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SPECTRAL SENSITIVITY OF DWARFISM IN PEAS

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Abstract

Growth of three varieties of dwarf peas was compared with growth of a tall variety. Dwarfism is determined by light intensity. No difference was found between the effects of light of narrow spectral regions (460 mμ, 560 mμ, 589 mμ and 660 mμ) of high energy (17.000 ergs/sec/cm²).

A transitory difference in growth inhibition was found between the dwarfs and the tall variety.

1. Introduction

In previous experiments (Gorter, 1961) the growth of three varieties of dwarf peas ("Meteor", "Gloire de Quimper" and "Petit Breton") was compared with the growth of a "normal" variety, "Alaska". In total darkness all four varieties attained the same length, which suggests that dwarfism is determined by light. When plants were grown under different light intensities, the degree of dwarfism was found to be dependent on light intensity; the higher the intensity, the more growth was reduced. This also held for the "normal" variety, but here the same growth inhibition occurred at a light intensity 100 times stronger than in the dwarfs.

At intensities between 350 and 33.000 ergs/sec/cm² (cross section sphere) of fluorescent tubes (Philips T.L. 29) the dwarfs attained different heights, but always "Meteor" was the tallest, followed by "Gloire de Quimper" and then "Petit Breton". In "Alaska" growth inhibition was rectilinearly proportional to the log of the light intensity; in the dwarfs this correlation did not occur, for at the lowest light intensity they were immediately very much reduced in size and therefore far more sensitive.

The present paper discusses the influence of light of different wavelength on dwarfism.

2. Experimental methods

The peas were sown in soil in pots and placed directly in growth chambers supplying the different colours of light. Thus they received continuous illumination from the very beginning. The light chambers are described in detail by Wassink and Stolwyk (1954). They consist of cabinets 110 cm long, 35 cm wide and 85 cm high. In the "white" light chamber the walls and top are of colourless glass. In the "coloured" light chambers this is replaced by the appropriate glassfilters. Over this cabinet is placed another box in which fluorescent tubes cover the longest sidewalls and the top. In the "blue" light chamber there are blue glassfilters and 30 blue fluorescent tubes. The number of tubes is higher than in the other chambers, because blue filters of good spectral characteristics have low transmission values. The maximum energy of transmitted light is at about 460 mμ. The "green" chamber had 20 green fluorescent tubes, combined with yellow glass filters. The yellow filters absorb the violet and blue mercury lines of the emission from the fluorescent tubes. This chamber has light of maximum energy at 560 mμ.

The "yellow" chamber has five 140 W sodium lamps and orange filters to eliminate the blue and green lines. Maximum energy was at 589 mμ. In the "red" chamber are fluorescent tubes with a maximum energy at 660 mμ. Red glass filters cut off all light below 610 mμ. The "white" light chamber was provided with 8 daylight type fluorescent tubes (Philips T.L. 55).

Light in all chambers was of the same intensity (17.000 ergs/sec/cm^2, cross section sphere), as was shown by the measurements of a spherical photometer, described by WASSINK and VAN DER SCHEER (1951). All these light chambers were placed in a room in which a constant temperature of 20° C was maintained. If necessary, the temperature in the cabinets could be reregulated by ventilation.

A dark chamber was placed in the same room. Thus six chambers are used:

colour:	*maximum energy at:*
blue	460 mμ
green	560 mμ
yellow	589 mμ
red	660 mμ
white	—
dark	—

In each chamber were placed 2 pots of all four varieties, with 20 seeds per pot.

The length of the different internodes was measured after 7, 9, 11 and 13 days. In this paper only records of the growth of whole plants are given. The experiments were repeated eight times, but the green chamber was used only five times and the yellow one but once. (The data of the measurements in the yellow light are included in a previous paper (GORTER, 1961).

3. RESULTS

In the first experiments only growth in red and blue light was compared. The results of these measurements are presented in Tables 1–4, each set of measurements was taken two days after the previous. As growth in darkness was the same in all varieties (GORTER, 1961) growth in darkness of "Alaska" only is given.

It is obvious that:

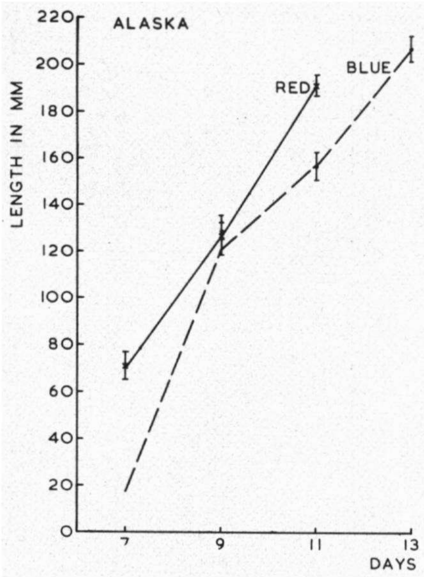

Fig. 1. Increase in length of "Alaska" in red and blue light.

a. Growth in length of all four pea varieties is inhibited by light.
b. In general inhibition is strongest in white light.
c. Blue and red light are inhibitive too.
d. In the beginning blue light is more inhibitive than red (see figures 1 and 2).
e. Later this difference disappears in the dwarfs and after 13 days, growth in blue and red light is the same (except in Meteor where a slight difference remains).

TABLE 1
Length in mm of the four varieties after 7 days.

Variety: Light	Alaska	Meteor	Quimper	Breton
White.	39.5 ± 0.8	28.6 ± 1.5	19.6 ± 0.7	13.2 ± 1.1
Blue	too small	too small	too small	too small
Red	70.9 ± 6.0	39.4 ± 3.2	33.0 ± 1.0	26.6 ± 1.1
Darkness . . .	109.4 ± 3.1			

TABLE 2
Length of the four varieties after 9 days.

Variety: Light	Alaska	Meteor	Quimper	Breton
White.	76.5 ± 4.1	51.0 ± 1.0	36.5 ± 1.3	32.9 ± 1.6
Blue	129.0 ± 3.2	50.5 ± 3.0	38.3 ± 1.6	32.0 ± 0.2
Red	127.0 ± 8.2	68.1 ± 3.5	49.6 ± 1.6	37.1 ± 1.3
Darkness . . .	158.6 ± 4.7			

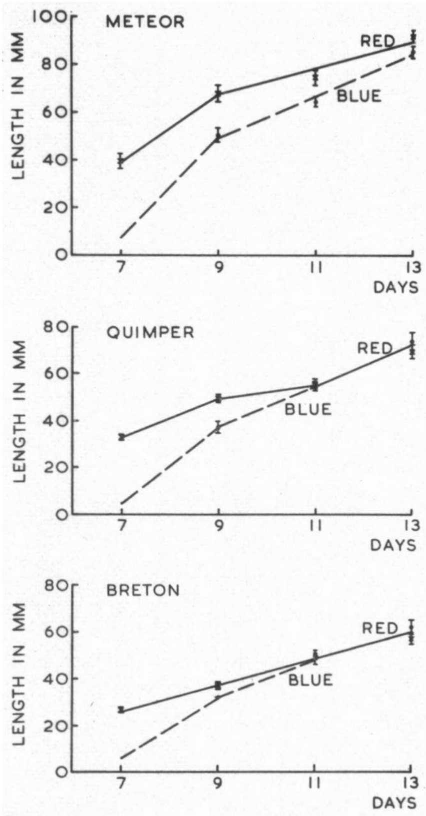

Fig. 2. Increase in length of the dwarfs in red and blue light.

TABLE 3
Length of the four varieties after 11 days.

Variety: Light	Alaska	Meteor	Quimper	Breton
White.	130.3 ± 8.6	70.0 ± 5.1	49.2 ± 2.6	43.0 ± 2.8
Blue	157.0 ± 5.7	64.5 ± 2.0	55.6 ± 1.6	50.6 ± 1.7
Red	191.6 ± 4.4	74.8 ± 2.9	55.4 ± 2.7	48.3 ± 2.4
Darkness . . .	196.0 ± 8.3			

TABLE 4
Length of the four varieties after 13 days.

Variety: Light	Alaska	Meteor	Quimper	Breton
White.	—	91.0 ± 2.0	60.1 ± 2.2	50.1 ± 1.4
Blue	207.0 ± 5.3	85.6 ± 2.5	74.0 ± 3.8	62.0 ± 3.0
Red	—	91.8 ± 2.5	69.6 ± 2.9	57.4 ± 2.3
Darkness . . .	255.4 ± 17.0			

The results of a typical experiment in which green light was included, are given in Table 5.

TABLE 5
Length in mm of the four varieties after 13 days.

Variety: Light	Alaska	Meteor	Quimper	Breton
White.	141 ± 6	45 ± 1.3	66 ± 3.0	59 ± 1.1
Blue	243 ± 1	63 ± 1.2	86 ± 1.7	92 ± 1.7
Green.	242 ± 7	62 ± 1.7	88 ± 1.3	79 ± 1.4
Red	225 ± 13	53 ± 2.0	87 ± 1.6	83 ± 1.8
Darkness . . .	373 ± 11			

From table 5 it is obvious that: the effect of blue, green and red light is similar, in Alaska as well as in the dwarfs. The slight increase of growth in blue of Breton and a slight decrease in red of Meteor are deviations, which are a consequence of experimental difficulties. This experiment was repeated 6 times and suchlike deviations were found at random.

4. Discussion

From Table 5 it is obvious that: the effect of blue, green and red dwarfism in peas is not determined by any special wavelength of visible light. No *qualitative* difference exists between the normal variety and the dwarfs. PARKER, BORTHWICK, HENDRICKS and WENT (1949) found that the spectral sensitivity of growth inhibition of a dwarf pea was correlated with phytochrome and also LOCKHART (1959) found the red-infrared-system active in a dwarf variety of pea, causing a transitory growth inhibition of the stem, which lasts for 4–5 days, after which period the plants resume growth at the dark-grown rate. In all those experiments the "low energy reaction" is responsible for a growth inhibition. In the above experiments, however, we have to deal with a "high energy reaction" (continuous illumination with 17.000 ergs/cm^2/sec) and there is an indication that the blue-infrared system has a transitory effect here. An analogous case was reported by LOCKHART and GOTTSCHALK (1959) who found that in "Alaska" the red-infrared system, though it is present in the plant according to the experiments of PARKER e.a. (1949) has no influence or only a transitory one on stem inhibition. The possibility that phytochrome and the "high energy" system are active but only transitory and in growth stages of special internodes, will be investigated in further experiments.

The relation between GA and these growth inhibitions can only be stated afterwards.

As white light is mostly more effective than any of the colours of the same intensity, we may assume that: – (a) the invisible light of large and small wavelengths has an effect too, and (b) the effects of light of various wavelengths influence each other. These points remain to be investigated.

The most probable assumption up to now, is that light of all wavelengths may cause a growth reduction, that this growth reduction is energy dependent and that dwarf varieties show different sensitivity. Light causes a decrease in plasticity of the cellwalls (LOCKHART, 1960) whereas GA causes an increase of plasticity. The action of GA could interfere directly with the light effect or be completely independent.

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