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SOME OBSERVATIONS ON THE INFLUENCE OF SPECTRAL REGIONS OF LIGHT ON STEM ELONGATION, FLOWER BUD ELONGATION, FLOWER BUD OPENING AND LEAF MOVEMENT IN *ARACHIS HYPOGEA* L.

by

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1. INTRODUCTION

For more than two centuries attention has been paid to the influence of various colours of light on development and behaviour of plants. Photoperiodism, phototropism, stem elongation, leaf and root formation and pigmentation have been investigated with regard to spectral sensitivity.

The spectral sensitivity of leaf movement and flower opening so far received little attention. The present author has tried to collect some information on the latter subjects in *Arachis hypogea* L. Besides this, he has investigated a few other reactions to light of various spectral compositions and high intensities in this plant species. Some of the more interesting findings are reported in the present paper.

2. SOME REMARKS ON LITERATURE

The influence of environmental factors other than spectral composition of light: light intensity, photoperiod, temperature, humidity and others, on leaf movement and flower opening have been investigated in detail. Many investigators have discussed the question, whether these movements are autonomic or aetionomic. We will not take part in this discussion, but we got the impression, that leaf movement and flower opening, if not directly, are indirectly regulated by light intensity, temperature, humidity, photoperiod or some of these factors simultaneously.

A. *Stem elongation*

In most cases, both stem elongation and curvature are ascribed to the magnitude of, and differences in production, distribution and inactivation of growth substances as regulated by light (9). However, the experiments on which these conclusions are based have, in majority, been made with etiolated material.

Light grown plants deviate herefrom in a large number of reactions. In etiolated plants, red light has an inhibitory effect on stem elongation (3), whereas plants grown in red light of high intensity show an excessive stem elongation (17). When red light is given supplementary to a short day in white light, it again has an inhibitory effect on stem elongation (18). BLAAUW (1), and many others demonstrated that blue light is very active in phototropism.

These examples will suffice to show that the action of light on stem elongation is a very complicated one, and the effect depends on wavelength, intensity, and on the plants being grown in light, or in darkness.

B. *Flower bud elongation and flower opening*

BROUWER (4) has given a detailed survey of the literature on flower movements. VIS (14) investigated the behaviour of a great number of flowers under constant environments. He distinguished between flowers, opening once, and flowers, opening repeatedly; photonasty appears to be more common than thermonasty.

In the tropics, several special flowering phenomena have drawn attention. We may mention here flowering of short duration, dial flowering, gregarious flowering and nocturnal flowering.

VAN DER PIJL (11) in investigating the dial flowering of *Sida rhombifolia*, concluded that some process starts as soon as darkness begins, as a result of which the flowers open after 13 hours (at a temperature of 21 °C). For this process, at least 4 hours of darkness are required. In this way he explains why the flowers do not open under continuous illumination.

Many investigations on the spectral sensitivity of flowering have been made in relation to the photoperiodic reaction, which will not be discussed here (see, *e.g.*, [2, 12]). Data on the effect of narrow spectral regions on flower bud elongation and flower opening do not seem to be available.

C. *Leaf movement*

BROUWER (4) also reviewed the literature on leaf movement up to 1926 in detail. This review shows the complexity of these phenomena and contradictions in their explanation. Many strange and so far inexplicable observations have been made.

SACHS already in 1857 concluded that the variation movements are due to turgor differences in lower and upper sides of the joints. He is among the first to conclude that the plants have a power of movement, fixed by heredity, which becomes manifest with a certain regularity, owing to alternative periods of light and darkness.

PFEFFER (10) ascribed the unequal changes in turgor pressure in upper and lower side of the joints to a direct effect of a change from light to darkness.

FISHER (6) is the first to point out that also gravitation influences the leaf movements. Other investigators think that they are due to changes in permeability of the joint cells, or to changes in temperature and humidity.

STOPPEL (13) and CREMER (5), from underground experiments, concluded that an unknown factor plays a part, which might be air electricity (13).

Among the most extensively investigated plants are *Mimosa*, *Phaseolus* and *Canavalia*. Especially *Canavalia* gives a strong reaction so that the leaf movements can easily be registered (BROUWER [4], KLEINHOONTE [8], DE GROOT [7]).

Summarizing, we may say that the literature suggests the existence of autonomic leaf movements, regulated by light. Sensitivity to temperature is generally mentioned. Data concerning spectral sensitivity were not found.

3. MATERIAL AND METHODS

A. Description of the equipment

a. Greenhouse. The temperature of the greenhouse used, could be regulated roughly by heaters and windows. In the cold months, the temperature could not be kept above 20 °C, but in summer the temperature was between 25 and 35 °C. Only natural day-light was used.

b. The "26 degrees room." Here the temperature ranged from 25° to 27 °C. The humidity could be raised up to 90% by sprinkling. Two cabinets, well ventilated, and each provided with 6 "day-light" type fluorescent tubes were used. At 40 cm below these lamps a light intensity of 10.000–17.500 erg/cm²/sec was measured. A set-up with one fluorescent tube was used for the application of low intensities (ca. 350 erg/cm²/sec).

c. Equipment for the application of high light intensities in narrow spectral regions. This equipment is the one described by WASSINK and STOLWIJK (17). It consists of 5 light cabinets (110 × 35 × 85 cm). The green, blue and red cabinets each had twenty 40 W fluorescent tubes: 8 at either side, and 4 on top. In the white one, these numbers were 3 and 2 respectively. The yellow compartment had five 140 W sodium lamps, 2 at each long side, and 1 on top. The spectral regions were restricted further by large filter glasses at each large side (70 × 110 cm) and at the top (30 × 110 cm). Thus the following regions were obtained:

Blue	370–450 mμ,	with a maximum energy at 400 mμ
Green	510–560 mμ,	,, ,, ,, ,, ,, 540 mμ
White	400–700 mμ,	,, ,, ,, ,, ,, 480, 550, 630 mμ
Yellow	590 mμ,	,, ,, ,, ,, ,, 590 mμ
Red	645–670 mμ,	,, ,, ,, ,, ,, 650 mμ

The arrangement of the light sources around the cabinets resulted in an almost equal light intensity at any point inside. Therefore, the intensity of the radiation was measured with a spherical radiation meter as developed in this laboratory (15), yielding the energy incident on a sphere with a cross section area of 1 cm². This energy amounted to 5,6 × 10⁴ erg/sec, in each cabinet. The relative humidity was 60%; in winter the temperature was set at 20 °C during the light period and was allowed to decrease to 15 °C during the dark period. In summer it was set at 26° to 27 °C during the light period, and 20 °C during the dark period, for the purpose of the present experiments. It was not possible to raise the temperature during winter because at that time another experiment was going on in the same room. The results reported in this paper are chiefly there obtained during the summer period, so at a day temperature of 26° and a night temperature of 20 °C. For further details see (17).

d. Equipment for the application of lower light intensities in narrow spectral regions. This equipment is the one described by WASSINK and VAN DER SCHEER (16). Five cabinets of 210 × 45 × 120 cm were used. The blue, green and red light cabinets had four 40 W fluorescent tubes on top. The yellow cabinet had two 140 W sodium lamps, the infra red one had six 60 W incandescent lamps. Also in this equipment the various regions were restricted further by glass filters (110 × 35 cm) on top 5 cm beneath the lamps. The following spectral regions were obtained:

Blue	405–500 mμ,	with a maximum energy at 450 mμ
Green	505–560 mμ,	,, ,, ,, ,, ,, 540 mμ
Yellow	590 mμ,	,, ,, ,, ,, ,, 590 mμ
Red	610–695 mμ,	,, ,, ,, , ,, 650 mμ
Infrared	705–915 mμ,	,, ,, ,, ,, ,, 760 mμ .

At 10 cm from the bottom, the incident energy was 700 erg/sec/cm² sphere cross section. The relative humidity was 60%, while the temperature was practically constant at 20 °C. White light of the same energy was received from one "day-light" 40 W fluorescent tube. For further details, see (16).

B. *Plant material and treatment*

The experiments were made with *Arachis hypogea* L., bunch type, which plant is very suitable owing to its rapid growth, abundant flowering, and clear leaf movements.

The plants flower about a month after germination. Flowers opening on a certain day, do so a few minutes after the start of the illumination, and wilt about 8 hours later. Flowering is finished after the second month; when the plants are 5 months old, ripe seeds can be harvested. In leaf axils of seedlings, flower buds are already visible. The inflorescence is often considered as a spike. Each spike has 1–6 flowers of which never more than 3 open at once. The flowers are stalkless. What can be taken for the flower stalk is the elongated green coloured and toothed calyx. Out of it, the yellow, purple striped, masked corolla emerges.

Each of the 4 leaflets of the compound leaf is connected to the petiole by a small joint. The petiole is connected to the stalk by a similar, much bigger joint. At night, the leaflets close upwards, in pairs. In the day-time the leaflets of each pair are at an angle of about 120°.

As a rule, the plants were placed in the light cabinets when they were 3 weeks old. Three treatments were given. Group I received 16 hours of illumination with coloured light of high intensity, group II received 4 hours of coloured light in addition to 12 hours of white light, both of high intensity. Group III received 4 hours of coloured light of low intensity in addition to 12 hours of white light of high intensity. The treatments given will be described in detail, below.

4. OBSERVATIONS ON STEM ELONGATION

On April 7, 1953, plants cultivated in the greenhouse were placed in the light cabinets. Each plant had 6 leaves on the main stem. The first group (16 hrs) received a 16 hour illumination with high intensity, at a temperature of 26°. The second group received 12 hours of strong white light, and an additional illumination at high intensities in the colour series, including white light (12 + 4) both at a temperature of 26 °C. The third group received this additional illumination at low light intensities (12 + 4), the temperature being 22 °C during the supplementary light treatment. For each spectral region as well as in the white light controls two plants were used. The temperature during the dark period was 20 °C for all groups.

On May 22, 1953, the plants of group I in the red and in the yellow light were so much elongated that this group had to be removed from the boxes and placed in the greenhouse. The other groups were taken from the light cabinets on June 7, 1953.

Plate 1 represents the plants when group I was returned to the greenhouse. From plate 1A it is evident that in group I, *Arachis* elongates most in red, yellow and green light. The number of leaves, however, does not differ (see fig. 1). The same can be seen, although less clearly, from plate 1B, representing group II. Even 4 hours of red, yellow and green light of high intensity have a noticeable elongating effect. From plate 1C, representing group III, it is evident that blue and infra red light, if given in low intensities as additional light, have an elongating effect. It is remarkable that in all cases, the plants which received only white light, were shortest.

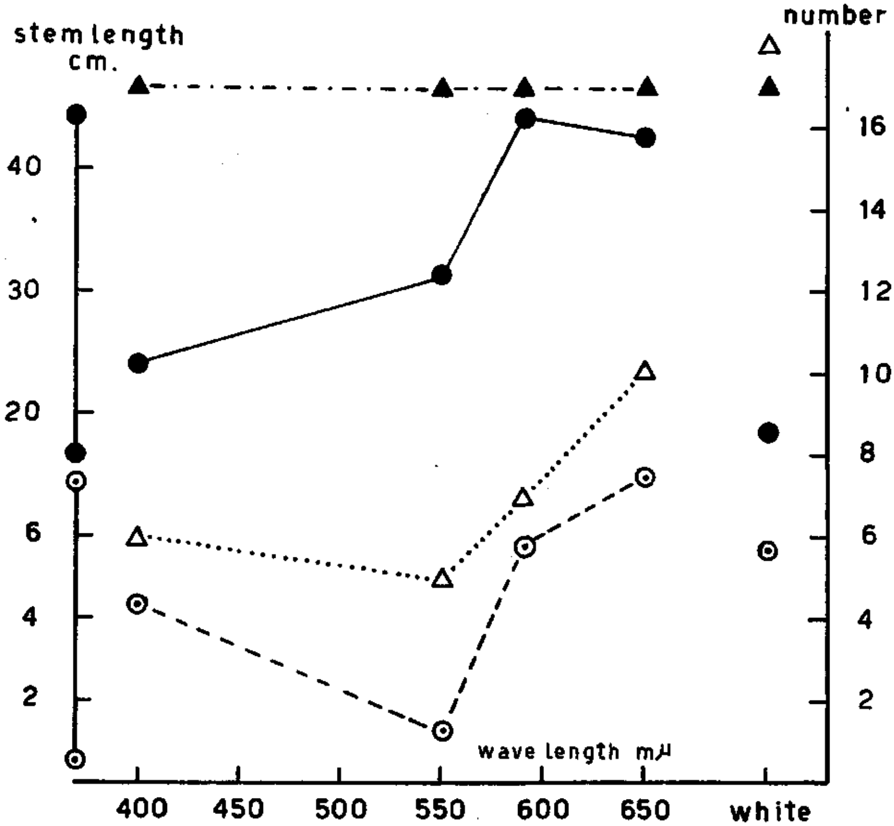

Fig. 1. Influence of wave length of light on stem elongation of *Arachis hypogea* L.
A comparison of main stem and average side stem lengths. Treatment with 16 hrs coloured light of high intensity started April 7, 1953. Plants were transferred to the greenhouse and measured on May 22, 1953. Number of leaves on main stem and number of flowers formed per plant, were included: ● Length of main stem; ⊙ average length of side stems; ▲ number of leaves on main stem; △ number of flowers formed per plant.

Fig. 1 represents the length of the main stem and the average length of the side stems of the plants of group I. They were measured at the moment of transport to the greenhouse. The number of leaves on the main stem and the total number of flowers, formed during the stay in the light cabinets were also included in fig. 1. It demonstrates that the number of leaves is independent of stem elongation.

The length of the side stems is not directly proportional to the length of the main stem. In group I the red, yellow and green plants elongated most. The side stems of these plants remained relatively short. Thus it seems as if the elongating effect of red, yellow and green light of high intensity, at the same time brings about an apparent increase of apical dominance, so that the side stems are growing less vigorously. Also in other experiments it appeared that the longest plants had relatively short side stems. In this connection it is worth mentioning that flowering was less in red and yellow light. In how far these effects arise from a competition for photosynthates still is to be investigated.

Comparing plates 1A and 1C, it is evident that in high intensities of coloured light, red has an elongating effect while in low intensities especially the violet-blue part of the spectrum shows such an effect.

It is remarkable that a similar result was obtained in an experiment of still another type. Some seed plants, the cotyledons of which were just visible, were placed in red, white and blue light of high and low intensities. Both groups received a 16 hour day illumination. The length of the main stem was measured at various times. The plants at low light intensities died after 32 days, those at

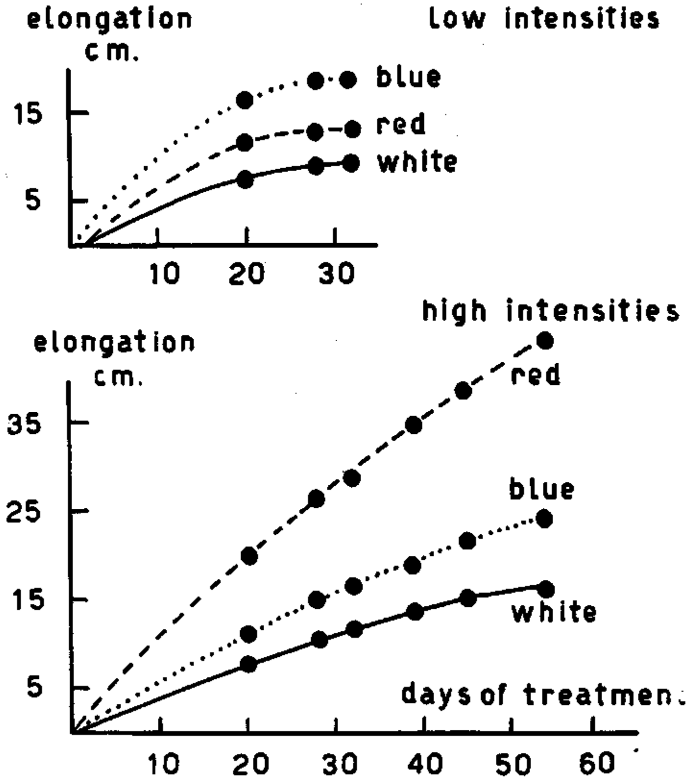

Fig. 2. A comparison of elongation of main stem in blue, red and white light of low and high intensities (700 and $5{,}5 \times 10^4$ erg/sec/cm^2 sphere c.s., respectively). Treatment with 16 hrs illumination daily started after germination. Plants in low intensities died after 32 days.

high intensities were removed to the greenhouse after 54 days. From plate 2, and figure 2, it is evident that strong red light and weak blue light have an elongating effect. Comparing this result with the elongation in group III, shown in fig. 3, we can conclude that blue light in low intensities has an elongating effect irrespective of the fact that this light is given as a 4 hrs additional illumination after 12 hrs white light of high intensity, or solely as 16 hrs blue light illumination. When comparing groups I and II, the same holds for red, yellow and green light of high intensities.

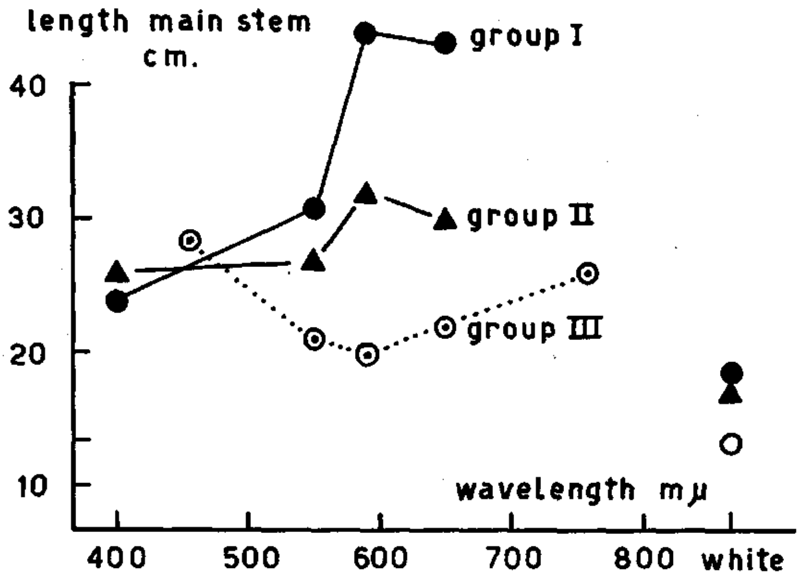

Fig. 3. The effect of various periods of illumination with coloured light of narrow spectral regions on stem elongation in *Arachis hypogea*. Treatment started April 7, 1953. Measurements on May 22, 1953.

Group I received 16 hrs coloured light of high intensity (5,5 × 10^4 erg/sec/cm² sphere c.s.)

Group II received 4 hrs coloured light of high intensity (5,5 × 10^4 erg/sec/cm² sphere c.s.) supplementary to 12 hrs white light of high intensity.

Group III received 4 hrs coloured light of low intensity (700 erg/sec/cm² sphere c.s.) supplementary to 12 hrs white light of high intensity.

The influence on stem elongation of a mixture of red and blue light of various intensities was also investigated. For this purpose, the lamps and filters at one side of the red light cabinet of high intensity were replaced by blue lamps and the corresponding filters. By partial screening it was attained that some plants received more red light, while others received more blue light. The plants, 10 cm high, were illuminated for 16 hours a day. The increase in length was measured after 20 and 25 days. Fig. 4 demonstrates the relationship between elongation and illumination. In spite of the fact that these plants did not receive equal total energies, which was impossible to realise with the method used, this figure shows that elongation is not determined primarily by the total amount of light energy, but by its composition. Plants 110 and 113 received almost the same total amount, although number 114 elongated much more, which obviously is due to the greater amount of red light.

Plant number 114 which received only 6% of its total illumination as blue light with an energy of 600 erg/cm²/sec, curved in the direction of the blue light, which is not remarkable in view of the small amount of blue light necessary for phototropism.

5. OBSERVATIONS ON FLOWER BUD ELONGATION AND FLOWER OPENING

The flower buds elongate in the night preceding the opening of the flower. In nature, the flowers open some minutes after sunrise; under experimental conditions they do so a few minutes after the start of an illumination. We will see later on, however, that the moment of opening depends also on the illumination given three days before.

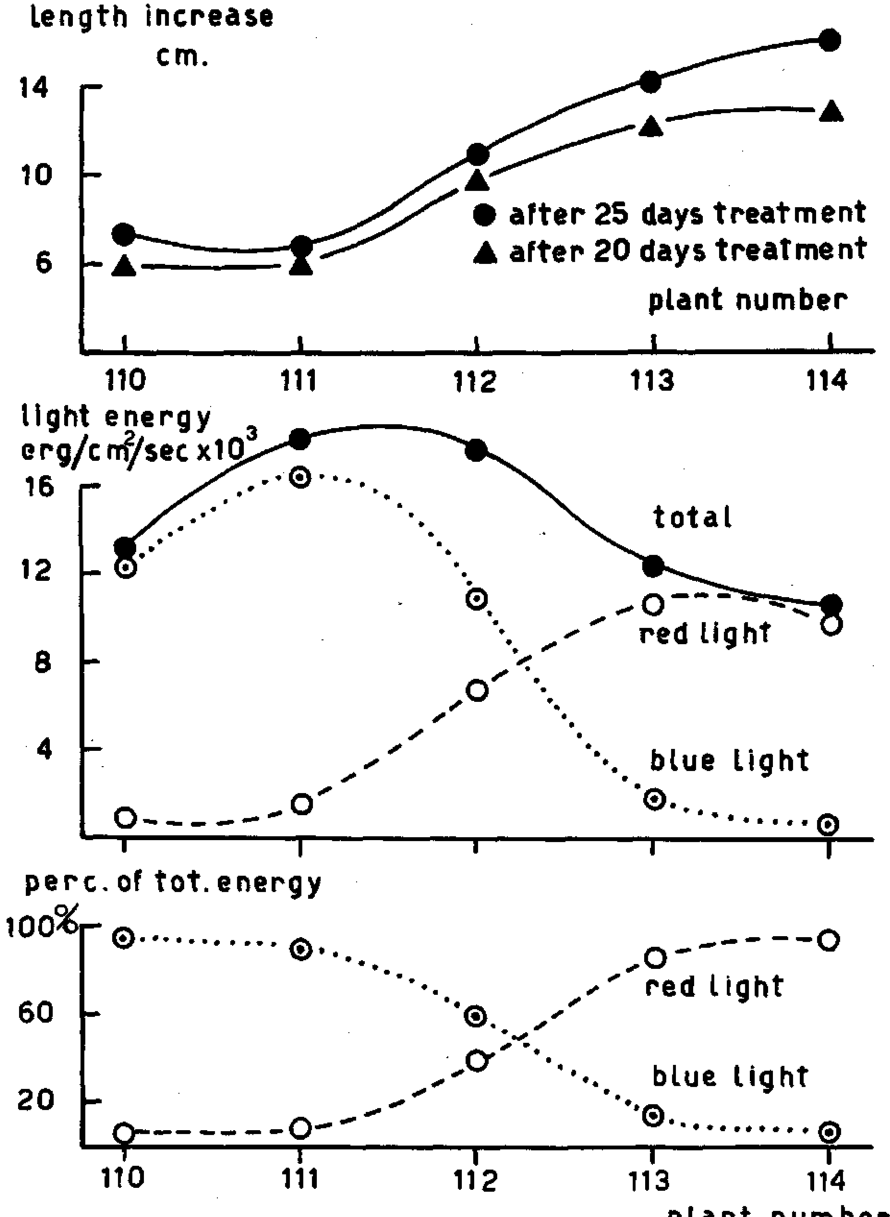

Fig. 4. The effect of combinations of red and blue light of different intensities on elongation of the main stem in *Arachis hypogea* L. 16 hours treatment, started when plants were 10 cm long. Measurements of length increase made after 20 and 25 days of treatment.

In groups I, II and III, the flowers were measured several times. In group I the flower buds elongate most in red, yellow and green light. The average length of the "flower stalk" in these colours was 11 mm. In the blue and white light it was only 6 mm. Thus, it appears that stem elongation and flower bud elongation are similar with respect to wave length dependence. The flowers on the plants of groups II and III, did not show such differences.

It was striking that the elongated flower buds did not open in the red and yellow light of high intensity. They died after several hours, without having opened. The opening in blue and white light was normal, while in green light some flowers remained closed. When plants with open flowers were transferred from blue to red light, the flowers remained open for the rest of the day. When brought over in the opposite direction, they remained closed. New flowers on such plants, which opened on the day after the transfer, showed their normal reaction to blue and red light respectively. From this it can be concluded that the wave length region of the light no longer influences the flower bud opening as soon as the buds are fully elongated. It also demonstrates that the reaction of flower bud opening to the spectral region is a direct one.

Observations in experiments with white light moreover indicated that light regulates the flower opening three days before. The flowers always opened a few minutes after the start of an illumination. When, however, the start of the illumination was delayed for, *e.g.*, 2 hours, the flowers opened at the normal time, *i.e.* when the plants still were in darkness. The flowers did not open 2 hours later until the fourth day after changing the start of the illumination. Thus, the moment for opening appears to be induced three days before, while the light colour at the moment of elongation determines whether the flower buds will open or remain closed. This is somewhat unexpected and needs a more extensive investigation.

It must be mentioned here that the flowers remained closed in red and yellow light only at relatively low temperatures (20 °C). At 26 °C, the buds opened in light of all wave length regions.

6. SOME OBSERVATIONS ON LEAF MOVEMENTS

Like flower opening, the leaf movements of *Arachis* also appeared to be photonastic, but without the "memory-effect" which was found for flower bud opening.

The leaves always closed a few minutes after the beginning of darkness and opened a few minutes after the start of illumination. The velocity of reaction was dependent on the duration and on the intensity of the preceding illumination, or on the duration of the preceding dark period respectively. The longer the duration of the illumination and the higher its intensity, or the longer the period of darkness was, the quicker was the subsequent response of the leaves. This points to something like light saturation or darkness saturation. In how far the light saturation has its basis in the amount of photosynthates remains to be investigated. In addition, the velocity of opening and closure is dependent on temperature. At low temperature the leaves react much more slowly than at high temperature. A sudden temperature drop of several degrees had the same effect as a sudden decrease in light intensity, *i.e.* it brings about closure of the leaves.

Moreover, there is a specific spectral sensivity on the leaf movements. It appeared that upon illumination the leaves only opened in the blue, green and white light. They remained closed in red and yellow light. In blue and white, the leaves opened even wider than in natural daylight. The leaflets of each pair formed a 210° angle, while the petioles were in an almost horizontal position. In green light, however, the leaf opening was "normal" (120°) while the petioles stood upward with an angle of 40° (see plate 3A and 3B). The opening, wider than normal, in blue and white light was perhaps due to the fact that the light intensities were relatively low, also in this "high intensity" equipment. It was found that the leaves opened normal (120°) in white light ("day-light" fluorescent tubes) at intensities above 17000 erg/cm^2/sec, while at intensities below 10.000 erg/cm^2/sec they always opened wider than normal. If compared with the leaf opening in blue and red light, we must consider the leaves in green light as half opened (see plate 1B).

In the low intensity light cabinets the leaf movements were less pronounced. The leaves showed specific reactions to the various spectral regions only if they had had darkness or a small amount of light before. In this case, the leaves opened in blue, green, and perhaps also in infra red light. The exact reaction of leaf movements to illumination in these light cabinets was difficult to establish because in many cases the reaction was not too clear. On the whole, we may conclude, that unlike stem elongation, leaf movements react to the spectral composition of the light in the same way at high and low intensities.

Leaves remained open in continuous white light. The same occurred in blue and green light in the two intensity ranges investigated (55.000 and 700 erg/sec/cm^2 sphere c.s.). In darkness, the leaves also opened but only when it lasted for more than 12 hours. In continuous red and yellow light the leaves passed very slowly into the opened position, in the course of days.

Plants from the various light cabinets were interchanged. It then appeared that plants from yellow or red light, being placed in blue light, reacted at once: the leaves opened. When a "blue" plant was transferred into red or yellow light, the leaves closed only after a very long time. A plant which was placed in strong blue light (16 hrs day) for 10 days maintained normally opened leaves for more than three days when put in red light of the same intensity. Thus, the after effect of blue light lasts much longer than that of yellow or red light.

Apparently, the response of the leaves is determined not only by the prevailing conditions, but also by the intensity, colour and duration of the preceding illumination and by the duration of the preceding dark period.

During the experiments with a mixture of red and blue light (see also section 4, page 9), it was found that the "opening action" of blue light is many times stronger than the "closing action" of red light: 100 erg/cm^2/sec of blue light were sufficient to open the leaves at an illumination of 9800 erg/cm^2/sec red light. Thus, the strength of the "opening effect" of blue light is very much like that of its phototropic activity.

7. DISCUSSION

Our conclusions about stem elongation are in good agreement with those by WASSINK and STOLWIJK (17). Low intensities of blue and infra-red radiation have an elongating effect, contrary to the effect of light of high intensities. In the latter case red, yellow and green light have an elongating effect, which is not observed in blue light (see fig. 4). WASSINK and STOLWIJK concluded from their results: "So much seems certain that there are two antagonistic reactions with different spectral sensitivity, which both are reversed by increasing the energy level."

Differences in the effect of blue light and that of the middle part of the spectrum were also found for flower bud opening and leaf movement. However, no difference with respect to light intensities, was found so far. At high intensities as well as at low ones, the elongated flower buds and leaves remained closed or open, dependent on the colour of the light, and on temperature.

Blue light causes a positive phototropism and red light is almost inactive in phototropism. OPPENOORTH (9) found that *Avena* coleoptiles react positively phototropic when irradiated from one side with blue light (436 μ) during 15 seconds at an intensity of 330 erg/cm²/sec, whereas irradiation at intensities of 3000 erg/cm²/sec and higher during 10 seconds, results in a negative curvature. No literature was found on the effect of different spectral regions on leaf movement and flower bud opening. Closer investigations on these two phenomena are necessary to determine whether also here there is a reversal in reaction when changing light intensities.

When comparing the actions of restictred spectral regions with the action of white light and that of darkness in *Arachis*, we arrive at the following conclusions.

Blue and, to a smaller extent, green light in a wide range of intensities have the same effect on stem elongation, flower bud opening and leaf movements as white light, whereas the reaction induced by red and yellow light resembles the effect of darkness.

The similarity in wave length dependence of these various processes is a strong indication that a similar basic mechanism is responsible in these various cases. A reversal of the effect of blue and red light with regard to light intensity, so far was only observed for stem elongation.

8. SUMMARY

The effects of illumination with light of narrow spectral regions on stem elongation, flower bud opening and leaf movement, in *Arachis hypogea* L., have been investigated. The following observations were made.

1. At high light intensities elongation is greatest in red, yellow and green light, at low light intensities it is greatest in blue light.

These observations are irrespective of the fact whether the illumination with these spectral regions is given as supplementary irradiation or as the only source of light. With low intensities, given as daylength extension, infrared light also has an elongating effect. In monochromatic light, elongation always was found to be greater than in white light of the same intensity (Section 4).

2. The number of leaves was practically not affected by the wave length of the light in our experiments (Section 4).

3. Even low intensities of blue light are phototropically active. Red light was inactive as far as could be seen (Section 4).

4. Flower bud elongation in high light intensities is greatest in red, yellow and green light (Section 5).

5. At a temperature of 20 °C, the flower buds remain closed in red and yellow light, at 26 °C they were found to open in all spectral regions. It was indicated that the moment of flower bud opening is induced three days before by the daily moment on which illumination starts. Light has no influence on the open flower (Section 5).

6. Leaf movement shows a definite spectral sensitivity. Leaves remained

closed in red and yellow light of high and low intensities at 20° and 26 °C. Leaf position is notonly determined by the condition of the moment but also by duration, intensity and colour of the preceding illumination. Blue light has a strong after-effect on leaf movement, red light has not. The "opening effect" of blue light on leaves is much stronger than the "closing effect" of red light (Section 6).

7. As far as high light intensities are concerned, stem elongation, flower bud opening, and leaf movement show conformity in spectral sensitivity, in as much as the blue and red regions of the spectrum have opposite effects in all these cases (Section 7).

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This investigation, made when the author was a senior student at the Agricultural University of Wageningen, is part of a more extensive series of experiments with *Arachis hypogea* L.

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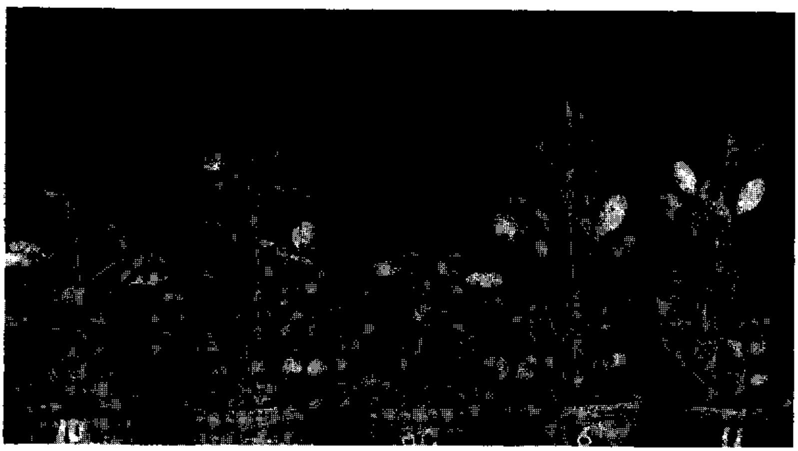
E. J. FORTANIER: Some observations on the influence of spectral regions of light on stem elongation, flower bud elongation, flower bud opening and leaf movement in *Arachis hypogea* L.

1A

blue green white yellow red

16 hrs coloured light of high intensity (26 °C).

1B



blue green white yellow red

12 hrs white light + 4 hrs coloured light of high intensity (26 °C).

1C

blue green white yellow red infrared

12 hrs white light + 4 hrs coloured light of low intensity (26 °C, 22 °C during 4 hrs coloured light).

Plate 1. Influence of spectral region of light on stem elongation (caption see below plate 2).

E. J. Fortanier: Some observations on the influence of spectral regions of light on stem elongations, flower bud elongation, flower bud opening and leaf movement in *Arachis hypogea* L.

2A

16 hrs high intensity $5{,}5 \times 10^4$ erg/sec/cm^2 sphere c.s.

blue white red

2B

16 hrs low intensity 700 erg/sec/cm^2 sphere c.s.

blue white red

Plate 2. Treatment with illumination during 16 hrs daily, started after germination. Photographed after 20 days.

2A: Plant in red light elongated most.
2B: Plant in blue light elongated most.

Caption of plate 1.

Arachis hypogea L. plants photographed on May 22, 1953 after 46 days of treatment with coloured light of narrow spectral regions.

1A: Plants which received 16 hours red, yellow and green light elongated most. Leaves of the "red" and "green" plants opened during photographing.

1B: In additional illumination with coloured light of high intensities during 4 hours, small differences in elongation. Note that the leaves of the "red" and "yellow" plants are closed.

1C: In additional illumination with coloured light of low intensities the "blue" and "infra red" plants elongated most. Photographed after exposition to white light.

E. J. Fortanier: Some observations on the influence of spectral regions of light on stem elongation, flower bud elongation, flower bud opening and leaf movement in *Arachis hypogea* L.

3A

blue green white yellow red

3B

blue white day white night red

Plate 3. Leaf opening after 4 hours illumination with light of different spectral regions. (high intensities).

3A: Plants, 2 months old, after 36 days treatment with coloured light of high intensity. Night and day temperatures were 15° and 20 °C respectively. Leaves in red and yellow light remained closed. In these colours, the flower also remained closed (not visible). Note that the "red", "yellow" and "green" plants elongated most.

3B: Leaves in blue light and "daylight" from fluorescent tubes opened. Leaves in red light and darkness closed. The two plants in the middle were grown in the 26 degrees room.