New Phytol. (1977) 78, 403–406.

EFFECT OF GIBBERELLIC ACID AND SOME POLYPHENOLS ON THE FLOWERING OF *IMPATIENS BALSAMINA*

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(*Received 23 July 1976*)

SUMMARY

Chlorogenic acid, tannic acid and gibberellic acid (GA_3) all induce floral buds in *I. balsamina* under strictly non-inductive photoperiods. Floral bud initiation is hastened when 100 mg/l GA_3 is used in combination with both polyphenols, the effect being most pronounced with 100 mg/l chlorogenic acid. 1 and 100 mg/l each of chlorogenic and tannic acids increase the number of floral buds also when used in combination with 100 mg/l GA_3 as compared with 100 mg/l GA_3 alone.

INTRODUCTION

Phenolic compounds have been reported to act as analogues of growth hormones (Gantzer, 1960; Vendrig and Buffel, 1961; Wain and Taylor, 1965). They have also been reported to affect dormancy (Phillips, 1961), growth (Henderson and Nitsch, 1962) and other physiological functions (Tomaszewski, 1964) in plants. In a previous paper, it was reported that the monophenols salicylic acid and β-naphthol resembled GA_3 in inducing floral buds in the qualitative short day plant *I. balsamina* under strictly non-inductive photoperiods (Nanda, Kumar and Sood, 1976). In fact, in combination with GA_3 they increased the number of floral buds as compared with GA_3 alone. It was considered of interest to study the effect of some other phenols on the flowering response of this plant under both inductive and non-inductive photoperiods. This paper deals with the polyphenols, chlorogenic acid and tannic acid, both singly and in combination with GA_3.

MATERIALS AND METHODS

Plants of *I. balsamina* L. cv. Rose were raised under continuous illumination and were maintained under this condition until use. For continuous illumination (long days–LDs), the plants received natural daylight from 09.00 to 17.00 hours and were then transferred to artificially lit cabinets in an air-conditioned room maintained at 28±1°C from 17.00 to 09.00 hours. For 8-h photoperiods (short days-SDs) the natural daylight was curtailed by screening the plants with a thick canvas sheet daily from 17.00 to 09.00 hours.

When they had five to seven unfolded leaves, 300 plants selected for uniformity of size were divided into two equal lots on 24 March 1976 and subjected to 24- and 8-h photoperiods, respectively. Each lot was further divided into fifteen groups of ten plants. Group 1 of each lot was treated with water to serve as control, groups 2–7 with 1 and 100 mg/l each of GA_3, chlorogenic acid and tannic acid, respectively and groups 8–15 with 1 and 100 mg/l each of GA_3 in combination with 1 and 100 mg/l chlorogenic and tannic acids, respectively.

The treatments were given on alternate days by applying the chemicals to the apices of plants wrapped with tiny cotton wads. The time of emergence and number of floral buds were recorded daily. For further details of the experimental procedure, see Nanda *et al.* (1976).

RESULTS

The results presented in Table 1 show that while water-treated controls did not flower under 24-h photoperiods, floral buds were initiated on all other plants, whether treated with GA_3, chlorogenic acid or tannic acid, alone or in combination. Initiation was earlier with 100 mg/l than with 1 mg/l GA_3 or with either concentration of the two phenols. Floral buds were initiated earlier with chlorogenic than with tannic acid and in both cases with 1 than with 100 mg/l. Initiation with either phenol was hastened when in combination with GA_3, the more effective combinations being 100 mg/l GA_3 + 100 mg/l chlorogenic acid and 100 mg/l GA_3 + 100 mg/l tannic acid. With both these combinations, floral buds were initiated earlier (in 14.0 and 17.0 days, respectively) than with 100 mg/l GA_3 alone (19.6 days).

The number of floral buds produced under 24-h photoperiods was higher in plants treated with 100 than 1 mg/l each of GA_3 and tannic acid, but with 1 than 100 mg/l chlorogenic acid, although the differences were not very marked. While the number of floral buds was higher in plants treated with 1 mg/l of either phenol than in those treated with 1 mg/l GA_3, at 100 mg/l each of the phenols had the same effect as GA_3. It may be noted that the number of floral buds was increased when either phenol was used in combination with GA_3, both concentrations of GA_3 being more effective with 100 mg/l of the phenols; the effect was most marked with the combination, 100 mg/l GA_3 + 100 mg/l chlorogenic acid, which produced 99.7 floral buds compared with 50.0 and 49.5 for 100 mg/l GA_3 and 100 mg/l chlorogenic acid respectively.

Under 8-h photoperiods, both concentrations of GA_3 slightly hastened, but chlorogenic and tannic acids did not significantly affect the time of floral bud initiation. However, 100 mg/l GA_3 in combination with either concentration of the two phenols hastened floral bud

Table 1. *Effect of gibberellic acid, chlorogenic acid and tannic acid, alone and in combination, on days to floral bud initiation and number of floral buds produced after 35 days on I. balsamina exposed to 24- and 8-h photoperiods*

Treatment (mg/l)	Days to floral bud initiation		Total number of floral buds	
	24 h	8 h	24 h	8 h
Control	35	8.0±0.10	0	35.6±0.63
GA_3, 1	22.0±0.70	7.2±0.38	46.2±1.20	42.8±0.72
GA_3, 100	19.6±1.25	6.4±0.41	50.0±0.15	45.6±0.63
Tannic acid, 1	21.5±0.08	8.4±0.38	48.0±0.60	34.0±0.63
Tannic acid, 100	27.5±1.25	8.6±0.26	51.0±0.52	36.8±0.81
Chlorogenic acid, 1	20.5±0.75	7.8±0.74	51.7±0.41	36.8±0.86
Chlorogenic acid, 100	22.8±0.41	7.3±0.45	49.5±0.42	37.6±0.63
Tannic acid, 1 + GA_3, 1	23.2±0.55	8.0±0.52	54.0±0.20	38.2±0.51
Tannic acid, 1 + GA_3, 100	18.0±1.00	6.2±0.28	70.0±0.35	44.0±0.85
Tannic acid, 100 + GA_3, 1	22.0±0.58	8.7±0.93	60.0±0.42	38.2±0.65
Tannic acid, 100 + GA_3, 100	17.0±0.58	6.0±0.19	82.5±0.35	49.0±0.52
Chlorogenic acid, 1 + GA_3, 1	19.2±0.21	7.1±0.51	53.8±0.42	42.3±0.70
Chlorogenic acid, 1 + GA_3, 100	18.3±0.35	6.9±0.48	75.5±0.75	44.8±0.90
Chlorogenic acid, 100 + GA_3, 1	19.5±0.55	8.0±0.61	66.0±0.15	42.4±0.63
Chlorogenic acid, 100 + GA_3, 100	14.0±0.60	4.8±0.54	99.7±0.41	54.8±0.41

initiation and this effect was most marked with 100 mg/l GA_3 + 100 mg/l chlorogenic acid. In fact, with this combination floral buds were initiated earlier than even with 100 mg/l GA_3 alone (Table 1).

GA_3 increased the number of floral buds under 8-h photoperiods. Although chlorogenic and tannic acids each alone had no effect, in combination with 100 mg/l GA_3, 100 mg/l of both increased the number of floral buds even more than 100 mg/l GA_3 alone, the combination with chlorogenic acid being more effective than with tannic acid. It may be noted however, that the number of floral buds produced was higher in all treatments under 24 than under 8 hour photoperiods.

DISCUSSION

The results clearly demonstrate that the polyphenols chlorogenic and tannic acids induce floral buds in *I. balsamina* under strictly non-inductive photoperiods and therefore resemble GA_3 in this respect. A similar induction of floral buds by the monophenols, salicyclic acid and β-naphthol was reported earlier from this laboratory (Nanda *et al.*, 1976). These results contrast with those of Umemoto (1971), who found that exogenously applied chlorogenic acid inhibited flowering in *Lemna gibba* G_3.

The fact that the induction of floral buds in *I. balsamina* is caused not only by poly- and mono-phenols, but also by the diphenols resorcinol and DOPA (unpublished data), suggests that phenolics play a significant role in the reproductive development of this plant. These phenols even enhance vegetative growth (unpublished data). Work is in progress to elucidate the mechanism of action of these phenolics in reproductive development and growth.

The most significant finding that emerges from this investigation is the synergistic effect of these phenols with GA_3. Synergism between IAA and phenols in their effects on some growth and differentiation processes other than flowering has been reported by a number of workers (Rabin and Klein, 1957; Nitsch and Nitsch, 1962; Gortner and Kent, 1958; Henderson and Nitsch, 1962; Tomaszewski, 1964 and also see Haissig, 1974). A synergistic effect of chlorogenic and tannic acids with GA_3 on flowering is reported here for the first time. This synergism is evident from the effect of the combination, 100 mg/l GA_3 + 100 mg/l chlorogenic acid, which accelerates the initiation of floral buds under both photoperiods and even enhances the number of floral buds produced under non-inductive photoperiods. These results are particularly interesting as tannins are reported to be gibberellin-antagonists (Corcoran, Geissman and Phinney, 1972) and endogenous chlorogenic acid is reported to accumulate in the leaves of both long-day and short-day species of *Nicotiana* (Zucker, Nitsch and Nitsch, 1965) and also in the fronds of *Lemna gibba* G_3 (Umemoto, 1971) under inductive conditions.

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