Sex Expression and Yield Responses of Squash Plants to Ethrel

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INTRODUCTION

The *Cucurbita pepo* L. is among the more important vegetable crops that supplies Libyan consumers with edible products all the year round. Sex expression of this crop is of primary yield importance since only the pistillate flower can ultimately produce fruit.

Sex expression has been shown to be influenced by many factors as genetic constitution and environmental conditions especially temperature (11), day length, humidity (10), spacing and fertilizers (14). In addition, various growth regulators applied exogenously have shown to affect sex expression of *Cucurbita pepo*. Wittwer and Hillyer 1954 found that the ratio of staminate to pistillate flowers was reduced when the young plants of cucumber and squash were sprayed with 100 ppm of naphthalen acetic acid (NA) or 25 ppm of 2,3,5-triiodobenzoic acid. Moreover, similar results were obtained by various growth regulators on Cucurbitaceae plants as indicated by Laibach and Kribben 1950 and Brantly and Warron 1960.

Investigations pertaining to Ethrel substance have indicated a significant increase in early femaleness in monoecious and gynoecious cucumber varieties (3,4). Similar results were obtained by Miller and Lower 1969, who reported that Ethrel induced pistillate flowers on many monoecious cucurbits and in some cases severely reduced the number of staminate flowers. Sims and Gledhill 1968 found that Ethrel induced the formation of female flowers of the monoecious cucumber variety SMR 58. No male flowers were developed until the eighth node in the single 50 and 100 ppm treatments. The higher concentrations induced the production of multiple female flowers (up to 9) at several nodes. Internodal length was reduced and dwarfing was evident in the double application and 250 ppm treatments. High concentrations of 250 or 500 ppm causing dwarfing and in some cases flower abortion. Robinson 1968 observed that 250 ppm of Ethrel as Amchem 66–329 applied to Zucchini squash seedlings induced early female flowers, shortened internode and increasing early yield. McMurry and Miller 1969 treated monoecious cucumber plants with different concentrations of Ethrel (0, 120, 180 and 240 ppm applied once, twice or 4 times). They found that both cultivars produced a significantly large number of fruit per acre. However, a trend toward increased production was present as treated Sc 19 produced about 10,000 more fruits per acre than untreated ones. Amchem products research on squash (from 1967–1968) indicates that

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Ethrel applied as a single or repeated application at weekly intervals at rates of 120 to 250 ppm will sharply reduce the number of male flowers and increase the number of female flowers.

The objective of this study is to throw light upon the effect of Ethrel (2-chloroethyl phosphonic acid) on the sex expression of squash, as well as to evaluate the use of this chemical in increasing the yield of squash plants.

MATERIALS AND METHODS

Two experiments were conducted at Sidi El Mesri Vegetable Station, Tripoli, to study the effect of Ethrel (2-chloroethyl phosphonic acid of the formulation manufactured by Amchem Products Inc.) on the flower formation and yield components of squash plants. The experiments were carried out in the spring and autumn of 1971. Twelve treatments, which were the combinations of Ethrel and two applications, were applied. Ethrel concentrations were 00, 125, 250, 500, 750 and 1,000 ppm. Each concentration was sprayed either once when the plants were 2–3 true leaves stage or twice; the first at 2–3 true leaves stage and the second at 4–6 true leaves stage. A split plot design was applied to each experiment with three replicates. Ethrel concentrations occupied the main plots, while the split plots were assigned for the times of applications.

The Monoecious cultivar used was the local squash variety. Seeds were sown on 3 April, 1971 for the spring trial and on 16 August for the autumn trial. Treatment plots consisted of four furrows; four meters in length and 60 cm in width. The distance between plants was 50 cm.

The soil was manured with 20 tons of well rotted manure during soil preparation. Chemical fertilizers were used at rates of 600, 600 and 300 kg/ha for calcium-superphosphate, ammonium sulfate and potassium sulfate, respectively. The general common cultural practices were followed as practised in Libya.

Data were recorded for the numbers of staminate and pistillate flowers (for the fifteen days after flowering stage), total yield and early yield which was the 10 days of the harvest period. Fruit dimensions were recorded from each pick. All data obtained were subjected to the analysis of variance.

RESULTS AND DISCUSSIONS

1. Flowering Pattern

Data in Table 1 indicates that the different concentrations of Ethrel had a drastic effect on the flowering pattern of squash plants. The treated plants produced a significantly smaller number of staminate flowers than the untreated ones. This was true in spring and autumn trials. The average number of staminate flowers was 8.33 for the untreated plants, and was reduced sharply to 0.17, with 1,000 ppm of Ethrel treatment, in the spring season. The corresponding numbers for the autumn season were 12.5 and 0.33, respectively. This agrees with the results reported by Robinson, et al. (1968), Sims and Cledhill (1968) and Eugchi and Sugwara (1968).

On the other hand, the production of pistillate flowers was induced by all Ethrel treatments. Plants tended toward femaleness as the concentration increased. The average number of pistillate flowers at 1,000 ppm level amounted to 11.66 while it was 0.83 for the untreated plants in spring season. The same trend was obtained in the autumn season, when it was 1.33 pistillate flowers for the untreated plants and increased to 12.50 at the

Table 1 Effect of different concentrations of Ethrel on number of pistillate and staminate flowers of squash plants (average of two applications)

Treatment p.p.m.	Spring Season			Autumn Season		
	No. of flowers		Ratio	No. of flowers		Ratio
	♂	♀		♂	♀	
00	8.33	0.33	0.1:1	12.50	1.33	0.1:1
125	4.33	3.67	0.8:1	8.67	2.83	0.3:1
250	3.00	4.33	1.4:1	4.83	6.33	1.3:1
500	0.67	9.33	13.9:1	4.00	9.66	2.4:1
750	0.50	10.66	21.1:1	0.50	11.17	22.3:1
1,000	0.17	11.66	68.6:1	0.33	12.50	37.8:1
L.S.D. at 5%	2.13	4.09	—	4.72	2.22	—

level of 1,000 ppm. The above results can be attributed to the effect of Ethylene which is normally produced by plant tissues or applied exogenously as Ethrel. Ethylene causes variety of physiological responses which lead to the alteration of plant development and metabolism. These results are in accordance with those obtained by Miller et al. (1969) and Robinson et al. (1969).

Staminate Pistillate flower ratios, as shown in Table 1, varied from 0.1:1 for the untreated plants to 68.6:1 for the treated ones at the rate of 1,000 ppm in spring planting. For the autumn season, the pistillate staminate flower ratios, were 0.1:1, and 37.8:1 for the untreated and treated plants, respectively.

The number of Ethrel applications affected the average number of staminate, and pistillate flowers, and staminate — pistillate flower ratios as indicated in Table 2. Two applications of Ethrel increased the pistillate flowers as well as in staminate — pistillate flower ratios. On the contrary, staminate flowers decreased when Ethrel substance was sprayed twice.

Treatment of squash plants with the different Ethrel concentrations had a significant effect on the total and early yield of fruits in spring and autumn seasons as shown in Table 3.

The average total yield increased as the concentration of Ethrel increased up to 500 ppm in spring and up to 750 ppm in autumn, and then decreased. Treated squash plants

Table 2 Effect of the number of Ethrel application on the pattern of squash flowers (Average of 7 Concentrations)

Number of Ethrel Applications	Spring Season			Autumn Season		
	No. of flowers		Ratio	No. of flowers		Ratio
	♂	♀		♂	♀	
Once	2.83	6.33	2.2:1	5.86	6.94	1.18:1
Twice	2.83	7.11	2.5:1	4.39	7.67	1.75:1
L.S.D. at 5%	N.S.	N.S.	—	0.87	0.69	—

Table 3 Effect of different concentrations of Ethrel on the total and early yield/ha and fruit characteristics of squash plants (average of two applications).

Treatment	Spring Season					Autumn Season				
	Yield/tons		Fruit Charac.			Yield/tons		Fruit Charac.		
	Total	Early	Weight gm	Length cm	Width cm	Total	Early	Weight gm	Length cm	Width cm
00	20.62	1.82	244	24.3	6.1	26.37	5.65	242	22.7	5.8
125	30.50	6.94	251	22.9	6.6	29.00	7.06	260	21.8	6.2
250	32.50	14.41	290	21.3	6.4	31.62	11.31	264	21.5	6.6
500	40.50	15.72	242	21.5	6.5	33.12	11.62	273	20.7	6.6
750	36.25	18.34	330	21.1	6.6	35.00	11.06	285	19.9	6.1
1,000	36.12	14.47	334	21.1	6.7	28.25	8.69	287	19.3	6.5
L.S.D. at 5%	8.50	3.15	N.S.	2.7	N.S.	5.40	1.53	N.S.	N.S.	0.6

yielded twice as much as the untreated ones when sprayed with 500 ppm in spring, and 1.6 times when sprayed with 750 ppm in autumn season. In all cases, treated plants produced greater yields than the untreated ones, depending on the concentrations used. On the other hand, the drop in the total yield at high concentrations in spring or autumn trials, might be due to the abscission of fruits at an early stage. Sims and Gledhill (1969) indicated that Ethrel employed at high concentration caused dwarfism and flower abortion.

Ethrel application enhanced the formation of pistillate flowers, and therefore increased the early yield. The average of early yield increased from 1.82 tons/ha for untreated plants to 18.34 tons/ha for plants sprayed with 750 ppm in the spring trial. These yields represented 8.8 and 50% of the total harvest for the untreated and treated plants, respectively. For the autumn trial the average early yield varied from 5.65 tons/ha for the untreated plants to 11.62 tons/ha for the plants sprayed with 500 ppm McMurry and Miller (1969) found an increase in the value of the early yield. This value represented 47% of the total yield for the treated cucumber plants with Ethrel, while those untreated produced 27% of the total yield.

The average fruit weight was affected by Ethrel treatments, the higher the concentration, the heavier the fruits obtained. Using Ethrel at 1,000 ppm increased average fruit

Table 4 Effect of the number of Ethrel applications on the components of squash yield/ha (average of 6 concentrations).

Number of Ethrel Applications	Spring Season					Autumn Season				
	Yield/tons		Fruit Charac.			Yield/tons		Fruit Charac.		
	Total	Early	Weight gm	Length cm	Width cm	Total	Early	Weight gm	Length cm	Width cm
Once	29.89	11.72	285	22.1	6.48	29.00	8.56	262	21.5	6.3
Twice	35.62	13.31	296	21.9	4.48	32.12	9.90	275	20.4	6.5
L.S.D. at 5%	2.68	1.24	N.S.	N.S.	N.S.	N.S.	1.00	N.S.	N.S.	N.S.

weight by 90 grams more than the untreated plants in the spring trial, and 45 grams in the autumn trial.

For the dimensions of fruit, the fruit length reached its maximum in the untreated plants in both the spring and autumn trials. On the other hand, fruit width tended to increase slightly at any rate of Ethrel concentration compared with the untreated sample.

Treatment of squash plants, with two applications of Ethrel increased significantly the total and early yield in both the spring and autumn trials as shown in Table 4. No significant differences in fruit weight or dimensions were obtained when Ethrel was applied either once or twice.

SUMMARY

Two experiments were conducted at Sidi El Meseri Vegetable Station, Tripoli to study the effect of Ethrel Concentrations and the number of applications on sex expression and yield components of the local Squash Variety.

The results obtained could be summarized as follows:

1. Pistillate — staminate flower ratios tended to increase by spraying the plants with Ethrel material. These were 0.1 : 1 for the untreated plants and 68.6 : 1 for plants treated at the rate of 1,000 ppm in spring planting. For the autumn season, they were 0.1 :1 and 37.8 :1 for the respective treatments.
2. The two applications of Ethrel increased the pistillate flowers than the single one.
3. Ethrel application at the rate of 1,000 ppm increased the average fruit weight by 90 grams more than the untreated plants in the spring trial, and 45 grams in the autumn trial.
4. Fruit length tended to decrease, while fruit width slightly increased by treating squash plants with Ethrel material.
5. The average total yield increased as the concentration of Ethrel increased up to 500 ppm in spring, and up to 750 ppm in autumn. It was 40.50 tons/ha for the treated plants against 20.62 tons/ha for the untreated ones in spring. The corresponding yields for autumn were 35.00 and 26.37 tons/ha, respectively.

The average early yield represented 8.8 and 50 % of the total yield for untreated plants with 750 ppm, whereas in autumn it was 21.4 % for the untreated plants and 35.1 % for plants sprayed with 500 ppm.

LITERATURE CITED

1. Amchem products, Inc. 1967. Amchem 66–329 new plant growth regulator. Inf-Sheet No. 37.
2. Brantly, B. B., and G. F. Warren 1960. Sex expression and growth in the muskmelon. C. F. Proc. Amer. Soc. Hort. Sci. 1960. Vol. 45.
3. Eguchi, M. and Y. Sugawara. 1968 (kurume Horticultural Research Station, Kurume/Japan.) C. F. Amchem products, Inc. sheet No. 44.
4. Fujiada, K. and C. Odawara, 1968. AcP 68–329 (2-chloro ethaneophosphonic acid) as a sex expression regulator on cucurbits (Coita Agr. Technical Center. Usa, Kyushu, Japan.) C. F. Amchem products, Inc. Inf. Sheet No. 44.
5. Wittwer, S. H. and I. G. Hillyer, 1954. Chemical induction of male sterility in cucurbits. Science 120 : 893–894.

6. Laibach, F., and F. J. Kribben, 1950. Uber die Bedeutung der B. Indolylessigsaure fur die Blutenbildung der deutsch bot. Ges 63 : 119–120. C. F. Amer. Soc. Hort. Sci. 1960. 45:648.
7. McMurray, A. L. and C. H. Miller, 1968. The effect of 2-chloroethane ophosphonic acid (ETHREL) on the sex expression and yield of cucumis Sativus. J. Amer. Soc. Hort. Sci. 94(4) : 400–402. 1968.
8. ———. 1968. Cucumber sex expression modified by (2-chloroethane phosphonic acid) Science 182 : 1397–1398.
9. Miller, C. H., R. L. Lower, and A. L. McMurray, 1969. Some effects of Ethrel (2-chloroethane phosphonic acid) on Vegetable crops. C. F. Hort (Science, 42489–bibl.).
10. Mining, E. G. and P. O. Matekevitch, 1944. Sex expression of plants as affected by different moisture conditions of the medium. C. R. (Doklady) Acad. Sci. USSR., 421309–12.
11. Nitsch, J. P. et al. 1952. The development of sex expression in cucurbit flowers. Amer. Jour. Bot. 39 : 32–43.
12. Robinson, R., W. Shannon, and M. D. dela Guardia, 1968. Regulating of sex expression in the cucumber — Bio. Science 19(2) : 141–142.
13. Smis, W. L., and B. L. Gledhill, 1968. Ethrel effects on sex expression and growth development in pickling cucumbers. Calif. Agric. 23(2) : 4–6.
14. Taygl, M. A., M. A. Morsi, and K. Habbasha, 1967. Cultural Treatments affecting sex expression of cucumber. Ann. of Agric. Sci., Cairo 10(2):279–288 (bibl.).