EFFECTS OF CERTAIN GROWTH RETARDANTS ON GROWTH, FLOWERING, AND POLLEN VIABILITY IN FENU-GREEK (*TRIGONELLA FOENUM-GRAECUM* L.)

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SUMMARY

Effects of maleic hydrazide, FW-450 and coumarin on vegetative growth, flowering, pollen viability and yield in fenu-greek (*Trigonella foenum-graecum* L.) were studied.

Plant growth in general was retarded. Height and number of main branches in the mature plant were significantly reduced in all the treatments. Yield and its components namely, number of pods per plant and the number of seeds per pod were also significantly low in all the treatments.

Of all the chemicals, complete abortion of pollen grains was recorded in 0·75 per cent FW-450 applied before and after bud initiation. Application of 0·5 per cent FW-450 induced *in-situ* germination of pollen grains. The highest yield alongwith complete pollen sterility was obtained when 0·5 per cent solution of the retardant was applied before the initiation of floral buds. This yield was, however, markedly less than in the untreated control. The reduction in yield was partly due to the failure of pollination in the male sterile flowers and partly to the reduction in the number of seeds per pod. The latter may be due to partial female sterility.

INTRODUCTION

Male sterility in crop plants is receiving increased attention for its usefulness in the production of hybrid seeds. In many crop plants, where male sterile lines are not known and emasculation by hand on a large scale is economically prohibitive or the maintenance of naturally occurring male sterile lines is difficult, chemials inducing male sterility could be of great help. The present study was undertaken to assess the possibility of using

chemicals to induce male sterility in fenu-greek (*Trigonella foenum-graecum* L.) and also to study their effects on growth, flowering and yield.

Materials and Methods

The experiment was conducted at B. R. College, Experimental Farm, Bichpuri (Agra). A local variety of fenu-greek was treated in a randomized-block single-row design with four replications. The growth retardants used were maleic hydrazide (1, 2-dihydropyridiazine, 3, 6-dione); FW-450 (sodium, 2, 3-dichloroisobutyrate), and coumarin. Maleic hydrazide at 0·05, 0·10, and 0·25 per cent and FW-450 and coumarin at 0·25, 0·50, and 0·75 per cent were used. The retardants were applied as foliar sprays in aqueous solution either before the initiation of floral buds (T_1) or after their initiation (T_2) or both (T_1 T_2) or at the time of anthesis (T_3) or one spray before bud initiation and the second at the time of anthesis (T_1 T_3).

Observations on final height of the main stem, number of branches and pods and seeds per pod, yield and the time of flowering were recorded. Pollen viability was tested by staining with 0·5 per cent acetocarmine. While large, plump and deeply stained pollen was considered viable; small, shrunken, unstained pollen or the one germinating *in-situ* was considered as non-viable.

Results and Discussion

Morphological effects.—Effect of the chemicals became apparent six days after their application and was proportional to their concentration. Maleic hydrazide retarded plant growth appreciably. Leaves became thick and brittle and chlorotic patches appeared. Leaves formed subsequent to treatment were narrow. Maleic hydrazide is reported to cause similar effects in bushbean, sunflower and red coleus also (Moore, 1950). In some cases the lateral leaflets were reduced in size while in a few, they were completely absent. Maleic hydrazide and coumarin caused curling of the main shoot. Coumarin caused inhibition of growth without causing any sign of burning in contrast to its effect on cotton (Singh, 1964). FW-450 caused slight burning of the shoot apices and leaf margins, the effect increasing with the concentration. FW-450 is also reported to cause similar effects in soybean (Starnes and Hadley, 1962) and alfalfa (Miller

and Hittle, 1963). Leaves produced subsequent to the application of FW-450 remained with their leaflets folded for nearly ten days.

Root growth.—Root growth in general was retarded by all the three chemicals. At higher concentrations both primary and lateral roots became affected. Inhibition of root growth with maleic hydrazide in field corn (Moore, 1950), sesame (Kumar, 1963) and cotton (Singh, 1964) and by FW-450 and coumarin in sesame (Kumar, 1963) and cotton (Singh, 1964) is also reported. This inhibition seems to affect water absorption from the soil as was evidenced by the wilting of these plants.

Height of the main stem and number of branches.—The final height attained and the number of branches produced in different treatments are summarized in Table I.

Table I. Effects of different concentrations of maleic hydrazide, FW-450 and coumarin on the final height attained, number of branches produced and flowering

Chemical	Concentration (per cent)	Plant height (cm)	No. of branches	Time taken for flowering (days)
Maleic hydrazide	0·05	50·70	8·000	88·20
	0·10	31·75	6·865	91·20
	0·25	24·15	7·875	98·70
FW-450	0·25	65·00	6·250	78·20
	0·50	50·45	7·230	82·75
	0·75	44·25	6·015	84·40
Coumarin	0·25	57·05	8·355	83·90
	0·50	49·50	7·300	90·15
	0·75	41·00	8·035	93·65
Control	0·00	80·75	12·650	62·75
C.D.[1] at 5 per cent level		2·414	0·728	1·668
C.D.[2] at 5 per cent level		1·400	0·432	0·943

C.D.[1]—for comparison with control.
C.D.[2]—for comparison between the treatments.

Final height attained and the number of branches produced till the end were significantly reduced in plants treated with these chemicals, the effect increasing with their concentration. Growth inhibition by maleic hydrazide has also been described in tomato (Moore, 1950) and chrysanthemum (Beach and Leopold, 1953) and by FW-450 in cotton (Meyer *et al.*, 1958; Singh, 1964).

The number of branches produced was also reduced with the application of these chemicals. However, the differences with concentration of a chemical were not marked.

Flowering.—Flowering was delayed in all the treatments, the delaying effect increasing with the concentration of the chemical. Maleic hydrazide has been reported to delay flowering in raspberry (David, 1950) and cotton (Josephson, 1961), FW-450 in cotton (Eaton, 1957; Singh, 1964), and coumarin in cotton (Singh, 1964) and *Cajanus cajan* (Kaul and Singh, 1967).

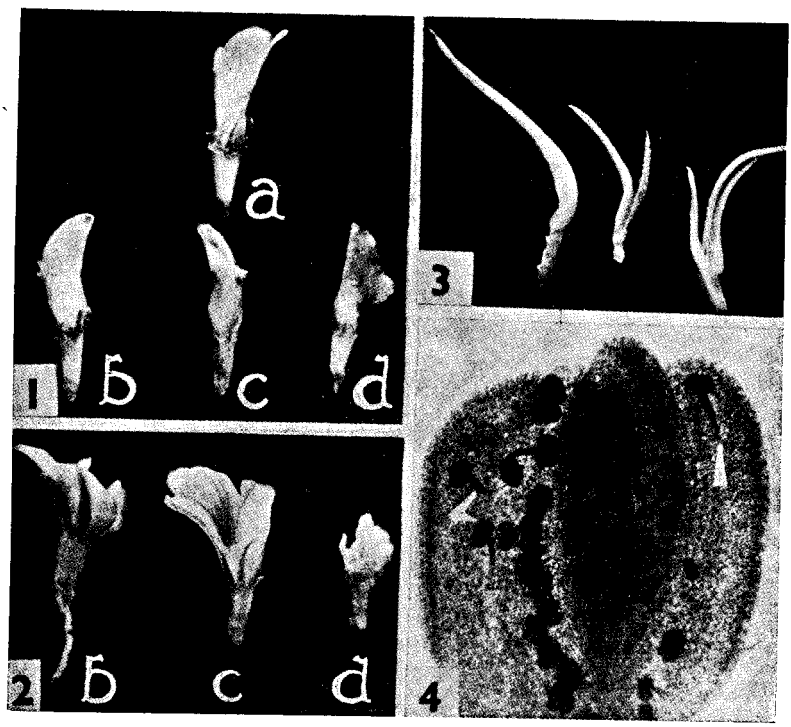

FIG. 1. Flowers from untreated (a) and 0·25 (b), 0·50 (c), and 0·75 (d) per cent FW-450 treated plants.

FIG. 2. Flowers from 0·05 (b), 0·10 (c), and 0·25 (d) per cent maleic hydrazide treated plants.

FIG. 3. Mono-,bi-,and tri-carpellate fruits from maleic hydrazide treated plants.

FIG. 4. Germination of pollen grains inside an anther from 0·5 per cent FW-450 treated plant.

Flowers borne subsequent to treatment were small (Figs. 1, 2). Treatment with maleic hydrazide has also been reported to cause a decrease in the size of corolla in day-flower

(Moore, 1950), sesame (Kumar, 1963), and cotton (Singh, 1964). In maleic hydrazide treated fenu-greek, corolla became smaller and was also malformed (Fig. 2). The ovary is monocarpellary in *Trigonella foenum-graecum*. When treated with maleic hydrazide, occurrence of more than one carpel was frequent (Fig. 3). These remained separate or underwent various degrees of fusion. When treated with FW-450 the size of the flowers was reduced without any malformation of corolla or pistil as was also reported in soybeans (Starnes and Hadley, 1962), alfalfa (Miller and Hittle, 1963), sesame (Kumar, 1963), and cotton (Singh, 1964). However, at 0·5 and 0·75 per cent FW-450, frequently the anthers remained clumped together to form a ring encircling the style, as was observed in *Cajanus cajan* (Kaul and Singh, 1967). Size and shape of the flowers was not affected by coumarin.

Yield.—The number of pods per plant, number of seeds per pod and the total grain yield per plant was significantly reduced when the plants were treated with the retardants (Table II).

Table II. Effect of different concentrations of maleic hydrazide, FW-450 and coumarin on the yield

Chemical	Concentration (per cent)	No. of pods per plant	No. of seeds per pod	Grain yield per plant (g)
Maleic hydrazide	0·05	15·92	11·80	2·690
	0·10	13·20	11·15	1·630
	0·25	9·72	10·75	1·090
FW-450	0·25	37·75	10·50	5·280
	0·50	23·90	7·45	2·050
	0·75	20·98	6·65	2·005
Coumarin	0·25	37·70	12·50	6·930
	0·50	31·15	9·85	4·005
	0·75	21·22	7·80	2·180
Control	0·00	59·75	18·10	11·000
C.D.[1] at 5 per cent level		2·092	0·681	0·606
C.D.[2] at 5 per cent level		1·208	0·405	0·120

C.D.[1]—for comparison with control.
C.D.[2]—for comparison between the treatments.

The decrease in the grain yield although was more with the higher concentrations of FW-450 and maleic hydrazide, the difference in the yield between the lower concentration of these

two retardants was not statistically significant. Maleic hydrazide in wheat (Chopra *et al.*, 1960), FW-450 in cotton (Pate and Duncan, 1960; Singh, 1964); and coumarin in cotton (Singh, 1964) have also been reported to reduce the yield.

Pollen production.—Maleic hydrazide at 0·25 per cent concentration sprayed before the initiation of floral buds, alone or supplemented with another spray after the initiation of floral buds, produced maximum pollen sterility of about 55 per cent (Table III). Induction of only partial male sterility with maleic hydrazide has been reported in hybrid corn (Warren and Dimmock, 1954), cotton (Singh, 1964), and *Cajanus cajan* (Kaul and Singh, 1967).

Table III. Effect of different concentrations of maleic hydrazide, FW-450, coumarin and the time of application on pollen sterility percentage

Chemical	Concentration (per cent)	Time of application				
		T_1	T_2	T_3	T_1T_2	T_1T_3
Maleic hydrazide	0·05	42·00	44·00	38·00	49·50	40·75
	0·10	42·75	49·75	40·75	47·50	39·25
	0·25	54·50	49·25	35·75	55·75	42·25
FW-450	0·25	79·75	76·25	58·25	80·25	52·00
	0·50	100·00	93·00	73·50	100·00	87·50
	0·75	100·00	100·00	85·00	100·00	100·00
Coumarin	0·25	36·00	40·75	30·75	41·00	31·25
	0·50	51·25	52·75	34·25	50·25	42·50
	0·75	70·50	60·75	54·25	66·25	54·00

S.E. for means—0·3316

About 70 per cent of pollen were sterile when 0·75 per cent coumarin was sprayed at before-bud-initiation stage. Singh (1964) in cotton and Kaul and Singh (1967) in *Cajanus cajan* also reported partial pollen sterility by coumarin.

Complete pollen sterility was obtained in plants treated with 0·5 and 0·75 per cent solution of FW-450. FW-450 is known to cause pollen sterility in other plants as well (Eaton, 1957; Moore, 1959; Cameron and Eaton, 1959; Kumar, 1963; Singh, 1964; Kaul and Singh, 1967).

Some pollen grains were found aborted and a large number germinated *in-situ* (Fig. 4). This *in-situ* germination appears to

be due to the non-dehiscence of anthers. Pollen sterility induced by FW-450 is temporary since viable pollen appeared in the flowers opened about 14 days after the opening of the first flower. Similar observations have been reported in other plants (Rehm, 1950; Chopra *et al.*, 1960; Kaul and Singh, 1967). However, in red clovers, sterility of the pollen could be maintained throughout the blooming period (Wit, 1960).

Yield in completely male sterile treatments.—Effect of different concentrations of FW-450 on the yield per plant and its components, namely number of pods per plant and the number of seeds per pod, is presented in Table IV.

Table IV. Effect of different concentrations of FW-450 at various times of application on the number of pods per plant, number of seeds per pod, and the total yield per plant (g)

Concentration (per cent)	Variate	Time of application					
		T_1	T_2	T_3	T_1T_2	T_1T_3	T_0
0·25	i. No. pods per plant	41·75	39·00	39·50	35·50	34·00	..
	ii. No. seeds per pod	17·50	12·25	14·75	7·50	5·50	..
	iii. Yield per plant	7·125	4·95	7·10	3·15	4·075	..
0·50	i. No. pods per plant	27·25	25·00	25·00	22·75	19·50	..
	ii. No. seeds per pod	10·25	9·25	7·00	5·75	5·00	..
	iii. Yield per plant	3·225	2·65	1·87	1·475	1·05	..
0·75	i. No. pods per plant	22·675	21·50	24·25	17·75	18·75	..
	ii. No. seeds per pod	8·75	8·75	7·00	4·50	4·25	..
	iii. Yield per plant	2·725	2·60	2·125	1·275	1·30	..
Control							
	i. No. pods per plant	..	..	..	..	..	59·75
	ii. No. seeds per pod	..	..	..	..	..	18·10
	iii. Yield per plant	..	..	..	..	..	11·00

Complete male sterility with maximum number of pods, seeds and the yield per plant was recorded with 0·50 per cent FW-450 applied before the initiation of buds. The yield, however, was much less in comparison with control. Although number of flowers was more in these plants, majority of them abscised on account of the failure of pollination. As a result, the reduction in yield was due to the reduction in the number of pods per plant and the number of seeds per pod. Reduction in the number of seeds per pod may be due to female sterility also.

These results are similar to those reported in other plants (Starnes and Hadley, 1962; Miller and Hittle, 1963).

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