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GROWTH AND FLOWERING OF THE TOMATO IN ARTIFICIAL LIGHT

I. VEGETATIVE DEVELOPMENT

(met een samenvatting in het Nederlands)

by

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§ 1. INTRODUCTION

Two of the present writers (15) in a previous publication showed that good growth, flowering and fruiting is secured when the tomato in mid-winter is grown by supplementing the poor winterlight with artificial light *during the day*. The Philips high tension mercury lamp HO 2000 was used in these experiments. This procedure gave better results as regards healthiness, sturdy growth, quality and quantity of flowers and early fruit yields than literature mentions for tomatoes irradiated at night.

The length of day in mid-winter in the Netherlands is about eight hours. It was during these hours, from 9 h. in the morning until 16 h. in the afternoon, later on from 8 h.–16 h. that artificial light was used for intensification of the daylight.

From an economical point of view three questions are of first rate importance for a good crop the expenses of which have to be compensated for by a spring yield early enough to secure high prices. One of the questions concerns the 8-hour period of artificial irradiation of our former experiments and whether this period might be shortened. The other two questions have to consider the intensities, high and low, of the artificial light, factors also important for photosynthesis, for formative development and for flower initiation.

Consequently, these questions had to be considered for the vegetative and the reproductive development. This paper, which is the first one of a series, deals with the vegetative development.

§ 2. TECHNICAL DETAILS

The tomato used throughout the experiments is the Vetomold 121. The plants were grown under artificial light exclusively in a glasshouse that had been obscured with a double sheet of reed mat (Plate II, fig. 3). The house was centralheated and illuminated by high tension mercury lights HO 2000 and incandescent lights of 100-, 15- or 5-watt, the 15-watts without, all others with reflectors. For special reasons to be mentioned in § 3 the mercury and 100-watt lamps were burned at night from 22 h. or later until 7 h. in the morning, the 15- and 5-watt lights from 7 h. on during various periods by day. Three of the windows in the roof were open night and day. To guard against CO_2 deficiency and to prevent overheating three fans were light-tight installed below the windows and working day and night. In addition, each compartment was provided with two small ventilators giving a rapid exchange of air about the lamps.

The 10 by 5 meter north-south house is divided by black curtains into three compartments, I with a 7½-hour, II with a 6-hour, III with a 9-hour daily period of photosynthetic light. The west-side of each compartment received mercury light only, the plants on the eastside were exposed to mercury light and light from a 100-watt incandescent lamp as the source of photosynthetic light. Besides this, each west or east side was divided into several blocks, shielded from one another by screens. The screens served also as reflectors and for this purpose had been white washed on the inside; the house held 18 blocks in total. Further details concerning the different types and intensities of illumination within the blocks will be found in subsequent §§.

At the beginning of the experiments each block contained about 200 seedlings. For the investigations into the phenomena of flower initiation plants were picked at regular intervals. This reduced the total number and as the plantlets were growing into plants space was available for repotting into larger pots of 5 in. diameter.

The temperature in one of the compartments was automatically recorded by means of a thermograph. Within the screens a daily maximum temperature of 22 °–23 ° C was registrated at 7 h. in the morning, when the lights had burned all night. When the lights were switched off the temperature gradually fell to 12 °–13 ° C which value was reached at 14 h. and held within this range until the lights switched on in the late evening. Temperature in this way was maintained at a fairly low level during a sufficiently long dark period for the thermoperiodicity requirement of the tomato.

The plants received no daylight at all. They were sown on December 22th in subdued incandescent light and as soon as they were coming up exposed to the light desired for them. As night and day have been reversed for reasons explained in § 3 sowing, pricking etc. took also place at night.

Pricking was somewhat delayed as it took place in the night of January 9/10th. Afterwards growth was normal and potting and repotting took place after reasonable time intervals.

§ 3. THE DAILY PERIOD OF ILLUMINATION

In order to get some information as to the minimum duration of irradiation for tomatoes and the minimum intensity which still would give good plants, the plants had to be grown entirely in artificial light. Since the previous study (15) indicated the efficiency of the Philips high tension mercury lamp HO 2000 this light was chosen. The lamp emits bands in the violet, blue, green and yellow of the visible spectrum with a main output at wave lengths 4358 Å, 5461 A and 5770/5791 Å (14). About the importance of these wave lengths in photosynthesis cf. GABRIELSEN (7) and HOOVER (8).

For tubular fluorescent lamps (TL lamps) coated with a special phosphor the beneficial effect of blue light on plants (tomato and Mirabilis) has been shown by

VAN DER VEEN (16, 17). As far as we know the high tension mercury lamp HO 2000 has not been tried before now as the sole source of light, and is used in our present experiments for the first time. The lamp proved satisfactorily well, see below.

This is evidence that the blue and violet light is produced in sufficient intensity to give normal vegetative growth, at least for the tomato, a plant that cannot thrive without the short wave length part of the spectrum. The high tension mercury lamp Philips HO 2000 seconds – to a certain extent – the prophesy of CROCKER (5, p. 299) that green plants will perhaps only have a chance of growing normally in monochromatic light in the blue or violet, if lamps are constructed where this spectral region is produced in sufficient intensity. Good growth of the tomato was not obtained in the recent experiments of WITHROW and WITHROW (21) with a high tension mercury arc, as the authors themselves suppose because of a shortage of the blue and violet.

The daily periods of exposure to light in the 18 blocks of the three compartments of the darkened greenhouse varied from 6 to 16½ hours; the reader is referred to § 2 and § 6 for special details. The lengthening of the basic illumination with small incandescent lamps was for purposes of a renewed investigation of photoperiodic responses of the tomato especially as regards flowering. This seemed desirable in connection with the still existing controversy in literature. Because, however, photoperiods are important for vegetative development too, this part of photoperiodic response will be treated in § 6.

The glasshouse is only equipped with two clocks for the regulation of all of the photosynthetic and supplementing photoperiodical lights. That is why we had no choice between giving the photosynthetic or the photoperiodic illumination during the night. The photosynthetic light was given at night from 22 h. on, or later, depending on a 9-, 7½- or 6-hour daily period of irradiation and was clock-regulated in the last two cases. From 7 h. on in the morning all photosynthetic light was switched off by hand and the photoperiodical lights were turned on and off again, also by hand, in the different blocks of the three compartments at the end of the different periods planned. The longest one lasted from 7 h. until 14 h.30 in the afternoon. Had the photoperiodical experiments been run at night a regulation by hand would have been hardly possible under these circumstances.

Plate I, fig. 1 on left shows a plant, aged 68 days from seed, grown with a 7½-hour period of exposure to light from the mercury lamp *at night*, without a supplement of photoperiodic light. The plant is satisfactorily low in stature and scarcely taller than plants grown in the ordinary glasshouse in mid-winter which received supplementing mercury light during the daily natural photoperiod. There is practically no difference in colour or form of the leaves.

The superficial reader perhaps concludes that we are modifying here or even deviating from our previous point of view. A year ago (15) we claimed that the tomato should not be exposed to artificial light *at night*. However, the cases are not alike. In these new experiments of ours day has been changed into the night and night into day. In the experiments presented here light meant for photosynthetic purposes is only given during a *relative short period in* 24 *hours*. It is here where we differ from authors, mentioned in our previous article (see also CROCKER (5) p. 304), who expose tomatoes to the winter daylight and then to artificial light during different periods of the night. The plants in our experiments of last year and those plants shown in Plate I fig. 1 in the first two pictures on left, got a long period of uninterrupted darkness and this seems te be one of the fundamental factors for the good development of the tomato. This is all the more evidenced by the results of experiments where we lengthened the photosynthetic light with photoperiodically active light of different duration (see § 6). Whether in 24 hours the photosynthetic light is given during the day or during the night period does not matter for the tomato.

The photoperiodic illumination was stopped at the moment we were sure of a flowering response from at least two of the blocks. This was on February 27 th. As it was now more convenient to have the plants getting the photosynthetic illumination during the day for reasons of control, the irradiation was reversed on the same day. This too the plants endured without showing any symptoms of trouble or defects. Since the plants from then on were entering upon a new phase of their development, *viz.*, that of flowering, further details will be postponed to a subsequent paper.

§ 4. THE INFLUENCE OF DURATION OF PHOTOSYNTHETIC ILLUMINATION

We might repeat here that the greenhouse had been divided into three compartments each with a different period of illumination. One compartment received light from 23 h.30, a second one from 1 h., the third one from 22 h. on. All irradiations ended at 7 h. in the morning. So the durations of illumination were 7½, 6 and 9 hours for the compartments I, II and III respectively.

The illumination in one half of each of the compartments was supplemented with 100-watt Philips incandescent lights during the same period. The purpose of this was to secure the influence of supplementing the high intensity of the blue (and yellow) with a relatively low amount of the red part of the spectrum. The intensity of the 100-watt incandescent light was 130 foot candles at the tip of the plants at the end of the experiments. Each mercury lamp in such a block was accompanied by one 100-watt light. Further details on light intensities are given below.

In compartment II growth was slow in seedlings and young plants (plantlets) compared to the plants of the same age in the other compartments with 7½- and 9-hour daily periods (Plate I, Fig. 2). A 6-hour daily period of light is apparently too short. Fig. 2 shows the plantlets in compartment I, II and III, grown with the mercury light as the sole source of illumination. But the same differences existed under the mercury and incandescent light. In all plantlets, also those of II, the third and the fourth leaves were present on February 1st, but all the leaves were better developed in I and III, in the latter compartment only slightly better in this stage of growth than in I.

Plate I, fig. 1 on left and in center and fig. 3 on left shows the plants when they had grown for 68 days in these compartments. Growth in the 6-hour-plant has been very bad. Note that the 7½-hour-plant is now even slightly better developed than the 9-hour-plant. In other plants of these groups there was virtually no difference. It seems that a daily period of 7½ and 9 hours has about the same influence on the rate of vegetative growth in this stage of development. At the beginning of the experiments the light intensities in all the compartments were virtually alike or at least of the same order. However, the lamps in compartment III were aging faster so that the intensity at the tip of the plants after 68 days was about 400 foot candles in the block with mercury light only and 550 foot candles in the block with the mercury light and the 100-watt incandescent lamp. The intensity in compartment I and II slowed down too, but was still of the order of 750 foot candles. At first it seemed this aging of the lamps in III might have

Fig. 1. Left, grown with a $7\frac{1}{2}$-hour daily period of mercury light (M); center, the same lamp used with a 9-hour daily period; right, $7\frac{1}{2}$ hours mercury light followed by an $1\frac{1}{2}$-hour daily period of photoperiodic light of a 5-watt (at first 15-watt) lamp. Plants 68 days old. × $\frac{1}{4}$.

Fig. 2. Plantlets 40 days old, grown with different daily periods of mercury(M) light. →

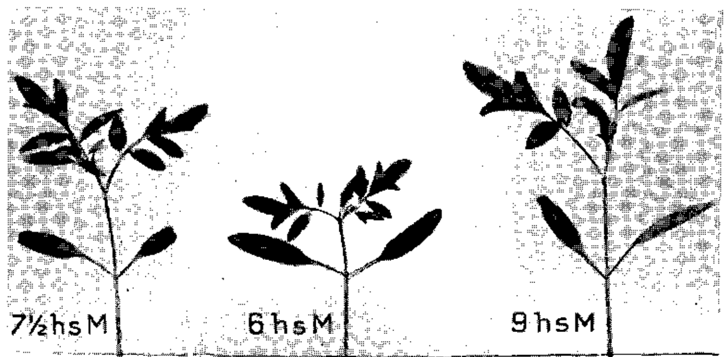

Fig. 3. Left, grown with 6-hour daily period of mercury (M) light, cf. fig. 1, left and center. Right, the 6-hour period followed by $1\frac{1}{2}$ hour daily period of photoperiodic light of a 5-watt (at first 15-watt) incandescent lamp. Plants 66 days old. × $\frac{1}{4}$. →

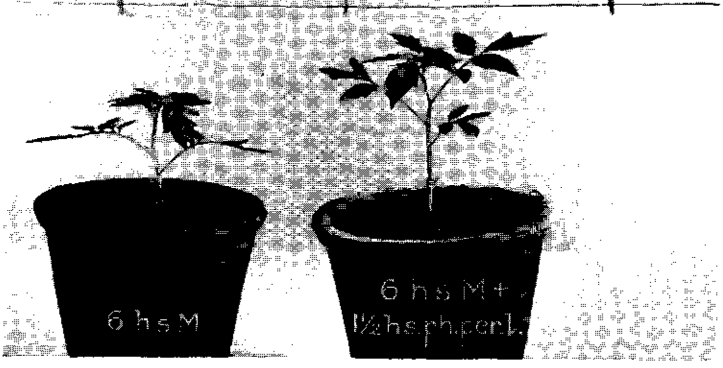

Fig. 1. Right, grown with a 6-hour daily period and exposed to both mercury and incandescent light of high intensity (100-watt light); center and left, the same lights but different daily periods (left, $7\frac{1}{2}$-hour; center, 9-hour). Plants 66 days old. Compare right one also with fig. 3, left (Plate I); cf. center and left one with fig. 1, center and left one (Plate I). $\times \frac{1}{4}$.

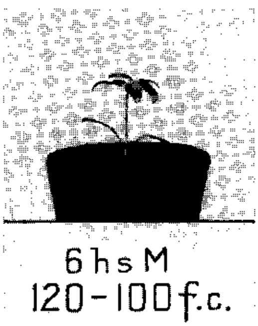

Fig. 2. Plant 69 days old. Grown with a 6-hour daily period of only 120 foot candles mercury light, or when the lamps aged 100 foot candles. $\times \frac{1}{4}$.

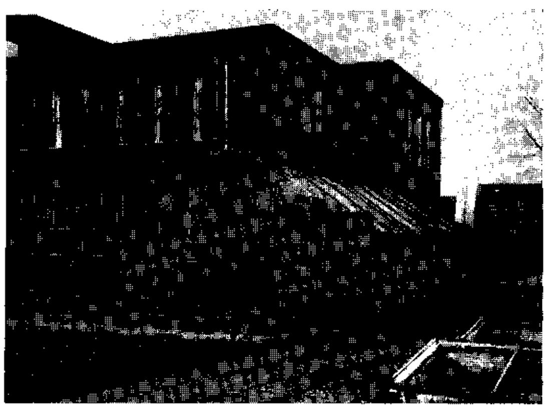

Fig. 3. The greenhouse, south elevation, obscured with a (double) sheet of reed mats. Further details in § 2.

produced the equal development in the mercury-blocks of I and III, the more so since the plants in the mercury-with-100-watt-block of III were still advanced in development over the comparable plants in I; so it seemed as if 550 foot candles during 9 hours was a better illumination than the 750 foot candles of I in a 7½-hour daily period. However, on March 15 th no plants in III were advanced over the I-plants, neither in the mercury nor in the mercury-incandescent group. Since at this date the flower clusters were readily visible to the naked eye we may make the following statement concerning the influence of a photoperiod of fairly high intensity on vegetative development. A daily photoperiod of 9-hour has a slight beneficial influence over a 7½-hour period in the first stages of development. Towards the flowering stage the advancing influence has disappeared. Further research, if necessary, should be concerned with differences in dry weight gain; in this year experiments no plants were available with this purpose in view.

The plants that were grown under the 6, 7½ or 9 hour daily illumination from mercury light supplemented by 100-watt incandescent lamps during the same period are advanced over those grown in mercury light only, but they show too much of spindly growth from a cultural point of view. The advancement shows up in the following characteristics in all of the compartments: (a) An increase in number of leaves, in I one, in III two leaves more over the corresponding mercury-group. (b) An increase in leaf area. (c) The leaves are somewhat greener. (d) An increase in thickness of stem. (e) The reproductive development seems to be a little ahead too, but we shall consider this point in the next article in connection with the influence of illumination on flowering response.

The advantageous effects (a), (b), (c), (d) and (e) were to some extent destroyed by too much of spindly growth (Plate I, Fig. 1 on left and in center, Fig. 3 on left; Plate II, Fig. 1). This cannot be due to the influence of the infrared rays of the incandescent lamps as the heat production of the mercury lamps was very much greater. Besides, a fan in each block exchanged the air about the lamps (see § 2) so that the temperature did not exceed 20°–22° C. From the point of view of the grower who does not desire much growth in length the better plants are those in compartment I and III grown with mercury light only, then come the plants from I with mercury and incandescent light and the least are those with the 9-hour period and incandescent light. The rate of development, however, increases as the mercury light is supplemented with the 100-watt incandescent lamp and the arrangement of the different blocks becomes: I and III, mercury and incandescent light no appreciable difference, I and III mercury light showing the least development with no difference between each other. The plants in II with the 6-hour period are not good enough to be considered for a place in these series.

The experiments indicate that the high tension mercury lamp is a good light source for the vegetative growth of the tomato. We will mention here that Johnston (10) had very good results at least in one of his experiments where a combination of Mazda incandescent lamps and a mercury lamp was used, but only with very much higher intensities, such as 3000 foot candles, 2800 of which were produced by the Mazda light.

§ 5. THE INFLUENCE OF THE INTENSITY OF THE MERCURY LIGHT

The influence of the intensity of the light could be studied in each separate block of one series (the series without the 100-watt lights) as there were several levels of light intensity within each block depending on the distance of the plants from the lamps. Even within the light unit itself (lamp + reflector) the light intensity fell from e.g. 1000 to 800 foot candles at 19 in. below the lamps or from 750 to 500 foot candles when the lamps have been utilized for two months. „Using the plant as a light meter" (LAWRENCE (11) p. 132) proves that the plants within the edges of the reflector show no appreciable differences in development; this will be partly due to the fact that it is all but impossible to replace the plants at exactly the same spot they occupied before potting and repotting.

Beyond the edges of the reflector light intensity is falling fastly, to 100 and 80 foot candles at the end of the block. If the blocks had not been encircled by white washed screens and glass panels light conditions would have been even worse.

The lamps in our experiments were used in a horizontal position and fitted with an aluminium reflector ("aluminium diamant") 33 × 16,5 in. (84 × 42 cm). We tried whether more light or uniformity of light intensity, especially within the edges of the reflector, might be secured with a vertical position of the lamps with the Philips reflector 65774 AG 06. This, however, was not the case. The arrangement did not improve light conditions, not even over small areas. Besides this, it greatly reduced the intensity of the light and the 1000 foot candles were not reached, not even when the lamps were new.

The arrangement as it was now, enabled to get an idea about the amounts of light wanted for growing plants under the high tension mercury lamp HO 2000. All the plants mentioned in the preceding §§ or later have been sampled well within the edges of the reflector, if not stated otherwise. Light intensities of the order of 1000 foot candles seem to be necessary for a normal vegetative growth of the tomato. With lower intensities growth is possible but at a slow or too slow rate. Plate II, Fig. 2 shows a plant 69 days old grown with a 6-hour daily period of 120 to 100 foot candles. The slow growth is not due to the short period of irradiation as plants grown for 7½- or 9-hour periods with the same light intensity did not do better. This growth occurs near to the compensation point (cf. BLACKMAN and WILSON (2)). It may be added that the Weston Light meter nr 756 is more sensitive to the light of this mercury lamp than e.g. the light meter used by WASSINK and VAN DER SCHEER (18); a factor 4/5 is involved.

§ 6. THE INFLUENCE OF THE PHOTOPERIODIC LIGHT OF LOW INTENSITY

The tomato, Lycopersicum esculentum Mill., with all its varieties in literature is looked upon as a short-day plant, a long-day plant (12) or a photoperiodically neutral plant (see MURNEEK and WHYTE (13) and CROCKER (5)) with temperature sensitivity, the phenomenon of thermoperiodicity described by WENT (20).

According to common opinion plants respond the same whether artificial light for flower initiation is given at the beginning or end of the dark period (13). This is not in agreement with recent investigations of BÜNNING and associates (3, 1, 4). BÜNNING (3) emphasizes his opinion about the importance of the photophilic and skotophilic phase of the endonomic rhythm in plants. Light only that reaches the plant in the photophilic phase has photoperiodic induction qualities both in short-day and in long-day plants. The beginning of the skotophilic phase may sometimes be recognized from the inset of nyctinastic movements of leaves or leaflets. In short-day plants this phase begins about 16 h. in the afternoon and lasts until 24 h. The skotophilic phase in long-day plants exists from 6 h. until 14 h. in the afternoon.

Whether the two phases exist also in photoperiodically neutral plants or how the long range over which flower initiation may be induced in such plants should be explained does not seem to be studied by Bünning until now.

According to Bünning and associates the endonomic rhythm cannot be changed by external conditions and is even existing in the seed and in tissue cultures (1, 4).

Now let us see how the tomato Vetomold 121 reacts from this point of view. The leaves of the tomato especially those of seedlings and young plants, but also those of older plants, show nyctinastic movements, that in ordinary winter and summer cultivations begin in the late afternoon. The leaves move just the other way as the leaves of the short-day Soybean, as they are raised until an almost vertical position has been reached. These movements, however, are not time-bound. In mid-winter they set in at three or four o'clock in the afternoon, later on in early spring typically at the time of sun setting. In our blacked out greenhouse nyctinasty set in at 8 h.30 in the morning and lasted until 22 h.10 in the night, 10 minutes after illumination had begun.

This does not seem to indicate that the tomato, strain Vetomold 121, is either a short-day or a long-day plant. Since the nyctinastic movements of the Vetomold 121 are not time-bound, the extra light might be tested on its influence before or at the end of the photoperiod of high intensity. But, for reasons mentioned in § 3 we had no choice and we have only irradiated at the end of the photosynthetic period.

In each of the three compartments there were blocks where the photosynthetic period was extended with an extra photoperiod of low intensity and different length. In III there were 4 such blocks, two of which received 1½-hour and the other two a 7½-hour daily period of extra photoperiodic light. It may be recalled that each compartment has a mercury series and a mercury with a 100-watt incandescent series of blocks, hence the two-fold 1½-hour and 7½-hour photoperiods.

In the same way 4 such blocks occur in compartment II with the 6-hours photosynthetic light.

Compartment I forms an exception in that the extra photoperiods in one of the two series had a duration of 1½-hour and 4½-hours.

The different photoperiods are summarized here; the abbreviations mean: m = mercury light; i = 100-watt incandescent light; ph. per. l. = photoperiodic light of an incandescent lamp of low intensity.

At first 15-watt lamps were used yielding 2–5 foot candles, afterwards the lamps were changed to 5-watt lamps with reflectors adjusted in such a way that they gave 4 foot candles at the tips of the plants.

Compartment	III,	9 hours m + 1½ hours ph. per. l.	= photoperiod of 10½ hours.
,,	III,	9 hours m + 7½ hours ph. per. l.	= photoperiod of 16½ hours.
,,	III,	9 hours m + i + 1½ hours ph. per. l.	= photoperiod of 10½ hours.
,,	III,	9 hours m + i + 7½ hours ph. per. l.	= photoperiod of 16½ hours.
,,	II,	6 hours m + 1½ hours ph. per. l.	= photoperiod of 7½ hours.
,,	II,	6 hours m + 7½ hours ph. per. l.	= photoperiod of 13½ hours.
,,	II,	6 hours m + i + 1½ hours ph. per. l.	= photoperiod of 7½ hours.
,,	II,	6 hours m + i + 7½ hours ph. per. l.	= photoperiod of 13½ hours.
,,	I,	7½ hours m + 1½ hours ph. per. l.	= photoperiod of 9 hours.
,,	I,	7½ hours m + 4½ hours ph. per. l.	= photoperiod of 12 hours.
,,	I,	7½ hours m + i + 1½ hours ph. per. l.	= photoperiod of 9 hours.
,,	I,	7½ hours m + i + 7½ hours ph. per. l.	= photoperiod of 15 hours.

As is known since the beginning of research on photoperiodism there is a minimum length of photoperiod necessary for flower initiation. Although such a photoperiod may be composed of periods of high and low intensities, light intensity, to some extent, is a factor of importance. Too short a photoperiod of intense light for photosynthesis does not give a satisfactory crop or gives too slow a growth. From our this year investigations the minimum length of a photoperiod of high intensity appears to be about 7½ hours. If this minimum period of high intensity is lengthened to 9 hours, vegetative growth and development are good too (Plate I, fig. 1, center) and summer cultivations even show that very long periods of light of high intensity are even more efficient.

If, however, this 9-hour period or even that of 7½-hours is lengthened with light of low intensity, no beneficial effect and, to some extent, even a damaging effect on vegetative development was found. Plate I, fig. 1, left and right, illustrates this statement. The plant on left received 7½ hours of mercury light, the plant on right in addition to the mercury light of 7½ hours an extra irradiation of 1½ hours photoperiodic light. The weak photoperiodic light has especially affected stem growth, the leaves have a normal appearance and even a slightly larger area. So the minimum length of 7½ hours of intense light required for good growth, cannot be lengthened with photoperiodic light of low intensity without injury to the plants.

The same and even to a greater extent holds if the photoperiod of 7½ hours is lengthened with light of low intensity to 12 hours and applies also to the blocks that received mercury light and 100-watt incandescent light during the 7½-hour period of photosynthetic light.

If the 9-hour period of high intensity is lengthened with light of low intensity the injurious effect is even more striking and affects the whole plant in that it is behind in development with a reduced number and area of leaves. This becomes the more obvious with the longer duration (7½ hours) of the period of low light intensity.

To bring our summary of the facts about the influence of weak photoperiodic light to a close a last example out of compartment II might be given. This compartment received photosynthetic light during 6 hours daily, a photoperiod too short to give satisfactory vegetative growth as we have seen. If, however, this 6-hour period is lengthened with 1½ hour of photoperiodic light there is a beneficial effect over the 6-hour plants, but not such as to compensate the shortage of high intensity. This is shown in Plate I, fig. 3. A longer duration of light of low intensity, however, here too is injurious.

The facts show that only the photoperiod of 6 hours of light of high intensity may be lengthened with light of low intensity but not or not much longer than over a period of 1½ hour. Since a period of 7½ hours of light of high intensity is apparently the minimum period of high intensity wanted for normal growth we may now make the following statement.

The minimum period that is necessary for good growth is already longer than the maximum period of light of high intensity that may be lengthened with light of low intensity without injury to the tomato.

We may further conclude that it is not prudent to expose the tomato to light of incandescent lamps during winter or spring cultivations after a daily photoperiod of sufficient duration for assimilation purposes.

Our results at first appear to be different from those of WASSINK c.s. (19). These authors found stem elongation in the blue and violet with a variety of

Brassica rapa. Closer examination, however, indicates the dissimilarity of the cases. WASSINK c.s. examined the influence on elongation of a flower stalk, whereas our work was concerned with the effect of light on the vegetative stem. Indeed, there is evidence enough that plants do not respond in the same way to light, see e.g. FUNKE (6).

§ 7. LIGHT AND THE GLASSHOUSE

The costs of lighting the glasshouse are great, hence the importance of attempts to a better understanding of the light requirements of each separate crop. In connection with this, breeding work for winter crops of tomatoes should not only go towards producing varieties or selections with pickings in early spring but also with a minimum of light requirement. Preliminary work and observations of the last mentioned of the authors suggest that crosses with Farthest North have great potentialities. This variety may be readily grown on 4 or 3 stalks and as such does not spread more than any other tomato; because of its low stature it might be economically qualified to be raised in mid-winter with supplementing artificial light even after the planting-out stage.

LAWRENCE (11) supplemented winter light with an additional gift of artificial light and tested three periods of the *night.* The light intensity reaching the plants was 500 foot candles in one and 250 foot candles in the other experiment. Although a much earlier and a higher total yield was recorded, LAWRENCE, it seems, does not propose the scheme for practical glasshouse growing (11, p. 157).

We ourselves wish to continue our investigations by supplementing the winter light in glasshouses *during the day.* Two of us thought out and used this method a year ago, established their arguments and advised further research.

The results secured with the high tension mercury lamp provide a basis for further research in the glasshouse in view of the economic possibilities for a better growth of seedlings and plantlets regarding application of artificial light during the winter months. The intensity required of mercury light if it is the sole source of illumination is now known and so is the length of the photoperiod for assimilation purposes. Injurious effects may occur if tomato plants are exposed to incandescent light of low intensity after a photoperiod of 7½ hours or more of mercury light. This fact too will have its consequences for glasshouse culture.

SUMMARY

The tomato may be grown under the high tension mercury lamp HO 2000 as the sole source of irradiation in a blacked out glasshouse, also when natural night and day are reversed. For purposes of photosynthesis the light intensity under these circumstances should be of the order of 1000 foot candles at the tip of the plants. The minimum length of the photoperiod of high intensity is about 7½ hours, 6 hours being too short. The 6-hour period may be lengthened with a maximum duration of 1½ hour of light from incandescent light of low intensity (4 foot candles) without injury to the plants. If the 7½-hour or 9-hour daily periods are lengthened the plants grow spindly or show reduced leaf areas. Spindly growth is also shown in plants grown with mercury light and 100-watt incandescent lamps (130 foot candles) when the illumination is given simultaneously but leaf area is slightly larger.

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SAMENVATTING

De tomaat, Vetomold 121, werd in een verduisterde kas gekweekt met uitsluitend kunstlicht. Doel hiervan was enig inzicht te verkrijgen welke minimum intensiteit en dagelijkse duur van belichting nodig is voor een goede ontwikkeling van genoemd ras.

Feiten hieromtrent zijn nodig als basis tot verder onderzoek voor de toepassing van kunstlicht in de stooktomatenteelt en deze ontbreken, voor zover ons bekend, ten enenmale.

Als lichtbron werd gebruikt de hogedruk-kwiklamp Philips HO 2000, al dan niet aangevuld met 100-watt gloeilampenlicht.

In de literatuur bestaat nog enig verschil van mening of de tomaat een korte- of een lange-dag plant is of voor daglengte ongevoelig. Ook dit punt werd, in verband met BÜNNING's theorie, wat de vegetatieve ontwikkeling aangaat, in dit eerste artikel behandeld.

Een dagelijkse periode van 6 uur photosynthetisch licht bleek te kort, ten minste een 7½-uur periode is nodig (Plaat I, fig. 1 links en midden, fig. 3 links). De lichtintensiteit moet zijn van de orde van 10000 lux op de top der planten. Het verlengen van de genoemde minimum duur van 7½ uur sterk licht met 1½ uur zwak licht (40 lux) bleek ongunstig voor de vegetatieve ontwikkeling. De planten groeiden te sterk uit (Plaat I, fig. 1, rechts). Nog ongunstiger werkte een verlenging van de 7½ uur met 4½ uur zwak licht of een verlenging van de 9-uur periode met 1½ uur of langer zwak licht, doordat dan de etiolementsverschijnselen ook het blad betreffen. Indien echter de 6-uur periode van sterk licht werd verlengd met 1½ uur, was het effect hiervan gunstig (Plaat I, fig. 3, rechts), maar hetzelfde als met 1½ uur sterk licht (de 7½-uur plant) wordt niet bereikt. Een verdere verlenging had echter ook hier dezelfde etiolementsverschijnselen ten gevolge.

De planten, die behalve het kwiklicht tegelijkertijd licht ontvingen van een 100-watt gloeilamp (1300 lux) vertoonden eveneens etiolementsverschijnselen, doch alleen wat de lengtegroei betreft; het bladoppervlak is integendeel zelfs wat groter dan bij kwiklicht alleen.

Het zwakke licht werd overdag toegediend aan de verschillende groepen; in verband hiermede moest het assimilatie licht 's nachts gegeven worden. Dit lijkt, als of wij het principe, hetwelk wij in onze vorige publicatie (15) huldigden, laten varen. De lezer zal echter begrijpen, dat wij geen bezwaar maakten tegen een eventuele omwisseling van dag en nacht, zoals hier geschiedt. Ons bezwaar betrof het feit, dat men de tomaat eerst aan het natuurlijke licht blootstelde en daarna gedurende langer of kortere tijd 's nachts aan kunstlicht. De gegrondheid van ons bezwaar wordt reeds gedeeltelijk bewezen door de uitslag van de hier beschreven proeven met zwak licht.

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