

Gibberellin-Like Activity in Pea Seedlings during Growth under Red, Blue and White Light

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Abstract. The influence of blue, red and white light and gibberellic acid (GA_3) on gibberellin-like activity in tissue extracts of leaves, stems and roots was investigated during growth of pea seedlings (*Pisum sativum* L. cv. Bördi). Higher GA -like activity was found in leaves and stems of pea plants that were growing in blue light than in those under red or white light. Patterns of change of activity were different in leaves, stems and roots, and in GA_3 -treated plants.

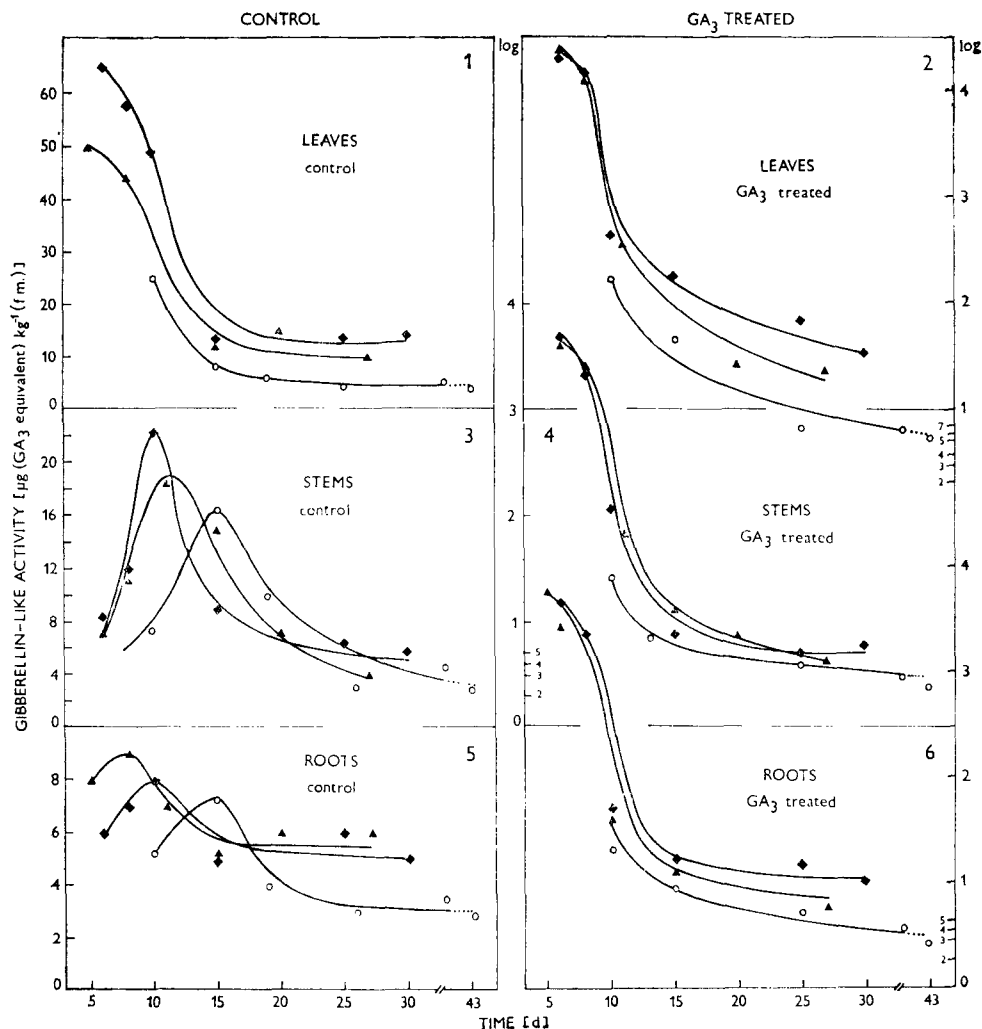
In a recent study (ROMANOWSKA *et al.* 1984) we observed that pea seedlings after treatment with gibberellic acid (GA_3) or grown under blue light exhibited higher rates of apparent photosynthesis (P_N) and dark respiration (R_D) as compared with plants not treated with this hormone or grown under red or white light. Surprisingly little information is available in the literature on the effect of light quality on content of gibberellin-like substances in plants. However, an enhancement of biosynthesis of gibberellin and its conversion into gibberellin-like substances by red light has been reported (REID *et al.* 1968, 1972, LOVEYS and WAREING 1971, KOPCEWICZ 1972, KOPCEWICZ and PORAZIŃSKI 1973).

We hypothesized that the reason for higher rates of P_N and R_D of plants grown under blue as compared with red or white light or treated with gibberellic acid might be due to the alteration of the level of gibberellin-like activity by these factors in plant organs during seedling growth. The work described below is a part of our study mentioned above and presents data on the content of gibberellin-like activity in pea seedlings during their growth under blue, red and white light or treated with gibberellic acid.

MATERIAL AND METHODS

In the present study the content of GA -like substances was determined on the pea seedlings (*Pisum sativum* L. cv. Bördi) which were used for measurements of CO_2 exchange as described in detail previously (ROMANOWSKA *et al.* 1984). In all experiments the gibberellin-like activity in plant organs was determined during 43 days of growth under blue, red and white light. GA -like

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Figs. 1—6. Gibberellin-like activity in tissue extracts of pea seedlings grown under blue (■), red (▲), or white (○) light.

substances were determined in leaves, shoots and roots of seedlings as follows.

Plant material was ground in a mortar with sand and 0.2 M "Tris" buffer at pH 7.2. The ratio of tissue to buffer was 1 : 3 m/v. The homogenate was shaken, stored for 24 h at 4 °C, then centrifuged at $15\,000 \times g$ for 15 min in order to remove the cell debris. The supernatant was acidified to pH 2.5 with 0.1 M HCl and centrifuged at $15\,000 \times g$ for 25 min. The resulting supernatant was partitioned 3 times against equal volumes of ethyl acetate. The acidic ethyl acetate fraction was dried over anhydrous sodium sulphate and evaporated to dryness at room temperature. The residue was dissolved in ethyl acetate. Thin-layer chromatography in CCl_4 : acetic acid : water (8 : 3 : 5) v/v the lower phase and 10 % ethyl acetate was used as developing

solvents. The bands from the chromatogram were scraped off and the silica gel was eluted with ethyl acetate for 2 h on a shaker and the extracts then evaporated to dryness. The residues were dissolved in a solution of 0.05 % Tween-20 and used for bioassay using the dwarf pea test (*Pisum sativum* L.) KENDE and LANG (1964).

The data presented below represent the mean values of 6 separate experiments.

RESULTS

During the development of pea seedlings, marked quantitative differences were found in the activity of gibberellin-like substances between different plant organs. GA-like activity in the leaves of young control plants (C-plants) was high, and then declined at least 5-fold by the time plants were about 20 days old (Fig. 1). During later stages of growth activity did not change. The results also show that GA-like activity was dependent on the quality of the applied light. Under blue light conditions GA-like activity was higher than in red and white light during the whole period of plant development.

GA-like activity in the leaves of GA-plants was higher (Fig. 2), but nevertheless showed a similar trend as in the leaves of control plants. The effects of coloured light on GA-like activity was the same as in control plants.

Fig. 3 illustrates the GA-like activity in stems of C-plants. Activity reached a maximum and thereafter declined in blue, red and white light. The maximum occurred earliest in blue light (10 days of growth) and latest in white light (16 days of growth). No such differences were observed in the GA-like activity in older plants. Fig. 4 shows that GA-like activity in young stems of GA-plants (6–10 day old) was initially very much higher and then steadily decreased. Activity was the same in blue and red light, but rather lower in white light. We observed a positive relationship between stem height and GA-like activity in stems under all light regimes used (data not shown).

GA-like activity in the young roots (Fig. 5) of control plants passed through a maximum before it reached a plateau in the older plants. The earliest maximum was observed in the red light at about 8 days and the latest in white light (about 14 days). In older plants, no significant differences were found in GA-like activity under blue and red light conditions, although in white light activity was only about 60 % of that under red or blue light.

GA-like activity in the roots of GA-plants (Fig. 6) changed in a similar manner to levels in leaves and stems of these plants. In young roots (5–9 day old) GA-like activity was at first very high, and then sharply decreased. In older plants, levels were slightly higher in blue light, intermediate in red light and lowest in white light.

DISCUSSION

In a previous paper (ROMANOWSKA *et al.* 1984) we described the effect of GA₃ and quality of light on CO₂ exchange rates in pea seedlings. Our present study provides some evidence that an interaction exists between the effects of quality of light during the growth of pea plants and exogenously applied gibberellin upon levels of gibberellin-like activity in various organs. Control plants grown under blue light had a higher GA-like activity than those exposed to red light and particularly to white light. In GA-plants, moreover, the effect of light quality on GA-like activity was different as compared with the control plants, although the highest GA-like activity was also

found in leaves of young plants grown under blue light. We observed that GA-like activity in leaves decreased with the progress of seedling growth whereas it increased in stems (see Figs. 1 and 3). Furthermore, a positive relationship exists between GA-like activity in stem and the elongation growth of this organ (data not shown). It is of interest that these responses persisted during a relatively long period of seedlings growth. All these observations indicate that light quality and application of exogenous gibberellin on plants exert a continuous regulatory action on the level of GA-like activity in plant organs during growth. Clearly, plants possess specific regulatory photo-receptors to perceive the light signal and adjust their growth and development appropriately. A blue light receptor, thought to be flavoprotein and phytochrome, have been identified (SMITH 1975, MOHR and SHROPSHIRE 1983). Several investigators have reported that blue light induced protein biosynthesis and concomitantly enhanced the activity of several enzymes (KULANDAIVELU and SAROJINI 1980, RUYTERS and KOWALLIK 1980). Gibberellins elicit a wide range of responses, but the molecular mechanisms involved in GA-mediated responses are still unknown. Recently it has been shown that long day and GA₃ increased the length and number of epidermal cells of meadow-grass (HAY and HEIDE 1983). GA₃ mimicked all the effects of long days on the growth of this plant, and also exhibited an interaction with photoperiod (HEIDE *et al.* 1985). The literature cited as well as our present results indicate an interaction between light and gibberellin in regulating metabolic processes in plants at each stage of their growth and development.

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