Responses of “Little Leaf” vs. Normal Cucumber to Planting Density and Chlorflurenol

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Abstract. Two field experiments were conducted in Bet Hashita (1992) and Newe Ya'ar (1993), Israel, in order to examine the possibility of using plant growth habit, chlorflurenol, and plant population density to concentrate yield of pickling cucumber (*Cucumis sativus* L.) under a simulated once-over mechanical harvest system. Two near-isogenic cucumber lines, WI 1983G normal and WI 1983G little leaf, were grown under three plant densities, 5, 10, and 20 plants/m², and at flowering half of the plants were treated with 50 mg·L⁻¹ chlorflurenol solution. The little leaf line produced a smaller canopy than the normal line under five plants/m² but a larger canopy under 20 plants/m². The average commercial yield of the little leaf line was higher than that of the normal leaf line by 28% and 55% in Bet Hashita and in Newe Ya'ar, respectively. The highest yield of each line was achieved under the highest plant density. The average commercial yields under 20 plants/m² were 1.13 and 0.91 kg·m⁻² in Bet Hashita and 1.86 and 0.92 kg·m⁻² in Newe Ya'ar for little leaf and normal leaf, respectively. Chlorflurenol increased fruit number per unit area but did not increase yield. Nevertheless, it increased the proportion of small fruits, which are more valuable. The present study shows that the little leaf growth habit can increase the yield concentration in pickling cucumber and make this crop more suitable for a once-over mechanical harvest. Chemical name used: methyl-2-chloro-9-hydroxyfluorene-9-carboxylate (chlorflurenol).

Great efforts have been made in recent decades to concentrating harvest time of pickling cucumber to make this crop suitable for a once-over mechanical harvest. Research has focused on breeding, physiology, and production practices. In breeding, the main aim has been to increase gynoecey (Connor and Martin, 1971; El-Shawaf and Baker, 1981). In physiology, research has focused on understanding the mechanism of fruit set and the nature of inhibition of the fruit set by developing fruits (Fuller and Leopold, 1977; Watkins and Cantliffe, 1980). Studies of cultural practices have included the effects of plant population density and arrangement, and the use of plant growth regulators, fertilization, and irrigation (Cantliffe and Phatak, 1975; Ogawa et al., 1990; O'Sullivan, 1980; Tan et al., 1983). Nevertheless, mechanical harvesting of pickling cucumber has remained a minor practice. Johnson and Zahara (1985) estimated that only ≈30% of the total acreage in the United States, and much less elsewhere, was mechanically harvested. Mechanical harvest of pickling cucumber in the United States has declined in recent years (Haffar and Vanee, 1992). The main problem is low yield because

of poor simultaneity of fruit set, and this problem is considerably magnified in places where the processing industry rejects large fruits (diameter >38 mm).

“Little leaf” in cucumber is a unique growth habit, characterized by a leaf blade much smaller than normal (Goode et al., 1980). Published data concerning possible horticultural uses of this characteristic are limited. Cook et al. (1991) found that a wide range of plant densities (59,000–98,000 plants/ha) for once-over mechanical harvest in the little leaf line ‘Ark H-19’ did not affect yield. Andersen (1994) reported that the rate of fruit development in a little leaf line was slower than that of a standard cucumber line.

The main purpose of the present study was to evaluate the capability of little leaf cucumbers, under various production conditions, to produce a concentrated yield suitable for once-over harvest.

Materials and Methods

Two field experiments were conducted to determine the effects of genotype, spacing, and a plant growth regulator on the yield of pickling cucumbers under a simulated once-over harvest. One experiment (1992) was carried out in Bet Hashita (BH) and the other (1993) in Newe Ya'ar (NY) Research Center. Both locations are in the Yizre'el Valley (northern Israel), and only 40 km apart. However, BH, located in the eastern part of the valley, is characterized by much higher temperatures and much lower rainfall.

Plant material. Two nearly isogenic breeding lines, WI 1983 G—normal leaf (NL) and WI 1983 G—little leaf (LL), were kindly donated by Jack E. Staub, Univ. of Wisconsin, Madison. These lines were grown in isolated plots in Newe Ya'ar during Summer 1990 to increase the seed stocks. Both lines are perfectly gynoeceous and have multiple disease resistance. The leaf blade area of the LL line is ≈25% to 50% of that of the NL (J. Staub, personal communication).

Experimental design. The two breeding lines were seeded on raised beds, 2 m from center to center, with three rows per bed, 0.4 m apart. Three in-row spacings of 30.0, 15.0, and 7.5 cm gave three plant population densities of 50,000, 100,000, and 200,000 plants/ha, respectively. Sowing dates were 6 Apr. 1992 in BH and 15 Apr. 1993 in NY. The field was fertilized in the previous autumn with ammonium sulfate (250 kg·ha⁻¹) and superphosphate (600 kg·ha⁻¹). Additional nitrogen (ammonium nitrate at 300 kg·ha⁻¹) was supplied as a sidedressing at the fourth leaf stage. The experimental plots were sprayed with chlorflurenol (50 mg·L⁻¹) or water (control) when 5–10 flowers/plant were at anthesis ±1 d. Chlorflurenol was applied between 18 and 22 May in BH and 2 and 8 June in NY, with a maximum of 6 d between the plots treated first (highest plant density) and those treated last (lowest plant density). The experiments were conducted in a randomized block design with four replicates, and each plot was 6 (BH) or 4 m² (NY) in area. After treatment with chlorflurenol, each plot was inspected daily and was harvested destructively when ≈10% of the fruit were oversized (diameter >50mm). The center (1 × 2 m) of each plot was harvested 7–10 d after the spray treatment. The plots were surrounded by a monoecious cucumber cultivar (‘Bet Alpha’) to provide a prolific pollen source. The fruits were graded into four groups according to diameter: 1, <27 mm; 2, 27–38 mm; 3, 38–50 mm; 4, >50 mm; and offshaped (culls). The number and mass of each grade were recorded. The total fresh mass of the shoots of each plot (2 m²) was also recorded to determine the relationship between vegetative development and fruit yield.

All the data were subjected to a three-way analysis of variance (ANOVA) to evaluate statistical differences between the main factors and interactions among them. Means expressed as percent (Tables 2 and 3) were arcsin transformed before ANOVA was performed.

Results and Discussion

Fresh mass of the canopy increased with plant population in all treatments (Fig. 1). However, under low density (five plants/m²) the NL type accumulated more fresh material per unit area than the LL, while under high density (20 plants/m²), it accumulated less, resulting in a significant leaf-type × plant density interaction.

The commercial yield (grades 1–3) of the LL plant type was higher in both locations than that of the NL plant type (Table 1). Chlorflurenol treatment increased the number

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of fruits per unit area but, in general, did not affect the yield. Fruit number and yield increased consistently with plant population density. The highest fruit number per unit area in the two experiments and in the two leaf-types was achieved with the highest plant density plus treatment with chlorflurenol. Under these conditions, fruit numbers per square meter of LL and NL, respectively, were 36.9 and 29.1 in BH, and 38.8 and 20.8 in NY.

These results demonstrate the high yield potential of the LL plant type under high population density in a once-over harvest. The highest commercial yield per unit area in both experiments and with both leaf-types was achieved at the highest plant density, and only in one case (BH, LL) with chlorflurenol treatment (not presented). In BH the yields for LL with and without chlorflurenol were 1.36 and 0.91 kg·m⁻². The same values for NL were 0.90 and 0.93 kg·m⁻², respectively. The corresponding yields in NY were 1.85, 1.88, 1.01, and 0.84 kg·m⁻².

The chlorflurenol spray increased fruit set (number), but decreased mean fruit mass, resulting, in most cases, in yields equal to those of the controls. As the cash value of the pickling cucumber crop is higher for small fruits (Colwell and O'Sullivan, 1981), this effect of chlorflurenol may be beneficial. In contrast with the results of many previous studies (Cantliffe et al., 1972; Dean and Baker, 1983; Nerson et al., 1985), chlorflurenol did not increase the commercial yield. A possible explanation may be that a prolific pollen source was available in our field plots, and that the development of early-set cucumber fruit impairs the efficacy of chlorflurenol as a fruit-setting agent (Cantliffe, 1977).

Considering fruit number alone, LL and NL did not differ significantly in size distribution of commercial fruit (Table 2), but LL produced fewer oversized (OZ) and off-shaped (OS) fruits (Table 3). However, based upon fruit mass, LL plants had higher proportions of marketable yield and lower proportions of culls than did NL plants.

Chlorflurenol did not markedly affect the numerical distribution of commercial fruits (Table 2), but significantly decreased the number and the yield of OZ fruits while increasing the number and the yield of OS fruits (Table 3). The main positive effect of chlorflurenol was the increased yield of small fruits, which are more valuable. The negative effect of chlorflurenol in increasing OS fruits limits its use.

Increasing plant density had only small effects on the distribution of commercial fruit by number, but significantly increased the yield of commercial (mainly in grade 3) fruit, while decreasing that of the unmarketable large (OZ) fruits. Commercial yields of plants at densities of 5, 10, and 20 plants/m² were 70%, 77%, and 78% of the total yields in BH, and 57%, 71%, and 77% of those in NY, respectively.

The results of the present study demonstrate the high-yield potential of the "Little-Leaf" pickling cucumber, grown under a once-

Fig. 1. Effect of plant population density on canopy fresh mass at fruit harvest in little leaf (LL) and normal leaf (NL) cucumbers in two locations (bars = SE).

Table 1. Main effects of leaf-type, chlorflurenol, and plant density on commercial yield (grades 1-3)^a in once-over harvest of cucumber.

Treatment	Bet Hashita		Newe Ya'ar	
	Fruits/m ²	kg·m ⁻²	Fruits/m ²	kg·m ⁻²
Leaf type ^b				
LL	20.9	0.78	25.0	1.29
NL	18.7	0.61	16.6	0.83
Chlorflurenol				
+	23.3	0.74	23.8	1.09
-	16.3	0.66	17.8	1.03
Density (plants/m ²)				
5	12.7	0.43	17.3	0.86
10	18.9	0.63	18.5	0.92
20	27.8	1.02	26.6	1.39
Main factors				
Leaf type (L)	NS	**	***	***
Chlorflurenol (C)	***	NS	***	NS
Density (D)	***	***	***	***
Interactions				
L × C	NS	**	NS	NS
L × D	NS	NS	NS	*
C × D	NS	*	NS	**
L × C × D	*	**	**	NS

^aGrade 1, <27 mm; grade 2, 27-38 mm; grade 3, 38-50 mm.

^bLL = little leaf; NL = normal leaf.

NS, *, **, ***Nonsignificant or significant at *P* = 0.05, 0.01, or 0.001, respectively.

over mechanical harvest system. High plant density and chlorflurenol spray may further increase yield concentration and cash return. Much research is still needed to refine this system under a variety of growing area conditions and to select the best adapted LL material.

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Table 2. Main effects of leaf-type, chlorflurenol, and plant density on small (grades 1 + 2)² and larger commercial fruit (grade 3) distribution (%) in once-over harvest of cucumber.

Treatment	Bet Hashita				Newe Ya'ar			
	Fruit no.		Fruit mass		Fruit no.		Fruit mass	
	1 + 2	3	1 + 2	3	1 + 2	3	1 + 2	3
Leaf type ³								
LL	78	15	49	36	59	25	27	45
NL	78	13	34	30	51	23	25	38
Chlorflurenol								
+	81	11	52	28	60	21	32	40
-	75	17	32	39	51	27	22	43
Density (plants/m ²)								
5	78	12	42	28	53	24	23	34
10	80	13	46	31	59	23	29	42
20	76	17	38	40	55	25	29	48
Main factors								
Leaf type (L)	NS	NS	***	*	NS	NS	NS	*
Chlorflurenol (C)	NS	***	***	***	NS	**	***	NS
Density (D)	NS	**	NS	***	NS	NS	*	***
Interactions								
L × C	NS	NS	NS	**	***	**	NS	*
L × D	NS	**	*	**	**	**	**	NS
C × D	NS	NS	NS	NS	*	NS	NS	**
L × C × D	NS	*	NS	NS	**	***	**	**

²Grade 1, <27 mm, grade 2, 27–38 mm, grade 3, 38–50 mm.³LL = little leaf; NL = normal leaf.NS, *, **, ***Nonsignificant or significant at $P = 0.05$, 0.01 , or 0.001 , respectively.Table 3. Main effects of leaf-type, chlorflurenol, and plant density on oversized (OZ) (grade 4)² and off-shaped (OS) fruit distribution (%) in once-over harvest of cucumber.

Treatment	Bet Hashita				Newe Ya'ar			
	Fruit no.		Fruit mass		Fruit no.		Fruit mass	
	OZ	OS	OZ	OS	OZ	OS	OZ	OS
Leaf type ³								
LL	3	3	12	2	7	8	21	4
NL	7	2	32	2	9	16	26	10
Chlorflurenol								
+	3	5	17	3	5	14	19	9
-	6	1	28	1	11	10	29	6
Density (plants/m ²)								
5	6	3	28	2	14	9	38	4
10	5	2	22	1	6	12	22	6
20	4	3	18	3	4	16	12	11
Main factors								
Leaf type (L)	***	***	***	NS	*	***	*	***
Chlorflurenol (C)	***	***	***	***	***	***	***	***
Density (D)	***	***	***	***	***	***	***	***
Interactions								
L × C	NS	NS	NS	**	NS	**	*	**
L × D	*	NS	**	**	*	**	*	*
C × D	NS	NS	NS	NS	NS	*	NS	NS
L × C × D	NS	NS	NS	*	*	**	*	*

²OZ = grade 4, >50mm³LL = little leaf; NL = normal leaf.NS, *, **, ***Nonsignificant or significant at $P = 0.05$, 0.01 , or 0.001 , respectively.

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