CHEMICAL REVERSION OF SEX EXPRESSION IN DIOECIOUS CUCUMBER (CUCUMIS SATIVUS L.) WITH ETHEPHON AND A BENZOTHIADIAZOLE

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ABSTRACT

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By

Jimmy Jude Augustine

Foliar applications of the chemicals, ethephon and 5-methyl-7-chloro-4-ethoxycarbonylmethoxy-2, 1, 3-benzothiadiazole (MCEB), were used to substantiate the role of ethylene in its association with femaleness in cucumber (*Cucumis sativus* L.).

The concn of ethephon (an ethylene releasing compound) for maximum female flower induction and the stage of growth at time of application on an androecious (all-male) cucumber were determined. In this study, the best treatment combination for induction of pistillate flowers without marked inhibition of growth was 50 ppm ethephon applied at the 3 to 4 leaf stage.

The effects of MCEB (a proposed inhibitor of ethylene action) and ethephon on sex expression were observed in androecious and gynoecious phenotypes of cucmber. MCEB had no effect in the androecious line while ethephon (50 ppm) induced pitillate flowers. The effect of MCEB on ethephon treatment was a marked reduction in the number of ethylene-induced pistillate flowers except when there was a 48 hr period

between applications of MCEB and ethephon. This suggests that after 48 hr MCEB appears to be inactive and the ethylene effect is not reversible with MCEB. In the gynoecious phenotype, MCEB (75 ppm) induced staminate flowers, ethephon had no effect, and the effect of MCEB on ethephon treatment was staminate flower production (nonsignificant) at relatively high concn of MCEB (150 ppm). These results further indicate the role of ethylene in female sex expression and of MCEB as an inhibitor of ethylene action.

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Guidance Committee:

Sections I and II are segments of related thesis research information condensed into formats suited and intended for publication in the Journal of the American Society for Horticultural Science.

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SECTION I

FEMALE FLOWER INDUCTION ON AN ALL-MALE (ANDROECIOUS) CUCUMBER, *CUCUMIS SATIVUS* L.

ABSTRACT

Ethephon, an ethylene releasing compound, when applied as a foliar spray causes USSR 1, an androecious line of *Cucumis sativus* L., to produce pistillate flowers. The degree of conversion depends on the concn of ethephon and the stage of growth at time of application. In this study, concn of 50 ppm applied at the 3 to 4 leaf stage was observed to be the best treatment for optimum induction of pistillate flowers without marked inhibition of growth.

INTRODUCTION

Kubiciki (16) reported an all-male, androecious phenotype of cucumber (*Cucumis sativus* L.) controlled by a single recessive gene, *a*. Production of 100% gynoecious hybrid cucumber seed would be simplified by the use of such an androecious pollen parent rather than present monoecious (5) or proposed hermaphrodite (24) parents. However, before the androecious phenotype can be used, a method must be developed to maintain and to increase the number of seeds of this non-fruiting type; that is, pistillate flowers for fruit and seed production.

Plant growth regulators are widely used to alter sex expression in cucumbers (2, 7, 13, 19, 20, 23, 26). Studies suggest that an endogenous auxin-gibberellin balance determines this sex expression (1, 2, 8, 10, 11, 22, 23). Modification of this balance in favor of auxin is associated with femaleness (7, 9, 12, 14, 17); conversely, an increase in gibberellin is associated with maleness (10, 11, 12, 22, 23, 26). Rudich *et al*. (27) suggests that the observed effects of auxin on sex expression result from auxin-induced ethylene formation and recently ethylene has been established as an endogenous regulator of sex expression of *Cucumis melo* L. (3).

Ethephon, an ethylene releasing compound (6, 29), has been used to enhance femaleness in cucurbits (4, 15, 18, 25, 27, 28). Therefore, the objective of this study was to chemically induce pistillate flower formation in an androecious (all-male) line of cucumber.

MATERIALS AND METHODS

Two similar experiments were conducted October 15, 1971 to December 13, 1971 and December 1, 1971 to January 30, 1972. Seed of the androecious line, USSR 1, was obtained from Dr. E. T. Mescherov, All-Union Institute of Plant Industry, Leningrad, USSR. The seeds were sown in soil in 6.25 cm peat pots and grown in a greenhouse with supplemental fluorescent lighting at 24^{o} C during the night (10 hr) and 29^{o} C during the day (14 hr). Plants were transplanted to 15 cm clay pots after 12 days with four single plant replicates in a completely randomized factorial design. They were treated with a freshly prepared aqueous solution of 0, 6, 25, 50, 100, and 200 ppm ethephon at the 1st, 2nd, 3rd, and 4th true leaf stage. The ethephon solution was applied to the foliage with an atomizer until run-off. Flowers developed on the main stem were classified for sex expression through the 20th node; height was measured up to the same point. Statistical analysis of the data was done using Tukey's Multiple Comparison Test.

RESULTS AND DISCUSSION

Significant differences for all of the variables were observed between ethephon concn within growth stages (Table 1). The control (0 ppm) and 6 ppm did not produce pistillate flowers; the concn of 6 ppm being inadequate for pistillate flower induction, regardless of stage of application. Significant differences between stage of inductive concn (25, 50, 100, and 200 ppm) were observed for five of the six observed variables; viz., number of pistillate nodes (except 200 ppm), number of pistillate flowers (except 100 and 200 ppm), number of staminate flowers, percent pistillate flowers, and plant height.

Node number of the 1st pistillate flower generally decreased within a stage with the increase in inductive concn, with the exception of 100 and 200 ppm which caused blind nodes or abortion of the floral buds at the lower nodes. Plants sprayed at the 3 and 4 true leaf stage produced pistillate flowers, on the average, lower than the second node indicating that the "labile period", or stage of development sensitive to modifying factors (13) such as chemicals, had not been passed. This might be caused by the pistil being differentiated last in the floral primordia (21).

Table 1. Effect of ethephon on sex expression of androecious line of cucumber.[z]

Leaf stage	Ethephon concn (ppm)	Node of 1st pistillate flower	No. of nodes with pistillate flowers	No. of pistillate flowers	No. of Staminate flowers	Percent Pistillate flowers	Plant height to 20th node (cm)
1st	0	0.0 c	0.0 g	0.0 f	104.8 a	0.0 e	109.2 ab
	6	0.0 c	0.0 g	0.0 f	110.6 a	0.0 e	113.0 a
	25	1.1 bc	1.0 g	1.0 ef	83.4 abc	1.2 e	93.2 abcde
	50	1.9 abc	4.4 fg	4.8 def	73.9 bcd	6.0 de	94.7 abcd
	100	1.9 abc	6.5 ef	11.5 bcd	58.1 cde	16.5 cde	88.1 abcde
	200	3.1 ab	8.5 def	10.1 cde	47.3 def	17.7 cde	63.3 efgh
2nd	0	0.0 c	0.0 g	0.0 f	105.7 a	0.0 e	112.3 a
	6	0.0 c	0.0 g	0.0 f	110.6 a	0.0 e	106.7 ab
	25	2.8 ab	8.5 def	8.9 cdef	56.3 cde	13.6 cde	88.7 abcde
	50	2.6 abc	11.3 bcd	12.9 abcd	43.6 ef	22.8 cde	85.1 abcdef
	100	1.9 abc	12.3 abcd	15.3 abc	36.6 efgh	29.4 cd	65.5 defgh
	200	4.1 a	8.8 def	12.0 abcd	39.8 efg	23.1 cde	51.1 ghi
3rd	0	0.0 c	0.0 g	0.0 f	103.9 a	0.0 e	108.5 ab
	6	0.0 c	0.0 g	0.0 f	96.9 ab	0.0 e	98.0 abc
	25	2.8 ab	11.5 bcd	12.6 abcd	40.3 cfg	23.9 cde	82.6 bcdef
	50	2.6 abc	16.3 a	20.3 ab	15.9 gh	56.1 ab	55.4 fghi
	100	1.6 abc	13.4 abc	16.3 abc	30.6 efgh	34.7 bc	57.4 fghi
	200	3.1 ab	10.3 cde	12.9 abcd	22.0 fgh	36.9 bc	37.9 hi
4th	0	0.0 c	0.0 g	0.0 f	102.7 a	0.0 e	113.0 a
	6	0.0 c	0.0 g	0.0 f	100.9 ab	0.0 e	97.0 abc
	25	2.8 ab	9.3 cde	13.6 abcd	48.6 def	21.9 cde	72.4 cdefg
	50	1.6 abc	15.5 ab	20.8 a	11.8 h	63.9 a	44.7 ghi
	100	2.3 abc	12.4 abcd	17.9 abc	14.8 gh	54.8 ab	42.4 ghi
	200	1.9 abc	11.6 bcd	16.4 abc	12.9 gh	56.0 ab	32.0 i

[z]Means within columns with common letters did not differ significantly at the 1% level by Tukey's Multiple Comparison Test.

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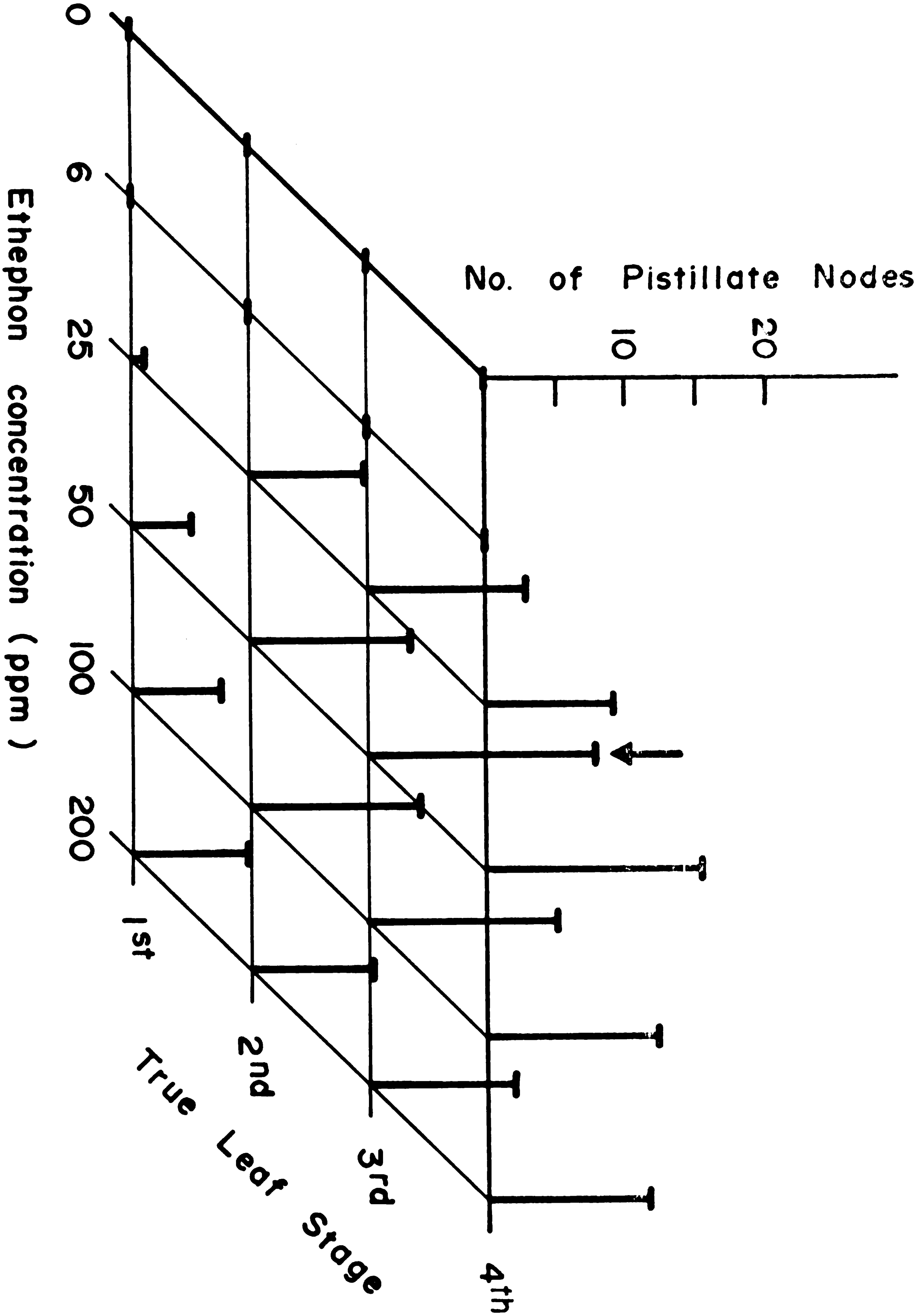
The number of nodes with pistillate flowers increased between stages for each concn (Figure 1) with the exception of a decrease in number at the 4 leaf stage when using concn of 25, 50, and 100 ppm. The response within stages with increasing concn is a bell shaped curve with the exception of the 1 leaf stage which gives a linear increase. The greatest number of nodes with pistillate flowers (16.3) was obtained with 50 ppm applied at the 3 leaf stage (indicated by the arrow). Pistillate flowers developed through the 16th node. Since ethephon is quickly broken down *in vivo* (29) it is unlikely that ethephon was available to induce changes in initiation and/or differentiation of primordia for more than a few days. A continuous supply of ethephon was probably not present from the time of application to the time of production of the 16th node; hence, several initiating and/or differentiating primordia must have been present at the 3 leaf stage.

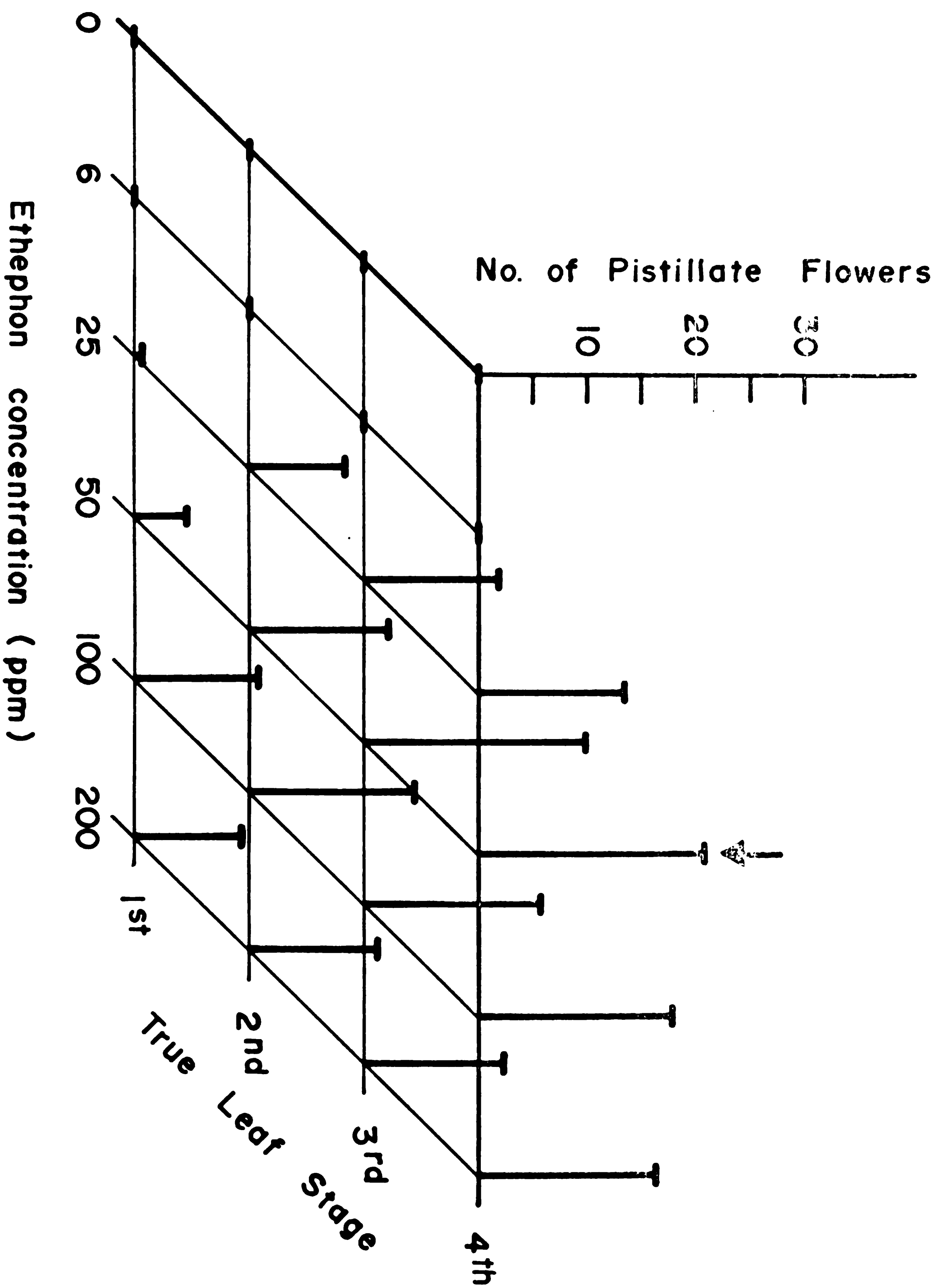
The number of pistillate flowers increased with each stage for each concn of ethephon (Figure 2). A bell shaped response was obtained within each stage with increasing concn. The greatest number of pistillate flowers (20.8) was induced with 50 ppm applied at the 4 leaf stage (indicated by the arrow). The higher concn, 100 and 200 ppm, caused blind nodes and, therefore, fewer total pistillate flowers. Conversely, a concomitant decrease in the total number of staminate flowers between each stage for each concn of ethephon was observed.

Figure 1. The effect of ethephon on the number of pistillate nodes in an androecious line of cucumber.



No. of Pistillate Nodes
10
20
Ethephon concentration (ppm)
0
6
25
50
100
200
1st
2nd
3rd
4th
True Leaf Stage

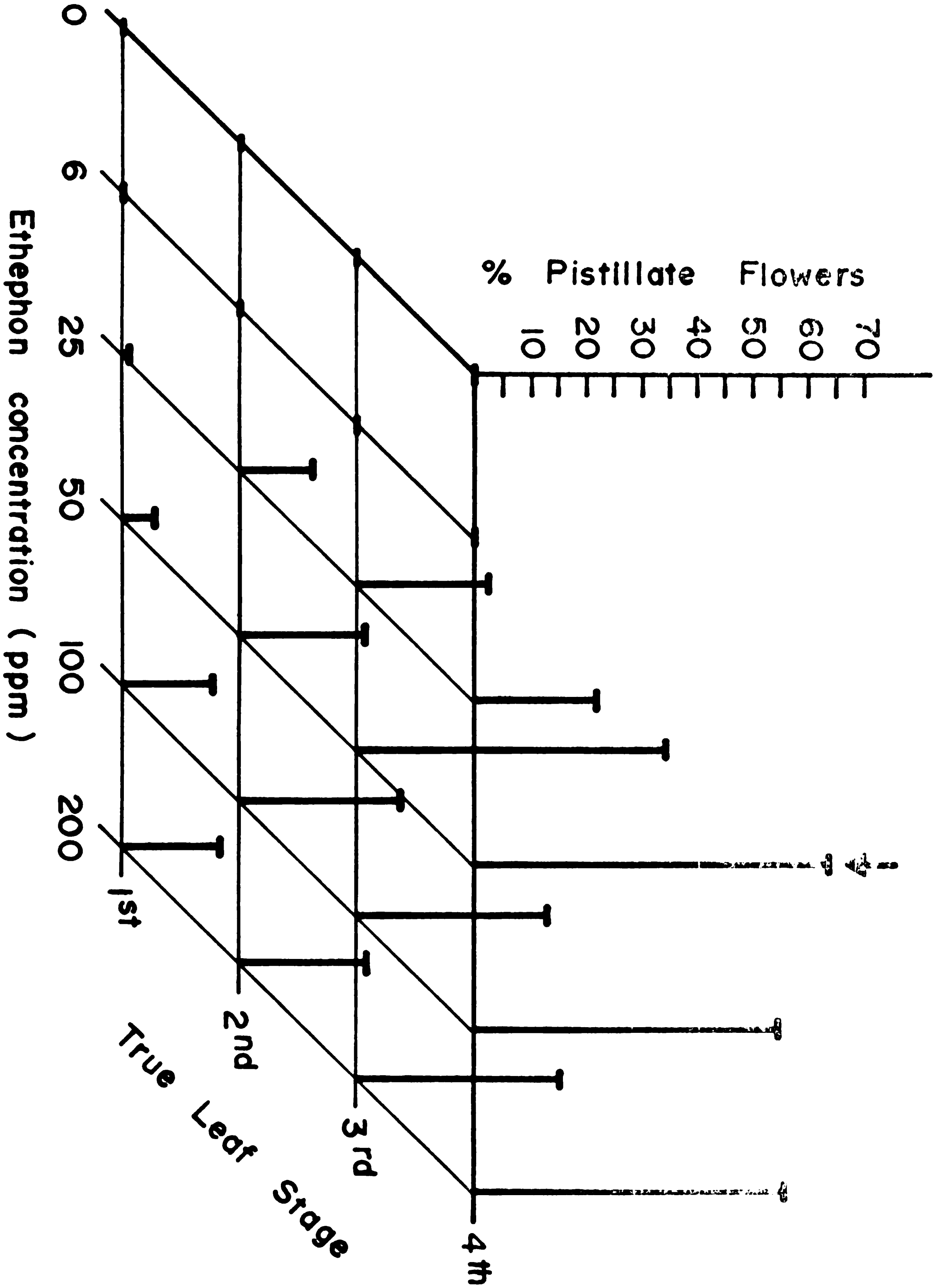
Figure 2. The effect of ethephon on the number of pistillate flowers in an androecious line of cucumber.


No. of Pistillate Flowers
10
20
30
0
6
25
50
100
200
Ethephon concentration (ppm)
1st
2nd
3rd
4th
True Leaf Stage

There was a general decrease within each stage with increased concn with the exception of 50 ppm which gave the greatest reduction when applied at the 3 (15.9) and 4 (11.8) leaf stage. This decrease in staminate flower numbers resulting from ethephon treatment agrees with Rudich et al. (27).

An increase in percent pistillate flowers was seen between stages for each concn of ethephon (Figure 3) except 25 ppm applied at the 4 leaf stage. Generally there is a bell shaped response within each stage with an increase in concn with the exception of the 1 leaf stage which exhibited a linear increase over all concn. The greatest percent of pistillate flowers was obtained with 50 ppm applied at the 3 (56.1%) and 4 leaf (63.9%) stages. Plant height decreases with the increase in stage of growth for each ethephon concn and within stages with increase in concn. So, the greater the concn and the later it was applied the greater the inhibition of growth. Increased development of secondary laterals was also noted with applications of 200 ppm ethephon.

Figure 3. The effect of ethephon on the percent pistillate flowers in an androecious line of cucumber


% Pistillate Flowers
10
20
30
40
50
60
70
0
6
25
50
100
200
Ethephon concentration (ppm)
1st
2nd
3rd
4th
True Leaf Stage

SUMMARY AND CONCLUSION

The optimum concn of ethephon for maximum pistillate flower production was 50 ppm. The stage of application was critical; the application of 50 ppm at the 3 to 4 leaf stage resulted in twice the pistillate flower production than at the 2 leaf stage. Application in the 3 leaf stage gave less inhibition of growth, but in the 4 leaf stage resulted in a greater percentage of pistillate flowers. In conclusion, ethephon, an ethylene releasing compound, caused a reversion in sex expression from staminate to pistillate flowers in an androecious line of cucumber. Whether this effect was related to auxin, gibberellin, or ethylene, *per se*, is not known.

LITERATURE CITED

1. Atsmon, D., A. Lang, and E. N. Light. 1968. Contents and recovery of gibberellins in monoecious and gynoecious cucumber plants. Plant Physiol. 43:806-810.

2. Bukovac, M. J. and S. H. Wittwer. 1961. Gibberellin modification of sex expression in Cucumis sativus L. Advan. Chem. Ser. 28:80-88.

3. Byers, R. E., L. R. Baker, H. M. Sell, R. C. Herner, and D. R. Dilley. 1972. Ethylene: A natural regulator of sex expression of Cucumis melo L. Proc. Nat. Acad. Sci. (US) 69(3):717-720.

4. Cantliffe, D. J. and R. W. Robinson. 1971. Response of cucumber to soil application of (2-chloroethyl) phosphonic acid. HortScience 6(4):336-337.

5. Connor, L. J. and E. C. Martin. 1971. Staminate-pistillate flower ratio best suited to the production of gynoecious hybrid cucumbers for machine harvest. Hort-Science 6(4):337-339.

6. Cooke, A. R. and D. J. Randall. 1968. Induction of flowering by 2-haloethanephosphonic acid. Nature 218:974.

7. Galun, E. 1959. Effects of gibberellic acid and naphthaleneacetic acid on sex expression and some morphological characters in the cucumber plant. Phyton (Buenos Aires) 13:1-8.

8. ________, Y. Jung, and A. Lang. 1963. Morphogenesis of floral buds of cucumber in vitro. Nature 194:596-598.

9. ________, S. Izhar, and D. Atsmon. 1965. Determination of relative auxin content in hermaphrodite and andro-monoecious Cucumis sativus L. Plant Physiol. 40:321-326.

10. Hayashi, F., D. Boerner, C. E. Peterson and H. M. Sell. 1971. The relative activity of gibberellin in seedlings of gynoecious and monoecious cucumber (Cucumis sativus). Phytochemistry 10:59-62.

11. Hemphill, D. D., Jr., L. R. Baker and H. M. Sell. 1972. Different sex phenotypes of Cucumis sativus L. and C. melo L. and their endogenous gibberellin activity. Euphytica 21:285-291.

12. Heslop-Harrison, J. 1957. The experimental modification of sex expression in flowering plants. Biol. Re. (Cambridge Phil. Soc.) 32:38-90.

13. __________________ and Y. Heslop-Harrison. 1957. Studies on flowering plant growth and organogenesis. II. The modification of sex in Cannabis sativa by carbon monoxide. Proc. Roy. Soc. (Edinburgh) B66:424-434.

14. Ito, H. and T. Saito. 1956. Factors responsible for the sex expression of Japanese cucumber. III. The role of auxin on the plant growth and sex expression. J. Hort. Assoc. (Japan) 27(1):101-110.

15. Karchi, Z. and A. Govers. 1972. Effects of ethephon on vegetative and flowering behavior in cucumber (Cucumis sativus L.). J. Am. Soc. Hort. Sci. 97(3): 357-360.

16. Kubiciki, B. 1969. Investigations on sex determination in cucumber (Cucumis sativus L.) VI. Androecism. Genetica Polonica 10:87-99.

17. Laibach, F. and F. J. Kribben. 1957. Der Einfluss von Wuchsstoff auf die Bildung mannlicher und weiblicher Bluten bei einer monezischen Pflanze. Ber. Deut. Bot. Ges. 62:53-55.

18. McMurray, A. I. and C. H. Miller. 1968. The effect of 2-chloroethanephosphonic acid (ethrel) on the sex expression and yield of Cucumis sativus L. J. Am. Soc. Hort. Sci. 94:400-402.

19. Mitchell, W. D. and S. H. Wittwer. 1962. Chemical regulation of sex expression and vegetative growth in Cucumis sativus L. Science 136:880-881.

20. Naugoljnyh, V. N. 1955. Changing the sex character in cucumber to increase their productivity. Botan. Zh. 40:715-719.

21. Nitsch, J. P. 1965. Physiology of flower and fruit development. Encyl. Plant Physiol. 15(1):1537-1647.

22. Peterson, C. E. and L. Anhder. 1960. Induction of staminate flowers on gynoecious cucumbers with gibberellin A_3. Science 131:1673-1674.

23. Pike, L. M. and C. E. Peterson. 1969. Gibberellin A_4/A_7 for induction of staminate flowers on the gynoecious cucumber (Cucumis sativus L.) Euphytica 18:106-109.

24. __________ and W. A. Muldey. 1971. Use of hermaphrodite cucumber lines in development of gynoecious hybrids. HortScience 6(4):339-340.

25. Robinson, R. W. and S. Shannon, M. D. deLaGuardia. 1969. Regulation of sex expression in the cucumber. BioScience 19(2):141-142.

26. Rodriquiez, B. P. and V. N. Lambeth. 1972. Synergism and antagonism of gibberellin and growth inhibitors on growth and sex expression in cucumber. J. Am. Soc. Hort. Sci. 97(1):90-92.

27. Rudich, J. A.,H. Halevy, and N. Kedar. 1969. Increase in femaleness of three cucurbits by treatment with Ethrel, an ethylene releasing compound. Planta (Berl.) 86:69-76.

28. ____________, N. Kedar, A. H. Halevy. 1970. Changed sex expression and possibilities for F_1-hybrid seed production in some cucurbits by application of Ethrel and Alar (B-995). Euphytica 19:47-53.

29. Warner, H. L. and A. C. Leopold. 1969. Ethylene evolution from 2-chloroethylphosphonic acid. Plant Physiol. 42:156-158.

SECTION II

EFFECTS OF A BENZOTHIADIAZOLE AND ETHEPHON ON SEX EXPRESSION OF CUCUMBER, *CUCUMIS SATIVUS* L.

ABSTRACT

The effects of 5-methyl-7-chloro-4-ethoxycarbonylmethoxy-2, 1, 3-benzothiadiazole (MCEB), a proposed inhibitor of ethylene action, and ethephon (an ethylene releasing compound) on sex expression were observed in androecious and gynoecious phenotypes of cucumber (Cucumis sativus L.). MCEB had no effect in the androecious line while ethephon (50 ppm) induced pistillate flowers. The effect of MCEB on ethephon treatment was a marked reduction in the number of ethylene-induced pistillate flowers except when there was a 48 hr period between applications of MCEB and ethephon. This suggests that after 48 hr the MCEB is inactive and the ethylene effect is not reversible with MCEB. In the gynoecious phenotype, MCEB (75 ppm) induced staminate flowers, ethephon had no effect, and the effect of MCEB on ethephon treatment was staminate flower production (nonsignificant) at relatively high concn of MCEB (150 ppm). These results further substantiate the role of ethylene in female sex expression and of MCEB as an inhibitor of ethylene action.

INTRODUCTION

Ethylene *per se* has been associated with increased femaleness in cucurbits (4, 5). Thus, endogenous levels of ethylene are higher in the gynoecious phenotype of cucumber than in the monoecious (4, 5) and the exogenous application of ethephon, an ethylene releasing compound, induces pistillate flowers on an androecious (all-male) phenotype of cucumber (1). Ethylene was demonstrated to be a natural regulator of sex expression by growing a gynoecious phenotype of muskmelon under hypobaric ventilation for removal of endogenous gases by diffusion, with a resulting induction of perfect flowers (4). Another method for the study of ethylene in sex expression was the chemical inhibition of ethylene action. The chemical, 5-methyl-7-chloro-4-ethoxycarbonylmethoxy-2, 1, 3-benzo-thiadiazole (MCEB), was reported to be an apparent inhibitor of ethylene action when foliar applications on tomato plants prevented 2,4-D induced epinasty (6); epinasty presumably caused by ethylene production (2). MCEB has also been reported to induce perfect flowers on gynoecious muskmelon (3) and staminate and perfect flowers on gynoecious cucumber (4). This study attempted to determine if MCEB inhibits ethylene action in sex expression of cucumber by observing the effects of ethephon and MCEB on androecious (all-male) and gynoecious (all-female) phenotypes and to determine the concn of MCEB necessary for induction of staminate flowers on gynoecious cucmber.

MATERIALS AND METHODS

Seed of USSR 1, an androecious line obtained from Dr. E. T. Mescherov, All-Union Institute of Plant Industry, Leningrad, USSR, and 713-5, a gynoecious line, were planted March 24, 1972. The seeds were sown in soil in 6.25 cm peat pots and grown in a greenhouse with supplemental fluorescent lighting at 24° C during the night (10 hr) and 29° C during the day (14 hr). Plants were transplanted to 15 cm clay pots after 15 days with two single plant replicates in a completely randomized factorial design. They were treated at the 3 to 4 leaf stage (1) with freshly prepared solutions of 0 and 50 ppm ethephon and 0, 25, 75, 150, and 300 ppm MCEB. Two orders of application (ethephon then MCEB and the reverse) at each concn were sprayed 0, 3, 12, and 48 hr apart. Both materials were applied as aqueous solutions to the foliage with an atomizer until run-off. Flowers were classified for sex expression through the 20th node and height was also measured through the 20th node. Statistical analysis of the data was analyzed using Tukey's Multiple Comparison Test. No significant differences existed between order of application of ethephon and MCEB; therefore, the data were presented as means of four replicates in Tables 1 and 3 with the mean for 0 ppm ethephon representing one random observation for each time interval.

RESULTS AND DISCUSSION

Androecious phenotype. As expected, MCEB applied in the absence of ethephon resulted in no significant differences for any of the variables observed; viz., number of pistillate flowers, number of staminate flowers, percent pistillate flowers, and plant height (Table 1).

Ethephon (50 ppm) applied in the absence of MCEB at 0, 3, 12, and 48 hr intervals induced 18.5, 19.6, 17.4, and 18.3 pistillate flowers per 20 nodes, respectively. There were 22.8, 24.9, 22.1, and 24.4 percent pistillate flowers for 0, 3, 12, and 48 hr intervals, respectively. For these time intervals and this concn of ethephon, there were no significant differences in either femaleness or plant height.

The effect of MCEB (5, 25, 75, 150, and 300 ppm) on ethephon treatment (50 ppm) was observed as a marked reduction in the number of induced pistillate flowers and percent pistillate flowers for the first three time intervals (0, 3, and 12 hr) but not in the fourth (48 hr). For a given time interval there were no significant differences observed for different concn of MCEB; that is, all concn of MCEB were equally effective in negating the action of ethephon (ethylene). MCEB reversed ethephon (ethylene) action with the lower concn at the 0 and 3 hr intervals. However, at the 12 hr. interval almost complete reversal occurred regardless of the MCEB concn. When 48 hr was the time interval between

Table 1. Effect of ethephon and MCEB on an androecious line of cucumber.[z]

Ethephon concn (ppm)	Time (hr)	MCEB concn (ppm)	No. of pistillate flowers	No. of staminate flowers	Percent pistillate flowers	Plant height (cm)
0	0-48	0	0.0 e	120.6 ab	0.0 e	117.1 a
		5	0.0 e	119.0 ab	0.0 e	121.4 a
		25	0.0 e	116.0 ab	0.0 e	111.8 a
		75	0.0 e	128.5 a	0.0 e	85.9 abc
		150	0.0 e	122.5 a	0.0 e	78.7 abc
		300	0.0 e	86.5 abc	0.0 e	80.8 abc
50	0	0	18.5 ab	62.5 abcd	22.8 abc	109.0 ab
		5	0.0 e	100.0 abc	0.0 e	110.0 ab
		25	1.0 de	85.0 abc	1.2 de	85.9 abc
		75	3.3 cde	88.0 abc	3.6 bcde	84.6 abc
		150	6.5 cde	97.3 abc	6.3 abcde	87.6 abc
		300	2.5 de	56.5 abcd	4.2 abcd	53.3 abcd
	3	0	19.6 a	59.2 abcd	24.9 a	106.2 ab
		5	1.0 de	120.8 ab	0.8 e	106.7 ab
		25	1.3 de	100.8 abc	1.3 de	111.3 a
		75	3.3 cde	104.0 abc	3.1 cde	60.5 abcd
		150	4.3 cde	80.5 abcd	5.1 abcde	52.1 abcd
		300	2.8 de	27.5 cd	9.2 abcde	19.8 cd
	12	0	17.4 ab	61.4 abcd	22.1 abcd	103.1 ab
		5	0.0 e	105.3 abc	0.0 e	111.3 a
		25	1.0 de	122.0 abc	0.8 de	104.1 ab
		75	0.3 e	107.3 abc	0.3 e	87.6 abc
		150	0.3 e	94.5 abc	0.3 e	69.9 abc
		300	0.0 e	.0.0 d	0.0 e	0.0 d

Table 1., cont.

Ethephon concn (ppm)	Time (hr)	MCEB concn (ppm)	No. of pistillate flowers	No. of staminate flowers	Percent pestillate flowers	Plant height (cm)
	48	0	18.3 ab	56.8 abcd	24.4 ab	109.5 ab
		5	16.8 ab	59.3 abcd	22.1 abcd	97.3 ab
		25	8.3 bcde	86.5 abc	8.8 abcde	94.0 ab
		75	13.3 abc	42.3 abcd	23.9 abc	74.9 abc
		150	11.3 abcd	67.5 abcd	14.3 abcde	71.1 abc
		300	9.5 bcde	30.5 cd	23.8 abc	40.1 bcd

[z]Means within columns with common letters did not differ significantly at the 1% level by Tukey's Multiple Comparison Test.

applications, MCEB appeared to be inactive when applied prior to ethephon and when MCEB was applied after ethephon, MCEB did not appear to reverse the ethephon effect.

Means of the number of staminate flowers were not significantly different with applications at different time intervals or at different concn of MCEB, except the phytotoxic concn of 300 ppm. The trend was a greater reversion to staminate flowers with 5 and 25 ppm MCEB. There were no plant height differences between time intervals of application, but a linear decrease resulted with increasing concn, 300 ppm being phytotoxic, sometime causing death.

Gynoecious phenotype. In the absence of ethephon, MCEB (75 ppm) induced a significant number of staminate flowers (16.8) in the gynoecious line of cucumber over all time intervals observed (Table 2). This caused a significant reduction in the percent (53.7) of pistillate flowers. At 300 ppm MCEB a significant reduction in number of pistillate flowers (8.5) was caused by a significant reduction in plant height (55.4%).

As expected, ethephon (50 ppm) had no effect on any of the variables observed (Table 3).

Overall, few significant differences were observed with MCEB on ethephon (50 ppm) treatment. The only significant effect of MCEB on ethephon treatments on number of pistillate flowers was a reduction using 300 ppm with 48 hr between applications. This was attributed to a significant reduction

Table 2. Effect of MCEB on a gynoecious line of cucumber.[z]

MCEB concn (ppm)	No. of pistillate flowers	No. of staminate flowers	Percent pistillate flowers	Plant height (cm)
0	18.1 a[y]	0.0 b	100.0 a	97.8 a
5	17.8 a	0.0 b	100.0 a	89.7 a
25	20.0 a	2.0 b	90.9 a	88.4 a
75	19.5 a	16.8 a	53.7 b	80.0 a
150	15.3 ab	3.0 b	83.6 a	52.8 b
300	8.5 b	0.3 b	96.6 a	16.0 b

[y]Means of four replicates of four plants.

[z]Means within columns with common letters did not differ significantly at the 1% level by Tukey's Multiple Comparison Test.

Table 3. Effect of ethephon and MCEB on a gynoecious line of cucumber.[z]

Ethephon concn (ppm)	Time (hr)	MCEB concn (ppm)	No. of pistillate flowers	No. of staminate flowers	Percent pistillate flowers	Plant height (cm)
0	0-48	0	17.8 abc	0.0	100.0 a	95.8 a
		5	18.4 abc	0.0	100.0 a	89.4 ab
		25	19.7 abc	2.2	90.0 ab	85.1 ab
		75	20.3 abc	15.7	56.4 b	80.3 abc
		150	14.9 abc	3.1	82.8 ab	62.7 abcde
		300	7.8 bc	0.5	94.0 ab	40.1 bcde
50	0	0	17.5 abc	0.0	100.0 a	89.7 ab
		5	18.3 abc	0.0	100.0 a	94.0 a
		25	16.8 abc	4.8	77.8 ab	82.0 abc
		75	18.5 abc	0.0	100.0 a	80.8 abc
		150	20.8 abc	15.0	58.1 ab	78.7 abc
		300	5.5 c	0.0	100.0 a	19.8 e
	3	0	18.2 abc	0.0	100.0 a	92.5 a
		5	17.0 abc	0.0	100.0 a	90.9 ab
		25	19.5 abc	0.3	98.5 ab	89.7 ab
		75	20.3 abc	0.8	96.2 ab	77.0 abcd
		150	15.0 abc	1.5	90.9 ab	56.6 abcde
		300	14.8 abc	2.5	85.6 ab	41.4 bcde
	12	0	17.1 abc	0.0	100.0 a	88.4 ab
		5	17.5 abc	0.0	100.0 a	101.6 a
		25	19.0 abc	0.8	96.0 ab	85.9 ab
		75	25.3 a	4.0	86.4 ab	85.1 ab
		150	21.8 abc	4.3	83.5 ab	78.7 abcd
		300	12.0 abc	0.3	97.6 ab	33.0 cde

Table 3, cont.

Ethephon concn (ppm)	Time (hr)	MCEB concn (ppm)	No. of pistillate flowers	No. of staminate flowers	Percent pistillate flowers	Plant height (cm)
	48	0	17.7 abc	0.0	100.0 a	90.2 ab
		5	14.3 abc	0.2	98.6 ab	100.3 a
		25	17.3 abc	3.0	85.2 ab	81.3 abc
		75	25.3 a	2.0	92.7 ab	52.1 abcde
		150	22.8 ab	12.0	65.5 ab	68.1 abcde
		300	8.8 bc	0.0	100.0 a	28.7 de

[z]Means within columns with common letters did not differ significantly at the 1% level by Tukey's Multiple Comparison Test.

in growth. The gynoecious cucmber has a high level of endogenous ethylene (4, 5) and the biologically active concn of MCEB needed for inhibition of ethylene may be phytotoxic for other plant processes and growth. Staminate flower production (nonsignificant) occurred at relatively higher concn of MCEB (150 ppm) than when MCEB (75 ppm) was applied in the absence of ethephon. A linear decrease in plant height was observed for each time interval but no significant differences existed between time intervals.

SUMMARY AND CONCLUSION

In the androecious line of cucumber, MCEB in the absence of ethephon had no effect on sex expression. Conversely, ethephon (50 ppm) in the absence of MCEB induced pistillate flowers. When MCEB was added a marked reduction in the number of ethephon-induced pistillate flowers resulted. In the gynoecious phenotype, MCEB (75 ppm) in the absence of ethephon induced staminate flowers, ethephon in the absence of MCEB had no effect, and the effect of MCEB on ethephon treatment was staminate flower production (nonsignificant) at relatively high concn of MCEB (150 ppm). In conclusion, MCEB and ethephon treatments demonstrated the inhibitory effect of MCEB on ethylene action, which in turn substantiates the role of ethylene in female sex expression in cucumber.

LITERATURE CITED

1. Augustine, J. J., L. R. Baker, and H. M. Sell. Female flower induction on an all-male (androecious) cucumber, Cucumis sativus L. (In preparation).

2. Burg, S. P. and E. A. Burg. 1968. Role of ethylene in fruit ripening. Plant Physiol. 37:179-189.

3. Byers, R. E., L. R. Baker, D. R. Dilley, and H. M. Sell. 1972. Chemical induction of perfect flowers on a gynoecious line of muskmelon, Cucumis melo L. Hort-Science 7(3):283-284.

4. Byers, R. E., L. R. Baker, H. M. Sell, R. C. Herner, and D. R. Dilley. 1972. Ethylene: A natural regulator of sex expression of Cucumis melo L. Proc. Nat. Acad. Sci. (U.S.) 69(3):717-720.

5. Rudich, J. A., H. Halevy, and N. Kedar. 1972. Ethylene evolution from cucumber plants as related to sex expression. Plant Physiol. 49:998-999.

6. Van Daalen, J. J. and J. Daams. 1970. Substituted aldoxy-carbonyl-methoxy-2, 1, 3-benzothiadiazoles. A new group of synthetic growth regulators. Naturwiss. 8:395.