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Effect of Plastic Mulch and Trellises on Cucumber Production in High Tunnels

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Abstract
Cucumbers (Cucumis sativus L.) are high yielding summer vegetables but are extremely frost-sensitive. Most vegetable growers in Iowa grow cucumbers and constantly explore ways to start the crop early in the spring. One method to extend the production season and start early production of cucumbers is using a high tunnel. A high tunnel helps protect plants from early season frost, warms the soil, increases ambient temperature, and enhances crop growth. High tunnel production is gaining popularity in the Midwest. Common vegetables grown in high tunnels include tomato, pepper, leafy greens, and cucumber.

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Introduction

Cucumbers (*Cucumis sativus* L.) are high yielding summer vegetables but are extremely frost-sensitive. Most vegetable growers in Iowa grow cucumbers and constantly explore ways to start the crop early in the spring. One method to extend the production season and start early production of cucumbers is using a high tunnel. A high tunnel helps protect plants from early season frost, warms the soil, increases ambient temperature, and enhances crop growth. High tunnel production is gaining popularity in the Midwest. Common vegetables grown in high tunnels include tomato, pepper, leafy greens, and cucumber.

In high tunnels, cucumbers are generally grown on raised beds that are covered with black plastic mulch. Advantages of black plastic mulch are many—increase in soil temperature, reduced weed problems, reduced nutrient leaching, and increased plant growth. Soil temperatures under black plastic mulch during the daytime are generally 3-4^{o}F higher at a 2-in. depth and 2^{o}F higher at a 4-in. depth compared with those in bare soil. Apart from black plastic mulch, there are mulches available in colors such as blue, red, coextruded white on black (referred to as white), and also ones that are highly reflective (silver). Of all these, the most commonly used are black and white. White plastic mulch helps cool the soil and also control weeds. White plastic mulch does not heat the soil to the level that black plastic mulch does, but it has other advantages. In high tunnel situations where the amount of light received by plants is decreased, white plastic mulches could prove beneficial. White plastic mulch would reflect light back to the plant canopy and enhance photosynthetic efficiency of the plant. In addition, high tunnels often experience excessive heat buildup and higher temperatures, which could be detrimental for plant growth. White plastic mulches reflect light and result in slightly cooler soil temperatures.

Most growers allow cucumber plants to trail and grow on the ground, however, in a high tunnel situation, where space is limited, trellising would conserve space and facilitate other cultural practices. Trellising would also keep the fruit above ground, keep them clean and reduce attack by soil pathogens. Although trellising has benefits, it is labor intensive. This study was designed to evaluate the effect of two plastic mulches (black or white) and their possible interaction with the production technique (trellising or no-trellising) in high tunnel cucumber production system. The objective of this study was to determine if the use of white plastic mulch in conjunction with trellising will improve cucumber crop growth, yield, and quality attributes.

Materials and Methods

On April 26, 2012, cucumber seeds (*Cucumis sativus* L. 'Dasher II') were seeded into a soil-less greenhouse medium (Sunshine LC1 Mix) in 98-celled flats. Transplants were grown in the greenhouse for two weeks and later moved into a lath-house for acclimation. On June 18, 2012, cucumber was transplanted on raised beds covered with black or white plastic mulch inside a 16 ft by 48 ft high tunnel. Each bed had a single row of plants spaced 18 in. apart. Each treatment had a single bed with eight plants. Experimental design was

randomized complete block design with four replications. Treatments included 1) black plastic mulch, 2) black plastic mulch + trellising 3) white plastic mulch, and 4) white plastic mulch + trellising. Plants receiving trellising treatments were trellised using plastic clips onto cattle panels on June 8, 2012. As plants kept growing and producing vines they were continuously clipped onto the cattle panel. Soil temperature sensors were installed at 4-in. depth under plastic mulches on June 6, 2012. Along with soil sensors light sensors were also installed on the top of the beds. Sensors pointed toward the plastic and were 12 in. above the surface of plastic mulch. Cucumbers were picked 11 times starting June 26, 2012 through August 22, 2012. Data were collected on marketable number and weight, non-marketable number and weight, and fruit quality attributes (average fruit length, diameter, and weight). To determine fruit quality, eight cucumbers were randomly selected from the marketable category and measurements were taken.

Results and Discussion

Color of plastic mulch modified soil temperature at 4-in. depth. Soil temperatures were higher under black plastic as compared with white (Figure 1). This has direct implications on root growth, development, and other physiological processes. Plastic color also affected light intensity (Figure 2). The light sensor used in this study measures a broader spectrum of light wavelengths than are visible to the human eye. Sensor intensity readings are maximum for light hitting the sensor directly on-axis and are reduced for light coming in at an angle. Sensors captured light from all directions but because they were installed facing the plastic, they primarily recorded light intensity that was reflected off the plastic. In this study, white plastic mulch reflected almost twice the amount of light than the black.

There were no significant differences in marketable number of cucumbers between black or white plastic mulches. However, within each mulch treatment, trellis system significantly increased yield. Marketable numbers were almost one and a half times more when trellis system was used.

Marketable weight also followed the same pattern with trellised treatment yielding higher than non-trellised treatment. There was no difference in marketable yield between black or white plastic trellised system. Fruits were graded based on USDA grades as marketable (U.S. Fancy, U.S. Extra #1, U.S. #1, U.S. #1 Small, and U.S. #1 Large) or non-marketable (deformed, overgrown, damaged by cuts, scars, sunscald, sunburn, dirt, disease, or insects) (Figure 3). Non-marketable fruit weight was highest in trellised treatment, irrespective of plastic color. Fruit quality attribute with respect to average fruit length was highest in the black plastic mulch + trellis treatment. Growers could benefit from this trait since longer, larger cucumber fruits will bring a better market price. There were no statistically significant differences found in average fruit diameter or weight between treatments.

Results from this study indicate that trellising cucumbers in high tunnel production systems yield higher number of marketable fruits compared with non-trellised systems. Growers should consider trellising their cucumber plants especially when growing them in high tunnels. Trellising allows for better air movement and heat dissipation and reduces occurrence of fungal and bacterial diseases. Although white plastic mulch reflected twice the amount of light when compared with black mulch, it did not translate to enhanced yield or productivity. White plastic mulch kept the soil cooler than black and could be used in high tunnel production when crop plantings occur during peak summer.

Table 1. Effect of plastic mulch and trellis system on cucumber yield.*

Treatment	Marketable		Non-marketable	
	Number†	Weight (kg)	Number	Weight (kg)
Black plastic	95 b	32.6 b	63 ab	15.4 b
Black plastic + trellis	159 a	57.4 a	71 a	18.9 a
White plastic	96 b	34.6 b	53 b	14.1 b
White plastic + trellis	147 a	54.7 a	77 a	19.4 a

*Means are values from eight plants.
†Mean separation within columns; means followed by same letter(s) are not significantly different ($P \leq 0.05$).

Table 2. Effect of plastic mulch and trellis system on average length, width, and fresh weight of cucumber.

Treatment	Average fruit length† (in.)	Average fruit width^{NS} (in.)	Average fruit weight^{NS} (g)
Black Plastic	8.5 b	2.0	329.7
Black Plastic + Trellis	9.0 a	2.1	372.5
White Plastic	8.4 b	2.0	339.6
White Plastic + Trellis	8.6 b	2.0	336.9

†Mean separation within columns; means followed by same letter(s) are not significantly different ($P \leq 0.05$).
^{NS} Non-significant at $P \leq 0.05$.

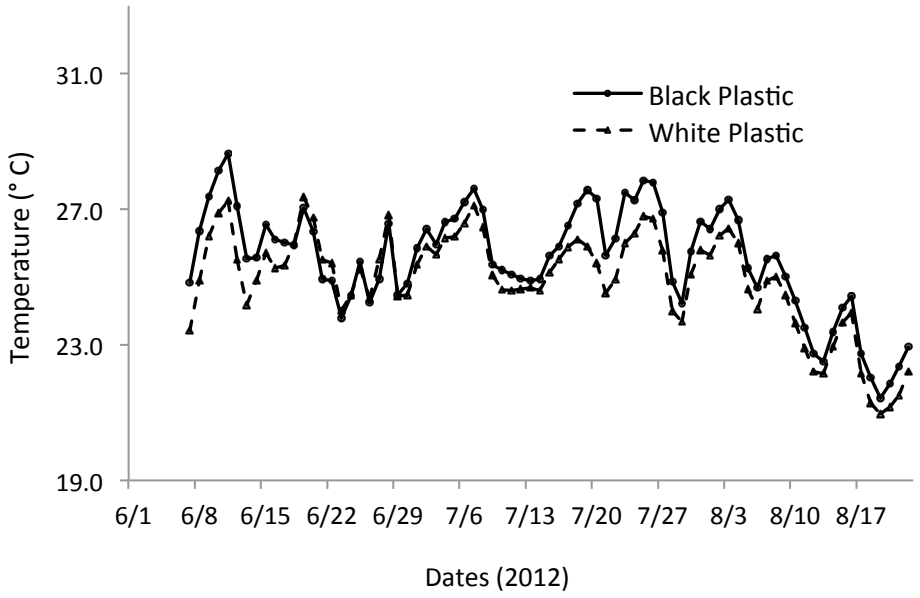

Figure 1. Soil temperature 4 in. under soil in plastic mulch treatments.

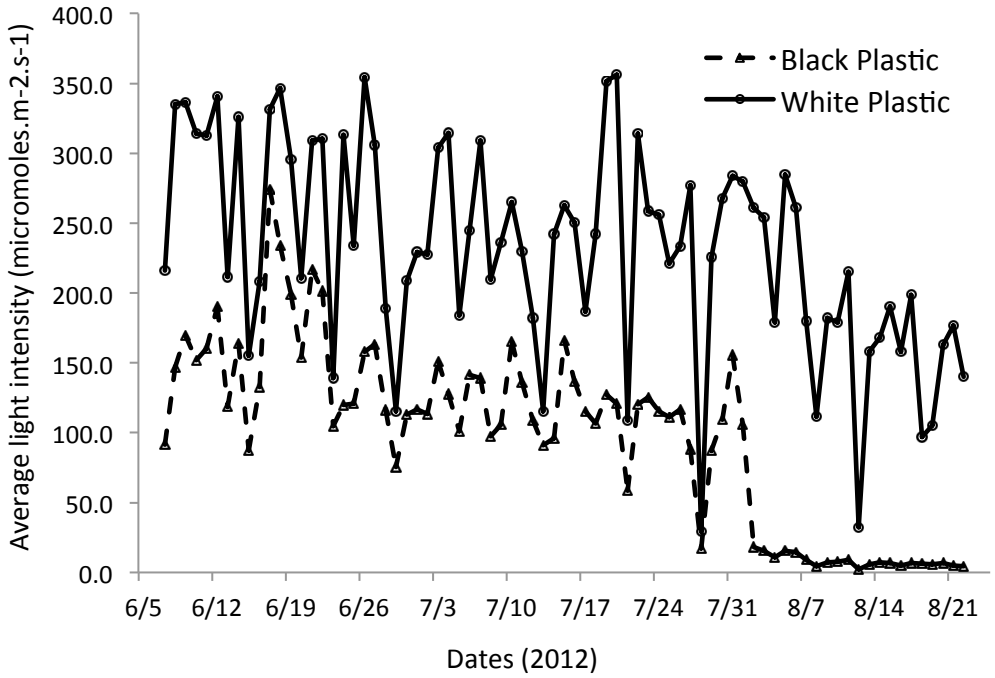

Figure 2. Average light intensity reflected from black and white plastic mulches during the growing season in 2012. Light sensors were installed facing down at 12-in. height from the surface of plastic mulch.

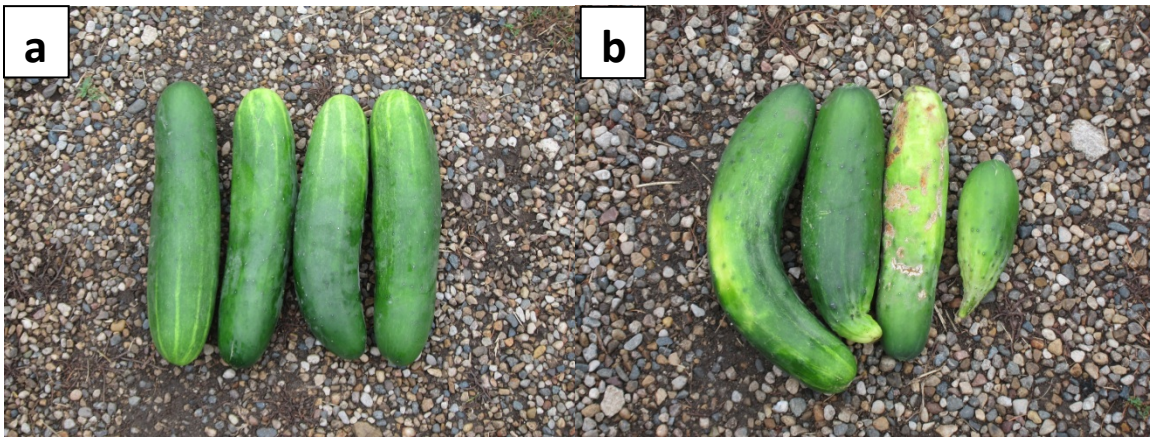

Figure 3. Categorization of cucumber fruits as marketable (a) and non-marketable (b) categories.