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Phytogametocidal action of F. W. 450 (Mendok) on the Characters of Madras Cambodia Uganda. 1. Cotton *

by

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Introduction: Exploitation of the phenomenon of hybrid vigour for increasing crop yield on a commercial scale is the most important step in agriculture. Technical difficulties like smallnes of flowers, laborious emasculation, hand pollination, and bagging have proved to be time consuming and increased the cost of hybrid seed production. Several methods have been suggested to overcome these difficulties and the use of male sterility as a possible measure was emphasized by Jain (1959). But, cytoplasmic genetic male sterility is not yet available in cotton to exploit successfully the hybrid vigour. Hence, a method for inducing a high degree of male sterility with a selective gametocide chemical assumes special importance. In recent years, several attempts have been made to induce male sterility by treating the cotton plants with a gametocide F. W. 450 or Mendok (Sodium 2, 3 dichloroisobutyric acid) of different strengths. In this paper, the results on the effect of F. W. 450 spray on Madras Cambodia Uganda. 1. cotton, are presented and the possibility of inducing male sterility in breeding programmes is discussed.

Review of Literature: The results on the use of F. W. 450 have been disappointingly poor in many cases, but in some they have been promising to solve the problems involved with its usage. (Rohm and Haas, 1959). Eaton (1957) was the first to use this compound for artificial induction of male sterility in cotton. He found that 1% aqueous solution of F. W. 450, was freely absorbed by cotton plants and remained active for a long time. Subsequently he concluded that a high degree of male sterility could be maintained with minimum toxicity, with the spray of 0·25% solution of the chemical Eaton (1958). Bhardwaj and Santhanam (1961) observed that 0·20% of this chemical sprayed six times at weekly interval induced 100% pollen sterility on asiatic cotton. However, the chemical did not appear to be highly selective and caused damage to female gametes resulting in reduced seed set per boll. Avtar singh and Sehgal (1963) had also found that this gemetocide did not show selective action against male gametes alone on Punjab American Cotton 320 F. Treatment on Pope cottons with F. W. 450 resulted in high degree of self sterility and the treated plants were less productive. (Pate and Duncan, 1960). The effect of 0·25% and 0·40%

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solution of F. W. 450 on six characters of American Upland cotton was studied by Richmond (1962) who concluded that the gametocide induced somewhat higher percentage of female sterility than male sterility and reduction in percentage of boll set, seed, lint yield and germination percentage The highest percentage of hybrid seed (50%) was obtained from plots treated with 0·4% solution. At the Indian Agricultural Research Institute, New Delhi, an expriment with F. W. 450 on H. 14 cotton *(G. hirsutum)* with concentrations of 0·15%, 0·20% and 0·25% indicated that 0·15% solution sprayed at weekly intervals for seven times ensured desired level of male sterility, but expressed adverse effect on other plant parts (1962) Anon. Semenova (1964) induced artificial male sterility in 54 cultivated varieties of *Gossypium* species. 2, 3–dichloroisobutyric and dichloropropionic acids were used in different concentrations for different species and hybrid seeds were obtained from 80 to 90%. Mohan Ram and Rustagi (1966) have reviewed the various effects incited by the gametocidal compounds. In a preliminary study with C^{14} labelled Mendok on cotton, Mc Rae and Usdin (1958) found that the label moves from leaves to flowers and was consistently higher in the anthers than in the ovules. The exact role of F. W. 450 salt at the cellular level still remains obscure.

Material and Methods: With a view to determine the optimum concentration of F. W. 450 spray and standardise the frequency of the spray in inducing male sterility, a trial with MCU. 1, cotton, *(G. hirsutum)* was laid out under irrigated conditions. The lay out was of the randomised block design, replicated twice, with the following treatments:

(i) Concentration of the gametocide:
O (water). 0·1%, 0·2% and control (no spray)

(ii) Number of sprays in each concentration:
1, 2, 3, 4, 5 and 6

(iii) Frequency of the spray: Once in 10 days.

(iv) Initial spray: About 15—20 days before blooming.

For each main treatment viz., water spray, there were six sub-treatments like spraying once, twice and so on. The various concentrations of the solution were applied in full coverage sprays to the point of run off. After each spray, pollen samples were collected from each plot and pollen grain stained in acetocarmine glycerine were examined for the fertility.

The effect of the spray on the following characters was also observed: (1) Plant height, (2) Earliness, (3) Length of petal and style, (4) No. of anther sacs per flower (5) Percentage of non-dehiscent anther,

(6) No. of bolls per plant, (7) Size of bolls, (8) Boll weight, (9) No. of seeds per boll, (10) Halo-length, (11) Ginning percentage, (12) Seed index and (13) Lint index.

Based on the findings of the experiment during the first year, a modified spraying schedule was formulated for testing its practical utility in the second year.

(i) Spraying schedule : 0·2% upto four sprays at 10 days interval and 0·1% for 5th and 6th sprays.

(ii) Varieties used : 1. MCU. 1 (Green pigmented plant body)
2. Macnamara vinesap (Pink coloured plant body) (*G. hirsutum*).
(To find out the percentage of hybrid seeds).

(iii) Lay out : Three plots one cent each. Two plots with alternate rows of MCU. 1 and Macnamara vine sap and one plot with MCU. 1 alone as control.

In the first two plots, the spraying schedule was applied on MCU. 1 cotton rows alone, to induce male sterility and maintain the desirable level without much adverse effects. The first treated plot was left out for open pollination. The second treated plot was hand pollinated by dusting the pollen of the pink variety on MCU. 1 cotton. Data on number of bolls per plant, number of seeds per boll and percentage of hybrid seeds were collected for each plot.

Results and Discussion : Macrae and Usdin (1958) found that the first reaction of the flowers was retarded dehiscence, since the chemical was found to be higher in anthers than in the ovules or any part. After completing two sprays at 10 days interval, the effect on non-dehiscence of anther was noticed. The data collected on percentage of dehiscent anthers are furnished in table 1.

TABLE 1. *Effect of gametocide on dehiscence of anthers (in percentage)*

Concentration	No. of sprays at 10 days interval					
	1	2	3	4	5	6
0·1% ...	100	100	93	96	89	80
0·2% ...	94	40	10	0	0	0
0 (water) ...	100	100	98	99	98	99
Control ...	100	—	—	—	—	—

In general, normal dehiscence of anthers was regained if the spray is not continued after 10 days interval. In the case of 0·2% concentration, from the 4th spray on wards, the regaining of normal condition was less or even absent.

The number of anthers was also found to be reduced in the treated plots as compared to water spray plot and control. Most of the anthers in treated plots (0·2%) were whitish in colour instead of being yellow at maturity.

TABLE 2. *Number of anthers per flower*

Concentration	No. of sprays at 10 days interval						Mean
	1	2	3	4	5	6	
0·1% ...	59	70	66	60	71	64	65·0
0·2% ...	61	60	56	47	70	58	58·6
0 (water) ...	73	78	74	80	96	90	81·8
Control ...	—	—	—	—	—	—	98·0

The reduction in general, was more in treatments with 0·2 per cent spray. It is observed that the plot receiving 0·2 per cent solution four times, recorded the lowest on an average.

The effect of chemical on the reduction of the fertility of pollen was more perceptible only on completion of the third spray (30 days from initial spray) in all the treated plots. The non-stainable condition of power in flowers remained at that level for a very short period of 10 days and the fertility was gradually restored to normal in the subsequent formed flowers when there was no further spray. In the case of 0·2 per cent concentration with four sprays and above, the sterility was however, in all the flowers at 100 per cent throughout.

Other morphological characters: Particulars on length of petal, style, boll measurement and final plant height are furnished in table 3. The flower size (length of petal and style) was much reduced in plots sprayed with 0·20 per cent concentration. Similar reduction was reported by Kho and Debruyn (1962) in *Antirrhinum* plant. Lippert and Hall (1961) reported that spray of 0·20 to 0·70 per cent F. W. 450 on cantaloupe, reduced the number of flowers, growth of corolla and fruit set.

TABLE 3. *Effect of gametocide (F. W. 450) on some morphological characters of MCU. 1 Cotton.*

S. No.	Treatment		Length (mm)		Boll size (mm)		Final height of the plants (cm)
	Concentration	No. of sprays	Petal	Style	Length	Broadth	
I.	0·1 per cent	1	4·8	2·1	2·83	1·53	62·5
		2	5·0	2·6	2·92	1·38	66·5
		3	4·8	2·2	2·98	1·62	65·6
		4	5·4	2·6	2·71	1·49	(59·5)
		5	4·8	2·4	2·79	1·49	(61·5)
		6	4·6	2·0	2·66	1·41	(53·5)
		Mean	4·9	2·3	2·83	1 42	61·5
II.	0·2 per cent	1	4·1	2·3	2·86	1·50	64·5
		2	4·0	2·1	3·56	1·39	(55·0)
		3	4·0	2·3	2·71	1·51	(62·5)
		4	4·2	2·3	2·77	1·37	(43·0)
		5	3·8	2·0	2·39	1·41	(52·5)
		6	3·5	1·8	2·59	1·45	(45·5)
		Mean	3·9	2·1	2·65	1·44	53·8
III.	0 (water)	1	4·6	2·1	3·18	1·53	72·5
		2	5·0	2·6	2·82	1·50	69·0
		3	4·8	2·2	2·84	1·56	75·0
		4	5·5	2·6	2·74	1·45	65·5
		5	5·1	2·5	3·04	1·46	66·0
		6	5·0	2·4	3·16	1·61	69·0
		Mean	5·0	2·4	2·96	1·52	69·5
IV.	No spray (Control)		5·2	2·8	2·92	1·56	70·5
	Significance by 'F' test		...	...	...	...	Yes
	S. E.		...	...	...	...	2·31
	C. D. (P = 0·05)		...	...	...	...	6·86

Note:— ( ) = Significantly poorer values than control.

The small size of the cotton flower with non-dehiscent anthers from the plot treated with more than four sprays of 0·2 per cent concentration and the normal flower from the control plot are shown in Plate A. The boll size also was slightly smaller in higher concentration of the chemical, sprays while it was bigger even to the control in plots sprayed with water. This trend was also observed in the case of the height of plants. Statistically significant reduction in height was noticed in 0·2 per cent concentration with two sprays and above and in 0·1 per cent with four sprays and above. Pate and Duncan (1960) indicated in similar experiment that overall plant size appeared to be an important factor in determining the effect from a particular rate of F. W. 450 treatment. The leaves of the

treated plants were also injured from slight crinkling through distortion, contact burning or marginal necrosis. The normal leaf along with the affected ones are shown in Plate B.

PLATE. A : Size of Normal and treated flowers.

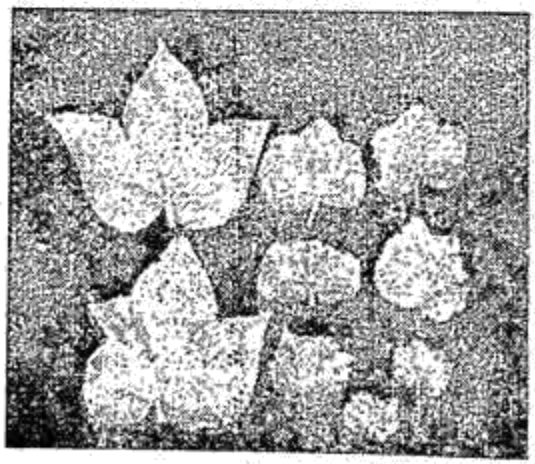

PLATE. B : Normal leaf in comparison with injured leaves

Effect on economic characters: The data assessed on halolength, ginning percentage, lint and seed indices, boll weight and number of bolls per plant are presented in detail, in table 4. There was appreciable reduction in all the above characters in higher concentration of 0·2 per cent of the chemical. With regard to production of bolls, the treated plots with 0·1 per cent and 0·2 per cent solution recorded significantly poorer number than control. Richmord (1962) also has reported that by the use of more concentrated solution of the gametocide, there was corresponding reduction in amounts of lint and seed. Similariy Pate and Duncan (1960) found that treated plants were less productive indicating the effects of female sterility and phytotoxicity.

TABLE 4. *Effect of gametocide (F. W. 450) spray on some economic characters of M. C. U. 1 Cotton.*

Treatment	No. of sprays	Halo length (mm)	Ginning per cent	Lint Index	Seed Index	Boll weight (gm)	No. of bolls per plant
Concentration (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I. 0·1 per cent	1.	25·0	39	49	76	3·2	(2·5)
	2.	35·2	40	55	77	3·4	(3·7)
	3.	22·4	37	60	104	3·3	(2·7)
	4.	26·1	37	55	85	2·4	(1·4)
	5.	23·5	38	61	94	2·3	(2·3)
	6.	23·3	38	55	85	2·1	(1·4)
	Mean	24·3	38	56	87	2 1	2·3
II. 0·2 per cent	1.	25·5	37	58	117	4 0	(2·6)
	2.	22·7	38	48	76	3·5	(0·9)
	3.	24·9	38	67	109	1·5	(1·0)
	4.	22·4	37	50	87	2·2	(0·8)
	5.	22·5	34	32	65	2·2	Nil.
	6.	23·7	36	52	84	1·8	Nil.
	Mean	23·6	37	53	90	2 5	0 9
III. 0 (water)	1.	26·2	36	63	114	3·7	5·9
	2.	29·2	36	61	105	3·9	4 9
	3.	26·0	37	64	115	3·5	7·8
	4.	26·1	35	61	113	4·0	5·1
	5.	24:3	34	60	123	3·1	6·0
	6.	23·4	36	63	109	3·0	5·3
	Mean	25·9	36	62	113	3·5	5·8
IV. No spray (control)		26·8	37	64	103	4·5	5·8
Significance by 'F' test		...	...	...	...	...	Yes
S. E.		...	...	...	...	...	0·54
C. D. (P = 0·05)		...	...	...	...	...	1·62

Note: —— Significantly better value than control.
( ) Significantly poorer value than control.

Female sterility percentage : The number of seeds per boll was gathered from all the plots, compared with the control and female sterility. (Table 5).

TABLE 5. *Effect of F. W. 450 on female sterility percentage*

Concentration	No. of sprays at 10 days interval					
	1	2	3	4	5	6
0·1% ...	—	—	4·4	21·7	27·1	34·8
0·2% ...	—	13·0	27·1	21·7	43·5	34·8
0 (water) ...	—	—	13·0	—	—	4·4
Control ...	—	—	—	—	—	—

The boll setting percentage was worked out and the trend of results for each treatment is depicted in Figure I.

Boll setting was found to be very poor in 0·2 per cent concentration. Under five and six sprays of this concetration, there was practically no boll-set. Water spray has recorded satisfactory boll set.

By considering the above results, 0·2 per cent concentration with four rounds of sprays can be considered for further investigation in inducing safe level of male sterility with minimum adverse effects on other characters.

Modified schedule of spray for practical utility : Two parents one with green pigmented body (MCU. 1) and the other with pink body (Mcnamara vinesap) was planted in alternate rows. Variety MCU. 1 was sprayed with 0·2 per cent aqueus solution of F. W. 450 for four rounds at 10 days interval followed by 0·1 per cent in the last two rounds. This schedule produced promising result of male sterility with minimum adverse effect on other characters. The ovules of the sprayed row were fertilized with the pollen produced by the unsprayed rows. One plot was allowed for natural open pollination while other plot was hand pollinated by dusting the pollen of unsprayed plants on the flowers of the treated plants. The data collected from these observation plots are given in the Table 6.

TABLE 6. *Effect of modified schedule of spray on MCU. 1 cotton*

S. No.	Characters studied		"One cent" plots		
			Open pollinated	Hand pollinated	Control
1.	No. of bolls per plant	...	5·0	8·6	7·5
2.	No. of seeds per boll	...	32·0	33·0	29·0
3.	Percentage of immature illfilled seeds	...	10·6	7·5	Nil
4.	Percentage of hybrid seed	...	62	78	Nil
5.	Phytotoxic effect on plants	...	very slight effect		normal

The production of bolls in open-pollinated plot was poor since flowers or young bolls without cross pollination from neighbouring rows, shed. Eaton (1958) has indicated from similar experiments that bees are essential for the production of cotton seeds and without bees, the rows sprayed will set only few bolls. He also suggested that for optimum cross pollination with honey bees, ten bees should be found inside each 100 flowers throughout the field. One colony per acre may be sufficient if several hundred acres are involved but ten per acre may not be enough if the field is small. Hand pollination by employing boys can be undertaken considering the high percentage of hybrid seed and production.

As suggested by Wit (1960), such methods though not 100 per cent effective, would enable the breeder to produce in an economical way sufficient quantities of hybrid seed to test the value of large number of hybrid populations on a commercial scale. The most promising combinations could be stabilised later. In Uganda, (Anonymous 1958) field trials were undertaken with four varieties of green leaf planted in 40 feet rows between alternating rows of a cotton with red leaf and considerable success in obtaining potentially useful hybrids were obtained.

Summary: The effect of the gametocide F. W. 450 (Mendoka sodium salt of 2, 3–dichloroisobutyric acid) on the morphological and economical attriubuts of MCU. 1 cotton was studied in detail. With the study for one season, a schedule of spray was formulated with 0·2 per cent concentration for four sprays (10 days interval) and 0·1 per cent for subsequent two sprays for maintaining high level of male sterility with minimum adverse effects on other characters. This was applied for practical utilisation of producing hybrid seeds and encouraging results were obtained.

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* = Original not seen.