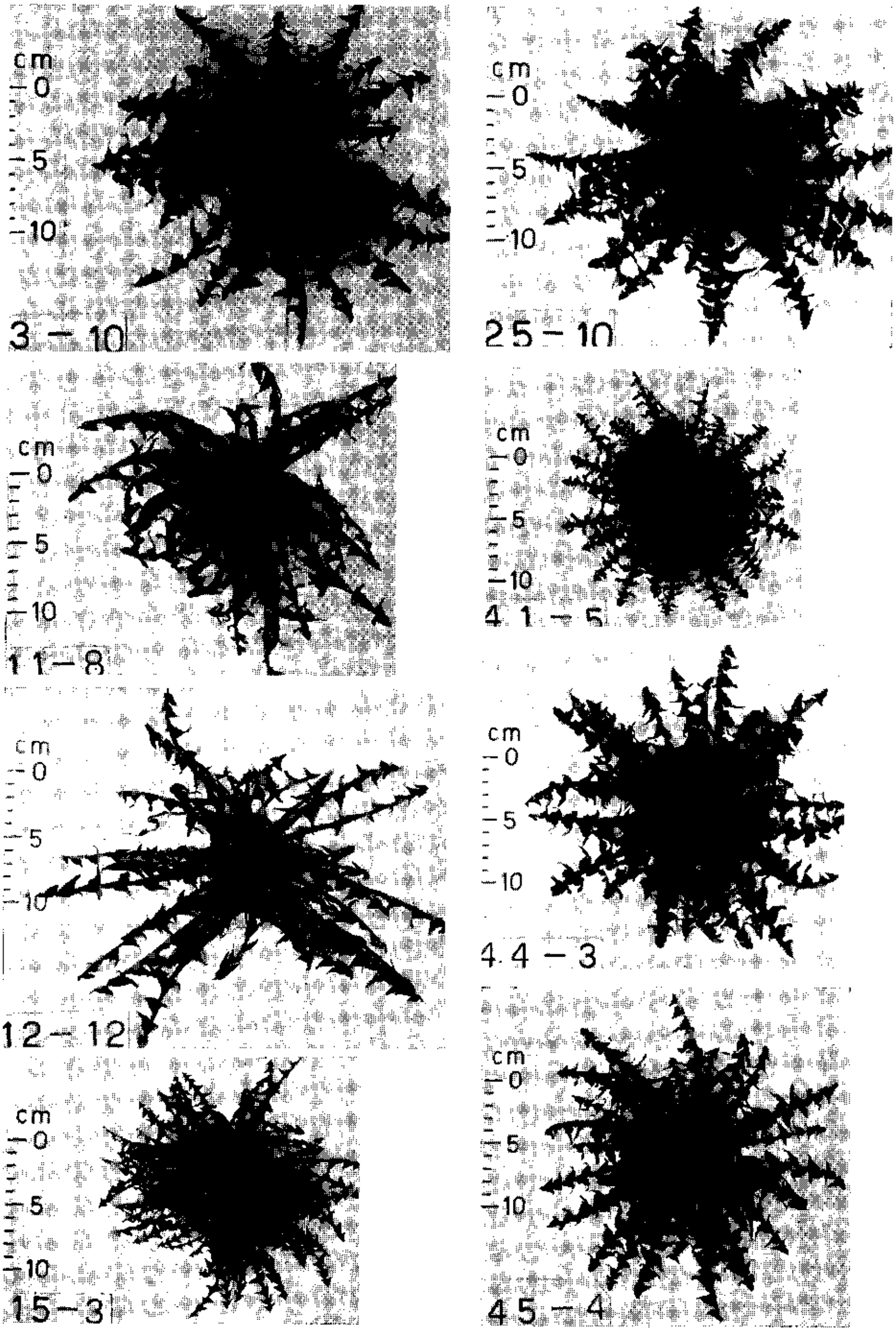


PLATE 2. Individual plants of various strains of *Taraxacum officinale*, showing variation between strains. Photographed 8–IV–1963 in situ, with 2 half sheets of white paper, with a half circular cut-out fitted beneath the plants.
First number: strain number, second: plant number, e.g., 3–10 is: strain 3, plant number 10, etc.

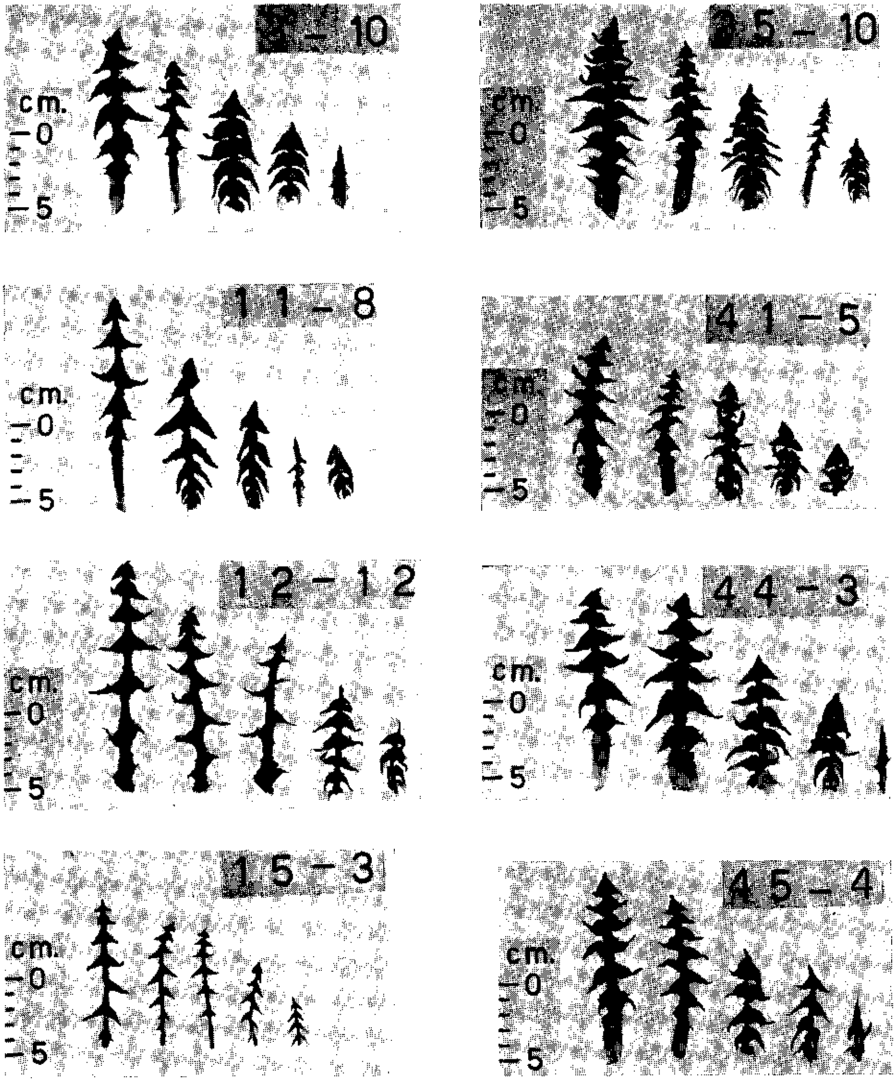


PLATE 3. Representative leaves of plants from plate 2, taken from outside to inside, along one radius. Photographed 9–IV–1963.

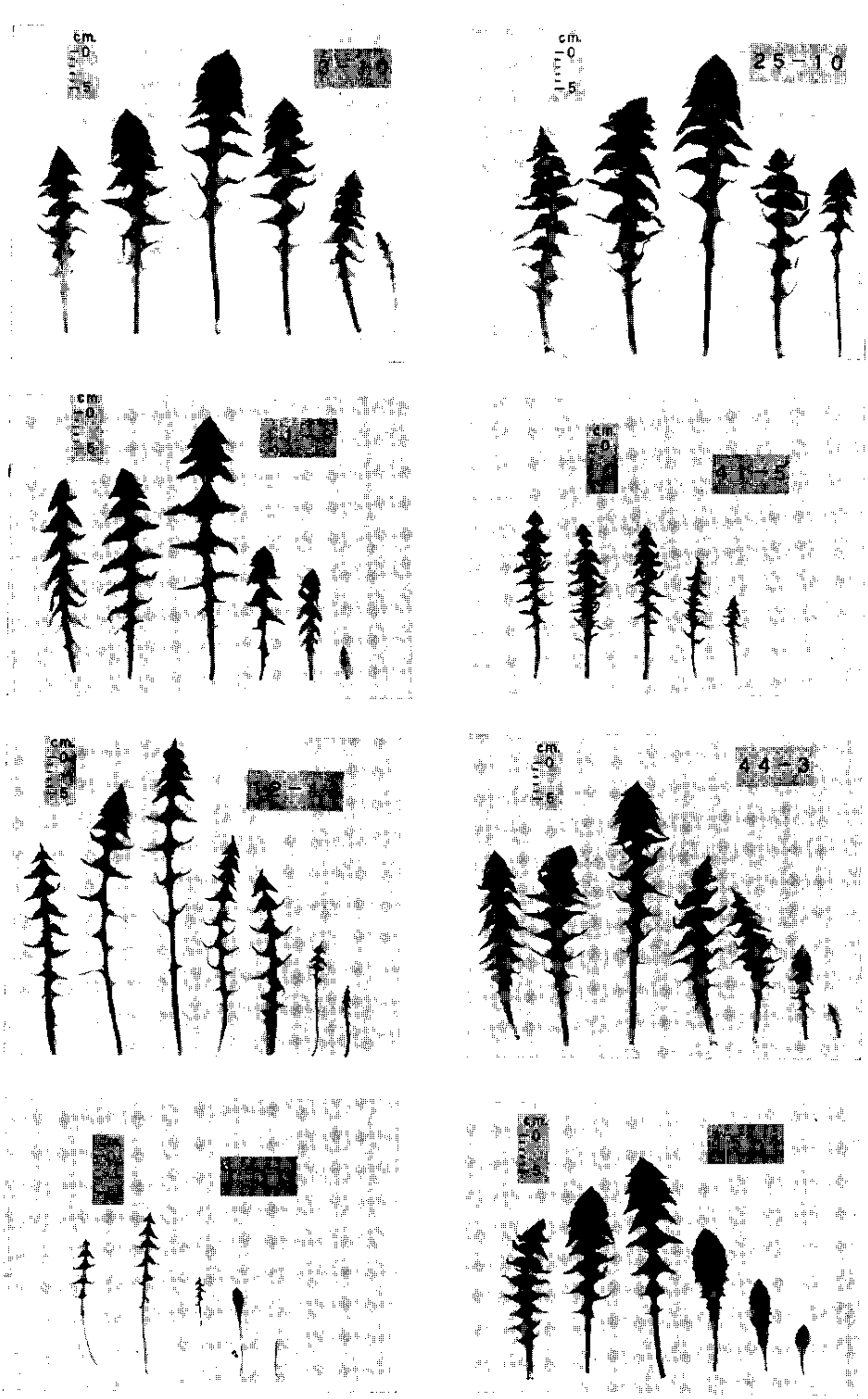


PLATE 4. Same as plate 3, leaves from same plants, photographed 28–V–1963.

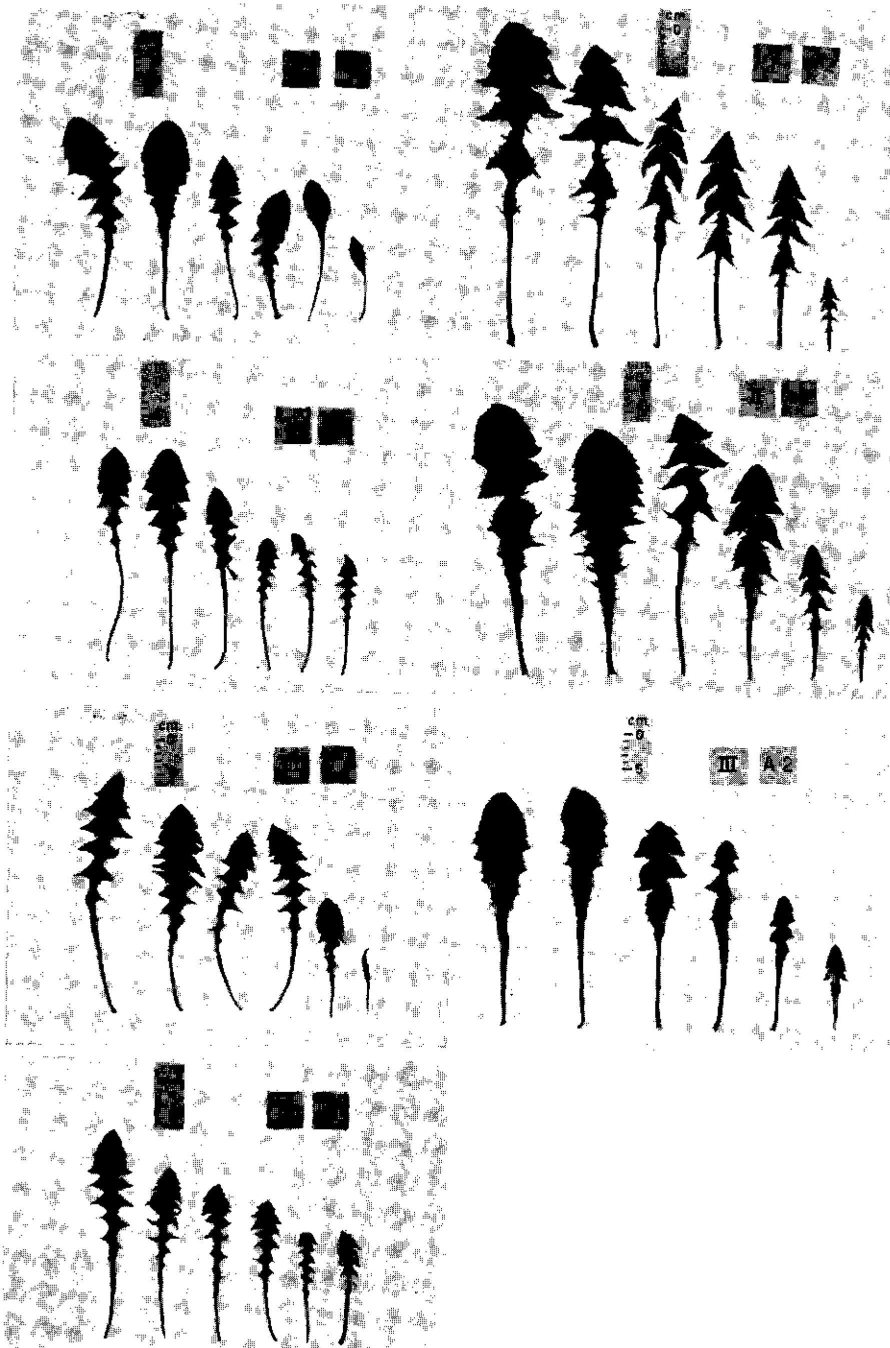


PLATE 5. Representative leaves from plants of strain 45, grown at 4 different light intensities (I–IV), at 2 successive harvests (1, 2) (A means the row in the planting scheme, see p. 4, indicating strain 45). Photographed 30–V–1963 (1) and 1–VIII–1963 (2).

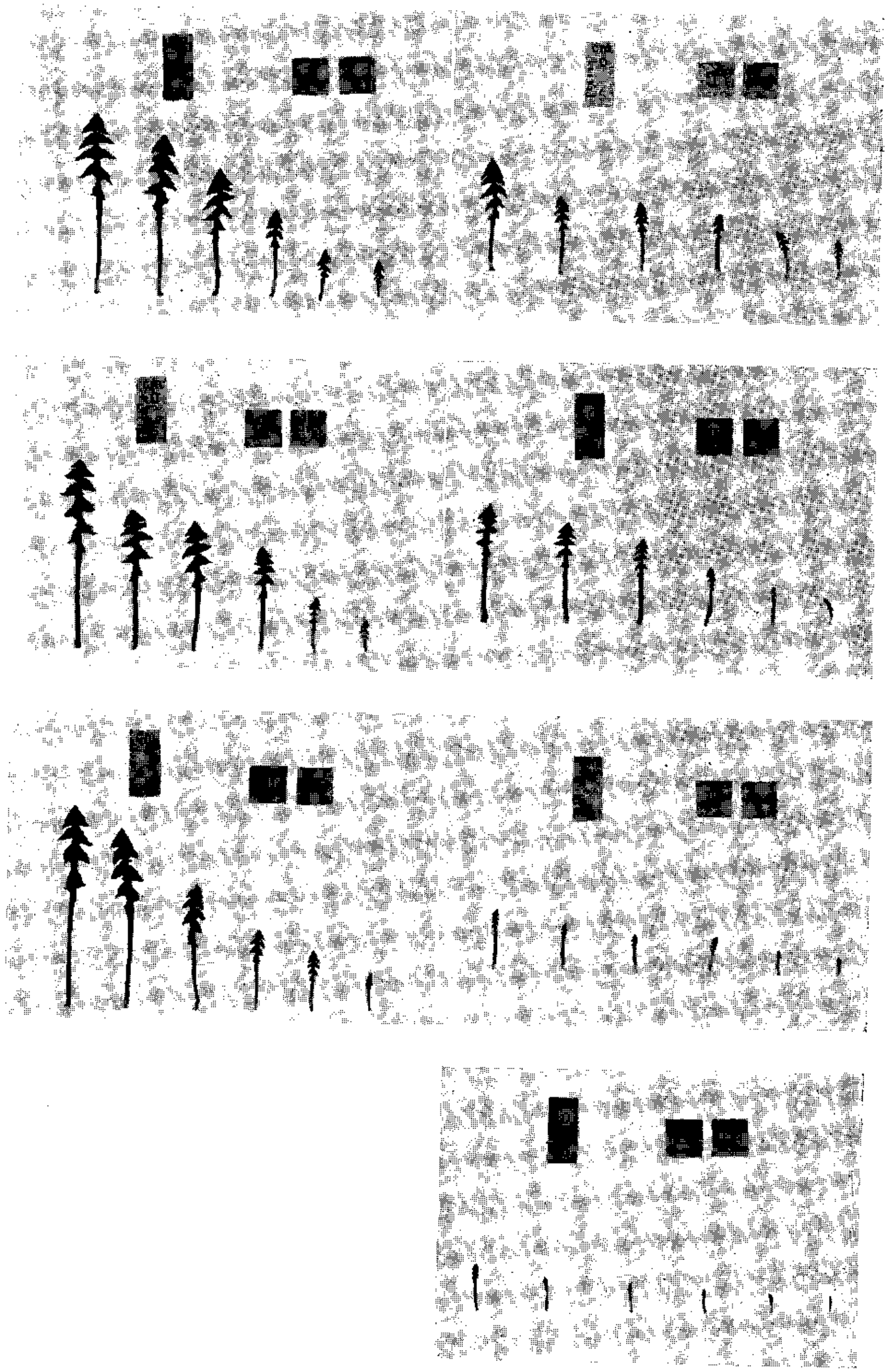
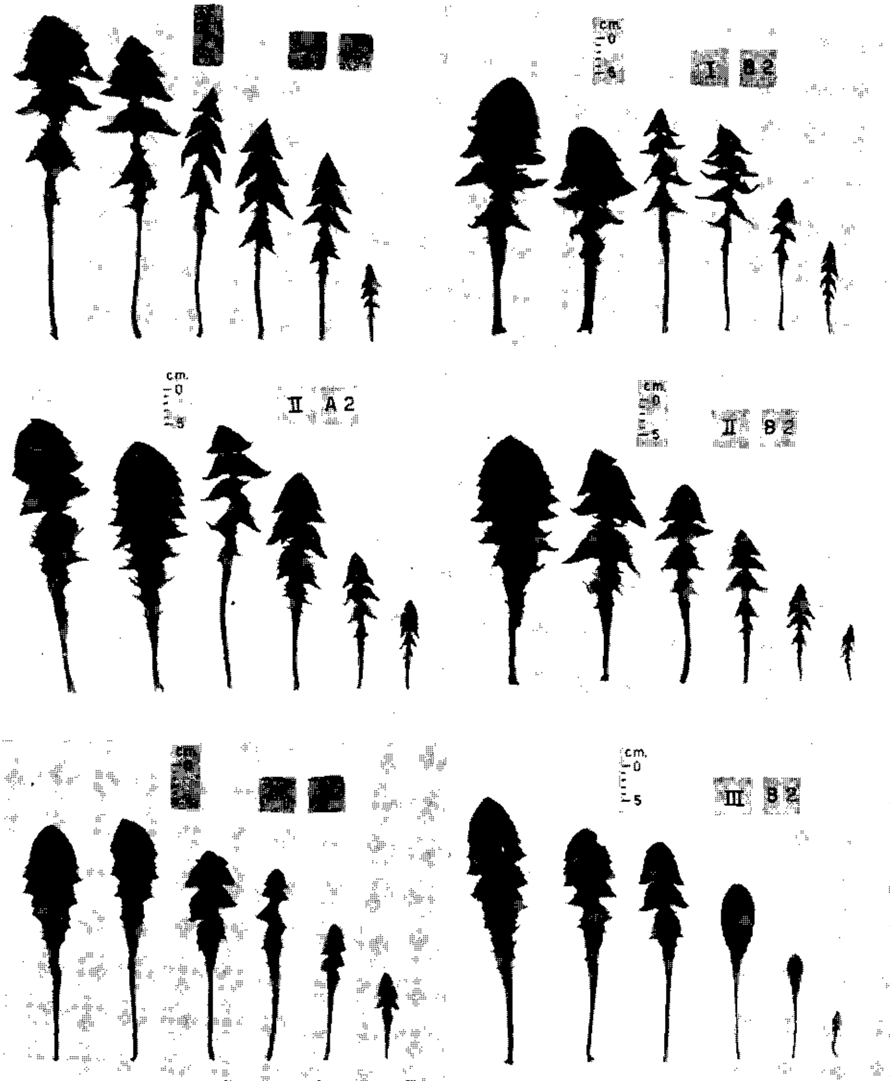
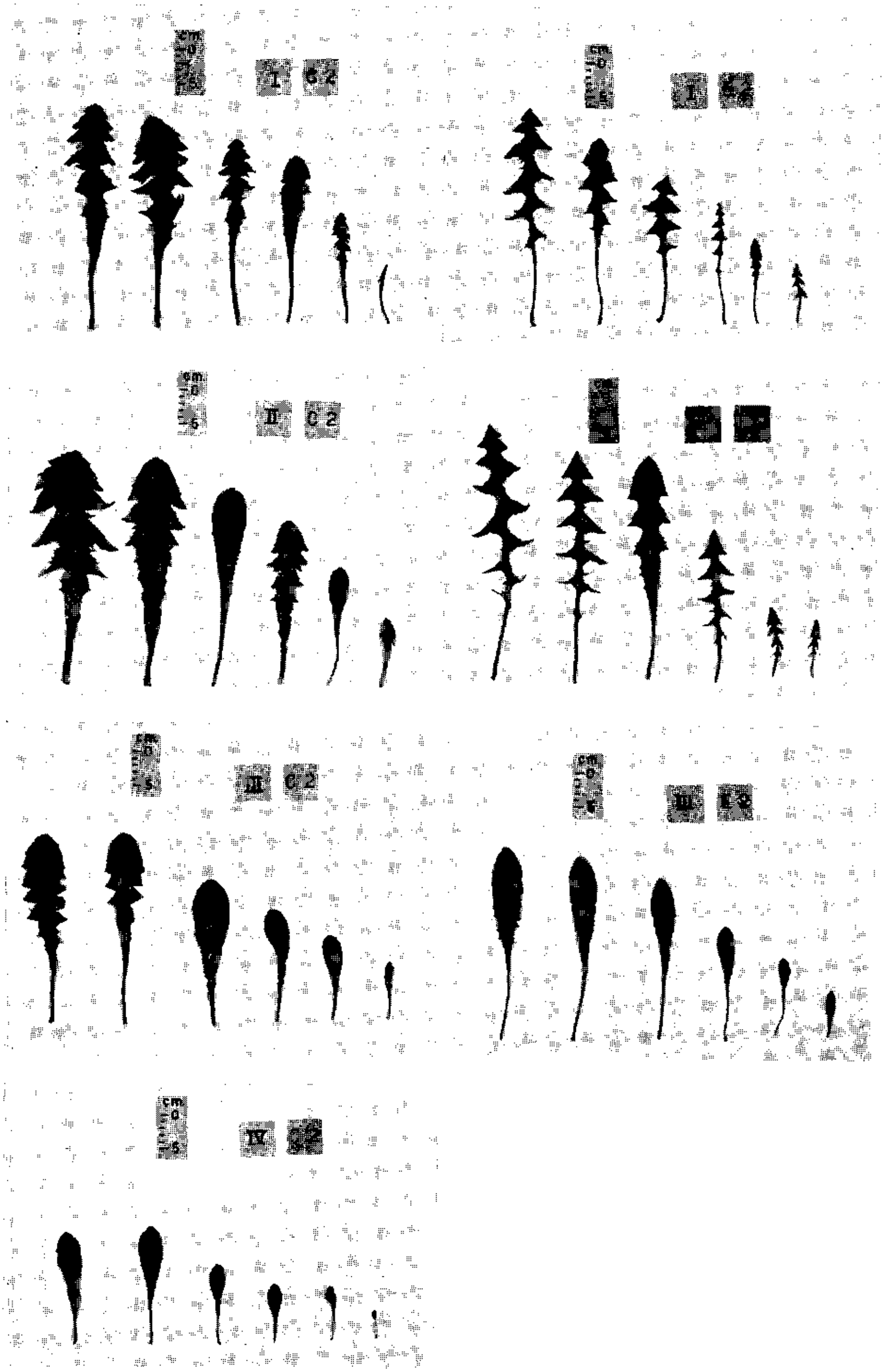
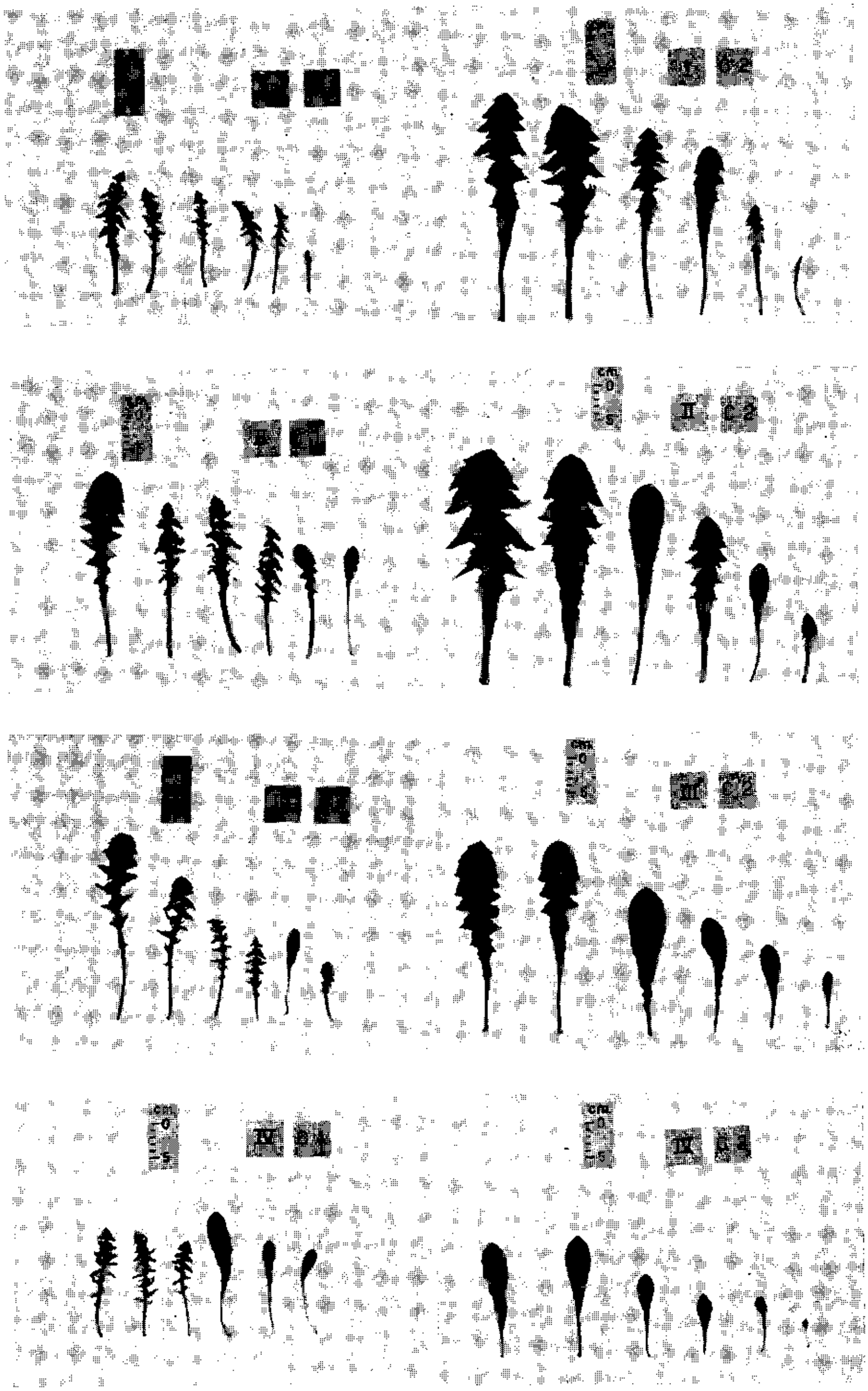


PLATE 6. As plate 5, representing two further harvests (3, 4); photographed 22–X–1963 (3) and 27–XI–1963 (4).



PLATES 7 and 8. Survey of leaves of main strains used in 1963 light intensity experiment, (intensities I–IV), at harvest number 2, strains 45 (A), 44 (B), 41 (C), and 15 (E), showing differences in type and reaction upon light intensities of these strains at time of best leaf development. Photographed 1–VIII–1963.


cm
0
5
I C2
II C2
III C2
IV C2



PLATES 9 and 10. Same as plates 5 and 6, for strain 41 (indicated as C according to planting scheme). Photographed at same dates as plates 5 and 6.