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Short Communications

Induction of Male Flowers on Female Plants of *Cannabis sativa* by Gibberellins and Its Inhibition by Abscisic Acid

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Summary. Gibberellins (GA_3, GA_{4+7}, GA_7 and GA_9) induce male flowers on female plants of *Cannabis sativa*. This is, depending on concentration, partially or fully inhibited by abscisic acid (ABA). The ABA effect can in turn be partially overcome by increasing the concentration of GA_3.

We reported the induction of female (pistillate) flowers and feminization of flowers in male plants of *Cannabis sativa* L. by treatment with 2-chloroethanephosphonic acid (Mohan Ram and Jaiswal, 1970) and a morphactin (Mohan Ram and Jaiswal, 1971). Earlier, Herich (1960) had shown that soaking of seeds of *C. sativa* in gibberellin stimulated the development of a larger number of female individuals while Heslop-Harrison and Heslop-Harrison (1961) had observed that gibberellic acid (GA_3) treatment of the plants had no effect on primary sex differentiation in the same species. We have noted marked stem elongation and production of male (staminate) flowers in gibberellin (GA)-treated female plants of *Cannabis*. Various GA-induced responses, including shoot elongation, seed germination, senescence, and production of hydrolases and synthesis of endoplasmic reticulum in barley aleurone cells, can be counteracted or inhibited by abscisic acid (ABA) (Addicott and Lyon, 1969; Evins and Varner, 1971). This communication describes the effects of gibberellins and ABA on the production of male flowers in female plants of *Cannabis sativa*.

Seedlings of *C. sativa* were raised and their sex was determined after flower initiation. Only female plants were selected for study because male plants showed no change in sex expression when treated with GAs. Ten plants were used for each treatment. GAs and ABA (RS form), separately or in combination, were applied in cotton wicks to the shoot apices of the plants; control plants received distilled water. The GAs were first dissolved in ethanol and ABA in 1 N NaOH; both were subsequently diluted with distilled water. The number of nodes bearing male flowers and the average number of male flowers in each treated plant were recorded.

Plants treated with GA_3 on 10 consecutive days, to a total of 50 μg/plant (Table 1, Experiment 1) show two types of response: marked inter-

Table 1. Interaction between gibberellins and ABA on male flower formation in female plants of *Cannabis sativa*

Treatments[a]	Average no. of nodes/plant with ♂ flowers	Average no. of ♂ flowers/plant
Experiment 1		
Control	0	0
GA_3 50	3.6	33.8
ABA 25	0	0
ABA 50	0	0
ABA 75	0	0
ABA 100	0	0
GA_3 50 + ABA 25	0.5	6.8
GA_3 50 + ABA 50	0	0
GA_3 50 + ABA 75	0	0
GA_3 50 + ABA 100	0	0
GA_3 100 + ABA 50	1.1	23.5
Experiment 2		
Control	0	0
ABA 50	0	0
GA_3 50	3.8	35.0
ABA 50 after 5 days GA_3 50	1.2	23.8
GA_3 50 after 5 days ABA 50	1.0	19.0
Experiment 3		
Control	0	0
ABA 50	0	0
GA_{4+7} 50	1.2	17.0
GA_{4+7} 50 + ABA 50	0	0
GA_7 50	2.3	25.0
GA_7 50 + ABA 50	0	0
GA_9 50	0.6	7.5
GA_9 50 + ABA 50	0	0

[a] Total amount of chemicals applied in μg per plant.

nodal elongation accompanied by certain formative changes in the vegetative parts, and production of male flowers. Only the latter response will be considered in this note. 2–3 weeks after treatment the plants start bearing male flowers in the newly formed 3–6 nodes (Fig. 1 A, C). At the end of the following week the plants begin to form also female flowers (Fig. 1 B). In a few instances the terminal node, in addition to male flowers, may also bear flowers with organs of both sexes. The induced male flowers have normal stamens with viable pollen grains.

ABA at 25, 50, 75, or 100 μg per plant, applied alone did not cause any significant change in extension growth. It caused abscission of leaves,

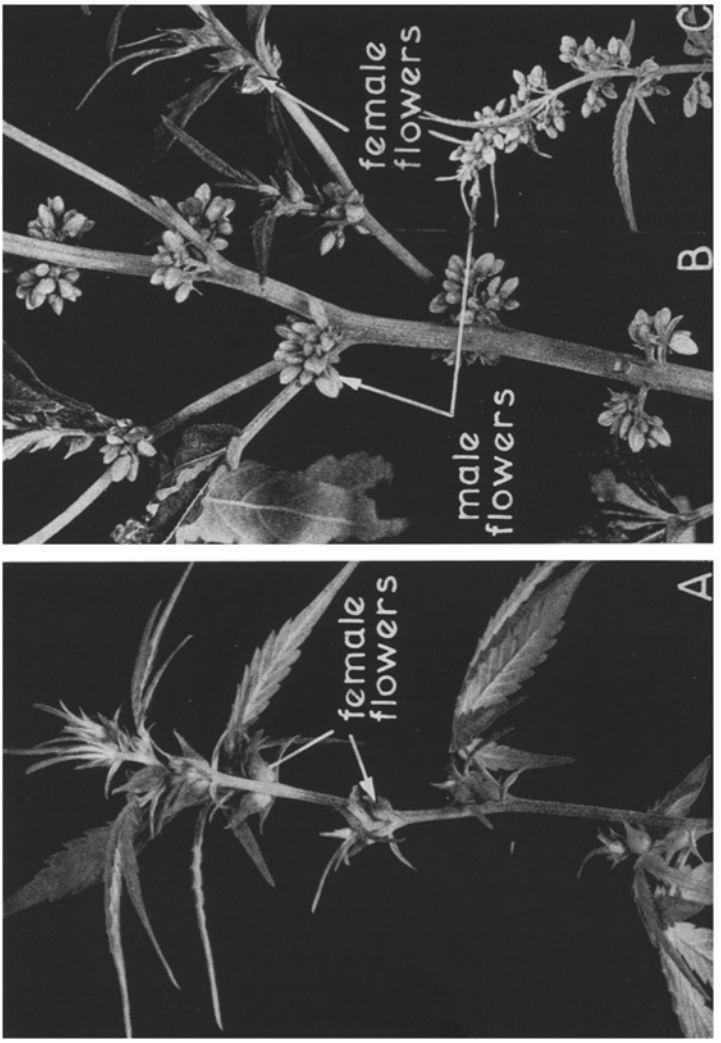

Fig. 1. A Control female plant with flowers and fruits. ×0.3. B Portion of GA-treated female plant showing clusters of male flower buds in the nodes. The branch on right shows female flowers in the upper node indicating reversion to the genetical sex. ×0.5. C Terminal portion of control male plant with flower buds. ×0.2

senescence of portions of younger leaves, and slight injury to the apex, but there was no effect on flowers.

When 25 μg of ABA and GA_3 were applied together there was marked reduction in the number of nodes showing male flowers (Table 1). Plants receiving 50 μg of GA_3 along with 50, 75 or 100 μg of ABA showed complete inhibition of the formation of male flowers. If the GA_3 concentration was increased from 50 μg to 100 μg/plant and the ABA concentration was kept at 50 μg/plant, the GA_3 effect dominated over the inhibitory effect of ABA.

In another experiment (Table 1, Experiment 2) it was found that subsequent application of 50 μg of GA_3 to plants which had received 50 μg of ABA permitted, on the average, 1.2 nodes to bear male flowers. Thus GA_3 could exert its influence after an initial ABA treatment. If GA_3 was supplied first and ABA later on, the latter was able to decrease the extent of formation of male flowers but not totally suppress it.

It was of interest to know whether GAs other than GA_3 elicited the induction of male flowers in female *C. sativa*. At equal concentrations, GA_3 was found to be most effective, followed by GA_7, a mixture of GA_4 and GA_7 (Ca. 77 and 23%, respectively), and GA_9. ABA was able to overcome the effect of all the GAs when applied simultaneously (Table 1).

The results clearly demonstrate that all the GAs used in our experiments (GA_3, GA_{4+7}, GA_7, GA_9) stimulate the formation of male flowers on female plants of *C. sativa*. The GA-induced formation of male flowers can be inhibited by ABA either totally (at 50 μg) or partially (at 25 μg) and this inhibition can be overcome to some extent by increasing the concentration of GA_3 (100 μg). We know of only one report (Abdel-Gawad and Ketellapper, 1969) in which ABA has been shown to stimulate the initiation of female flowers.

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