The Effect of 2-Chloroethanephosphonic Acid (Ethrel) on the Sex Expression and Yields of *Cucumis sativus*[1]

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Abstract. The effect of 2-chloroethanephosphonic acid (ethrel) on the sex expression of pickling cucumbers was studied. Tests to determine concentrations, effect on sex expression, and yield potential were conducted in greenhouse and field situations.

As many as 19 successive pistillate nodes were observed for the treated monoecious cultivar 'SC 23'. The most effective concentrations of ethrel were 120, 180 and 240 ppm for these studies. These rates in single or multiple application resulted in the greatest number of continuous female nodes with the least shortening of internodes. A much lower concentration of 24 ppm had little effect as to stunting and only limited effect on sex conversion. Significant yield increases, as measured by value per acre, were obtained for 3 monoecious cultivars, 'Model', 'SC 23' and 'Chipper', treated with ethrel.

Introduction

Sex expression of *Cucumis sativus* L. is of primary yield importance since only pistillate flowers can ultimately produce fruit. Sex expression has been shown to be influenced by genetic constitution (5, 13, 14, 16) and environmental conditions (1, 3, 4, 8). In addition, various exogenously applied growth regulators have been shown to affect the sex expression of pickling cucumbers. The gibberellins tended to induce staminate flowers on gynoecious cultivars (9, 10, 11, 17) while the application of auxin compounds, notably napthaleneacetic acid, resulted in an increase of pistillate flowers on monoecious lines (18) and increased yields of those lines (1).

A class of compounds known as ethylene inducers, especially the 2-haloethanephosphonic acids, have recently been introduced (2). Preliminary studies with 2-chloroethanephosphonic acid (ethrel) showed an effect on the sex expression and yield of pickling cucumbers (7). Other workers (12, 15) have reported that ethrel promoted femaleness in cucumbers. Additional studies revealed that higher concentrations, 480 ppm and above, resulted in severe stunting whereas a concentration of 24 ppm was relatively ineffective (6).

The objective of this study was to broaden the knowledge of the effect of 2-chloroethanephosphonic acid on the sex expression of cucumber and to evaluate the use of this chemical in increasing yields of monoecious lines grown for pickling.

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Materials and Methods

All tests were conducted using ethrel of the 66-329 formulation manufactured by Amchem Products, Inc., Ambler, Pennsylvania. Concentration levels of the chemical were 0, 24, 120, 180 or 240 ppm in single or multiple applications, depending on the test involved. Chemical applications were made to the point of run-off with a pressurized hand sprayer when the first true leaf was 2–4 cm in diameter. Several hundred untreated monoecious plants were grown nearby to assure an adequate supply of pollen.

Monoecious cultivars used in the various studies were 'Model', 'Chipper', 'SC 19' and 'SC 23'. The gynoecious cultivar 'Southern Cross' was utilized in one study.

In greenhouse studies staminate and pistillate flowers were counted daily during the blooming period. In the field, nodes were classified as being either staminate or pistillate according to the type of flower produced.

Greenhouse plantings were made on raised beds with trellised plants spaced 15 by 20 inches. Field plantings were in rows 4 or 5 ft apart and of varying length and planting density of 4 and 6 inches respectively between plants.

Field trials for sex ratio studies utilized plots 8 ft long with 10 plants per plot. Ethrel concentrations of 0, 120, 180 and 240 ppm were applied once, twice or 4 times.

The first field yield trial utilized single-row plots 40 ft long with 120 plants per plot. Two applications of

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by differences between fruit from a single plant. This variation could be due to differences in fruit maturity, the position of the fruit on the plant, and random variation. The values in Table 8 were calculated from the *Drosophila* resistance values of 15 fruit harvested simultaneously from individual 'Roma' plants. The relative standard deviations or coefficients of variation for the 14 plants ranged from 27.4% to 90.7% and averaged 48.9%.

Since the average number of eggs per fruit were highly correlated with the standard deviations, we made a log transformation of the data. Coefficients of variation calculated from the transformed data ranged from 4.69% to 32.69%. Thus, transforming the data greatly reduced the coefficients of variation, but they were still quite large. Another reason for using a log transformation is that we were only interested in small differences at the low end of the scale and not at the upper end. For example, if the average number of eggs laid per fruit is 50, a difference of ± 30 is very important; but if the mean is 200, a difference of 30 makes little practical difference.

The amount of variation encountered makes it necessary to replicate many times when testing for *Drosophila* resistance. We have obtained statistically significant differences with as few as 8 fruits per line, thus for preliminary screening of material that is nearly homozygous, 8 to 12 replications may be satisfactory. However, for more precise studies, it may be desirable to use 16 or more replications.

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ethrel at 240 ppm were made at a 48-hr interval. Plants were harvested 12 times on a 3-times-per-week basis from June 12 through July 8, 1968.

In a second yield trial single-row plots 30 ft long with 60 plants were used. Three applications of the chemical at 120 ppm were made at the following intervals: first true leaf 2–4 cm in diameter, 96 hr later and again 8 days later when plants were at the 6- to 8-true-leaf stage. Plots were harvested 9 times on a twice-a-week basis from August 16 through September 13, 1968.

The size grades and prices for the reported cucumber data were those recognized by North Carolina pickle packers, as follows: No. 1, up to 1 1/16 inches in diameter, $7 per cwt; No. 2, 1 1/16 inches, $3.50; No. 3, 1½–2 inches, $1.50. Fruit larger than 2 inches in diameter were classified as oversize and assigned no value.

Randomized complete-block designs were used in all trials with 2 replicates for greenhouse trials and 3 or 4 replicates for field trials.

Results and Discussion

The characteristic flowering pattern for untreated 'SC 23' in the greenhouse was pistillate flowers at nodes 3, 9 and 16. The remaining 17 of 20 nodes produced staminate flowers. Staminate-pistillate ratios, calculated from flower counts from 10 plants during a 4-wk period were approximately 10:1 (Table 1). On the other hand, ethrel-treated plants usually produced pistillate flowers at the first 12 to 16 nodes, depending on the concentration of the treatment solution. Further, staminate-pistillate flower ratios of treated plants varied from 1:6 for a single application of 120 ppm to 1:14 for a single application of 240 ppm.

Table 1. The effect of concentration of ethrel on number of staminate and pistillate flowers on cucumber cultivar 'SC 23' in the greenhouse. Totals for 10 plants per treatment.

ppm Ethrel	Staminate	Pistillate	Ratio
0	663	68	9.8:1
24	368	158	2.3:1
120	43	242	1:5.6
240	13	187	1:14.4

Field treatment of the same cultivar of cucumber in the spring indicated that in addition to concentration of ethrel, the number of applications at a given rate also affected the number of pistillate flowering nodes. Supplemental applications of the same concentration of ethrel generally resulted in about 3 additional pistillate nodes beyond those induced by the previous application (Fig. 1). For example, 1, 2 and 4 applications of 120 ppm resulted in 13, 16 and 19 pistillate nodes respectively. Multiple applications with 180 and 240 ppm resulted in similar increases. Untreated plants in this same test averaged 3.5 pistillate nodes, and these nodes were never consecutive.

Treatment of the cultivar 'Model' with 2 applications of ethrel at 240 ppm in the spring of 1968 induced the production of exclusively pistillate nodes for the first 2½ wk of the harvest season and resulted in an increase in the value of the early yield (Table 2). This value represented 47% of the total harvest for the treated plants while those untreated produced 27% of the total during the same period of the harvest season. The value of treated 'Model' compared favorably with that of the 5 highest-yielding gynoecious varieties included in the same trial.

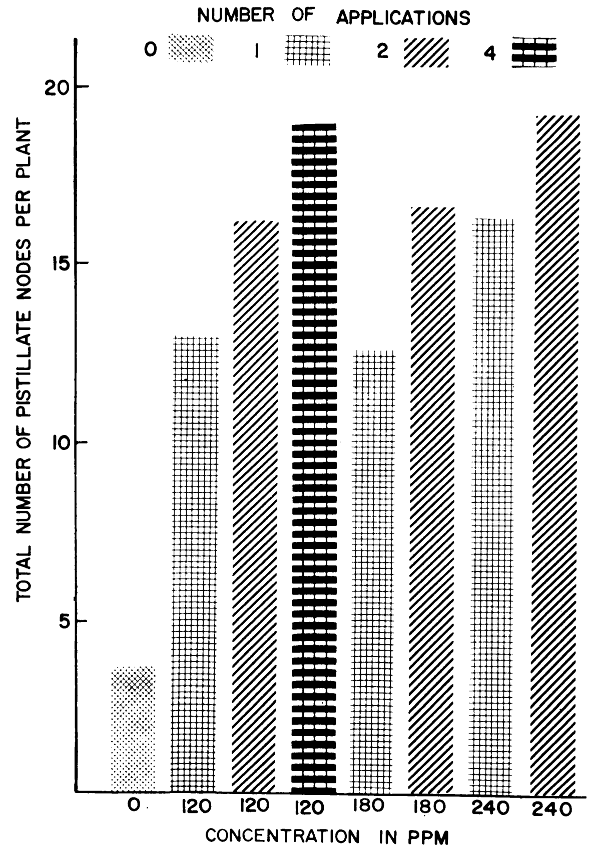

Fig. 1. Effect of concentration and number of applications of ethrel on the total number of pistillate nodes per plant of 'SC 23' cucumbers.

Table 2. The effect of ethrel application on the value and earliness index of the monoecious pickling cucumber 'Model' for 6 and 12 cumulative harvests, spring, 1968.

Treatment		Cumulative harvests		Earliness index[a]
Cultivar	Ethrel	6	12	
		$ *value/acre*		
Model	+	189.78	404.23	47
Model	−	90.06	337.53	27
LSD .05		65.40	115.79	—

[a]Earliness index equals the value for the first 6 harvests divided by the value for all harvests.

In the midsummer trial planted July 9, 2 monoecious cultivars, 'Chipper' and 'SC 23', when treated with 3 applications of 120-ppm ethrel, yielded significantly more, early in the season than the same varieties that were untreated (Table 3). In each case treated plants produced at least 6 percentage points greater yields in the first

Table 3. Yield and earliness index of 4 cultivars of pickling cucumber as influenced by ethrel treatment.

Treatment		Cumulative harvests		Earliness index[a]	Number fruit/acre
Cultivar	Ethrel	4	9		
		$ *value/acre*			*thousands*
Southern Cross	+	405.19	790.43	51	198.7
Southern Cross	−	392.49	700.04	56	180.1
SC 19	+	402.70	849.05	47	168.5
SC 19	−	408.32	865.61	47	158.7
SC 23	+	424.34	756.80	56	196.1
SC 23	−	306.28	637.60	48	156.7
Chipper	+	332.82	663.51	50	166.5
Chipper	−	247.65	565.46	44	134.0
LSD .05		64.19	103.34	—	22.2

[a]Earliness index equals the value for the first 4 harvests divided by the value for all harvests.

portion of the harvest season than did the untreated plants. Both cultivars produced a significantly greater number of fruit per acre when treated with ethrel. The yield, as indicated by value, of the variety 'SC 19' was not significantly affected by ethrel treatment although inspection of the plants showed continuously pistillate nodes on the treated plants and monoecious flowering habit on untreated plants. However, a trend toward increased production was present as treated 'SC 19' produced about 10,000 more fruits per acre than untreated 'SC 19' (Table 3).

The gynoecious hybrid 'Southern Cross' treated with ethrel was delayed approximately 4 days in maturity. The tendency toward increased value and number of fruit per acre by treatment with ethrel was attributed to the conversion of the monoecious pollinator plants to phenotypically gynoecious plants and not to an increase in production of the genotypically gynoecious plants.

While there were no striking fruit-quality differences, the fruit from ethrel-treated plants tended to be slightly shorter, as measured by length-diameter ratios, than those from nontreated plants. This shortening was probably caused by the stress of additional fruit load on the plant.

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