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COLORED PLASTIC MULCHES AND TOMATO MORPHOGENESIS

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Abstract. Several colors of plastic mulch (black, red, silver and white) were evaluated for effects on tomato morphogenesis (growth and development). Effects of mulch color on fresh and dry weights, leaf area, amount of laterals, and main stem internode lengths were observed on plants harvested at a preflowering stage (22 days after transplanting). At a later harvest (50 days after transplanting), significant effects were observed on flower and fruit number. Measured differences in the quantity and spectral distribution (quality) of light reflected off the colored mulch treatments suggested a role for reflected light in the growth and development of tomato plants grown with mulch culture.

Introduction

Plastic mulch has been successfully used in the production of several vegetable crops (6, 10, 12, 14). Black, white, and clear sheets of polyethylene have been evaluated for use as mulch material with effectiveness dependent upon color, crop, season and location. In most instances, water use (6) and nutrient leaching (10) are reduced when a plastic mulch is used. Additionally, crop establishment and weed control are often enhanced (13), root development encouraged (6), and early and total fruit production increased (4, 6, 10, 12).

Yield determinations have been used in most previous studies to document mulch effects on vegetable production, but little information

is known on plastic mulch effects on plant growth and development (morphogenesis). In addition, beneficial crop response to mulch might be directly related to modifications of the plant microclimate (11). Research on microclimate modifications with the use of plastic mulch has primarily investigated effects on soil warming and moisture (6, 14). Essentially, no research has been directed at alterations of the plant light environment (through light reflection off the plastic) with the use of plastic mulch culture. This paper presents experiments designed to quantify the effects of several colors of plastic mulch on a) the growth and development of tomato, and b) the plant light environment.

Methods and Materials

To facilitate accurate biological and physical measurements, as well as minimize environmental extremes, a plant bed system in a greenhouse (2) was used in these experiments. Six plant beds (3.4 m x 1.0 m x 0.25 m) were built and placed in a glass greenhouse and filled with soil. Lime and fertilizer were applied to the soil according to soil test recommendations. Trickle irrigation tubing and plastic mulch were placed over the soil prior to transplanting.

Several colors of plastic mulch were evaluated. Treatments were established by uniform painting of a black polyethylene mulch surface with the appropriate colored paint (Table 1). Plots were 1.6 m in length. Experimental plots were arranged in a randomized complete block design with 3 replicates.

Table 1. Paints utilized to produce colored plastic mulches.

Mulch Color	Paint
Black	Not painted
Red	Rust-oleum Regal Red #7765
Silver	Ace Hardware Aluminum #504
White	Rust-oleum Gloss White #7792

The tomato (Lycopersicon esculentum L.) cultivar Mountain Pride was used in this study. Five to six week old transplants were placed in the beds at a 30.5 cm spacing (one row per bed). Pruning of laterals was not practiced and insecticide and fungicide sprays were not needed.

Half plots were harvested at 22 and 50 days after transplanting. Total plant biomass, and fruit and flower numbers were recorded. Analysis of variance was used to determine significant effects and least significant difference (LSD) calculations to compare means.

Environmental measurements of light reflection off the plastic and soil temperature were recorded during the study. Light intensity and quality (spectral distribution) of reflected light were measured on a representative cloudless day at solar noon with a Licor 1200 Spectroradiometer. Light intensity measurements are reported as photosynthetic photon flux density (PPFD) and quality as the quantum ratio of far-red to red light. Soil temperatures at a 2.5 cm depth were measured continuously in all plots for a three week period with a Campbell CR7 Data Logger equipped with fixed thermocouplers.

Results and Discussion

Fresh weight, dry weight and leaf area of tomato plants harvested at a preflowering physiological stage of development (22 days after transplanting) were affected by mulch color treatments (Table 2). Plants grown with black or white mulch produced more leaves and petioles, and had larger stems than plants with silver or red mulch. Plants in the white mulch treatment also had greater amounts of lateral leaves (suckers) than those in the other treatments. Plants in the darker colored mulches (red or black) tended to have longer internode lengths at the lower nodes than plants in the lighter colored mulches (white or silver) (Table 3).

Table 2. Influence of mulch color on the growth and development of tomato 22 days after transplanting.

Mulch Color	Biomass Production		Leaf Area/Plant	
	Leaves & Petioles	Stem	Main	Lateral
	(g DW/plant)		(cm^2)	
Black	33.4	0.58	795.04	46.77
Red	20.8	0.38	545.19	15.62
Silver	21.8	0.43	605.87	15.76
White	32.7	0.53	735.04	111.27
LSD (0.05)	7.9	0.15	225.11	82.29

Table 3. Influence of mulch color on main stem internode lengths of tomato 22 days after transplanting.

Mulch Color	Internodes				
	1+2	2+3	3+4	4+5	5+6
	Length (mm)				
Black	26.1	29.1	38.4	40.9	46.7
Red	28.7	27.8	27.5	36.6	30.7
Silver	17.1	19.9	22.0	33.1	35.3
White	15.4	19.2	21.6	29.8	35.8
LSD (0.05)	8.5	4.3	5.2	8.4	10.3

At a later harvest (50 days after transplanting), plants in the white mulch treatment had fewer flowers than plants in the other treatments (Table 4). The greatest number of fruits were observed on plants in the silver treatments, while the largest fruits were measured in the black mulch treatments.

Table 4. Influence of mulch color on fruit and flower production of tomato 50 days after transplanting.

Mulch Color	Fruit			Flower
	(no./plant)	(g FW/plant)	(ave. FW/fruit)	(no./plant)
Black	18.5	1616.00	87.72	16.0
Red	19.7	1228.18	58.50	18.0
Silver	29.1	1745.67	64.39	16.2
White	22.0	1585.00	78.68	5.1
LSD (0.05)	7.3	nsd	29.82	10.7

The color of the mulch influenced the plant light environment. The lighter color mulches reflected more total light; but a lower ratio of far-red relative to red light (Table 5). Increase in light intensity can affect plant development and yield through increases in the photosynthetic rates (16), and the ratio of far-red relative to red light is important in phytochrome regulation of plant physiological processes (1) and can affect internode lengths and stem elongation (3), chloroplast ultrastructure (7), photosynthetic efficiency (9), and photosynthate partitioning among leaves, stems and roots (8).

Table 5. Light reflection upward to selected points above the plastic.

Light Parameter	Mulch Color	Distance Above Plastic (cm) 10	20	30
Photosynthetic Photon Flux Density (umol $m^{-2}s^{-1}$)[a]				
	Black	94	92	87
	Red	167	151	175
	Silver	737	411	385
	White	794	594	537
Far-Red/Red Ratio Relative to Ratio in Direct Sunlight				
	Black	1.01	1.06	1.06
	Red	1.15	1.13	1.12
	Silver	0.96	0.96	0.97
	White	0.95	0.97	0.97

[a] PPFD of direct sunlight was 1673 umol $m^{-2}s^{-1}$.

The warmer root zone temperatures were recorded under the darker color mulch treatments (Table 6). The warmest mean soil temperatures were recorded in the black and the coolest in the white mulch treatments. While soil temperatures can influence tomato growth and yield (15), their role in this study is not well understood since the average recorded soil temperatures of the individual color treatments were within a range previously reported (5) for maximal growth of tomato. Future research on soil temperature effects on plant growth needs to address the importance of diurnal soil temperature fluctuations that have been observed (2) under mulch treatments.

Table 6. Mean soil temperatures under plastic mulch treatments.

Mulch Color	Root-Zone Temperatures (^{o}C)[a]
Black	23.7
Red	23.6
Silver	23.2
White	22.9

[a] Measured continuously over a 3-week period at a 2.5 cm soil depth.

Conclusions

The results of this study suggest that plastic mulch can affect plant growth and development as well as yield. The plant response appears to be related to the color of mulch. Mulch effects on internode lengths suggest a role for reflected light (and particularly the far-red to red light ratio) on tomato plant development. Biomass accumulation, and flower and fruit production were also affected by mulch color treatments and may be due to mulch effects on the plant light environment and/or root zone temperatures.

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