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EFFECT OF CHLORFLURENOL AND NITROGEN FERTILIZATION ON PICKLING CUCUMBER

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ABSTRACT

EFFECT OF CHLORFLURENOL AND NITROGEN FERTILIZATION ON PICKLING CUCUMBER

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"Premier" pickling cucumbers were grown at 120,000 plants/ha on Conover loam soil in 1975. Chlorflurenol at 250 ppm was applied when 5, 7, or 9 female flowers reached anthesis. Nitrogen was applied at 28 and 112 kg/ha. Yield increase (kg/ha and $/ha) was greatest when chlorflurenol was applied early in plant development (5 flower stage). Increased yield was attributable to increased fruit number in the smaller and more valuable size grades with chlorflurenol. Undesirable effects of chlorflurenol were an increase in the number of misshapen fruits and a reduction in the length-diameter ratio. Length-diameter ratio reduction was greater with earlier application of chlorflurenol. Nitrogen rate had no significant effect on yield or frutt shape and did not reduce the undesirable effects of chlorflurenol.

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INTRODUCTION

As a result of labor shortages and higher labor costs, a large percentage of the pickling cucumber crop in Michigan is being once-over destructively harvested by machine. The transition from hand to machine harvest required changes in cultural practices and cultivars. It was reported (9) that the use of new hybrid cultivars and improved production practices increased yield from once-over mechanically harvested cucumbers within the past 5 years. However, production costs have increased over the same period and mechanical harvesting of cucumbers has resulted in only a slight increase in actual net returns to growers (9). With increased production costs, improvement in cucumber yield is needed for growers to obtain an economic return.

In the once-over harvest system for pickling cucumbers, the ability of the plant to produce several fruits simultaneously would increase yield (9). However, continued cucumber fruit set is usually inhibited by seed development in the earliest set fruit and this restricts the development of additional fruit (9,15). Parthenocarpy, either genetic (26), or chemically induced (2, 4, 7, 27) overcomes this inhibition. The application of growth regulators to induce parthenocarpic fruit development in cucumber (2, 10, 23) and in many other crops is possible (14, 28), however, the results are widely varied depending on the crop and the chemical being used (2, 4, 14).

The experimental morphactin "chlorflurenol" (CME-74050) and other auxin transport inhibitors have been reported to induce parthenocarpic fruit development in cucumber and to overcome the inhibition of additional fruit set by the first set fruit (7, 10, 27). Results from previous work on cucumber treated with chlorflurenol usually indicated an increase in percentage of misshapen fruits (9).

The purpose of this study was to investigate the effect of chlorflurenol and nitrogen fertilization level on pickling cucumber yield and quality.

LITERATURE REVIEW

Chlorflurenol is a common name for 2-chloro-9-hydroxyfluorene-9 carboxylic acid (29). This substance and several other derivatives of fluorene-9-carboxylic acid, collectively known as morphactins, have been the subject of scientific and practical interest as representatives of a new type of growth regulator (29, 30). The physiology and performance of these new growth regulators have been critically reviewed (29, 30) and summaries on their possible uses were provided by many authors based on preliminary tests on a world-wide scale (30).

The particular characteristics of morphactins which distinguish them from other synthetic regulators were described by Schneider (29) as follows:

(1) A wide growth regulating concentration range and high tolerance: Experiments have shown that the nontoxic growth regulating concentration range extended over five to seven orders of magnitude depending on the particular derivative concerned. Among growth regulators, this was only equaled by gibberellic acid.

(2) Favorable therapeutic index: The concentration of dosage can be adjusted to suit the purpose of the experiment or of the intended application. With other synthetic regulators, this is usually possible only within relatively narrow limits.

(3) Prolonged action by overdosing: There is a possibility of

regulating not only the intensity but also the duration of the action by an appropriate adjustment of the dosage. By "overloading" the plant, it is possible to achieve prolonged action similar to that of a "depot supply".

(4) Subsidence of action, recovery capability of the plant: The high tolerance and the rapid metabolic degradation of morphactins result in the fact that the treated plants are capable of resuming normal development after a dose-dependent period of inhibition. With morphactins it is possible to achieve both an induction of short-lasting "development impulses" and a prolonged inhibition for general growth control without loss of capability for final recovery of the great majority of species.

(5) Differential spectrum ranges: Morphactins have a broad spectrum of action and vary within wide limits including weeds, grasses, as well as woody species.

It was further mentioned (29) that the action of morphactins is systemic and slow. Modification, inhibition, and sometimes promoting effects are seen only gradually. High concentrations result in dwarfism, whereas low concentrations have a transient effect on shoot growth, branching, and the morphogenesis of new growth subsequent to the treatment. It is because of this fundamental action on the morphogenesis of plants that these new regulators were given the name "morphactins".

Morphactins have been reported to cause inhibition of seed germination and seedling growth (21, 29), stem elongation growth (20, 29), and formation of shoot organs (29). They also abolish the polarity of cell division and apical dominance (29), delay bud break of dormant buds and affect many other phenomena in the vegetative growth of plants (17, 24, 29, 30, 35, 36).

Effects of morphactins on flowering have resulted in improvements and changes in fruit production practices, as they were reported to show promise for fruit thinning, loosening, improvement in quantity and distribution of fruit buds (29, 30, 37, 38). Morphactins have been reported to increase the number of flowers formed in some herbaceous species and fruit trees (30, 34, 37, 38), change the sex of flowering in some monoecious crop species (6, 18, 19), stimulate parthenocarpic fruit set (7, 10, 27, 28), fruit growth, ripening, and abscission (37, 38).

The use of morphactins, particularly chlorflurenol, in cucumber was reported by many workers since the early 1970's (6, 10, 27). Robinson et al. (27) reported that foliar application of chlorflurenol at 100 ppm induced parthenocarpic fruit development in cucumber grown under greenhouse conditions. Compared to other growth regulators, chlorflurenol was most effective in inducing parthenocarpy when applied in the flowering stage. Application of ethephon (2-chloroethyl phosphonic acid) prior to chlorflurenol treatment, enhanced the response of the plant. However, ethephon alone applied to cucumber at anthesis was not effective in inducing parthenocarpy (9). Ethephon only increased the number of pistillate flowers, particularly on monoecious cultivars (3, 8, 9, 16).

Chlorflurenol tested on cucumber grown under field conditions has been reported (9, 10). Cantliffe et al. (10) reported that chlorflurenol at 50 and 100 ppm increased fruit production of both normally pollinated and inadequately pollinated cucumber. Application of ethephon followed by chlorflurenol produced over twice as many fruit as controls when pollen was plentiful, and more than four times as many when pollen supply was limited. It was also reported (9) that chlorflurenol increased the proportion of fruit in the smaller, more valuable size grades, and therefore advantageous for once-over harvesting systems.

Fruit shape has been affected by chlorflurenol treatments. Rudich and Rabinowitch (28) reported that tomatoes treated with chlorflurenol at 5 ppm or higher produced a considerable percentage of deformed fruits. Working with cucumbers, Cantliffe et al. (10) reported that fruit of chlorflurenol treated plants were slightly shorter, particularly in large size grades, but were still commercially acceptable. In their recent report, Cantliffe and Phatak (9) suggested that application of ethephon followed by chlorflurenol will slightly improve fruit shape of pickling cucumber. However, Shannon and Robinson (31) reported that chlorflurenol at 50 and 100 ppm had no detrimental effect on fruit shape of cucumber.

In a once-over harvest system of pickling cucumber production, nutrient conditions were most important to secure a good stand of the plants and maximum yields (25). Nitrogen fertilization particularly was reported to increase fruit yield by forming more pistillate flowers and improved fruit shape (11, 25). Combination treatments of chlorflurenol and nitrogen fertilization on cucumbers would likely improve the quality and quantity of fruit yield.

MATERIAL AND METHODS

Pickling cucumber (cv. Premier) containing 15 percent monoecious pollinator was planted in field plots on Conover loam soil at the Horticulture Research Center, Michigan State University, in 1975. The first crop (spring) was sown on June 10 and the second crop (fall) on July 16. Experimental design was a split-split plot with four replicates. Nitrogen fertilization levels were mainplots, time of chlorflurenol treatments were subplots and chlorflurenol rates were sub-subplots. Fertilizer was disked into the seedbeds at the rate of 28-56-56 kg/ha as the soil was fitted. Plots were 2 m by 8 m with four rows 40 cm apart in each plot. Seeds were sown with a Dahlman seeder using a 5 cm in-row spacing. Following emergence the seedlings were hand thinned to obtain a uniform 120,000 plant/ha density. Chloramben methyl ester at 2.25 kg/ha was applied as a pre-emergence herbicide immediately after planting. Hand weeding kept the plots weed free. Recommended cultural practices were followed throughout the growing season to obtain maximum yields for once-over harvest. An additional 84 kg/ha N (NH_4NO_3) was topdressed on one half the mainplots 10 days after planting.

A single full-coverage spray of chlorflurenol (CME-74050) at 0 and 250 ppm was applied with a CO_2 pressurized hand sprayer when 5, 7, or 9 female flowers reached anthesis. The spray volume was

374 l/ha. Spray solutions were prepared immediately before application using 0.1% Regulaid as a surfactant.

Leaf petiole samples for NO_3-N content analysis were collected randomly 24 hrs after chemical application and repeated at 48 hrs intervals three times. The petioles were rinsed with tap water and dried in a forced air oven at 38°C for 24 hrs. Petiole nitrate content was analysed by the method of Baker and Smith (1).

Plots were hand harvested once when approximately 10% by weight of the cucumber fruits were judged to exceed 5.1 cm in diameter. Fruits were size graded and weighed. Dollar value was computed as follows: dollar value = $132/metric ton size 1 + $66/m.t. size 2 + $44/m.t. size 3 + $22/m.t. size 4. Size 1 fruit are 1.9 to 2.9 cm in diameter, size 2 fruit are 2.9 to 3.8 cm, size 3 fruit are 3.8 to 5.1 cm, and size 4 fruit are those greater than 5.1 cm in diameter. Dollar values were calculated using the pricing system adopted by the Pickling Cucumber Improvement Committee (PCIC), St. Charles, Illinois 60174.

Length-diameter ratio was determined using 20 number 3 size fruits from each plot.

RESULTS

Table 1 shows the fruit yield by size grades as affected by chlorflurenol rate, time of application, and nitrogen fertilization rate for the spring crop. Tables 2, 3, and 4 show the three main effect results.

Chlorflurenol at 250 ppm applied as a single spray on pickling cucumbers at flowering stage significantly increased the fruit yield in the smaller size grades (1A and 1B) and reduced the fruit yield in the larger size grades (2B and 4)(Table 2). The increased yield in small fruits and the decreased yield in large fruits resulted in no significant change in total yield or in the dollar value. Nub and crook fruits were slightly increased due to chlorflurenol treatment, however, the difference was not significant.

Time of chlorflurenol application had a significant effect on fruit yield as shown in Table 3. Earlier application resulted in a greater effect on fruit yield compared to application at the later stage of flowering. This effect was significant in size grades no. 1A, 1B, and 2A. The nub and crook fruits and also the marketable fruits were slightly increased at the five flower stage application. The PCIC dollar value was significantly greater at the earliest application compared to the later applications.

Table 1. Cucumber fruit yield as affected by N fertilization and chlorflurenol treatments in a spring crop.

N fertilization (kg/ha)	No. of flowers at anthesis	Chlorflurenol (ppm)	Yield (100 kg/ha)								
			Grade size								
			1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 - 3	Total
28	5	0	.9	2.6	9.3	11.0	50.1	48.2	4.0	73.9	126.1
		250	2.4	12.9	13.4	10.5	43.5	20.7	6.2	82.7	109.6
	7	0	1.2	3.3	10.5	10.9	52.3	35.4	4.9	78.1	118.5
		250	1.8	9.4	10.2	8.8	46.1	26.9	3.2	76.3	106.4
	9	0	1.7	4.0	10.2	10.6	58.2	37.0	4.6	84.7	126.3
		250	1.2	4.6	8.9	8.0	61.9	51.6	4.7	84.7	141.0
112	5	0	1.5	3.5	8.2	10.7	61.1	52.9	3.8	85.0	141.7
		250	2.6	12.6	15.0	11.5	53.0	22.4	7.6	94.8	124.7
	7	0	1.2	3.1	9.5	11.2	58.1	66.3	4.3	83.2	157.8
		250	1.8	9.6	9.2	6.4	50.0	24.5	4.8	77.0	106.3
	9	0	.7	2.7	9.6	9.4	54.3	48.7	2.2	76.8	127.7
		250	1.8	4.4	6.8	8.8	53.0	47.2	4.1	74.8	126.1

Table 2. Effect of chlorflurenol on cucumber fruit yield and dollar value in a spring crop.

Chlorflurenol (ppm)	Yield (100 kg/ha)									
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1-3	Total	Dollar/ ha (PCIC)
0	*)1.2[a]	3.2[a]	9.6[a]	10.6[a]	55.7[a]	48.1[a]	3.9[a]	80.3[a]	132.4[a]	490[a]
250	1.9[b]	8.9[b]	10.6[a]	9.0[b]	51.2[a]	32.2[b]	5.1[a]	81.7[a]	119.0[a]	534[a]

*)Overall mean values, obtained from plots fertilized with 28 and 112 kg N/ha respectively.

Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test).

Table 3. Effect of time of application of chlorflurenol on cucumber fruit yield and dollar value in a spring crop.

No. of female flowers at anthesis	Yield (100 kg/ha)									
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1-3	Total	Dollar/ ha (PCIC)
5*)	1.9[a**)]	7.9[a]	11.5[a]	10.9[a]	51.9[a]	36.0[a]	5.4[a]	84.1[ab]	125.5[ab]	545[a]
7	1.5[b]	6.3[b]	9.8[b]	9.3[b]	57.6[a]	38.3[a]	4.3[b]	78.6[ab]	121.3[ab]	500[b]
9	1.3[c]	3.9[c]	8.9 [c]	9.2 [b]	56.9[b]	46.1[b]	3.9[b]	80.2[ab]	130.3[ab]	490[b]

*) CFL was applied when indicated number of female flowers reached anthesis.

**) Overall mean values obtained from treated and untreated plots.

Mean values followed by common letters are not significant at 5% level (Duncan's Multiple Range Test).

Table 4. Effect of nitrogen fertilization on cucumber fruit yield and dollar value in a spring crop.

N fertilizer (kg/ha)	Yield (100 kg/ha)									
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 - 3	Total	Dollar/ ha (PCIC)
28	*) 1.5[a]	6.1[a]	10.4[a]	9.9[a]	53.0[a]	36.6[a]	4.6[a]	80.0[a]	121.3[a]	505[a]
112	1.6[a]	6.0[a]	9.7[a]	9.7[a]	52.9[a]	43.6[a]	4.5[a]	81.9[a]	130.1[a]	518[a]

*) Overall mean values obtained from plots treated with chlorflurenol at 0 and 250 ppm respectively.

Mean values in columns followed by common letter are not significant at 5% level

(Duncan's Multiple Range Test).

Nitrogen fertilization had no significant effect on fruit yield. Dollar value was greater at the higher nitrogen fertilization rate compared to that of the lower rate, however, the difference was not significant (Table 4). Nitrate-N content in petioles indicated that plants receiving high nitrogen fertilization contained higher NO_3-N compared to those receiving low nitrogen fertilization, however, the difference was not significant (Table 5 and 6). Chlorflurenol treatment did not significantly influence NO_3-N content in petioles compared to controls.

Interactions occurred among the three main effects as indicated in Table 7. In the first order, significant interactions were observed between rates and time of application of chlorflurenol in size grades no. 1A, 1B, 2A, 4 and in total yield and in dollar value. Interactions between nitrogen fertilization and chlorflurenol rates were not observed, whereas interactions between nitrogen fertilization and time of application of chlorflurenol were significant only in total 1 to 3 size grade fruits. In the second order, interactions among the three main effects were significant only in size grade no. 1A. These interactions indicate that increases in fruit yield and dollar value were primarily the result of chlorflurenol rates and time of application.

Table 5. NO_3-N content in cucumber leaf petioles (percent dry weight) twenty-four hours after chlorflurenol application in a spring crop.

Nitrogen fertilization (kg/ha)	Chlorflurenol (ppm)	No. of flowers at anthesis		
		5	7	9
28	0	*)2.53[a]	2.25[a]	2.17[a]
	250	2.38[a] (2.45)[x**)]	1.78[b] (2.01)[x]	2.13[a](2.15)[x]
112	0	2.58[a]	2.55[a]	2.57[a]
	250	2.65[a] (2.61)[x]	2.57[a] (2.56)[y]	2.48[a](2.52)[x]

*)Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test).

**)Values between brackets indicate means for nitrogen fertilization.

Table 6. NO_3-N content in cucumber leaf petioles (percent dry weight) taken from the five flower stage treatment.

Nitrogen fertilization (kg/ha)	Chlorflurenol (ppm)	Time after treatment(days)		
		1	3	5
28	0	*) 2.53^a	2.27^a	2.17^a
	250	2.38^a $(2.45)^x$ **)	2.10^a $(2.18)^x$	1.95^a $(2.06)^x$
112	0	2.58^a	2.43^a	2.52^a
	250	2.65^a $(2.61)^x$	2.33^a $(2.38)^x$	2.40^a $(2.46)^x$

*) Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test).

**) Values between brackets indicate means for nitrogen fertilization.

Table 7. Statistical significance of main effects and interactions for cucumber yield by weight in a spring crop.

Main effects and their interactions	Grade size									
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total size 1 - 3	Total	Dollar PCIC
N	-	-	-	-	-	-	-	-	-	-
CFL	+	+	-	+	-	+	-	-	-	-
T	+	+	+	-	-	-	-	-	-	+
NXCFL	-	-	-	-	-	-	-	-	-	-
NXT	-	-	-	-	-	-	-	+	-	-
CFLXT	+	+	+	-	-	+	-	-	+	+
NXCFLXT	+	-	-	-	-	-	-	-	-	-

N = Nitrogen rates

CFL = Chlorflurenol rates

T = Time of application

+ = Significant at 5% level

- = Not significant at 5% level

Results of the fall crop in most cases were similar to those of the spring crop. Table 8 shows the distribution of fruits in different size grades. The main effects of chlorflurenol, time of application, and nitrogen fertilization appear in Tables 9, 10, and 11, respectively. Chlorflurenol significantly increased the yield of size 1A, 1B, 2A, and nub and crook fruit (Table 9). Earlier chlorflurenol application produced significantly greater yields in size 1A, 1B, 2A, and nub and crook fruit. Earlier chlorflurenol application also had a greater dollar value (Table 10). Nitrogen fertilization rate had no significant effect on cucumber yield or dollar value (Table 11).

Table 12 shows the effect of chlorflurenol on fruit number per hectare. Chlorflurenol treatment significantly increased fruit number per hectare in size grades no. 1A, 1B, and in the total fruit number.

The effect of time of application on fruit number is shown in Table 13. Chlorflurenol application at the earlier flowering stage resulted in significantly greater fruit number compared to treatments at later stages of flowering. The differences were significant in size grades no. 1A, 1B, 2A, and in total yield. The effect of nitrogen fertilization on fruit number was not significant for any size grades (Table 14).

Table 8. Cucumber fruit yield as affected by N fertilization and chlorflurenol treatments in a fall crop.

N fertilization (kg/ha)	No. of flowers at anthesis	Chlorflurenol (ppm)	Yield (100 kg/ha)								
			Grade sizes								
			1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 - 3	Total
28	5	0	.9	4.7	6.3	7.1	25.6	35.0	4.5	44.6	84.1
		250	2.8	9.6	8.8	7.1	19.0	30.0	9.4	47.3	86.7
	7	0	1.2	3.3	4.7	5.4	21.6	22.6	2.8	36.1	61.5
		250	2.5	6.9	6.6	4.9	23.4	34.1	7.8	44.3	86.2
	9	0	1.3	4.0	4.9	5.5	25.3	25.5	3.8	41.1	70.3
		250	1.1	4.3	6.3	7.9	26.7	41.1	4.4	46.2	91.9
112	5	0	1.0	3.2	5.7	5.9	32.0	41.3	5.1	47.9	94.3
		250	3.2	7.9	9.4	6.2	22.7	28.7	7.1	49.4	85.2
	7	0	.9	3.5	5.6	7.1	31.9	41.0	5.0	48.9	94.8
		250	2.3	4.9	4.6	4.1	24.9	35.7	4.9	40.8	81.3
	9	0	1.3	3.7	5.4	4.9	26.3	35.9	4.1	41.5	81.5
		250	1.3	3.1	4.3	3.9	24.7	28.1	4.7	37.4	70.2

Table 9. Effect of chlorflurenol on cucumber fruit yield and dollar value in a fall crop.

Chlorflurenol (ppm)	(Yield (100 kg/ha)									
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 - 3	Total	Dollar/ ha (PCIC)
0	*) 1.1^a	3.7^a	5.4^a	5.9^a	27.1^a	33.5^a	4.2^a	43.3^a	81.1^a	295^a
250	2.2^b	6.1^b	6.6^b	5.7^a	23.6^a	33.0^a	6.4^b	44.2^a	83.6^a	331^a

*) Overall mean values obtained from plots fertilized with 28 and 112 kg N/ha respectively.

Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test).

Table 10. Effect of time of application of chlorflurenol on cucumber fruit yield and dollar value in a fall crop.

No. of flowers at anthesis	(Yield (100 kg/ha)									
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 - 3	Total	Dollar/ ha (PCIC)
5	*)2.0[a]	6.4[a]	7.6[a]	6.6[a]	24.8[a]	33.7[a]	6.5[a]	47.3[a]	87.6[a]	350[a]
7	1.7[b]	4.6[b]	5.4[b]	5.3[a]	25.4[a]	33.3[a]	5.1[b]	42.5[ab]	80.9[ab]	303[b]
9	1.2[c]	3.8[c]	5.2[b]	5.3[a]	25.8[a]	32.7[a]	4.3[c]	41.5[b]	78.5[b]	286[c]

*)Overall mean values obtained from the treated and untreated plots sprayed when 5, 7, or 9 female flowers reached anthesis.

Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test).

Table 11. Effect of nitrogen fertilization on cucumber fruit yield and dollar value in a fall crop.

N fertilization (kg/ha)	(Yield (100 kg/ha)									
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 - 3	Total	Dollar/ ha (PCIC)
28	*)1.6[a]	5.5[a]	6.3[a]	6.3[a]	23.6[a]	31.4[a]	5.4[a]	43.3[a]	80.1[a]	315[a]
112	1.6[a]	4.4[a]	5.8[a]	5.3[a]	27.1[a]	35.1[a]	5.1[a]	44.3[a]	84.5[a]	311[a]

*)Overall mean values obtained from plots treated with chlorflurenol 0 and 250 ppm respectively.

Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test).

Table 12. Effect of chlorflurenol on cucumber fruit number per ha (1000's) in a fall crop.

Chlorflurenol (ppm)	Grade sizes								
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 - 3	Total
0	*)23.0[a]	27.5[a]	17.2[a]	10.3[a]	23.7[a]	16.4[a]	7.2[a]	101.7[a]	125.3[a]
250	47.7[b]	48.4[b]	21.1[a]	10.7[a]	22.3[a]	17.0[a]	9.3[a]	150.3[b]	176.7[b]

*)Overall mean values obtained from plots fertilized with 28 and 112 kg N/ha respectively.

Mean values in columns followed by common letter are not significant at 5% level

(Duncan's Multiple Range Test).

Table 13. Effect of time of application of chlorflurenol on cucumber fruit number per ha (1000's) in a fall crop.

No. of flowers at anthesis	Grade sizes								
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 -3	Total
5	*) 43.9^{a}	49.2^{a}	23.7^{a}	12.3^{a}	23.2^{a}	17.3^{a}	10.3^{a}	152.2^{a}	179.8^{a}
7	35.1^{b}	36.2^{b}	15.9^{b}	9.6^{a}	22.8^{a}	16.7^{ab}	7.5^{b}	119.6^{b}	143.8^{b}
9	27.0^{c}	28.6^{c}	17.8^{c}	9.6^{a}	23.2^{a}	16.0^{b}	7.1^{b}	106.2^{c}	129.3^{c}

*) Overall mean values obtained from the treated and untreated plots sprayed when 5, 7, or 9 female flowers reached anthesis.

Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test).

Table 14. Effect of nitrogen fertilization on cucumber fruit number per ha (1000's) in a fall crop.

N fertilization (kg/ha)	Grade sizes								
	1A	1B	2A	2B	3	4	Nubs & Crooks	Total size 1 - 3	Total
28	*)35.6[a]	42.1[a]	20.5[a]	11.3[a]	22.1[a]	15.7[a]	8.8[a]	131.7[a]	156.2[a]
112	35.0[a]	33.8[a]	17.8[a]	9.7[a]	24.0[a]	17.7[a]	7.8[a]	120.3[a]	145.8[a]

*)Overall mean values obtained from plots treated with chlorflurenol 0 and 250 ppm respectively.

Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test).

Data for NO_3-N content in petioles appears in Table 15 and Table 16. As in the spring crop, NO_3-N content in petioles was higher in plots receiving higher nitrogen fertilization, however, the difference was not significant. No significant differences in NO_3-N content was apparent due to chlorflurenol treatment (Table 15).

Chlorflurenol significantly reduced the L/D ratio of no. 3 grade fruit when applied at the 5 and 7 flower stage (Table 17). Nitrogen fertilization rate did not influence L/D ratio.

As in the spring crop, interactions occurred among the three main effects. Table 18 and Table 19 show their interactions expressed as fruit yield by weight and by count respectively. As indicated in Table 18, in the first order, significant interactions occurred between chlorflurenol rate and time of application for size grades no. 1A, 1B, and 2A. No significant interactions were observed between nitrogen fertilization and chlorflurenol rate or between nitrogen and time of application of chlorflurenol. In the second order, interactions among the three main effects were not significant in any size grades.

In Table 19, first order interactions were significant between chlorflurenol and time of application for size grades no. 1A, 1B, 2A, nub and crook, total sizes 1 to 3, and total yield. In the second order, interactions among the three main effects were significant only for nub and crook fruits. It can be concluded, therefore, that increases in fruit yield were primarily due to chlorflurenol and time of application.

Table 15. NO_3-N content in cucumber leaf petioles (percent dry weight) twenty four hours after chlorflurenol application in a fall crop.

Nitrogen fertilization (kg/ha)	Chlorflurenol (ppm)	No. of flowers at anthesis 5	7	9
28	*) 0	*) 2.80^a	2.14^a	1.71^a
	250	2.73^a (2.76)^{x}**)	2.09^a (2.11)^x	1.65^a (1.68)^x
112	0	3.01^a	2.40^a	2.11^a
	250	2.98^a (2.99)^x	2.53^a (2.46)^x	2.06^a (2.08)^x

*)Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test)

**)Values between brackets indicate means for nitrogen fertilization.

Table 16. NO_3-N content in cucumber leaf petioles (percent dry weight) taken from the five flower stage treatment.

Nitrogen fertilization (kg/ha)	Chlorflurenol (ppm)	Time after treatment (days)		
		1	3	5
28	0	*) 2.30^{a}	2.16^{a}	2.01^{a}
	250	2.73^{a} $(2.76)^{x}$ **)	2.19^{a} $(2.17)^{x}$	2.20^{a} $(2.10)^{x}$
112	0	3.01^{a}	2.35^{a}	2.21^{a}
	250	2.98^{a} $(2.99)^{x}$	2.45^{a} $(2.40)^{x}$	2.51^{a} $(2.36)^{x}$

*) Mean values in columns followed by common letter are not significant at 5% level (Duncan's Multiple Range Test).

**) Values between brackets indicate means for nitrogen fertilization.

Table 17. Length-diameter ratio of no. 3 grade size cucumber fruit as affected by chlorflurenol treatment in a fall crop.

N fertilization (kg/ha)	Chlorflurenol (ppm)	No. of flowers at anthesis			Mean for Nitrogen
		5	7	9	
28	0	*)2.3^{a}	2.3^{a}	2.3^{a}	
	250	1.9^{b} $(2.1)^{x}$	2.1^{b} $(2.2)^{x}$	2.2^{a} $(2.3)^{x}$	2.2^{m} **)
112	0	2.3^{a}	2.3^{a}	2.3^{a}	
	250	1.9^{b} $(2.1)^{x}$	2.1^{b} $(2.2)^{x}$	2.2^{a} $(2.3)^{x}$	2.2^{m}

*) Effect of chlorflurenol comparison within columns for each nitrogen level, significant at 1% level.

Effect of time of application (within rows), significant at 1% level.

**) Effect of N fertilization, means of the 3 bracketed values, not significant at 5% level.

Table 18. Statistical significance of main effects and interactions for cucumber yield by weight in a fall crop.

Main effects and their interactions	Grade size 1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 - 3	Total	Dollar (PCIC)
N	-	-	-	-	-	-	-	-	-	-
CFL	+	+	+	-	-	-	-	-	-	-
T	+	+	+	-	-	-	+	-	-	+
NXCFL	-	-	-	-	-	-	-	-	-	-
NXT	-	-	-	-	-	-	-	-	-	-
CFLXT	+	+	+	-	-	-	-	-	-	-
NXCFLXT	-	-	-	-	-	-	-	-	-	-

N = Nitrogen rates

CFL = Chlorflurenol rates

T - Time of application

+ = significant at 5% level

- = not significant at 5% level

Table 19. Statistical signficance of main effects and interactions for cucumber yield by fruit count in a fall crop.

Main effects and their interactions	Grade size 1A	1B	2A	2B	3	4	Nubs & Crooks	Total Size 1 - 3	Total	Dollar (PCIC)
N	-	-	-	-	-	-	-	-	-	
CFL	+	+	-	-	-	-	-	+	+	
T	+	+	+	-	-	-	+	+	-	
NXCFL	-	-	-	-	-	-	-	-	-	
NXT	-	-	-	-	-	-	-	-	-	
CFLXT	+	+	+	-	-	-	+	+	+	
NCCFLXT	-	-	-	-	-	-	+	-	-	

N = Nitrogen rates

CFL = Chlorflurenol rates

T = Time of application

+ = Significant at 5% level

- = Not significant at 5% level

DISCUSSION

Foliar application of chlorflurenol (CME-74050) at 250 ppm on pickling cucumber (cv. Premier) at the flowering stage was found to increase the yield of valuable small sized fruits and reduced the yield of the larger, less valuable fruits. In both the spring and fall crops, the effect of the chemical was significant. The chemical was also found to reduce the L/D ratio of the larger fruits and slightly increased the percentage of misshapen fruits. In this study, two levels of nitrogen fertilization were given to the plants and three different dates of chlorflurenol application were employed. Results indicated that the effect of chlorflurenol was much greater than those of nitrogen fertilization. Interactions were found between chlorflurenol and time of application, however, interactions with nitrogen fertilization were not observed.

In both crops, application of chlorflurenol at the five flower stage resulted in the greatest effect on cucumber yield. The yield of 1A and 1B grade fruit was doubled, and yield of 2A increased by 30% over the controls. Yield of no. 4 grade fruit was reduced significantly (Fig. 1 and Fig. 2).

All plots in both crops were planted on the same day and harvested on the same day. Therefore, it is evident that chlorflurenol treatment reduced the rate of growth of the earliest set fruit since

Figure 1. Fruit yield of cucumbers treated with chlorflurenol when 5 female flowers were at anthesis. Planted June 10, 1975.

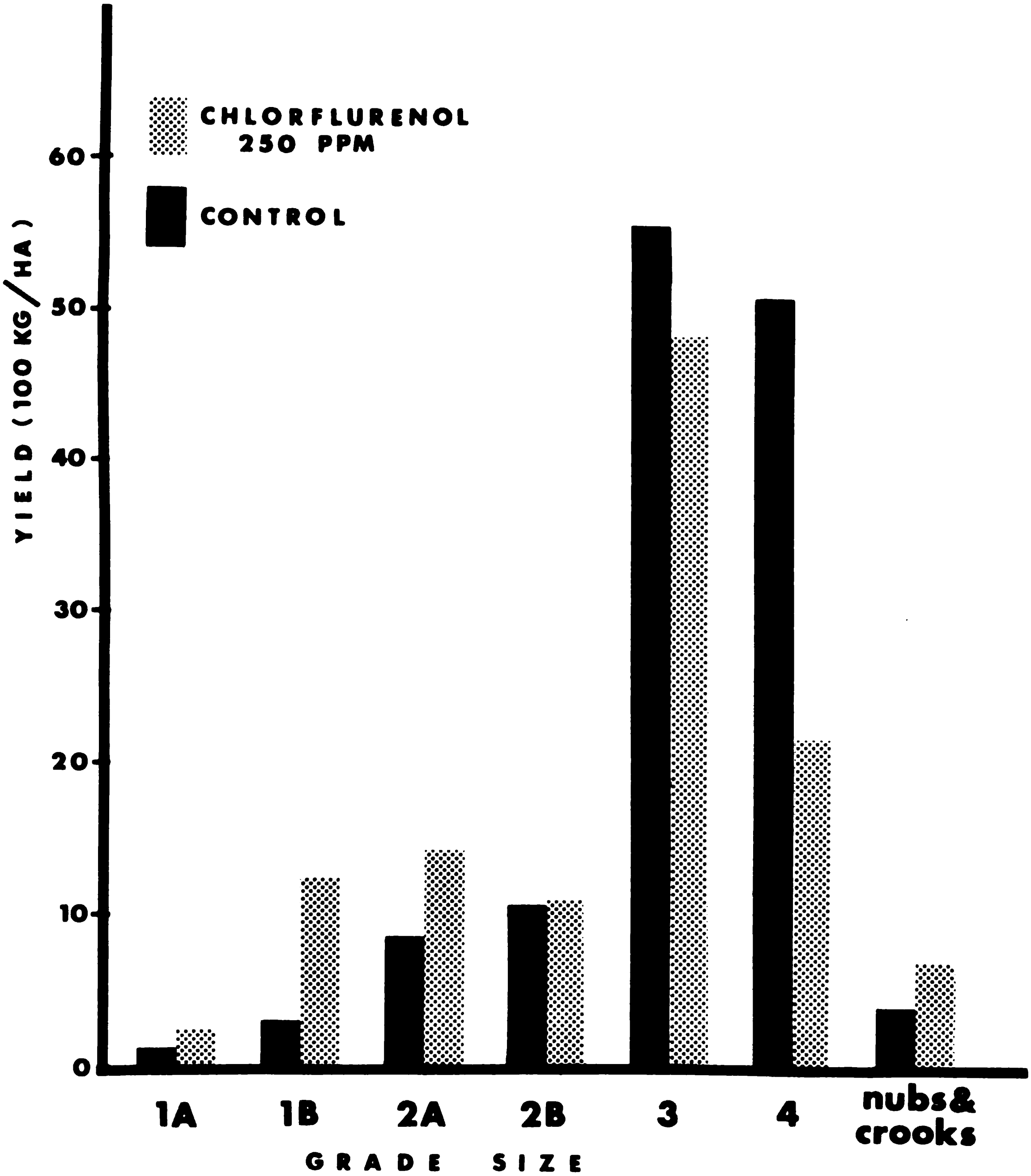

CHLORFLURENOL
250 PPM
CONTROL
YIELD (100 KG/HA)
0
10
20
30
40
50
60
1A
1B
2A
2B
3
4
nubs&
crooks
GRADE SIZE

Figure 2. Fruit yield of cucumbers treated with chlorflurenol when 5 female flowers were at anthesis. Planted July 16, 1975.

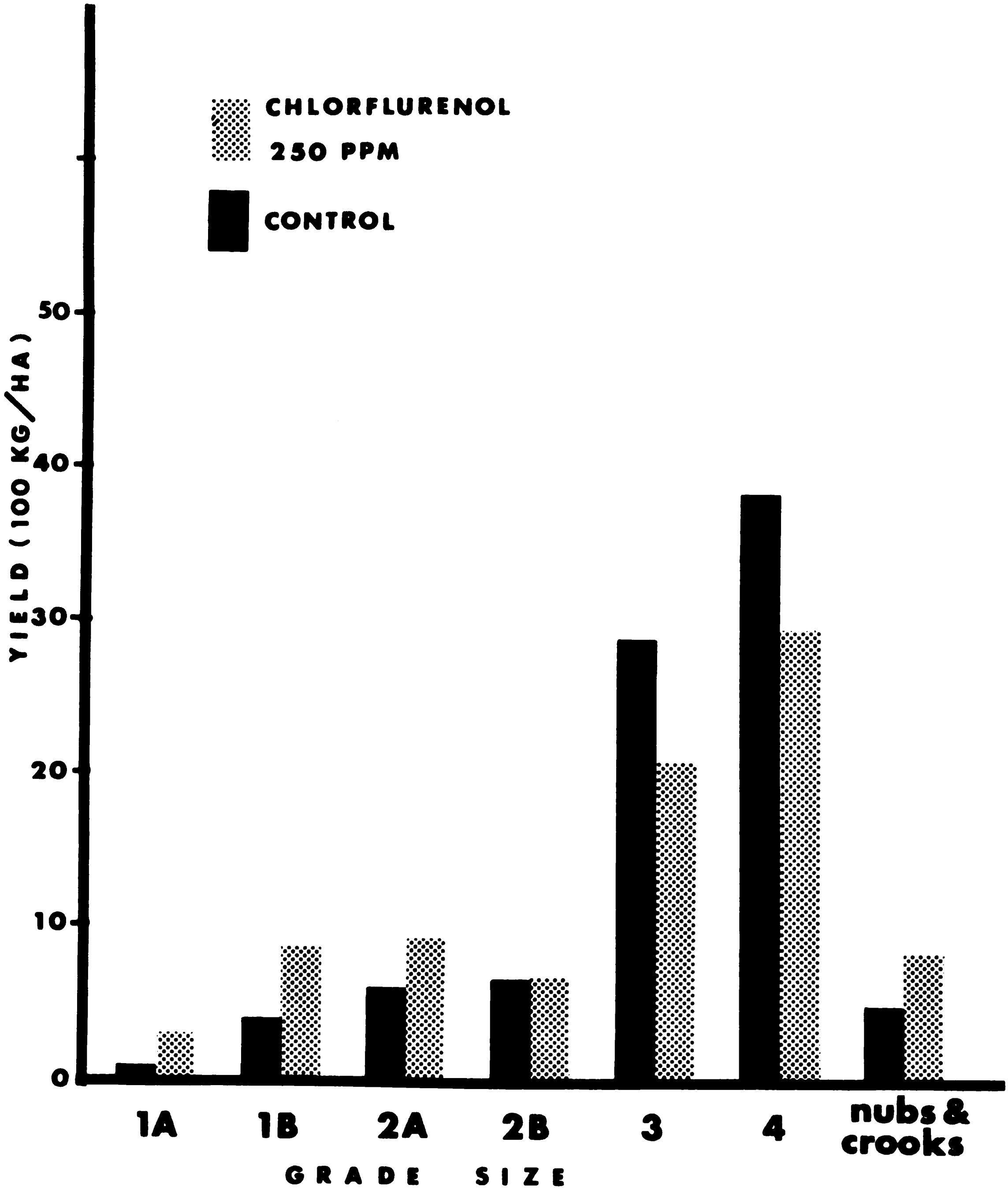
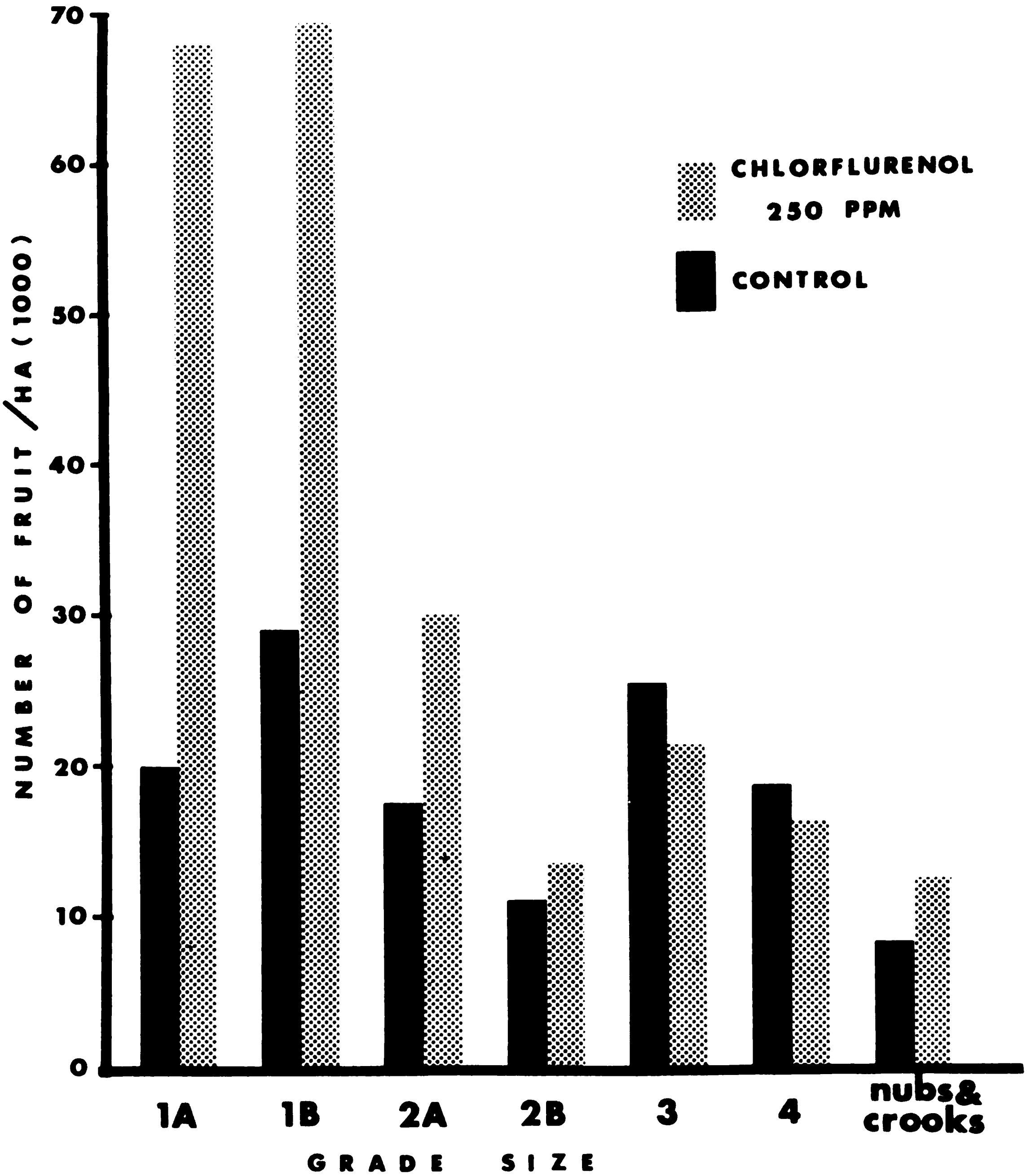

CHLORFLURENOL
250 PPM
CONTROL
YIELD (100 KG/HA)
50
40
30
20
10
0
1A
1B
2A
2B
3
4
nubs & crooks
GRADE SIZE

Figure 3. Number of fruit produced by cucumbers treated with chlorflurenol when 5 female flowers were at anthesis. Planted July 16, 1975.



NUMBER OF FRUIT / HA (1000)
70
60
50
40
30
20
10
0
CHLORFLURENOL
250 PPM
CONTROL
1A
1B
2A
2B
3
4
nubs& crooks
GRADE SIZE

yield of no. 4 fruit was reduced. It has been suggested that the mode of action of chlorflurenol is auxin transport inhibition (2). These results support this explanation of mode of action. Auxin is normally produced in the first set fruit and translocated out of that fruit to prevent development of additional fruit on the cucumber plant (2).

Late application of chlorflurenol at the nine flower stage had less effect than earlier application. This was apparently due to the large size of first set fruit at the time of application and the short interval between chemical application and harvest. First set fruits were 2.5 to 3 cm in diameter at the time of treatment for the nine flower stage of application.

Fruit number produced per hectare indicated that chlorflurenol applied at the five flower stage increased the yield of 1A and 1B grade fruit more than 300%, of 2A grade fruit more than 75%, and of 2B more than 15%, resulting in a total increase of approximately 80% over the controls (Fig. 3). Results from the later applications were less than the above figures, so in this study the five flower stage was the most suitable time for chlorflurenol application to obtain maximum fruit production in the Premier cultivar. Previous work suggested the 6 to 8 flower stage for cvs. Pioneer and Pickmore (9), or to spray the plants 1 to 10 days after anthesis (for cv. Pioneer) (31).

Premier, Pioneer and Pickmore cultivars are predominantly female. Normally the first and sometimes the second flowers are female and then one to four or five male flowers develop on the main stem of the plant before more female flowers are produced. Seed quality and the degree of environmental stresses influence the field sex expression (5, 12). The optimum time for chlorflurenol application and the response to chlorflurenol on these commercial predominantly female cultivars will vary depending upon the sex expression of the plants. An increase in maleness will increase the time from the onset of flowering until five, seven, or nine female flowers are at anthesis. Delay in achieving seven or nine female flowers at anthesis allows the first set fruits to enlarge to the 2.5 to 3.5 cm diameter size and the effect of chlorflurenol on yield is reduced. This occurs since the early crown set fruit enlarge to 5.1 cm in diameter in three to four days after chlorflurenol treatment requiring harvest to avoid a large percentage of oversized, worthless fruit.

Dutch workers (13, 15, 32) have reported large yield increases from chlorflurenol applications on pickling cucumber. Cultivars used were gynoecious and, since no pollen is produced, crown fruit set would not be a problem and timing of chlorflurenol application would be less critical. With no pollen present gynoecious cucumber plants produce a large number of flowers that remain on the plant and may develop parthenocarpically after chlorflurenol is applied.

Timing of chlorflurenol application on predominantly female hybrid cucumbers should probably be based on crown fruit size rather than number of female flowers at anthesis. From data and observations in this research, chlorflurenol application would produce maximum positive yield effects if applied when crown fruits attain 1.5 to 2 cm in diameter.

Chlorflurenol reduced the L/D ratio of no. 3 size fruits. Nitrogen fertilization did not overcome that undesirable chlorflurenol effect on fruit L/D ratio. Application of ethephon prior to chlorflurenol treatments has been reported to lessen the reduction in L/D ratio (9).

Nitrogen fertilization had no significant effect on fruit yield and it was apparent that higher nitrogen rates did not overcome the undesirable effect of chlorflurenol which causes an increase in nub and crook fruits. Controversial results have been reported concerning chlorflurenol and misshapen fruits (9, 31). Reports from the Dutch group (13, 15, 32), using gynoecious cultivars, were that the best results with chlorflurenol treatment were obtained from extremely low rates of nitrogen fertilization. However, low nitrogen rates were used primarily to control vine vigor with the absence of fertilized fruit on the vine.

Chlorflurenol increased the PCIC dollar value in both the spring and the fall crops. The increase was greater with earlier chlorflurenol application. Increases in dollar value were attributable to the higher yields of the smaller size grade fruit. Previous work reported similar results (9).

As a general consideration, in a once-over mechanical harvesting system for cucumbers, application of chlorflurenol at flowering stage increases the fruit yield and dollar value. The yield increase would have been much greater if the cucumber plants were highly female. Also, the optimum time of application would probably be at a later stage of plant development (about 5 to 7 female flowers) since rapid sizing of early set crown fruit would be less of a problem.

SUMMARY AND CONCLUSION

Use of the morphactin "chlorflurenol" in production of pickling cucumbers was tested by field plot experiments in 1975. Plots were 2 by 8 m with four rows 40 cm apart in each plot. Seeds of "Premier" were sown in 4-row beds to provide 120,000 plants/ha. Experimental design was a split-split-plot with four replicates. Nitrogen fertilization levels were mainplots, time of chlorflurenol treatments were subplots, and chlorflurenol rates were sub-subplots. Recommended cultural practices were followed throughout the growing season to obtain maximum yield for once-over harvest.

A single full coverage spray of chlorflurenol at 250 ppm was applied with a CO_2-pressurized hand sprayer when 5, 7, or 9 female flowers reached anthesis. Leaf petiole samples for nitrate nitrogen content analysis were collected at three different times beginning 24 hours after chemical application. Plots were hand harvested once when 10% by weight of cucumber fruits were judged to exceed 5.1 cm in diameter. The PCIC grade sizes and dollar values were used for evaluation of the yields.

Chlorflurenol applied at 250 ppm when 5 female flowers reached anthesis was effective in increasing cucumber yield. Yield by weight and by count of smaller fruits was significantly increased, resulting in more marketable fruits and higher dollar value. Application of chlorflurenol at the later stage of flowering was less effective in increasing yield and dollar value.

Chlorflurenol slightly increased the formation of deformed fruits and reduced the L/D ratio of the fruit. Nitrogen fertilization level did not significantly influence the percentage of deformed fruits or the L/D ratio.

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