EFFECTS OF LIGHT INTENSITY ON DRY MATTER PRODUCTION AND MORPHOGENESIS OF *IRIS* "WEDGWOOD", AS COMPARED WITH *GLADIOLUS* AND TULIP.[1]

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1. INTRODUCTION

The International Biological Programme (IBP) was prepared in circles of the International Union of Biological Science since 1959, and officially launched by the end of 1963. It is concerned with research of 'basic biological nature' which intends to be 'truly relevant to human welfare', and is divided into several sections and subsections. Contacts with the organized Photobiology research is of recent date, viz. from the meeting at Hvar, Jugoslavia, 1967 (2,3).

The PP-photos. subsection of IBP is concerned with the study of plant production processes, and of the yield of solar energy conversion. International collaboration and mutual exchange of information proceeds in investigations of various levels of complexity. It comprises, e.g., technically simple types of experiments, applying e.g. sowing date or plant density variation. On the other hand, sophisticated techniques are being used in e.g. microclimatological investigations, changes in the carbon dioxide flux inside vegetations as an estimate for photosynthesis, and gas exchange measurements on entire plants or vegetations at their site.

The mentioned types of work have in common that the conditions of the en-

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[1] The essence of this paper served as a lecture given for the 5th International Congress of Photobiology, Dartmouth, Hanover, New Hampshire, U.S.A., August-September 1968 (1) which the author primarily attended in his quality of IBP-PP-phot. deputy convener, and, more intensively, at the University of Raleigh, N. Carol., U.S.A. after the Congress, upon kind invitation by Professor NOGGLE.

vironment are, in most cases, carefully measured, and at the same time, are kept untouched by the investigator as far as possible. Evaluation of the results often requires computer facilities, or at least some sort of polyfactor analysis.

The classical plant physiological type of approach, in which it is aimed to evaluate the effect of one single environmental factor by intentional variation of this one factor only seems to meet with some hesitation with regard to production studies, and has been practised so far only at a few places. One hesitation against this type of experiment is the feeling that a truly monofactorial variation is hardly possible. Plant physiological experimentation, however, has always struggled with this inference, and has developed methods which attempt at keeping a variation as nearly monofactorial as possible.

This type of experimentation has received a great impulse during recent years by the increasing availability of establishments with controlled environment ('phytotrons'). But also under field conditions it is possible, with due precautions, to submit some factors to virtually monofactorial variation. Among these are e.g. daylength and light intensity. Variation of water supply, temperature, CO_2-content, and soil factors mostly is much less unambiguous, since interference with other factors is more difficult to avoid.

Plant density variations are easy to apply, but they introduce more complications for interpretation, since they involve changes in the competition of the plants for various environmental factors simultaneously.

2. OUTLINE OF EXPERIMENTS

Our laboratory has carried out, among others, a number of investigations of the effect of light intensity, daylength, and plant density, on production and morphogenesis ('size and shape') of plants, under both field and phytotron conditions.

The general type of investigation is as follows (4): Four different degrees of daylight intensity are obtained using three gauze screens (cages) of various densities (fig. 1), and an open '100%' light. An experimental field is 2 × 2 m., the cages have a top screen (2 × 2 m), and side screens (2 × 0.5 m each). Periodic harvests are taken during the growing season and several items measured each time, e.g., increase in dry weight of separate plant organs, roots, leaves, stems, flowers, fruits, bulbs, corms, etc. alongside with morphogenetic features, like leaf size, leaf shape, total leaf area, stem length, stem diameter. Developmental aspects such as flowering, seed production, tuber- or bulb formation, are observed. In some cases, anatomical features, carbohydrate contents, or the formation of specific chemicals has been studied. Monocultures have mostly been used up to now, recently elementary competition experiments with 2 species have been set up, as well as measurement of photosynthesis of leaves of different age during the season.

In this paper, another example of light intensity effects will be presented dealing with some bulbous plants, including bulbous irises, of which the cultivar

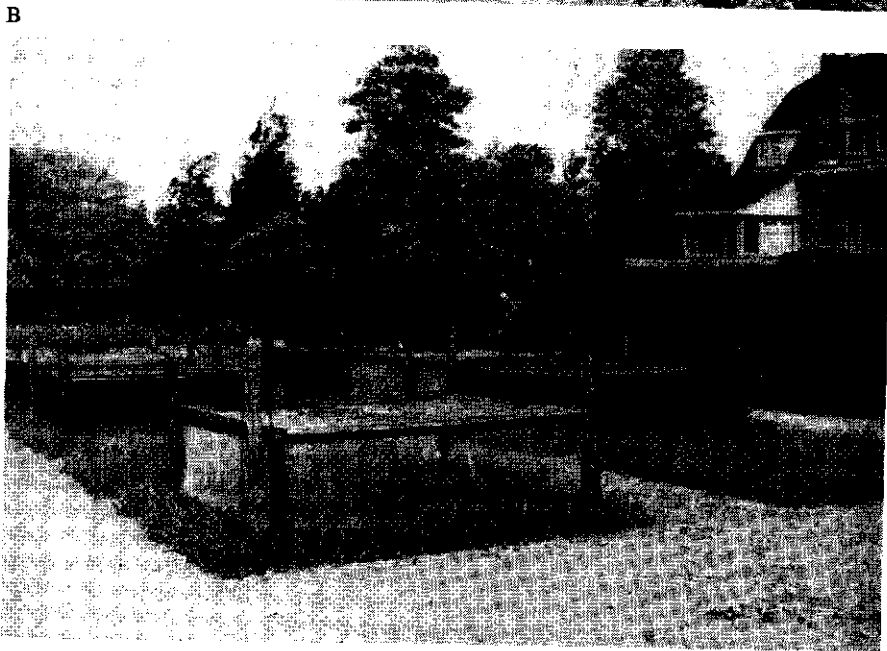2 *Meded. Landbouwhogeschool Wageningen 69-20 (1969)*

Fig. 1. Shading equipment used in field experiments. A: A gauze cage for weakening the intensity of light, with corner posts, and chains to raise the cage if necessary (the chains are barely visible). The air and soil thermometers can be seen inside. B: A double series of four light intensities, produced by two open plots and 2 × 3 cages (as illustrated in Figure A), using different gauze densities.

'Wedgwood' (*Xyphium praecox*, var. Wedgwood) was used, in field experiments.

The experiments with bulbous Irises, carried out in 1965 and 1966, intended to fill a gap between the earlier ones with tulips and *Gladiolus*, (5,6)[1] since, culturally, bulbous Irises are more or less intermediate between tulips and *Gladiolus*, e.g. with respect to the time of initiation of the flowers, the light requirements, and the seasonal development.

Bulbs are planted at 20 cm distance, a restricted weight range is selected, all bulbs are separately weighed, and thoroughly randomized for planting. Dry weights of samples from three weight regions are determined.

3. SOME ASPECTS OF GROWTH AND DEVELOPMENT OF IRIS AS COMPARED WITH TULIP AND GLADIOLUS

The planted bulbs are in the field during winter, loosely covered by straw. They appear above ground in early spring. The early dry weight development shows little light dependence; light dependence develops gradually (fig. 2). The development of leaf dry weight does not show much light intensity dependence, there is more light intensity dependence in stem and flowers, but above all in the new bulbs of which mostly more than one develop on each plant.

An impression of the variation in sensitivity to light intensity for dry weight development in the various plant organs is given by the relation (factor) between dry weights at 12 and 100% light intensity. This factor is much higher for bulbs than for the other plant organs, especially in the early stages. In the 1966 experiment it decreased from about 11 (on 1.6) to 4.7 on 19.7, and 4.4 on the final date 22.8. (Herein the earlier bulb development at high light intensities also plays a rôle). For leaves and stem this factor shows no clear time dependency and varies around 1.3 and 2.2 respectively (the values of 22.8, probably, are not quite representative any more since these organs deteriorate towards the end of the annual cycle). (Table 1, Fig. 3 I).

The above data point to a change in distribution of dry weight dependent on light intensity, which is indeed found. In the time from 1.6 to 19.7, leaves go from 47 to 36% at 12% daylight, from 33 to 8.2% at 100% light, so, no great difference. Bulbs, however, go from 4.2 to 43% at 12% light, and from 22 to 70% at 100% light. The opposite behaviour of leaves and bulbs, both with respect to seasonal development and with respect to light intensity is evident (Table 2, fig. 3 II).

It is remarkable, in connection with the above figures (from the 1966 experiment) that leaf area (expressed as L × B, averaged for leaves 1 to 4, showed hardly any light intensity dependence (ranging only from 94–100%; in the 1965 experiment the dependency was somewhat greater, viz. from 83 to 100%.

According to Table 1, leaf weight ranges by about a factor 1.3, or from 77

[1] Some results with *Gladiolus* have been discussed at the 3rd Intern. Congress of Photobiology at Copenhagen (1960), and some with tulips at the 4th Congress at Oxford (1964).
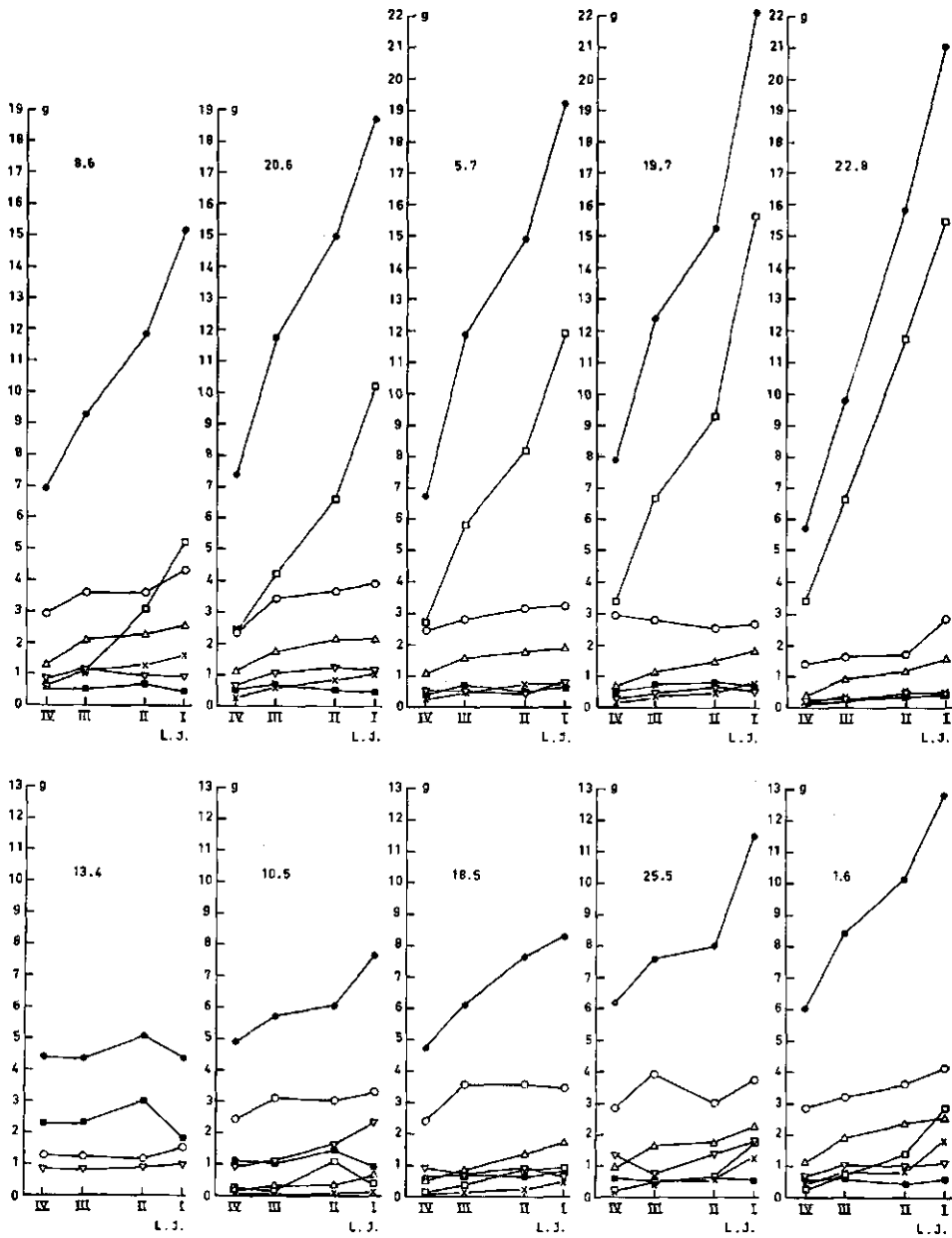
FIG. 2. *Iris*, var. Wedgwood (bulbous Iris). Field experiment 1966 with artificial shading. Dry weight development of various plant parts and total weight at successive harvest. Planted 8 Dec. 1965. ● Total, ○ leaves, ▽ roots, × flowers, ■ old bulb, △ stems, □ new bulb(s). I, II, III, IV: 100, 75, 37, and 10–12 % of full daylight.
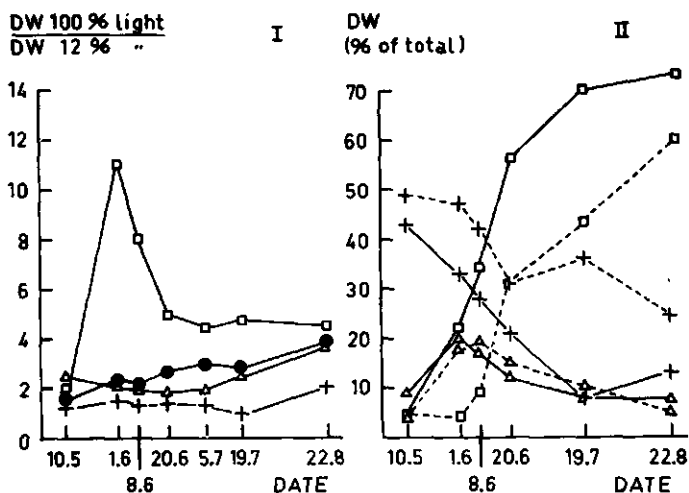
FIG. 3. I. Relation between dry weight at 100% light: dry weight at 12% light, for total dry weight and dry weight of different organs. II. Percents of total dry weight of different organs at 12 and 100% light. I, II: *Iris* field exp. 1966. ●: Total dry weight (I), +: leaves, △: stem, □: new bulb(s) (I, II); — 100%, - - - 12% light (II).

to 100% (in 1966), the somewhat larger range than for L × B probably reflecting changes in leaf thickness. (Leaf anatomy studies are being planned). It should be observed that the course of the relationships, percentwise expressed as in Table 2 and fig. 3, show an interesting consequence of the difference in assimilatory energy, as expressed by different light intensities. We have seen above that leaf area (1966 expt.) at 12 and 100% light is not much different. Photosynthetic efficiency appears notably higher at low light intensity, since 8 times more light energy only produces about 3 times as much total weight, and, ultimately, about 4.5 times more bulb weight. From these figures it is evident that, expressed percentwise, at 12% light the bulbs must occupy a smaller fraction than at 100%, noticeably the opposite effect (because of the percentwise expression) as for the leaves. The leaves are the food factory, its size does not vary much between 12 and 100% light, but the energy it receives does, so that

TABLE 1. Relation Dry wt 100%: dw 12% light for total dry wt and dw different organs; *Iris* (1966)

Date	10.5	1.6	8.6	20.6	5.7	19.7	22.8
Total dry wt	1.5	2.2	2.2	2.7	3.0	2.8	3.8
Leaves	1.2	1.5	1.3	1.4	1.3	0.9	2.0
Stem	2.5	2.1	2.0	1.8	1.9	2.5	3.8
New bulbs	2.0	11	8.0	4.9	4.4	4.7	4.4

TABLE 2. Percents of Total dry wt of different organs at 12 and 100% light; *Iris* (1966)

Date	Leaves 12%	Leaves 100%	Stem 12%	Stem 100%	Bulb 12%	Bulb 100%
10.5	49	43	4.1	9.0	5.1	5.2
1.6	47	33	18	20	4.2	22
8.6	42	28	19	17	8.7	34
20.6	31	21	15	12	31	56
19.7	36	8.2	9.1	8.2	43	70
22.8	24	13	6.2	7.2	60	73

the bulb, the storehouse of the assimilates, becomes much bigger, and, almost from the beginning, occupies a larger fraction of the total weight. It seems, however, justified to remark that this is not quite the whole story, since, according to this reasoning, one might expect that not only the leaves themselves, but also the stem would show this mirror image with respect to the bulbs. This, however, is not so; during the entire season, the stem occupies about the same percentages of total weight at 12 and 100% light (fig. 3 II). Interestingly, the stem percentages duely reflect the maximum at the time of flowering (around 1.6), and clearly demonstrate the shift towards somewhat earlier dates at the higher light intensity. Table 1 shows that the factor for stem weight between 12 and 100% is about 2.2 with little variation over the season. Stem weight thus, like total weight, increases more or less proportional to light intensity, like bulb weight; however, it receives a much lower proportion of the assimilates.

Rather contrary to leaf area, leaf shape shows a definite and regular decrease of L/B with increasing light intensity, of a similar nature as found in *Gladiolus* and tulip. Quantitatively, the differences over the range of light intensities appear somewhat smaller in *Iris*, B/L varies from around 65% to 100% (average of 1965 and 1966), against from ca. 50–55% to 100% in tulip and *Gladiolus* (Fig. 4). In tulip and *Gladiolus*, there was an almost exact correspondence between the courses of the light intensity dependence of leaf shape (expressed as B/L) and of dry weight, except at the lowest light intensity where weight figures were somewhat lower. This relationship is less close in *Iris* for which both the somewhat weaker reaction of leaf shape (see above) and the somewhat stronger reaction of dry weight (viz. from ca 35% to 100% in *Iris* against from about 45 to 100% in tulip and *Gladiolus*) are responsible (see also below). Also in *Iris*, however, the fact remains that leaf shape reacts much more strongly upon light intensity than total leaf area does. In *Iris* and *Gladiolus*, leaf area only changes from ca. 85% to 100% over the range of light intensities; in tulip, leaf area was found lowest at the highest light intensity. The fact of a closer correspondence between leaf shape (a truly morphogenetic feature) and production than of leaf area and production remains remarkable. Correction of production for the (generally small) differences in leaf area at the various light intensities does
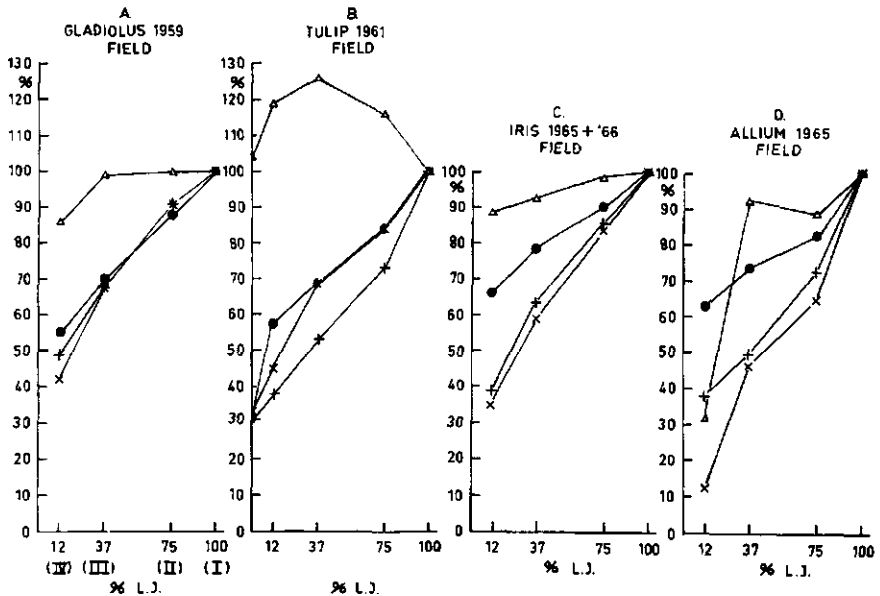
Fig. 4. Leaf size (△ : L × B), leaf shape (●: B/L), and weight of entire plant (×) in relation to light intensity; + : same corrected for differences in △ (leaf area). In percents of the 100 % light value, for *Gladiolus* (A), Tulip (B), *Iris* (C), and *Allium* (D), in field experiments.

not materially alter the situation. It seems worth notice that in *Gladiolus* this correction brings about full coincidence between leafshape and total dry weight values also for the lowest point; in tulip, however, correction for leaf area disturbes the quantitative correspondence between the light reaction of dry weight and of leaf shape (B/L) and makes the picture more alike that of *Iris*.

It is of interest to compare this data with figures recently published from our laboratory by BUTT(7) on 1st year's growth of onion from seeds, in relation to the same sequence of lig htintensities (fig. 4 D). This 1st year's growth ends up with bulb formation (which bulbs, after cold storage, produce a flower stalk next year). Since, in the first year's growth, there is no bulb to start with, the development of the entire plant is strongly dependent on light intensity. In all experiments made so far (1964 and 1965 field, and 1965 phytotron) this yielded a close correspondence between leaf area and dry weight at the lowest light intensity. In both 1965 experiments, in the field and in the phytotron, leaf area was nearly 100 % (as compared with full daylight) from 37 % light intensity onward. (In the 1964 field experiment leaf area developed almost linear with light intensity). Dry weight production was almost linear with light intensity over the whole range, thus ranging from ca. 10 to 100 %. Corrections for leaf area differences brought the lowest point up to ca. 40 %, so that the range of dry weight production then became about the same as in *Iris* (values at 37 and 75 % light, however,

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were somewhat lower, viz. 50 and 70% in onion, against 60 and 85% in Iris.) Leaf shape (expressed as D/L, D = diameter) showed about the same range as B/L in *Iris*, viz. from about 55–60 to 100%. In the range from 37 to 100% light, the relation between leaf size, leaf shape, and dry weight is about the same in the onion and in *Iris*; at 12%, as explained, the situation is different. In both both 1965 experiments, development of *leaf area* showed light saturation at a much lower value of the light intensity than holds for dry weight production and leaf shape development, the same as found in Iris, and, mutatis mutandis, in tulip and *Gladiolus*. (In the 1964 onion field experiment, there was a much closer correspondence between leaf area development and dry weight production, for which Dr. BUTT has given some explanation to which we may refer without further discussion (7)).

Fig. 5 I resumes for all 4 species the data discussed so far; it clearly shows that the triangles (L × B) are grouped in the top part, then the circles (B/L), rather closely together, and somewhat lower, still, especially at the lower light intensities, the + signs, the total dry weight data, corrected for differences in leaf size. The only exceptional point is the L × B for *Allium* at 12% light
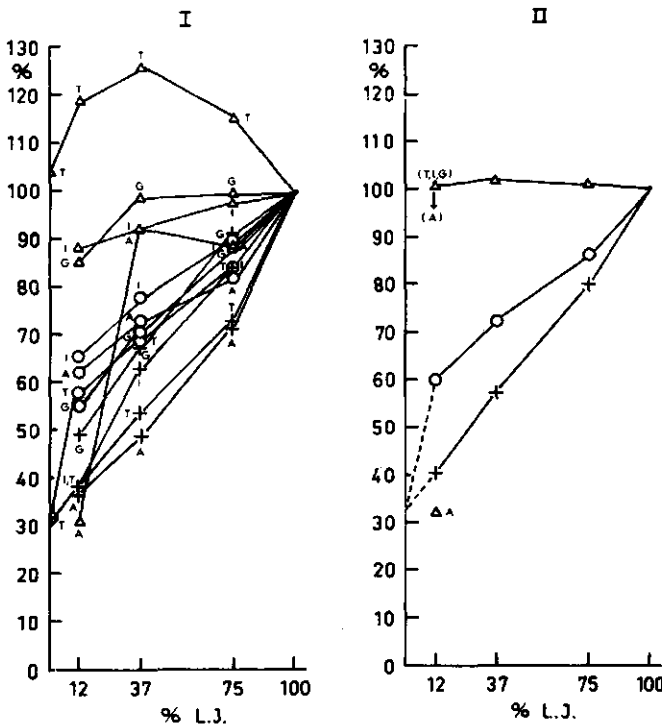

FIG. 5. I. The data of Fig. 4 A, B, C, D, combined. △: leaf size (L × B); ○: leaf shape (B/L); +: dry weight of total plant, corrected for differences in leaf area (△). G: *Gladiolus*, T: tulip, I: *Iris*, A: *Allium*. II. The data of I averaged over the four species, with the exception of the 12% light intensity value of L × B for *Allium*.

which corresponds more closely to the total weight figure than leaf shape which shows no deviation. It was already remarked that this is easily understood from the fact that in this case no reserves, in a bulb or corm, are available, and the production of food is limiting also for leaf size, as was not so in any other case in all of which leaf size seemed fairly independent of light intensity, and leaf shape's reaction corresponds much more closely to dry weight production.

The general similarity in all cases suggests looking at the average of the four which is produced in Fig. 5 [1]. Only the figures of leaf area for *Allium* at 12% light has been taken apart since, as explained above, another limitation for leaf area operated in this case. For the rest, it is clear that leaf area is hardly affected by light intensity, dry weight production obviously is, and the effect of light intensity on leaf shape is very similar to the latter.

It is worth notice that both relationships, on the average, are fairly linear to light intensity between 12 and 100% light. It may be remarked that the total dry weight, expressed in percents, and corrected for differences in leaf area, faily corresponds with the notation of 'net assimilation rate' for which, taken over the entire season, linearity was observed in *Gladiolus* (5).

Some more data about *Iris* are collected in Fig. 6, comparing stem growth data with the already discussed data on leaf growth and total dry weight production, for the 1966 field experiment. Stem growth, at the lower light intensities,
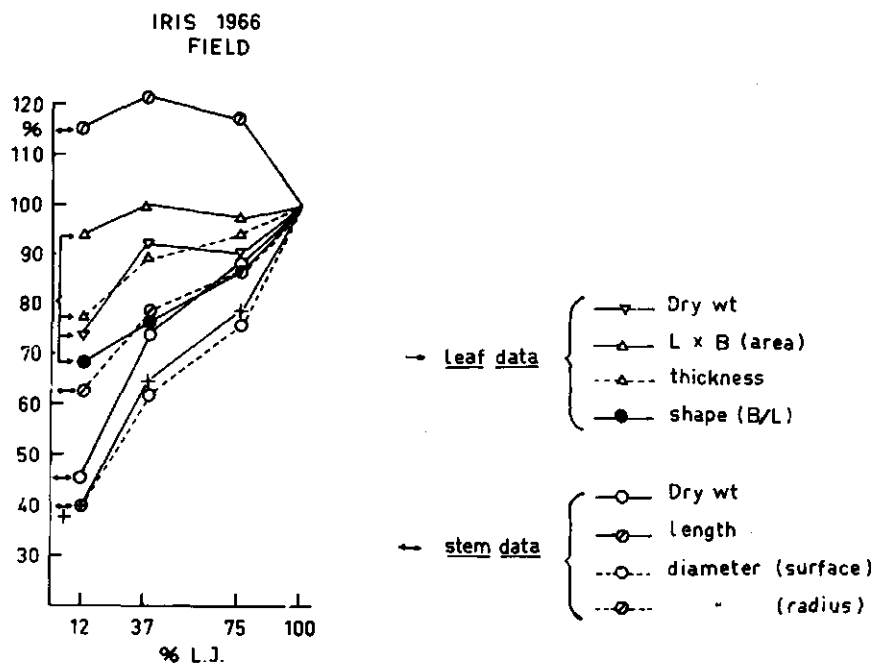

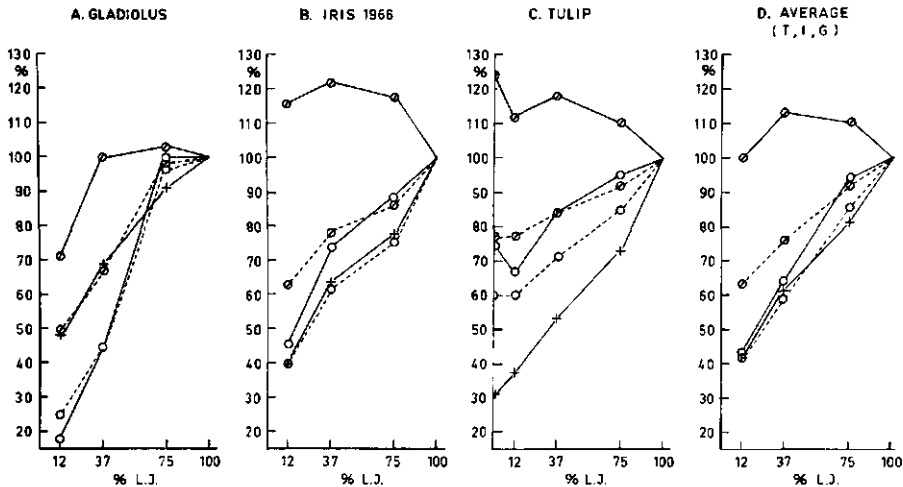FIG. 6. Some more data on *Iris*, 1966, in comparison with those collected in Fig. 4C.

FIG. 7. Stem length (–O–), stem thickness (- -O- - cross section, - -O- - diameter), stem dry weight (–O–) and total plant dry weight corrected for differences in leaf area (–+–) in *Gladiolus* (A), *Iris* (B), *Tulip* (C), and *Average* (D), in 100 % light intensity.

shows figures above 100 %, very similar to those found earlier in tulip (Fig. 7). Stem weight reacts upon light intensity much like total weight, and average stem thickness (wt/length) almost exactly coincides with the total dry weight curve corrected for differences in leaf area.

The behaviour of stem length, as well as of leaf area, probably is to be considered as a compromise between available assimilates, and a (morphogenetic) etiolation or dilatation effect induced by the lower light intensities.

It is of interest to compare, during the growing season, in the various plant species, the fractions of total dry weight which are contained in the combined storage organs (old and new bulb or corm) and the green tissues (stem and leaves) (Fig. 8). In this, there is a sequence of decreasing importance of bulb weight from tulip over *Iris* to *Gladiolus*. At the peak of flower development under the highest light intensity in tulip, the old and new bulb together occupy still some 50 % of total dry weight, stem and leaves about 40 %; in *Iris* these figures are about 15 and 70 %, in *Gladiolus* 10 and 90 % respectively. Interestingly, this sequence is the same as that for time of flower initiation and light requirement, the latter is least in tulip, and most in *Gladiolus*, *Iris* being in between. In tulip, most of the green parts rely on the old bulb for their development, in Gladiolus contemporary photosynthesis plays a much bigger rôle, and the position of a plant developing from a seed is approached. *Iris*, also in this respect, appears intermediate.

At the lowest light intensity (12 %), in tulip and *Iris* the green parts play a relatively larger rôle than at 100 % light, as was to be expected. In *Gladiolus*, this seems somewhat opposite which may be due to the relatively bigger rôle
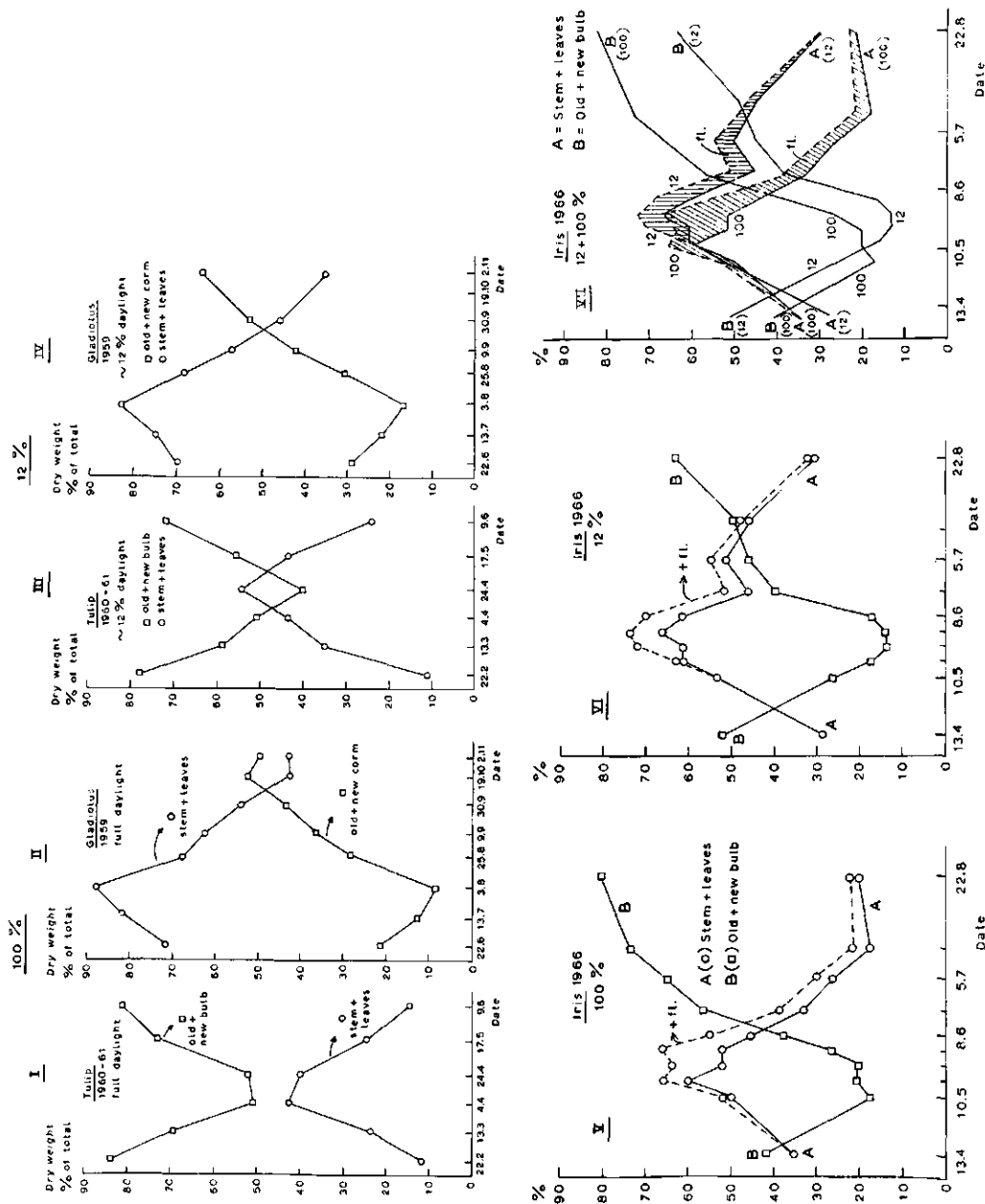
FIG. 8. Comparison between *leaf + stem dry weight* (○), and *old + new bulb (corm) dry weight* (□), *in % of total dry weight*, from field experiments. I Tulip, 100% light, II *Glodiolus*, 100% light, III Tulip, 12% light, IV *Gladiolus*, 12% light, V *Iris* (1966), 100% light, VI id., 12% light, VII id., schematic comparison between 12 and 100% light; hatched area: flower weight. Figures I–IV, publised; in fig. V–VII A = leaf + stem, B = old + new bulb(s), in A with and without flower weight.

the remainders of the old corm play in the in total, more scanty development of the entire plant at 12 % light.

In a combined figure for 12 and 100 % light (*Iris*, 1966) the above is easily demonstrated; it also shows the shift in time of flower development, and the rather considerable weight flowers add to stem weight in this species (fig. 8, VII).

Like we did for *Gladiolus* and tulip, we have made some preliminary observations on anatomy, in relation to the study of external morphology. The following observations refer to the cross section of the flowering stem of *Iris*, at about half height. The type of data collected is the same as in the preceding cases.

Figure 9 shows survey cross sections, with indication of the vascular bundles as counted, figure 10 indicates the determination of the distances of the bundles; Table 3 and figure 11 contain some preliminary quantitative data. As far as this goes, however, they seem to contain features of the behaviour of tulip as well as of *Gladiolus*, and again, appear to some extent intermediate. I remind the reader of the fact that the most salient difference between *Gladiolus* and tulip was that in the first mentioned one the number of vascular bundles was
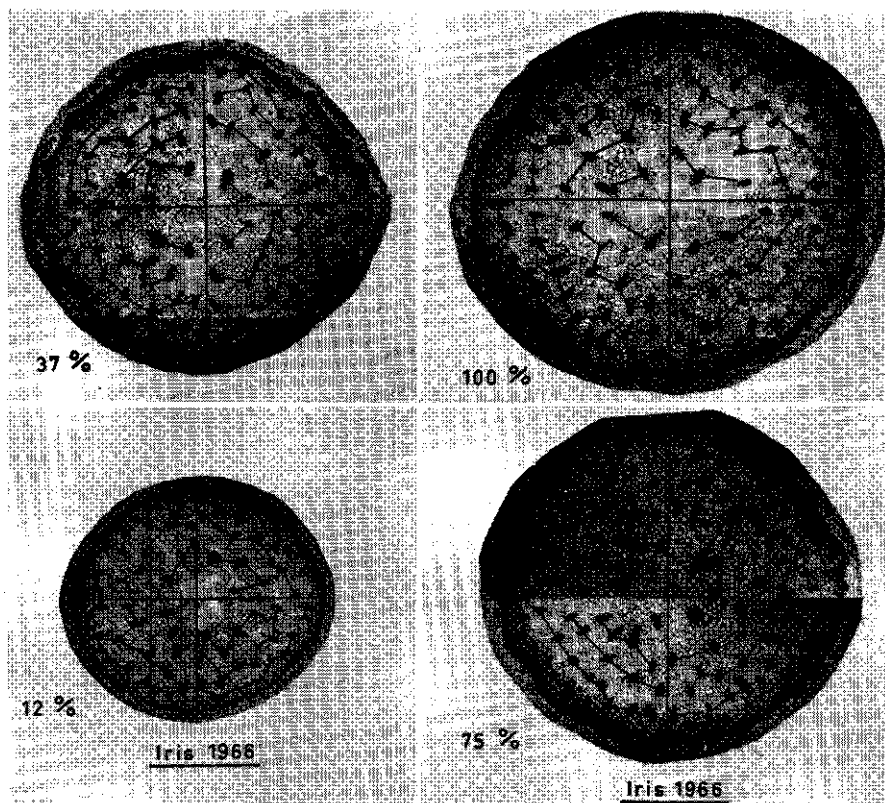

FIG. 9. Cross sections of stems of *Iris*, Wedgwood, grown at different intensities of natural daylight, with indication of counting the vascular bundles.
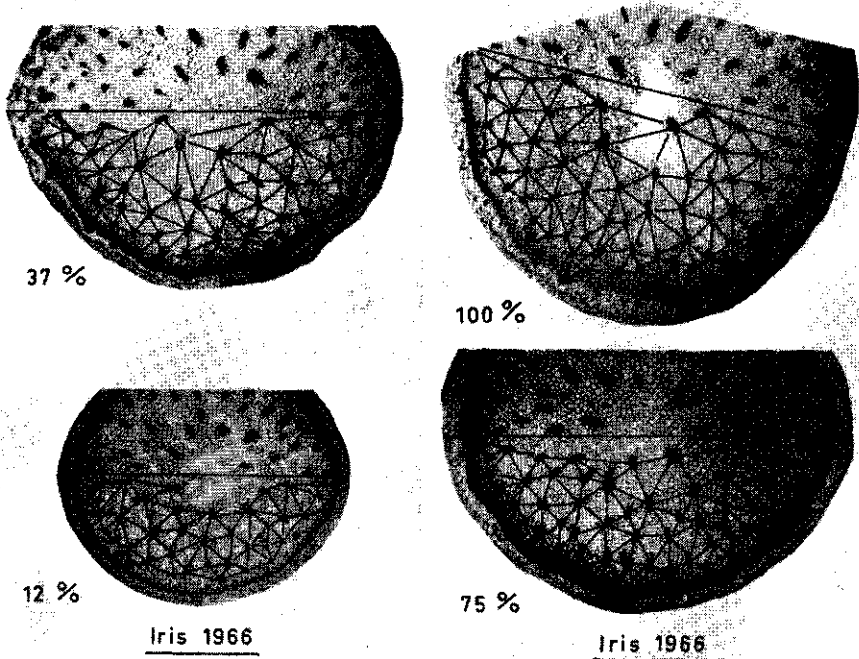
FIG. 10. Cross section of stems of *Iris*, Wedgwood, grown at different intensities of natural daylight, with indication of measuring distances of vascular bundles.
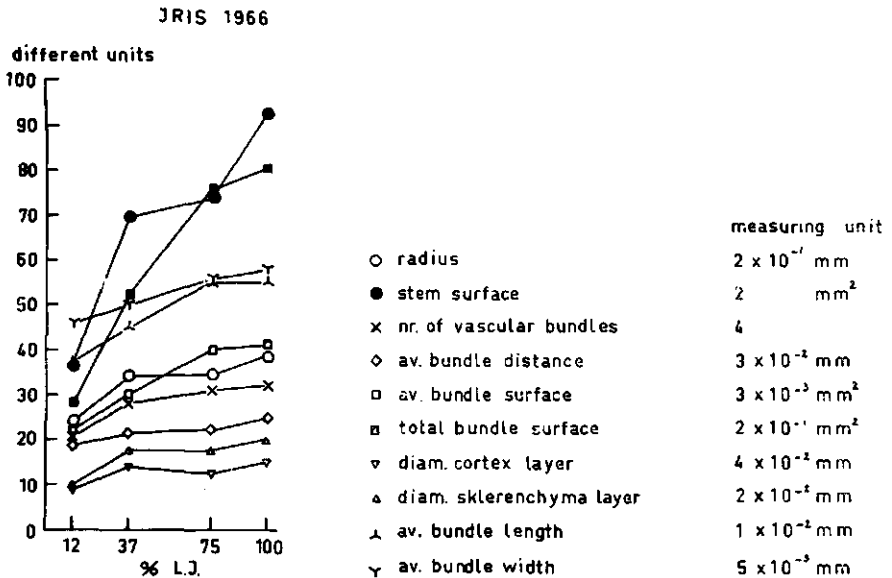

FIG. 11. *Iris*, Wedgwood, 1966 experiment. Some anatomical features in relation to light intensity, derived from sections as shown in figs. 9 and 10. Some anatomical features in relation to light intensity.

TABLE 3. Some quantitative data on dimensions of items in stem cross section in *Iris* 'Wedgwood', in relation to light intensity. Data of 1966 experiment.

Notation in figure 11	Items		Light intensity			
			I (100%)	II (75%)	III (37%)	IV(12%)
○	Radius of stem (average)	mm	7,7	6,9	6,8	4,8
		%	100	90	88	62
	Length of cross section	mm	16,4	14,2	13,9	10,2
	Width of cross section	mm	14,35	13,4	12,7	9,15
(l × b × π)●	Surface of stem cross section	mm²	185	149	139	73,3
		%	100	81	75	40
×	Number of vascular bundles in cross section		129	123	114	83
		%	100	95	88	64
◇	Average bundle distance in cross section	mm	0,735	0,66	0,635	0,575
		%	100	90	86	78
	Average bundle length	mm	0,55	0,55	0,45	0,37
		%	100	100	82	67
	Average bundle width	mm	0,29	0,28	0,25	0,23
		%	100	97	86	79
(l × b × π)□	Average bundle surface	mm²	0,125	0,121	0,091	0,067
		%	100	97	73	54
(□x ×) ■	Total bundle surface	mm²	16,1	15,0	10,4	5,6
		%	100	93	65	35
△	Thickness of cortex	mm	0,6	0,5	0,55	0,35
▽	Thickness of sclerenchyma layer	mm	0,4	0,35	0,35	0,2

light dependent (to the same extent as the stem radius) and their distance (hence) ± light intensitive, in tulip the reverse was true. Combined with the reaction of the sizes of individual bundles (6,8) this entailed a reaction of the total bundle corss section surface in tulip of the same extent as that of stem cross section; in *Gladiolus* total bundle cross sections surface reacted much more steeply to light intensity than stem cross section.

In *Iris* Wedgwood (Table 3) bundle length and bundle width appear somewhat less sensitive to light intensity than stem radius, hence average bundle cross section surface is somewhat less sensitive to light intensity than stem cross section surface. Since number of bundles on cross section is about as sensitive

as stem radius, total cross section area of bundles appears somewhat more sensitive than stem cross section surface. All these features illustrate the intermediate position of *Iris* between tulip and *Gladiolus* also with respect to these anatomical characteristics.

4. SUMMARY

With a similar technique as used earlier for *Gladiolus* and tulip, the effects of a series of light intensities were studied in bulbous Irises, var. Wedgwood (*Xyphium praecox*, var. Wedgwood) in field experiments.

In the present paper, some results are presented and discussed in relation to the corresponding data in *Gladiolus* and tulip, while also some data on *Allium*, collected in our laboratory, have been taken up for comparison.

In *Iris*, an impression of the variation in the sensitivity to light intensity of dry weight development for the various plant organs was given by the relation (factor) between dry weights at 12% and 100% light intensity. Thus, for dry weight of bulbs, between 12 and 100% daylight intensity, this factor was 4,4 at the end of the season, earlier in the season it was still higher. For leaves and stems it was generally lower, viz. around 2 at the end, and lower earlier in the season.

In the course of the main part of the growing season, leaves go from 47 to 36% of total plant dry weight at 12% daylight, and from 33 to 8,2% at 100% light; stems go from 18 to 9,1% at 12%, and from 20 to 8,2% at 100% light; bulbs, on the contrary, go from 4,2 to 43% at 12% light and from 22 to 70% at 100% light (between 1. VI and 19. VII in the 1966 experiment). The opposite behaviour of leaves and bulbs, with respect to both seasonal development and light intensity is evident, and reflects the differences in gradual deposit of reserves in the bulbs.

Leaf area (indicated by L × B) showed hardly any light dependence, leaf weight a little more.

Leaf area being hardly different, data show that photosynthetic effciency decreases with light intensity; 8 times more light producing only about 3 times as much total dry weight, and about 4,5 times more bulb weight, consistent with the finding that bulbs ultimately occupy a larger fraction of total dry weight at higher light intensities.

Contrary to leaf area, leaf shape shows a regular decrese (of L/B) with increase in light intensity, similar as found in *Gladiolus* and tulip. Correction for small differences in leaf area have been applied.

Data of BUTT for 1st year's growth of *Allium Cepa* from seeds, show a very similar behaviour, except that in this case, obviously owing to the small quantity of reserves in the seeds, leaf area at 12% light lags far behind that at the higher light intensities.

Further analysis and summarizing of data (cf. fig. 5 I and II) shows that, in all cases *(Gladiolus*, tulip, *Iris*, and *Allium)*, leaf area is hardly affected by light

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intensity with the exception of *Allium* at 12% light; dry weight production obviously is, while the effect on leaf shape is very similar to the latter. The two last mentioned relationships are fairly linear with light intensity; with the correction for (generally small) leaf area differences, dry weight expressed in percents fairly corresponds with the notation of 'net assimilation rate' for which, taken over the entire season, linearity was noted earlier in *Gladiolus* (5).

Stem growth, in *Iris*, inasmuch as length is concerned, corresponds fairly with leaf area; stem weight reacts upon light intensity much like total weight; average stem thickness (wt/length) coincides almost exactly with the total weight curve corrected for differences in leaf area. Stem length and leaf area reaction are probably to be considered as compromise between available assimilates and a (morphogenetic) etiolation of dilatation effect induced by lower light intensities.

The comparison between dry weights of old + new bulb (or corm) and of the green parts (stem + leaves) show that the behaviour of *Iris* is intermediate between those of tulip and *Gladiolus* (fig. 8).

Some preliminary observations on anatomical features of the cross section of the flowering stem in *Iris* show that, also for these characteirestics, the effects of light intensity, in several respects are intermediate between those observed in tulip and in *Gladiolus* (figs. 9–11).

5. ACKNOWLEDGEMENT

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