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Black Polyethylene Mulch Does Not Reduce Yield of Cucumbers Double-cropped with Tomatoes under Heat Stress

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Abstract. **Black polyethylene mulch is preferred for producing early spring tomatoes (*Lycopersicon esculentum* Mill.) because of its warming effect on the soil around the roots. However, using the same mulch for double-cropping cucumbers (*Cucumis sativus* L.) with tomatoes is considered by some growers to be undesirable because of the belief that heat accumulation under the mulch in midsummer or early fall is detrimental to cucumber yield. Eight studies were conducted from July to September in 1994, 1995, and 1996 to determine the effects of mulching spring tomatoes with black vs. white polyethylene mulch on the growth and yield of subsequent cucumber crops. Soil temperature recorded after planting cucumbers ≈4:00 PM for 3 weeks was higher under black mulch than under white mulch. Color of the mulch did not affect leaf length, leaf width, and plant dry weight of cucumbers in six of the eight studies. Cucumbers grown on black mulch produced longer leaves in one study and wider leaves in two studies, and plant dry weight was lower in two studies. Mulch color had no significant effect on the premium or total yields of cucumbers in all but one study. Cucumbers grown on black mulch produced lower percentages of culls in two studies.**

Thousands of hectares of staked fresh-market tomatoes are planted annually in the southern United States on black polyethylene-mulched and drip-irrigated beds. Black mulch increases early tomato yield by retaining moisture and heat (Bhella, 1988), conserving fertilizer (Sweeney et al., 1987), and retarding weed growth (Teasdale and Colacicco, 1985). Because the long growing season in the South offers the potential for double-cropping of existing mulched and drip-irrigated beds, many growers would like to produce a second short-season crop, such as cucumbers, following tomatoes. The practice of double-cropping vegetables reduces production costs by enabling succeeding crops to use the existing polyethylene mulch, drip tape, and fertilizers applied to the first crop (Bryan and Dalton, 1974; Hayslip et al., 1978; Stall et al., 1978). In Florida, cost analysis of this practice indicated that savings were great enough to justify double-cropping watermelon behind tomatoes (Hewitt and Zimet, 1987).

The color of a polyethylene mulch influences the microclimate around the root system. Black polyethylene is preferred for growing early season tomatoes, but heat accumulation under the black plastic during sunny days in mid-to late summer or early fall is thought to limit its use for a double-cropping system (Graham et al., 1995). To address this problem, they suggested the use of a mulch system that changes color from black to white at the termination of the spring crop and before planting the summer crop. Recent studies by Hanna et al. (1997) and Schmidt and Worthington (1998) indicated that soil temperature is somewhat lower under white than under black mulch. Our study was conducted to determine if black mulch used in spring tomato production would adversely affect growth and yield of subsequent cucumber crops.

Materials and Methods

Cucumbers were double-cropped with tomatoes twice in 1994 and three times in 1995 and 1996. Planting dates, harvest periods of cucumber crops, and soil temperature under both black and white polyethylene mulch were recorded (Table 1). Tomatoes were transplanted on equal number of black and white polyethylene mulched and drip-irrigated plots (raised beds) in early April of each year. Fertilizer rates and other cultural practices consisted of standard recommendations for growing staked tomatoes for fresh market production in Louisiana (Boudreaux, 1998). On their removal after the last harvest in early July, the plots were sprayed with *N*-(phosphonomethyl) glycine (glyphosate) at 3.4 kg·ha^{-1} to kill existing vegetation and expose the mulched plots to sun light. 'Dasher II' blend cucumber hybrid (12% Poinsett 76 pollinizer) was transplanted at July planting and direct-seeded at all other planting dates into 1.5 × 10-m tomato plots, with 30 cm between plants within a row. Transplants were raised in the greenhouse for 2 weeks prior to the July planting to allow for extra time to remove tomato plants from the field and clean the test plots. The black and white mulch treatments were replicated four times in a randomized complete-block design. Following transplanting or germination of direct seeded cucumbers, soil temperature was recorded at 10-cm depth ≈4:00 PM at the center of each plot for 3 weeks using a hand-held soil thermometer, and average temperature was calculated. Cucumber plants were trained vertically using existing tomato stakes for support (Hanna, 1993) and fertilized by injecting N at 14 kg·ha^{-1} from ammonium nitrate through the drip-irrigation system when the plants reached the third-leaf stage. Two more applications of equal amounts were made at 3-week intervals following the first application.

The length and width of 25 randomly selected mature leaves were measured during the 2nd week of harvest of each cucumber crop. All plants in each plot were removed without root or fruit after the last harvest and oven-dried at 71 °C for 5 d, and dry weight per plant was determined. Cucumbers were harvested three times each week and fruit were graded according to U.S. Dept. of Agriculture (1958) for U.S. Fancy, No. 1, No. 2, and culls.

Table 1. Planting dates, harvesting period of cucumbers, and soil temperature under black and white polyethylene mulch.

Planting date in field	Harvesting period	Avg temp (°C)[z]	
		Black mulch	White mulch
	1994		
12 July	29 Aug.–7 Oct.	34.0	32.7
19 Aug.	30 Sept.–26 Oct.	31.9	30.2
	1995		
1 July	14 Aug.–8 Sept.	35.8	33.4
1 Aug.	11 Sept.–13 Oct..	36.2	34.9
1 Sept.	18 Oct.–7 Nov.	30.9	29.7
	1996		
1 July	21 Aug.–18 Sept.	33.8	32.0
1 Aug.	12 Sept.–10 Oct.	33.5	31.7
2 Sept.	18 Oct.–30 Oct.	31.2	29.9

[z]Soil temperature was significantly higher under black than under white mulch ($P \leq 0.05$, *t* test).

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Premium yield was determined by combining the weight of fruit graded Fancy and No. 1. Total yield was the sum of all grades except culls. Data were subjected to analysis of variance (SAS Institute, 1994).

Results and Discussion

Soil temperatures was higher under black than under white mulch in all tests ($P \leq 0.05$, *t* test; Table 1). Graham et al. (1995) and Hanna et al. (1997) obtained similar results in double and single-cropped mulched beds respectively. Leaf length, leaf width, and plant dry weight of cucumbers planted on black mulch did not differ significantly from those of cucumbers planted on white mulch with few exceptions (Table 2). These exceptions included longer leaves on black mulch in Sept. 1996, wider leaves on black mulch in July and Aug. 1994, and lower plant dry weight on black mulch in July and Aug. 1995 (Table 2).

Premium and total yields of cucumbers planted in July and Aug. 1994, 1995, and 1996 were not affected significantly by color of the mulch (Table 3). Mulch color had no significant effect on the yield of cucumbers planted in Sept. 1995, but black mulch significantly increased the premium and total yields of cucumbers planted in Sept. 1996 (Table 3). Cucumbers planted in Aug. 1995 and Sept. 1996 had significantly lower percentages of culls on black than on white mulch (Table 3).

Producing early spring fresh-market tomatoes on black polyethylene mulch is a well established cultural practice (Sweeney et al., 1987). However, planting a second crop in the summer following spring tomatoes on the same black mulch is considered by some growers to be undesirable, apparently because of the belief that heat accumulation under the black mulch in July and August would be detrimental to the second crop (Graham et al., 1995). Results of these studies indicate that these concerns are unfounded. Growth and yield of cucumbers were similar when planted on black or white polyethylene mulch. Regardless of mulch color, cucumber yield declined noticeably when planting was delayed until August and declined further by delaying planting until September.

Cucumber growers should make every effort to plant cucumbers following tomatoes as early as possible in July to maximize cucumber yields. Seeding cucumbers in the greenhouse in early July and transplanting in the field a few weeks later is a good practice and should allow the grower plenty of time to clean tomato fields before planting cucumbers.

Results of these studies should encourage tomato growers to consider the numerous benefits of double-cropping tomatoes with cucumbers Benefits include reducing overhead costs by using the polyethylene mulch, drip irrigation, and trellising system for both crops. Residual fertilizer remaining in the soil after the termination of tomato harvest can be utilized by the cucumber crop and reduces the need for additional application.

Limiting fertilizer use, eliminating the need for new polyethylene mulch and drip irrigation materials, and possible reduction in herbicide use should contribute positively to environmentally sound multiple use of land.

Table 2. Effect of mulch color on leaf length, leaf width, and plant dry weight of cucumbers double-cropped with tomatoes.

	Leaf length (cm)			Leaf width (cm)			Plant dry wt (g)		
Mulch color	1994	1995	1996	1994	1995	1996	1994	1995	1996
				July planting					
White	13.4	13.3	13.0	17.0	16.7	16.8	75.9	70.0	64.4
Black	13.7	13.4	12.9	17.5	17.0	16.6	68.4	64.2	63.4
Significance	NS	NS	NS	*	NS	NS	NS	*	NS
				August planting					
White	11.2	14.5	11.8	15.0	18.2	15.8	28.5	60.9	67.5
Black	11.4	14.3	12.5	15.3	18.2	16.4	26.0	52.9	67.1
Significance	NS	NS	NS	*	NS	NS	NS	**	NS
				September planting					
White		11.8	11.3		15.4	15.6		53.7	55.7
Black		11.7	12.4		15.1	16.7		50.7	59.7
Significance		NS	*		NS	NS		NS	NS

NS, *, **Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

Table 3. Effect of mulch color on yield of cucumbers double-cropped with tomatoes.

	Yield (Mg·ha^{-1})								
	Premium			Total			Culls (%)[z]		
Mulch color	1994	1995	1996	1994	1995	1996	1994	1995	1996
				July planting					
White	37.3	37.2	37.6	44.9	43.0	48.6	16.1	11.9	13.2
Black	36.1	34.4	35.2	42.8	40.7	45.6	14.5	12.4	12.4
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
				August planting					
White	12.3	29.6	21.2	14.8	35.4	30.3	11.8	12.6	15.8
Black	12.3	28.3	24.8	14.9	35.5	33.1	12.0	10.0	12.3
Significance	NS	NS	NS	NS	NS	NS	NS	**	NS
				September planting					
White		9.4	6.7		12.3	10.6		12.5	17.1
Black		10.4	10.5		13.3	15.5		9.4	8.4
Significance		NS	*		NS	*		NS	*

[z]Of the total.

NS, *, **Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

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