Producing Trellised Cucumbers Double-cropped with Tomatoes

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Abstract. Several studies were conducted from 1988 to 1990 to determine the effect of using tomato plant skeletons as a support for trellised cucumbers double-cropped with tomatoes. In addition, the method by which tomato plants were killed before cucumbers were planted and the in-row spacing and row arrangement of cucumber plants on subsequent cucumber yield were also examined. Yields of trellised 'Dasher II' cucumber (*Cucumis sativus* L.) plants planted in tomato (*Lycopersicon esculentum* Mill.) plots fumigated with metam-sodium were not significantly higher than yields from plants grown in plots where tomato plants were killed with glyphosate or paraquat. The presence of tomato skeletons significantly reduced the average total yield, but not the average premium yield, of three cucumber cultivars in 2 years of the study. Cultivar effect on yield was significant, and there was a significant cultivar x tomato skeleton interaction for yield during 1988. Spacing cucumber plants in the row in the presence of tomato skeletons significantly influenced yields. Planting cucumbers in double rows per tomato bed with tomato skeletons in between significantly increased yield in 1988, had a mixed effect in 1989, and had no effect in 1990 when compared with planting cucumbers in a single row per bed. Chemical names used: 1,1'-dimethyl-4,4'-bipyridinium salts (paraquat); N-(phosphonomethyl)glycine (glyphosate); sodium N-methyldithiocarbamate (metam-sodium).

Increased yield and superior fruit quality of trellised cucumbers have been reported by several investigators (Baker, 1977; Hanna et al., 1987; Konsler and Strider, 1973; Russo et al., 1991). However, the expense of training plants to a trellis and frequent occurrence of low market prices during some periods of the year may discourage cucumber growers from using this cultural method. Trellising fresh-market tomato, however, is popular (Latin et al., 1984). Many growers use drip irrigation and polyethylene mulch in trellised tomato production (Bhella, 1988; Bogle et al., 1989). These expensive installations and the tomato plants must be removed after the last tomato harvest to prepare the land for future cropping.

Planting cucumbers following tomatoes in the same rows (double-cropping tomatoes and cucumbers) may lower the cost of trellising cucumbers. Tomato rows must be fumigated or plants treated with an herbicide after the last harvest to kill the existing vegetation and prepare the land for cucumbers. The dead tomato plants (skeletons) and the existing trellising structure can support climbing cucumber plants. Also, cucumber return per hectare can be enhanced by using tomato stakes, polyethylene mulch, and drip irrigation. The present study was undertaken to 1) compare the influence of fumigating and treating tomatoes with herbicides after the last harvest on cucumber yield, 2) evaluate the effects of the remaining tomato skeletons on cucumber production, and 3) examine the effects of cucumber plant in-row spacing and row arrangement in the presence of tomato skeletons on trellised cucumber yield.

Studies to accomplish the first objective were conducted in Summer (July to Sept.) 1988 and 1989. Plots planted with 'Celebrity' tomato were either fumigated with metam-sodium (178 kg a.i./ha) after the last harvest or sprayed with glyphosate or paraquat (3.4 and 1.1 kg a.i./ha, respectively). In both years, the three treatments were arranged in a randomized complete block with four replications. Three weeks after being fumigated or treated with herbicide, 'Dasher II' cucumbers were seeded in the tomato beds $\approx$ 5 cm to the side of the tomato skeletons so that the plants would receive more sunlight than if planted closer to the skeletons. Plants were spaced at 45 cm in

3-x 4.5m plots. Cucumber plants were trained vertically by tying the main stem once or twice to the tomato skeleton, to the existing trellising system, or both using a Max Tapener model HT B-2 system (A.M. Leonard, Piqua, Ohio). There was no need for further tying since the cucumber plants continued to climb on the tomato skeleton voluntarily, using their tendrils for support.

To evaluate the effect of remaining tomato skeletons on cucumber production, studies were conducted in Summer (July to Sept.) 1988 and 1989. Tomato plants were killed with glyphosate using the rate noted. 'Dasher II', 'Maximore 101', and 'Poinsett 76' cucumbers were seeded in the tomato beds as noted for the other study. Two support (trellis) systems were used: skeleton (as described) or twine. For the latter, experimental plots were cleared by removing tomato skeletons and debris. Cucumber plants were tied to twine wrapped around reinforcing rods (1.8 m x 1.3 cm) at four heights. Rods were spaced 90 to 120 cm apart, and the twine was tied tightly to the far end of an anchor rod. The four heights were spaced vertically at 25 to 35 cm starting 25 to 35 cm above the soil's surface. Using the Max Tapener, cucumber plants were tied to the twine (three to four times) until they reached the top level. The design was a 3 x 2 factorial arranged in a randomized complete block with three replications in 1988 and four in 1989. Plot size was 3 x 3.6 m, and plants were spaced at 30 cm.

Studies to examine the effects of cucumber plant in-row spacing and row arrangement in the presence of tomato skeletons on trellised cucumber yield were conducted in Summer (July to Sept.) 1988, 1989, and 1990. Tomato plants were sprayed with glyphosate after the last harvest, as noted. 'Dasher II' cucumbers were seeded in 3-x 3.6-m plots during the first week of July each year. The design was a 2 x 3 factorial in 1988 and a 3 x 3 factorial in 1989 and 1990, arranged in a randomized complete block with four replications. Treatments were 1) plant in-row spacings of 22.5 and 45 cm in 1988 and 15, 30, and 45 cm in 1989 and 1990 and 2) row arrangement (left, right, and both sides of tomato skeletons). Under experimental conditions, the left side of the tomato skeletons was sun-exposed in the morning and the right side in the afternoon. Cucumber plants were trained vertically using tomato skeletons for support as described.

Soil sample analyses indicated that test sites contained 566 to 678 ppm P and 236 to 252 ppm K. Cucumbers were fertilized by injecting 42 kg N/ha using drip irrigation at the third leaf stage, before the first harvest, and in the middle of the harvest season. There was no preplant or postplant fertilization with P or K.

No polyethylene mulch was used, and postemergence weeds were controlled by shielded paraquat application at 1.1 kg a.i./ha. Other cultural practices were standard for commercial cucumber production.

Cucumbers were harvested three times a week for a maximum of 6 weeks, and tomato skeletons had no effect on the ease of cucum-

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Table 1. Yield of three cucumber cultivars double-cropped with tomatoes in the absence (A) and presence (P) of tomato skeletons.

Cultivar	Premium yield (t-ha ⁻¹)		Contrast (A vs. P)	Total yield (t-ha ⁻¹)		Contrast (A vs. P)	Culls (%)		Contrast (A vs. P)
	A	P		A	P		A	P	
1988									
Dasher II	7.84	6.80	NS	8.94	7.69	NS	6.3	6.5	NS
Maximore 101	7.80	8.67	NS	8.96	9.37	NS	7.2	7.7	NS
Poinsett 76	6.15	4.39	**	7.91	4.97	***	8.8	8.5	NS
1989									
Dasher II	25.2	21.8	NS	29.6	23.8	**	13.8	9.5	*
Maximore 101	25.2	23.0	NS	29.1	25.7	NS	13.3	10.1	NS
Poinsett 76	20.3	20.6	NS	26.9	23.7	NS	19.0	8.8	***

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

ber harvest. Fruit were graded according to U.S. Dept. of Agriculture (USDA) standards (USDA, 1958) for U.S. Fancy, No. 1, No. 2, and culls. Premium yield was determined by combining fruit graded Fancy and No. 1. Total yield was the sum of fruit graded Fancy, No. 1, and No. 2.

Premium (14.9 to 20.0 t-ha⁻¹) and total (16.1 to 23.2 t-ha⁻¹) yields and cull yields (6.5% to 10.9%) of trellised cucumbers planted in tomato plots fumigated with metam-sodium were similar to average yields of cucumbers planted in plots treated with herbicides (glyphosate and paraquat). Also, yields of cucumbers planted in tomato plots treated with glyphosate (16.5 to 22.3 t-ha⁻¹) were similar to those of cucumbers planted in plots treated with paraquat (13.9 to 22.5 t-ha⁻¹). The lower yields apply to 1988, when a damaging hurricane passed through the area in the middle of the harvest season.

In the presence of tomato skeletons, 'Poinsett 76' produced significantly lower premium and total yields in 1988 and fewer culls in 1989; 'Dasher II' produced lower total yield and fewer culls in 1989 (Table 1). 'Maximore 101' yield was not affected by the presence of tomato skeletons in either year. On average, the presence of tomato skeletons significantly reduced the total but not the premium yield of the three cultivars during the two years of this study (Table 2). The main effect of cultivar on yield was significant, except for total yield in 1989, and there was a significant skeleton $\times$ cultivar interaction for yield in 1988 but not in 1989 (Table 2).

Cucumber plant in-row spacing in the presence of tomato skeletons significantly affected yield in every year of this study (Table 3). In 1988, cucumber plants spaced at 22.5 cm produced significantly higher premium and total yields than plants spaced at 45 cm. In 1989, plants spaced at 30 cm produced higher premium yields than plants spaced at 15 or 45 cm and higher total yields than plants spaced at 45 cm. In 1990, plants spaced at 30 cm produced significantly higher premium and total yields than plants spaced at 15 or 45 cm. Spacing had no effect on the percentage of culls, except in 1989, when plants spaced at 15 cm produced a significantly higher percentage than plants spaced at 30 or 45 cm (Table 3).

Table 2. Main effects and interaction of tomato skeletons on average yield of three cucumber cultivars grown during 2 years.

Tomato skeleton	Yield (t-ha ⁻¹), 1988		Culls (%)	Yield (t-ha ⁻¹), 1989		culls (%)
	Premium	Total		Premium	Total	
Absent	7.26	8.60	7.4	23.6	28.6	15.3
Present	6.62	7.34	7.6	21.8	24.4	9.4
Significance						
Skeleton (S)	NS	***	NS	NS	***	***
Cultivar (C)	***	***	NS	*	NS	NS
S $\times$ C	*	**	NS	NS	NS	*

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

Planting cucumbers in two rows per tomato bed significantly increased the premium and total yields compared with planting a single row on either side of the tomato skeleton in 1988 and increased the total yield compared with planting a single row on the right side in 1989. Row arrangement had no effect on cucumber yield in 1990. The percentage of culls was not affected by row arrangement in any year of the study. There was no significant spacing $\times$ row arrangement interaction for yield in any year of the study (Table 3).

Study results indicated that producing trellised cucumbers in the presence of tomato skeletons (double-cropping tomatoes and cucumbers) is feasible. Premium yields, which accounted for the bulk of total yields, were not significantly reduced in the presence of tomato skeletons. However, total yields decreased significantly, potentially resulting in some economic losses. These losses likely can be offset by reduced overhead costs. Hanna et al. (1989) demonstrated that double-cropping tomatoes and cucumbers can minimize the cost of trellising cucumber. It was much easier to kill tomato plants and existing vegetation with glyphosate or paraquat than with metam-sodium. Fumigating to achieve the same purpose and control soil-borne diseases did not affect yield and was not as easy.

Cultivar can influence trellised cucumber yield, but the interaction among cultivars and tomato skeletons on yield did not show a clear trend. In the presence of tomato skeletons, spacing cucumber plants at 30 cm seems to be the most productive, and planting two rows of

Table 3. Effect of in-row spacing and cucumber row arrangement on yield of staked cucumbers during 3 years.

Treatment	Yield (t-ha ⁻¹)		Culls (%)
	Premium	Total	
1988			
S ² (cm)			
22.5	9.6 a ^y	11.2a	7.9 a
45.0	7.2 b	8.3 b	4.5 a
R ²			
Left	7.3 b	8.7 b	6.6 a
Right	7.6 b	8.6 b	5.5 a
Both	10.3 a	12.0 a	7.0 a
S×R	NS	NS	NS
1989			
S (cm)			
15	22.5 b	26.0 ab	18.6 a
30	25.3 a	28.7 a	12.0 b
45	22.4 b	25.5 b	12.8 b
R			
Left	23.4 a	26.9 ab	13.7 a
Right	22.2 a	25.0 b	13.7 a
Both	24.7 a	28.4 a	16.0 a
S×R	NS	NS	NS
1990			
S (cm)			
15	19.0 b	22.1 b	21.0 a
30	21.7 a	24.8 a	19.5 a
45	19.2 b	22.1 b	19.0 a
R			
Left	19.9 a	23.0 a	19.4 a
Right	19.4 a	22.1 a	19.6 a
Both	20.5 a	23.8 a	20.6 a
S×R	NS	NS	NS

^yS = Spacing.

^aMean separation within groups by Duncan's multiple range test, $P = 0.05$.

^bR = Row arrangement.

cucumbers per tomato bed increases yield, in some cases. Kahn and Nelson (1991) demonstrated that trellised snow peas (*Pisum sativum* L.) grown in double rows produced a greater number and higher weight of fresh pods than plants grown in single rows.

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