Effects of Color Plastic Mulches and Row Cover on the Yield and Quality of Sweet Potato [*Ipomea batatas* cv. 'Beauregard']

by

Daniel McKinley Sullen

A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, Alabama
December 13, 2010

Keywords: *Ipomea batatas*, nutrition, antioxidant, earliness, yield

Approved by

Floyd M. Woods, Chair, Associate Professor of Horticulture
James E. Brown, Professor of Horticulture
Wheeler G. Foshee, Associate Professor Horticulture

Abstract

Sweet potato [*Ipomea batatas* ‘Beauregard’] was grown on an Orangeburg sandy loam soil in Shorter AL. Sweet potato slips were planted in single rows. The experiment consisted of twelve experimental treatments as follows: (1) black plastic mulch (BPM) + spun-bonded row cover (RC), (2) BPM, (3) white plastic mulch (WPM) + RC, (4) WPM, (5) red plastic mulch (RPM) + RC, (6) RPM, (7) bare soil (BS) + RC, (8) BS, (9) silver plastic mulch (SPM) + RC, (10) SPM, (11) blue plastic mulch (BLUPM) + RC, (12) BLUPM. Soil temperatures were 6°F lower than above mulch temperatures in all treatments. Both early root yield and total root yield were different among the treatments with SPM + RC being the highest, followed by RPM. However, RPM treatments exhibited the highest nutritional properties in sweet potato roots when compared to other treatments. Further studies need to be perform to have a better understanding of the effects on yield and nutritional qualities of vegetable crops grown with row covers and various colored plastic mulches.

Acknowledgments

I would like to thank God, my family, Dr. Floyd Woods, Dr. James E. Brown, Dr. Wheeler Foshee, III, Benjamin Blasius, Jason Burkette, and Dr. J.R. Kessler.

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CHAPTER I. INTRODUCTION

History, Plasticulture, and Crop Production

The discovery and development of the polyethylene polymer in the late 1930's, and its subsequent introduction in the early 1950's in the form of plastic films, mulches, and irrigation accessories, revolutionized commercial horticultural fruit and vegetable production system and gave rise to a system of production known as plasticulture.

A variety of color mulches have been used by growers and researchers in vegetable production. White plastic mulch has been shown to generate cooler soil temperatures than black plastic (Diaz-Perez and Batal 2002). Therefore, the use of white plastic mulch is preferred during the summer growing season in warmer climates globally compared to black plastic. Silver plastic mulch has resulted in less disease incidence. The use of red plastic mulch has been shown to result in higher yields in tomato and to generate a positive phytochrome compared to the use of black plastic or no plastic.

Floating spun-bonded polyester row covers are used with various vegetable crops. Floating row covers alter the plant's micro-environment by increasing temperatures during both the day and night which hastens early season production (Arancibia and Motsenbocker, 2002). Plant response to row covers is dependent on the temperature at the time of crop development and maturation. Few research papers involving colored plastic mulches with spun-bonded row covers have been published. The purpose of this study is to evaluate the effects of color plastic mulch with and without row cover on sweet potato (*Ipomoea batatas*) yield and nutritional quality.

CHAPTER II. LITERATURE REVIEW

Plastic Mulch

Polyethylene plastic mulch was generated for commercial use in 1939 and has been used extensively in commercial vegetable production since the early 1960s. Polyethylene plastic is made from polyethylene resin which is in the form of pellets. The pellets are heated and processed into bendable sheets of plastic film (Clarke, 1987). The most commonly selected mulch films include low density polyethylene (LDPE), linear density polyethylene (LLDPE), high density polyethylene (HDPE), and Metallocene (LLDPE) (Fleck-Arnold, 2000). LLDPE resins have puncture resistant and mechanical stretch properties. HDPE resins have reliable moisture and vapor barriers. Metallocene resins add strength and stretch properties. An ideal plastic mulch film should be flexible and rigid enough for easy removal from various growing environments. The main polyethylene used in mulches is low density polyethylene. Typical plastic mulch used in the U.S. is 1.25 mm thick and 1.21 m wide in rolls 731.71 m long and a width of 91.44 cm to 152.4 cm (Lamont, 2005). Plastic mulches are used to adjust the growing environment of a crop or group of crops. The primary effect of plastic mulch is an increase in soil temperature. Other advantages of color mulches include improved fruit quality, reduced weed population, reduced water evaporation, increased yields, reduced fertilizer leaching, reduced soil compaction, improved phytochrome response, and other benefits (Lamont, 2005).

Plastic Mulch Primary Effects

Soil Warming

Plastic mulch was first noted for its ability to increase soil temperature in the 1950's (Emmert, 1957). It is beneficial to adjust the soil's microclimate to prolong the growing season and increase plant growth (Tarara, 2000). Heating properties of plastic such as reflectivity, absorptivity, and transmittance and their interaction with the sun's radiation will have a direct effect on the soil temperatures beneath the plastic mulch (Schales and Sheldrake, 1963). Plant growth requires radiation as a source of energy for photosynthesis, the means by which the radiation from the sun is converted to chemical energy (Rajapaske and Kelly, 1994). Net radiation is defined as the sum of absorbed shortwave and long wave radiation minus emitted long wave radiation (Ham and Kluitenburg, 1994). Munguia et al. (1999) found that net radiation is higher in the plastic mulch than in non plastic mulch environment. This is important because it relates to the spectral properties of the plastic mulch to surrounding environment. There are three basic non-radiative components to radiant energy at the soil surface: conduction of heat into the ground; flux of latent heat in connection with evaporation from the soil; and convection of sensible heat into the layer of air between the soil surface and the mulch. The rate at which a soil increases or decreases heat over a period of twenty-four hours is closely associated with the diurnal cycle of surface temperature. The color of plastic will determine the plastic's energy-radiating abilities. Black plastic has intense high shortwave absorptance so it is anticipated to raise soil temperatures the fastest (Dobbs et al., 2003). Black mulch usually produces the highest soil temperature compared to other colored mulches (Diaz-Perez and Batal, 2002). White mulch film reflects radiant energy which makes it possible for the soil under it to have a decreased temperature in comparison to black mulch. Silver plastic mulch usually results in lower soil temperature compared to other colored mulches with white being the exception (Lamont et al., 2000). The physical characteristics of the plastic mulches were shown to directly influence soil and root temperatures (Ruiz et al., 2002). When the crop canopy covers the surface of the mulch bed, soil temperatures among different mulch colors are approximately equal (Lamont, 2004).

Air Warming

Much of the early research before 1960 is concerned with the impact of mulch on not only soil, but on air temperature (Emmert, 1957). Above ground effects of plastic are mainly due to the optical reflective properties of the mulch and the fact that plastic acts as a barrier to evaporation. The temperature of the air above the plastic is usually higher than the temperature of the air above bare soil. Rangarajan and Ingall (2001) found that air temperatures were significantly higher for mulch treatments compared to bare soil. Kwabiah (2004) reported maximum air temperatures up to 20°F higher under plastic mulch than on none plastic mulch plots.

Secondary Effects of Plastic Mulch

Early Yield

The use of color plastic mulch has resulted in enhanced growth and earlier yields than that of bare soil. A grower's ability to produce an early crop is not only beneficial in outperforming competitors but it gives the crop a chance to develop before the onset of disease. This in effect will provide a premium for early maturity and improved quality. Rangarajan and Ingall (2001) found that the use of red, silver, and blue plastic mulches increased earliness of radicchio lettuce head formation compared to bare soil. Early crop yield advantage of red mulch was evident in tomato yields compared to yields produced on bare soil (Kasperbauer and Hunt, 1998).

Improved Fruit Quality

Soil temperature under raised plastic mulch covered beds typically heats faster in the spring and excess water will drain from bed into row middles, keeping the plants drier and preventing deterioration in product quality from contact between harvestable portions of the plants and wet soil or standing water (Lamont, 2004). Fruit quality is measured by cleanliness, taste, insect damage, etc. Recently colored plastic mulch has been shown to have significant effects on fruit quality (Leskovar, 2000). Coventry et al. (2003) found that reflective mulch increased soluble solids (Brix), total phenolics (aromatic compounds which serve as anti-microbial protection), flavanols, and anthocyanins (water soluble pigments related to flavonoids properties) content in Ontario wine grapes. Reflective mulch was also found to increase soluble solids in plums (Kim et al., 2008). Kasperbauer and Loughrin (2004) observe that altering the color of plastic mulch can alter anthocyanins content in butterbean. Strawberries that ripened over red plastic mulch were significantly higher in aroma and flavor compounds (Loughrin and Kasperbauer, 2002). Antonious and Kasperbauer (2002) found that the use of yellow and black mulches resulted in higher concentrations of phenolics in carrot. Also, the use of yellow and white mulches resulted in higher β-carotene (organic compounds with orange pigments in plants) and ascorbic acid (water soluble sugar acid with antioxidant properties) content in carrots when compared to other colored mulches and bare soil treatments. Bell peppers grown on plastic mulch were found to be cleaner than those grown on bare soil (Brown and Channell-Butcher, 2001).

Other Positive Benefits

There are other benefits to using plastic mulch for vegetable crop production such as increased efficient use of fertilizer inputs through fertigation technology, reduced leaching of fertilizers, reduced soil erosion, decrease incidence of disease, improved management of insect pest, reduced weed populations, reduced soil compaction, and maximum efficiency through double or triple cropping (Lamont, 2004; Meulen et al., 2006). Reflective plastic mulch can be used to manage silver leaf whitefly populations equal to that provided by treatment with imidacloprid (Summers and Stapleton, 2002).

Row Cover

Row covers are flexible, transparent coverings made from polyester or polypropylene that are installed over single or multiple rows of horticultural crops for the purpose of enhancing plant growth by warming the microclimate around plants in the field (Lamont, 2004). Parchment paper row covers were original row covers used for field-grown vegetable crop production (Wittwer and Lucas, 1956). The next generation of row covers was made from polyethylene plastics and produced earlier yield than the paper mulches (Hall, 1963).

In the early 1980's, spun-bonded polyester row covers were introduced. Spun-bonded covers are composed of thin mesh of white synthetic fibers, which entrap heat and serve as a barrier to wind, insects, and pests. Rain or overhead irrigation freely passes through row covers. The weight of these covers ranges from 0.3 to about 2.0 ounces per square yard. The lightest covers are used primarily for insect exclusion while the heaviest are used for frost protection (Lamont, 2004). Spun-bonded polyester row covers maintains the soil moisture by allowing rain water to reach plants and thus helps to prevent soil compaction. Alexander and Clough (1998) reported the use of spun-bonded row covers resulted in increased marketable yields of tomato at the first harvest and over the season and blossom end rot and sunscald were reduced substantially by the use of row covers. The use of spun-bonded row covers resulted in greater mean relative growth rate and crop growth rate on watermelon compared to bare soil (Soltani et al., 1995).

Brown and Channell-Butcher (1999) found the use of row covers increased earliness of okra. Qureshi et al. (2007) found the use of row covers controlled whiteflies, reduced fruit damage and increased the size, weight, and quality of fruit.

Row Cover Effects

Air Temperature

Row covers are used to raise the air temperature in a crop's growing environment. The intended purpose of higher air temperatures is earlier seed germination and plant growth. The earlier a crop emerges and produces a fruit, the earlier a grower can get the crop to market. Brown and Channell-Butcher (1999a) found that row covers raised air temperatures compared to no row cover treatments.

Soil Temperature

Row covers not only have the ability to increase air temperature but they also can increase soil temperatures. Loy and Wells (1982) recorded a 5 degree (°F) increase in soil temperature with the use of row covers and black plastic mulch compared to that of bare soil. White mulch affected tomato plants light environment and soil temperatures resulting in significantly more fruit per plant compared to black mulch (Decoteau, 2007). Although, colored plastic has been directly linked to an increase in soil temperature, it may also influence plant growth through phytochrome and photomorphogenesis responses.

Phytochrome and Photomorphogenesis

Photo-morphogenesis is the ability of light to regulate plant growth and development independent of photosynthesis. Plant pigments will recognize variations in the growing environment such as direction and duration of light, light quality, and light quantity. The photo-morphogenic pigments include phytochrome, blue light, and UV absorbing receptors.

Phytochrome is a photoreceptor, a pigment plants use to detect light and is sensitive to light in the red and far-red region of the visible spectrum (Britz and Galston, 1983). One structure of phytochrome absorbs only red light and is denoted the inactive structure, while another active phytochrome structure is denoted as far-red and both of which are capable of maintaining plant's response and transduction. The ability of phytochrome to constantly switch between the two forms facilitates its regulatory function. Phytochrome receptors have the ability to detect wavelengths from 300-800nm. Red light is absorbed from 660 to 680nm and far-red light is absorbed from 730 to 740nm (Kasperbauer, 1999). Research conducted by Kasperbauer and Hunt (1992) helped to reveal that it was an increase in FR: R ratio (higher than that of full sunlight) inside the phytochrome that resulted in increased shoot-to-root biomass ratio in plants. Lower FR: R ratio (below that of full sun light) will result in larger roots and a lower shoot-to-root ratio. This research stimulated the use of color mulches other than the usual (black, white, clear, and silver).

The purpose of assorted colors is to reflect FR:R ratios that result in phytochrome regulation that may enhance plant growth and yield. In a tomato production study, Orzolek et al. (2000) found silver and red plastic mulches to have the greatest reflected FR:R ratios. This study reported an increase in marketable fruit yields occurred with tomatoes growing on silver or red mulch compared to the use of traditional black plastic. Kasperbauer and Hunt (1998) also found that red plastic mulch resulted in increased tomato yields compared to the use of black plastic. It was concluded that the high FR: R ratio caused by red plastic mulch generated a phytochrome induced response that controls photosynthate allocation to maturing fruit. Bell pepper plants grew taller and were heavier when grown on red plastic which exposed them to a greater FR: R ratio (Decoteau et al. 1990). Loughrin and Kasperbauer (2002) found that FR and R in light reflected from red mulch altered the natural phytochrome system to modify gene expression which resulted in greater concentration of aroma compounds in fresh strawberries.

Different Crops Yield Response to Colored Plastic Mulch

Extensive research utilizing certain photoselective mulch has been reported to increase yields of various horticultural crops (Lamont, 2004). For example, a 15% increase in marketable tomato fruit yield in response to red mulch compared to black mulch; a 20% increase in marketable peppers in response to metalized silver in comparison to black mulch; a 12% increase in marketable eggplant fruit yield in response to red mulch compared to black mulch; a 35 % increase in marketable fruit yield of muskmelon in response to dark blue mulch in comparison to black mulch; a 30% increase in marketable fruit yield of cucumber in response to dark blue mulch in comparison to black mulch; a 20% increase in marketable summer squash yield in response to dark blue mulch in comparison to black mulch; and a 24% increase in marketable fruit yield of onion and potato in response to red, metalized- silver, and black mulch in comparison to bare soil respectively. However, there has been limited research reported utilizing colored plastic mulch system for cultivation of sweet potato.

Sweet Potato

Sweet potato (*Ipomoea batatas*) is an economically important horticultural commodity that is produced globally in part because of its nutritive value and its starchy, sweet tasting flavor. Sweet potato is a dicotyledonous plant that belongs to the family *Convolvulaceae*. The sweet potato is distantly related to the potato (*Solanum tuberosum*). The edible storage root is long and tapered, with a smooth skin whose color ranges between red, purple, brown and white. Its flesh ranges from white through yellow, orange, and purple. Sweet potatoes are native to the tropical parts of South America, and were domesticated at least 5000 years ago. The crop is very sensitive to drought during the storage root initiation stage (50–60 days) after planting and is sensitive to water-logging conditions where it may cause root rots and reduce growth and storage of roots if aeration is poor (Ahn, 1993). Generally, sweet potatoes grow best under abundant sunshine and warm nights. Sweet potatoes are cold sensitive and should not be planted until all danger of frost is past (Islam et al., 2009; Woods et al, 1991ab). The optimum temperature to achieve the best growth of sweet potatoes is between 21°C and 29°C, although they can tolerate temperatures as low as 18°C and as high as 35°C (Kemble et al., 2006). They grow well under many farming conditions and have few natural enemies. In poor countries, small farmers with limited land, labor, and capital often grow sweet potato because of the crops ability to thrive in less fertile, marginal soils with limited water supply (Ray and Ravi, 2005).

Sweet Potato Production

Sweet potatoes production is a very important industry throughout the world. According to the United States Department of Agriculture statistics (2010), over 135 million tons of sweet potatoes were produced in 2002. China is the world leader in sweet potato production with over 113 million tons produced which represents roughly 83% of the world's sweet potato production. The next closest countries in sweet potato production are Nigeria and Uganda with 2.6 million tons. The United States ranks twelfth in the world in sweet potato production with only 583,550 tons, a fraction of the world's production. However, sweet potato production has increased in recent years to 922,600 in 2007. In 2007, North Carolina led the nation in sweet potato production with 354,750 tons, followed by California with 212,800 tons, Mississippi with

175,000 tons, and Louisiana with 146,250 tons. Economically, sweet potato is one of the most important vegetable crops produced in Alabama (Kemble et al., 2006). In 2001, Alabama sweet potato production accounted for 8.3 million dollars in cash receipts representing 3 percent of the total cash receipts among all horticultural crops produced in the state. Alabama ranked fifth in the nation in sweet potato production with 14,400 tons in 2007. However, Alabama's sweet potato production has decreased in recent years from 30,600 tons in 1998 which represent a 36% decline (USDA-ESMI, 2010).

Sweet Potato Nutritional Value

Sweet potatoes are well known for their popular culinary uses, but its nutritional value is often overlooked in the United States. Sweet potato ranks as the world's seventh most important food crop (Kemble et al., 2006). Compared to other vegetables, sweet potato ranks the highest in nutritional value. The raw sweet potato flesh nutritional values per 100 g include the following: Energy = 360kJ, Carbohydrates = 20.1g, Starch = 12.7g, Sugars = 4.2g, Dietary Fiber = 3.0g, Fat = 0.1g, Protein = 1.6g, Vitamin A equivalent = 709µg, beta carotene = 8509µg, Vitamin C = 2.4mg, Calcium = 30mg, Magnesium = 25.0mg, Phosphorus = 47.0mg, Potassium = 370mg, and Sodium = 55mg (USDA-AES, 2010).

According to Keys (1992), carbohydrates are the most abundant constituent in the sweet potato, comprising 80-90% of the dry matter of storage roots. Carbohydrates function as stored energy reserves, structural framework, and impact the sweetness which is the dominant taste sensation in the cooked roots. Starch in sweet potato can be separated into two categories: transitory starch that is formed in the leaves during the day and then degraded, converted to sucrose, and translocated out during the night; and reserve starch that is synthesized and stored in the enlarged edible storage roots of the plant. Generally, sweet potatoes are selected for low fiber content (Jones et al., 1980). Fiber content in sweet potato lines from a polycross nursery ranged from exceedingly low (20µg/mL) to such a high level (2,000µg/mL) that roots were woody. Proteins represent an extremely important class of organic components in that they regulate metabolism, act as structural molecules in sweet potato storage roots, represent storage forms of carbon and nitrogen (Keys, 1992). Enzymatic proteins are extremely important in that they regulate virtually all of the biochemical reactions taking place within the sweet potato. Control is exerted over the rate of specific processes within the plant largely through enzyme synthesis, activation, and degradation. This allows the plant to adjust to changes in its environment. A number of organic acids, in addition to functioning as intermediates in metabolism, may also contribute to taste. In the sweet potato, the most quantitatively prevalent organic acids are malic, quinic, succinic, and citric, with trace amounts of oxalic and oxaloacetic (Holloway et al., 1989). According to Keys (1992), there are four primary classes of pigments, three are found in the sweet potato – carotenoids, phenolics, and chlorophylls. These pigments impact the characteristic colors found in the roots and leaves of the plant. Chlorophyll is a magnesium containing porphyrin. Carotenoids are a group of phytochemicals in which more than 700 naturally occurring carotenoids are identified to date (Maiani et al., 2009). Approximately 90% of the carotenoids in the human diet is represented by β-carotene, α-carotene, lycopene, lutein acid, and cryptoxanthin (Melendez-Martinez et al., 2004). The orange and yellow colors of the roots are due to the presence of these carotenes, and normally there are multiple forms of carotene present within the roots of a cultivar (Keys, 1992). Phenolics represent a wide range of compounds that have at least one aromatic ring and hydroxyl group. As a group, their importance in sweet potatoes centers on their role in discoloration reactions and in response to pathological and mechanical stress (Keys, 1992). Vitamins are organic compounds that are required in relatively small amounts for normal plant metabolism and growth. Vitamins are thought of in regards to dietary requirement of humans; however, in plants vitamins perform, for the most part, the same biochemical functions. They are commonly separated into two classes based on their solubility: the water soluble vitamins (ascorbic acid, biotin, folic acid, nicotinic acid, pantothenic acid, pyridoxine, riboflavin, thiamine); and the lipid soluble vitamins (A, E, and K). Vitamin A is formed in the retinal intestine of animals from plant derived carotenes. Carotenes, therefore, are precursors of vitamin A and are commonly referred to from a nutritional standpoint as provitamin A. Finally, ascorbic acid is a lactone of a sugar that is synthesized by plants from glucose or other simple carbohydrates. Its concentration levels in sweet potatoes depend on the variety selected or analyzed (Keys, 1992).

Sweet Potato Plastic Mulch and Row Cover Research

Brown et al. (1998) reported that black plastic mulch + white tinted slitted plastic row tunnels and black plastic mulch + spun-bonded polyester floating row cover treatments produced the highest total yields, resulting in 46% and 34% increase respectively, over the bare soil (control). Other treatments included black plastic mulch and black plastic mulch + clear slitted plastic row tunnel. Black plastic mulch + white tinted slitted plastic row tunnels also produced significantly more U.S. #1 grade sweet potato roots as compared with the control. Black plastic mulch accelerated vine growth. Brown et al. (1998) found black plastic mulch + white tinted slitted plastic row tunnels and black plastic mulch + spun-bonded polyester floating row cover treatments to be alternative ways of increasing sweet potato yields. Research on the effect of colored plastic mulch and spun-bonded row covers has been limited. However, recent studies report various benefits of photoselective colored plastic mulch and spun-bonded row covers on okra and summer squash growth and yield.

Colored Plastic Mulch and Row Cover Effect on Okra and Summer Squash Yield

Colored Plastic Mulch and Row Cover Effect on Okra

Gordon et al. (2010) conducted research on the effect of colored plastic mulch and spun-bonded row cover on okra growth and yield. Treatments consisted of five mulch colors: black, white, red, silver, and blue, installed with or without spun-bonded row cover. The silver, red, white, and black plastic mulch were all 1.5 mm thick and 91.44 cm wide. The blue plastic mulch was 1.25 mm thick and 121.92 cm wide. No row cover treatments were higher in total marketable yield than row cover treatments. Black color mulch treatment yields were the highest in early harvest and total harvest marketable yields, but bare soil treatments were the lowest. In April 2004, early harvest marketable yields were significantly higher among no row cover treatments, but row cover treatments were higher in total harvest marketable yield. Red color mulch treatments were highest in early harvest yield and bare soil treatments were the lowest. In total marketable yield, black mulch treatments were the highest. Plots with row cover had higher air temperatures than plots without row cover. In 2003, air temperatures were highest above the silver mulch plus row cover treatment and were the lowest above the bare soil treatment. Silver plastic and silver plastic mulch plus row cover treatments had the lowest soil temperature. However, blue plastic mulch treatment had the highest soil temperature. In 2004, air temperatures were highest above the black plastic mulch plus row cover treatment and were the lowest above the bare soil plus row cover treatment. Bare soil treatment had the lowest soil temperature and blue plastic mulch treatment had the highest soil temperature. Air temperature was negatively correlated with early yield and soil temperature was positively correlated with early yield. However, warmer air and soil temperatures did not always correlate with increased yields.

Colored Plastic Mulch and Row Cover Effect on Summer Squash

Gordon et al. (2008) conducted research on the effect of colored plastic mulch and spun-bonded row cover on summer squash growth and yield. Treatments consisted of five mulch colors: black, white, red, silver, and blue, installed with or without spun-bonded row cover. The silver, red, white, and black plastic mulch were all 1.5 mil thick and 91.44 cm wide. Blue plastic mulch was 1.25 mm thick and 121.92 cm wide. Blue plastic mulch and black plastic mulch + row cover treatments were the highest in early marketable yield, while bare soil + row cover treatment was the lowest. Also, the highest in total marketable yield and total overall yield were black plastic mulch + row cover and blue plastic mulch treatments. Bare soil + row cover treatment was the lowest in total marketable yield and total overall yield. Yields for 2003 were significantly higher than yields of 2004. However, 2003 soil and air temperatures were significant lower than 2004 temperatures. Silver mulch soil and air temperatures were highest among all colored mulches. Air temperatures of row cover treatments were higher than treatments without row cover, but soil temperatures were not different. Increased soil and air temperatures did not always correlate with increased yields.

Objective

There has been limited research reported in regards to the growth of sweet potato with the use of color plastic mulches and row covers. Therefore, the objective of this study is to determine the effects of colored plastic mulches and spun-bonded row covers and their effects on the earliness, yield, and nutritional properties of sweet potato.

CHAPTER III. MATERIALS AND METHODS

Plant Material and Growth Conditions

Sweet Potato Slips

Sweet potato (*Ipomea batatas* cv. 'Beauregard') certified seed stock were obtained from Auburn University's North Alabama Horticulture Research and Extension Center in Cullman, Alabama and plants were propagated and grown at Auburn University's Patterson Greenhouse Complex in Auburn, Alabama. Sweet potato cuttings were propagated in saw dust and treated with Hi-Yield Captan fungicide (Voluntary Purchasing Groups Inc., Bonham, Texas) as specified by the manufacturer. Sweet potatoes slips were grown from April 16, 2008 to May 7, 2008 and from April 15, 2009 to June 8, 2009 on benches under ambient greenhouse conditions. Sweet potato slips were harvested at a length of 15.24 cm using pruning shears. Sweet potato slips were hand harvested one day prior to field transplanting. Slips were wrapped in moist paper towels and maintained overnight in a chromatography chamber (Fisher Scientific, Raleigh, North Carolina) at 10°C.

Field Establishment

Both field experiments were conducted at Auburn University E.V. Smith Research and Extension Center in Shorter, Alabama. The soil type was an Orangeburg Norfolk sandy loam with a soil pH of 6.1. White plastic mulch was 1.5 mm thick and the drip irrigation lines (Toro Ag. Products Inc., El Cajon, California) were 10 mm thick with emitters spaced at 30.48 cm. The drip lines and white mulch were applied simultaneously on raised beds (10.16 cm in height) using a 6215 John Deere tractor (John Deere, Mannheim Baden-Wurttemberg, Germany) attached to a plastic layering machine (Kenco Manufacturing Inc., Ruskin, Florida).

Field Experimental Design

Experimental plots were arranged in a randomized complete block design with four replications per treatment. Replications consisted of 12 rows with each row measuring 6.09 m in length and 0.91 m in width. Sweet potato slips were transplanted on May 8, 2008 and June 9, 2009 in single rows 30.48 cm apart with 18 slips per replication. The experiment consisted of 12 treatments: (1) black plastic mulch plus spun-bonded row cover (BPM+RC), (2) black plastic mulch (BPM), (3) red plastic mulch plus spun-bonded row cover (RPM+RC), (4) red plastic mulch (RPM), (5) bare soil plus spun-bonded row cover (BS+RC), (6) bare soil (BS), (7) silver plastic mulch plus spun-bonded row cover (SPM+RC), (8) silver plastic mulch (SPM), (9) white plastic mulch plus spun-bonded row cover (WPM+RC), (10) white plastic mulch (WPM), (11) blue plastic mulch plus spun-bonded row cover (BLUPM+RC), (12) blue plastic mulch (BLUPM). White plastic mulch laid during the establishment of the beds were manually removed between buffer areas and replaced with black, red, blue, and silver plastic mulches to correspond to treatments and experimental field design. For control treatment, the plastic mulch was manually cut and removed from the soil to expose the bare soil underneath the plastic. The buffer area between each treatment measured 0.91 m. Corresponding treatments of black, white, red, and silver plastic mulches (Ken-Bar Inc., Reading, Massachusetts) were 1.5 mm thick and 90 cm while blue plastic mulch (Pliant Corp., Schamburg, Illinois) was 1.25 mm thick and 152 cm wide. Row covers, 170.18 cm wide, were placed over the beds of corresponding treatments on May 8, 2008 and June 9, 2009, with edges of row cover strips firmly secured into the soil around the edges of each plot. Row covers were allowed to float loosely in an effort not to obstruct plant growth as well as to prevent loss of retained heat. Spun-bonded row covers (Reemay Inc., Old Hickory, Tennessee) were 170.18 cm wide.

Fertilizers and Herbicides Utilized

Pre-plant fertilizers were applied in accordance with soil test recommendations from Auburn University Soil Testing Lab (Auburn, Alabama). In 2008, 47.39 kg/ha (7.29 kg/ha N) calcium nitrate 15.5-0-0 was applied pre-plant and 0.93 kg N/ha was injected (Dosatron, Water Powered Dosing Technology, Clearwater, Florida) into the irrigation water weekly alternating calcium nitrate (9-0-0-11) and potassium nitrate (13-0-44). Applications were made weekly until the recommended amount of N (14.58 kg/ha) had been applied. In 2009, 91.94 kg/ha (14.58 kg/ha N) calcium nitrate 15.5-0-0 pre-plant were applied.

Eptam® 7E herbicide (Gowan Company, Yuma, Arizona; S-ethyl dipropylthiocarbamate) was applied on May 1, 2008 and June 2, 2009 in accordance to label directions as a pre-emergence herbicide for weed control at a rate of 10.68 kg/ha with a boom sprayer (Canaan Industries Inc., Dothan, Alabama). On June 20, 2008 and June 25,2009, Poast® herbicide (BASF, ; 2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one), a post-emergence herbicide for grass control, was applied at a rate of 10.53 kg/ha.

Soil, Air, and Environmental Parameters

Soil temperature was measured with a soil probe thermometer (Taylor® Switchable Digital Thermometer, Taylor Precision Products LP, Oak Brook, Illinois) at a depth of 15.24 cm in each plot. Air temperature was recorded with an indoor/outdoor thermometer (Taylor Precision Products LP, Oak Brook, Illinois) with sensors attached to the heat conducting wire (Toro Ag, Bloomington, Minnesota) placed in the center of each plot at 12.7 cm above ground level. Soil and air temperatures were manually recorded twice a week during the hours 12:00pm to 2:00pm, from May 8, 2008 to June 12, 2008 and June 10, 2009 to July 15, 2009 (35 days after planting). Row covers were also removed after 35 days while colored plastic mulch treatments remained in place through the growing season. Daily environmental air and soil data for 2008 and 2009 growing seasons were obtained from Auburn University's E.V. Smith Research and Extension Station's weather station located in Shorter, Alabama.

Sweet Potato Vine Parameters Measured

Vine length and vine fresh weights were sampled on June 12, 2008 and July 15, 2009. Three random plants were selected for sampling within each replication to determine vine length and vine fresh weight. Three of the longest vines per sampled sweet potato plant were cut. These vines were immediately weighed using a 120 Turner scale (Turner Scale Inc., Montgomery, Alabama) and length measurements were recorded.

Sweet Potato Roots Harvest

Sweet potatoes roots were hand harvested with shovels after removing the plastic mulch to expose the soil. In 2008, there were two sweet potato root harvests which were achieved by harvesting 9 sweet potato plants or half of the row (3.04 m) within each replication for each harvests. The first harvest was on July 31, 2008, 83 days after planting (represents early harvest). The second harvest was on August 21, 2008, 104 days after planting (represents late harvest). The only sweet potato harvest for 2009 was on November 4, 147 days after planting. Due to extensive and frequent rainfall in 2009, sweet potato maturity was delayed and quality was perceived to be inferior due to fungal rots. At harvest, storage roots were placed in wooden crates according to their corresponding treatment and replication. On the basis of established USDA grading system (Kays, 2008), sweet potatoes were graded as follows: (diameter): Jumbo = 8.75cm or greater, U.S. #1 = 8.75cm to 5.63cm, U.S. #2 = 5.63cm to 4.38cm, Canner = 4.38cm to 3.75cm, and Cull = 3.75cm or less. Wooden boards with the corresponding holes of grade size diameters were used to grade sweet potato roots from each harvest. These sweet potatoes were weighed using a Tronix scale (Tronix, Fairmont, Minnesota) according to there grades. Data were recorded for the corresponding treatments. After the sweet potato weights were recorded, canner storage roots according to USDA standards from 2008 were the only sweet potato grade collected for postharvest studies.

Postharvest Data Collected

Chemicals / Reagents Utilized

The 2, 2'- azino-bis (3-ethylbenzothiazoline-6 sulfonic acid; ABTS) as diammonium salt, 2, 2'-azobis (2–amidinopropane) dihydrochloride (AAPH) and 1,1–diphenyl-2-picrylhydrazyl (DPPH) were obtained from Wako Chemicals USA Inc. (Richmond, VA, USA). Trolox, Gallic and Chlorogenic acid were purchased from Sigma / Aldrich, all other chemical reagents, solvents or standards were either purchased from Sigma/ Aldrich Chemical Co. (St. Louis, MO), or Fischer Scientific (Fischer Scientific, Raleigh, NC) and were either high–performance liquid chromatography (HPLC) or analytical grade quality. Ultrapure Milli–Q water was used throughout this study and had electrical conductivity of 18.2 MΩ cm^2 obtained through a Millipore Direct -Q$^{TM.}$ 5 filter system (Millipore Corp., Bedford, MA).

Physicochemical Analysis

Tissue Preparation

Following harvest selected fresh roots were immediately hand washed and dried at ambient temperatures for two days prior to further laboratory tissue preparation. All subsequent sample extraction and quantification procedures were performed under amber fluorescent lighting conditions (GE F40/G0, 40W) to prevent photo-oxidation. Fresh unblemished canner sized roots with similar size were separated according to treatments and replications. Roots were cut radial into small thin pieces and immediately placed in freezer bags and stored in an ultralow -80^{o}C freezer (Kendro Laboratory Products, ULT 2586-9-A36; Asheville, NC) until subsequent analysis.

pH and Titratable Acidity (TA)

The pH and titratable acidity were determined using an automated titrimeter (Metrohm Titrino Model 751 GPD and Metrohm Sample Changer, Metrohm Corp., Herisau, Switzerland) with computer software (Brinkmann Titrino Workcell 4.4 Software, Brinkmann Corp., Westbury, NY). The automated titrimeter was housed in a Fisher Scientific refrigerated chromatography chamber maintained at 10^{o}C, Fisher Scientific model Isotemp Laboratory Refrigerator, cat# 13-986-1276; (Fisher Scientific, Raleigh, NC). Ten grams of frozen sample were weighed and 30 ml of bidistilled deionized purified water (Milli-Q distilled water purification system, Millipore Corp., Bedford, MA) were added to the sample in 60-ml Virtis shear beakers pre-chilled on ice. Samples were homogenized for one minute using a Virtis shear (Virtishear**,** model 225318, Gardiner, NY). The homogenate was centrifuged (Beckman Centrifuge, model J2-21, San Antonio, TX.) at 10,000 rpm for 15 minutes at 4°C , then filtered with Miracloth (Calbiochem, La Jolla, Ca). The supernatant was collected and 10 ml were placed into an auto Titrator sample cup. Acidity was titrated as percent citric acid equivalent using 1 N sodium hydroxide. The results were expressed as citric acid equivalent using the formula:

[(mL NaOH x 0.1 N x 0.064 meq ● g of juice $^{-1}$) x 100].

Total Soluble Solids (Brix)

Total soluble solids (TSS) were determined using a Leica Abbe Mark II Plus Refractometer (Leica Microsystems Inc., Buffalo, NY).

Dry Matter Determination (DM)

Approximately 10.0 grams of frozen root tissue were weighed into an aluminum weighing pan which was previously weighed (tare weight) and dried at 15°C (70°F) oven, Grieve Corporation (Grieve, Model SC-350, Round Lake, Illinois) for 72 hours. Weighing pans were cooled to room temperature and then weighed again for dry mass determination with four replicates performed for dry weight determination.

Total Soluble Sugars (TSS)

TSS was determined colorimetrically according to (Dubois et al., 1956). Approximately 250 mg of frozen root cortical tissue were pulverized with liquid nitrogen using a pre-chilled mortar and pestle and replicated four times for each treatment. The pulverized tissue was transferred to glass centrifuge tubes and extracted with 10 ml of 80% HPLC grade ethanol in a water bath (Fisher Scientific model ISOTEMP 210, Dubuque, Iowa) at 80-85^{o}C for 30 minutes. The homogenate was centrifuged (Beckman Centrifuge, model J2-21, San Antonio, TX) at 10,000 g for 15 min at 4°C, filtered with Miracloth (Calbiochem, La Jolla, CA), and the supernatant was retained. The extraction was repeated twice and the supernatant combined after filtration. The combined supernatant was evaporated in the water bath and reconstituted in Milli–Q water at a final volume of 50.0 ml.

A 0.50 ml aliquot of the clarified solution was combined with 0.5 ml of 5 % (w/v) phenol solution and 2.5 ml concentrated sulfuric acid. A 0.3 ml aliquot was placed in chemically resistant microplate (Costar # 3364; Fisher Scientific cat #, 07200696) and read at 470 nm using a microplate reader (Synergy HT, BIO-TEK Instruments, Inc., Winooski, Vermont) following a 30 minute incubation at room temperature against a reagent blank. The total soluble sugars were a regression equation of glucose (0.02 – 0.06 mg glucose ml^{-1}) and the results were expressed in terms of glucose/100gfw.

Antioxidant Properties

Extraction and Determination of Total Carotenoids(TC)

Total carotenoid content of storage root tissues was determined using the method of Talcott and Howard (1999). Total carotenoids were extracted (1 g / 30 mL) with a pre-chilled solution of HPLC grade acetone/ethanol (1:1) containing 200 mg L^{-1} butylated hydroxytolulene (BHT). Samples were extracted using a Virtis Shear homogenizer (Cyclone Virtishear) at a speed of 70 rpm for 1 min. The homogenate was centrifuged at 13,500 rpm for 15 min at $4^{o}C$ and filtered through four layers of Miracloth. The supernatant was collected and the remaining residue was re-extracted three times until the residue was colorless. Finally, all extracts were combined and brought to a final volume of 50ml using the same extraction solvent. A 0.3 ml aliquot was placed in chemically resistant microplate (Costar # 3364; Fisher Scientific cat #, 07200696) and absorbance measured at 470 nm using a microplate reader (Synergy HT, BIO-TEK Instruments, Inc., Winooski, Vermont).

Total carotenoids were calculated using the equation:

$$\frac{A \cdot V \cdot 10^{6}}{A^{1\%} \cdot 100 \cdot G}$$

where A is the absorbance at 470 nm, V is the total volume of extract, $A^{1\%}$ is the extinction coefficient for a mixture of solvents arbitrarily set at 2500, and G is the sample weight in grams (Talcott and Howard, 1999).

Extraction of Crude Phenolic Compounds and Other Antioxidants

The extraction of phenolic compounds was based on the extraction solvent system of Abeysinghe et al., (2007). Approximately 10 g of frozen root tissue were homogenized in 30 ml of extraction solvent (1.2 M HCl in 80% HPLC grade methanol / Milli–Q water in a Virtis Shear homogenizer (Cyclone Virtishear, model 225318, Gardiner, NY) at a speed setting of 70 for 1 minute. The homogenate was transferred into a 100 ml beaker and stirred on a Fisher Scientific multi-position Electronic Stirrer (Model 2008, Dubuque, Iowa) at 200 rpm and maintained at 4°C overnight in a Fisher Scientific model Isotemp Laboratory Refrigerator, cat# 13-986-1276; (Fisher Scientific, Raleigh, NC). The following morning the homogenate was transferred to a 50 ml Oak Ridge Centrifuge Tube (Nalge Nunc International Corporation, Rochester, NY), purged with nitrogen and sealed. Samples were incubated in a water bath (Fisher Scientific model ISOTEMP 210, Dubuque, Iowa) at 60 °C for 1 hour followed by a 10 minute sonication (Branson, model 5510 Branson Ultrasonic Corporation, Danbury, CT). Sonicated samples were clarified by centrifugation (Beckman Centrifuge, model J2-21, San Antonio, TX) at 13,000 rpm for 15 min at 4°C, filtered with Miracloth (Calbiochem, La Jolla, CA), and diluted to a final volume of 50 mL. Samples were purged again with nitrogen and stored in a -80 °C freezer until analyzed.

Determination of Total Phenolic Content.

Total phenolic content (TPH) was determined spectrophotometrically by the Folin-Ciocalteu method (Singleton and Rossi, 1965) as modified by Slinkard and Singleton, 1997. Appropriately diluted sample (200 µL) or standard solutions were mixed with 1.4 mL of Milli-Q water. Generation of a standard curve was achieved by constructing five different concentrations of either gallic acid (20, 40, 60, 80 and 100 mg/L) or chlorogenic (60, 120, 180, 240 and 300 mg/L) acid. A blank was prepared using Milli-Q water instead of sample. Subsequently, 200 µL of Folin-Ciocalteu's Reagent (FCR-1:5 dilution with Milli-Q water) were mixed with the sample, standard or blank. The reaction mixture was allowed to stand at room temperature for 6 min. Following incubation, 300 µL of 7% Na_2CO_3 solution was added to each mixture and allowed to stand at room temperature for 120 min. Absorbance was measured at 750 nm using a microplate reader (Synergy HT, BIO-TEK Instruments, Inc., Winooski, Vermont). Results are expressed as mg chlorogenic acid equivalent per 100g fresh weight (mg CAE/100g FW) and mg gallic acid equivalent per 100g fresh weight (mg GAE/100g FW).

Antioxidant activity determinations

ABTS Radical Scavenging Assay

Antioxidant capacity was measured based on the ability of antioxidants to quench the long-lived ABTS radical anion ($ABTS^{-\cdot}$), a blue/green chromophore in comparison to that of L-ascorbic acid (Vitamin C) (Kim et al., 2002). The $ABTS^{-\cdot}$ generated was used to assess hydrophilic and lipophilic antioxidants similarly to the ABTS cation radical ($ABTS^{+\cdot}$) utilized in TEAC (Schlesier et al., 2002). 2.5 mM of ABTS [2,2'-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid) diammonium salt] were mixed with 1.0 mM of AAPH [2,2'-azobis-(2-amidinopropane) HCl] in 100 mL phosphate-buffered saline (PBS) solution [100mM potassium phosphate buffer (pH 7.4) containing 150 mM NaCl]. The ABTS radical solution was heated in 68 °C water bath for 1 h with frequent agitation and filtered at reduced pressure through a ZAPCAP®-CR filter unit (Whatman Inc., Florham Park, NJ). The blue-green ABTS radical solution was adjusted with fresh PBS to an absorbance of 0.650 ± 0.020. 4 µL of sample solution or blank (80% HPLC grade methanol) were mixed with 196 µL of ABTS radical solution and immediately read at 734 nm at 37 °C for duration of 30 min in a microplate reader.

Generation of a standard curve was achieved by constructing five different concentrations of L-ascorbic acid (20, 40, 60, 80 and 100 mg/L). Samples were analyzed in triplicate. The ABTS radical anion scavenging capacities of the sample extracts were expressed on the fresh weight basis as mg Vitamin C equivalent per 100g fresh weight (mg VCE/100g FW).

DPPH$^{\bullet}$ Radical Scavenging Activity.

For the following *in vitro* antioxidant determinations crude methanolic extracts were used and obtained from extraction procedures as outlined above within the "*Extraction of crude phenolic compounds"* section. Antioxidant radical scavenging activity was measured according to the method outlined by Kim et al., (2002) with slight modifications. Briefly, 100µM 2, 2-Diphenyl-1-picrylhydrazyl (DPPH$^{\bullet}$) was prepared in 200 ml of 80% HPLC grade methanol. The radical solution was stirred at room temperature for 20 min and then adjusted to 0.650 ± 0.020 absorbance value at 517 nm. Generation of a standard curve was achieved by constructing five different concentrations of either two standards consisting of Trolox, a synthetic vitamin E analogue (±) (6-hydroxy-2, 5, 7, 8-tetramethylchroman-2-carboxylic acid) at concentrations of 0, 150, 300, 450, 600, and 750 µM Trolox or Vitamin C at concentrations of 0, 25, 50, 75, 100 and 125 mg/L. To determine the antioxidant capacity, 6.67 µl of clarified methanolic extract, blank, or L-ascorbic acid standard was mixed with 193.33 µl of DPPH radical solution. Two hundred (200µl) were pipetted into 96 well flat bottom plates (Costar cat # 3370, Corning Inc., Corning, NY) and the decrease in absorbance was measured at 517 nm for 30 min in a microplate reader (Synergy HT, BIO-TEK Instruments, Inc., Winooski, Vermont). Results are expressed in Trolox equivalent antioxidant capacity (µM TEAC/100gfw), or vitamin C equivalent antioxidant capacity, (VCEAC mg/100gfw).

Ferric Reducing Antioxidant Power (FRAP) Assay.

The FRAP assay was performed according to Benzie and Strain (1996) with slight modifications. This assay is based on the reducing power of a compound (antioxidant). A potential antioxidant will reduce the ferric ion (Fe^{3+}) to ferrous ion (Fe^{2+}); the latter forms a blue complex (Fe^{2+}/TPTZ), which increases the absorption at 593nm (Benzie and Strain 1996). The stock solutions included 300 mM acetate buffer (3.1 g $C_2H_3NaO_2 \cdot 3H_2O$ and 16 ml glacial acetic acid), pH 3.6, 10 mM TPTZ (2, 4, 6-tripyridyl-s-triazine) solution in 40 mM HCl, and 20 mM $FeCl_3 \cdot 6H_2O$ solution. The fresh working solution was prepared by mixing 50 ml acetate buffer, 5 ml TPTZ solution and 5 ml $FeCl_3 \cdot 6H_2O$ solution and then warmed at 37^{o}C before use. Fruit extracts (15 µl) were allowed to react with 285 µl of the FRAP solution for 30 min in the dark. Generation of a standard curve was achieved by constructing five different concentrations of either three standards consisting of Trolox, a synthetic vitamin E analogue (±) (6-hydroxy-2, 5, 7, 8-tetramethylchroman-2-carboxylic acid) at concentrations of 0, 150, 300, 450, 600, and 750 µM Trolox , Vitamin C at concentrations of 0, 20, 40, 60, 80, and 100 mg/L, or chlorogenic acid at concentrations of 0, 50, 100, 150, 200, 250 and 300 mg /L. The colored product (ferrous tripridyltriazine complex) was immediately transferred to multichannel pipette reservoir and 200µl was pipetted into 96 well flat bottom plates (Costar cat # 3370, Corning Inc., Corning, NY) and absorbance measured at 593 nm in a microplate reader maintained at 37^{o}C for the duration of sample determination (Synergy HT, BIO-TEK Instruments, Inc., Winooski, Vermont). Results were either expressed as vitamin C equivalent antioxidant capacity, (VCEAC mg/100gfw), Trolox equivalent antioxidant capacity (µM TEAC/100gfw), or chlorogenic acid equivalents (CAE mg/100gfw).

Ascorbic Acid Extraction and Determination

Vitamin C or ascorbic acid (AsA) was extracted based on the solvent system (Wall, 2006). Approximately 20g of frozen root tissue was homogenized in 80 mL of cold m-phosphoric acid-acetic acid solution (30 g MPA, 0.5g ethylenediamine tetraacetic acid, EDTA; and 80 mL glacial acetic acid diluted to 1L with Milli–Q water) in a pre-chilled Virtis beaker and homogenized with a Virtis Shear homogenizer (Cyclone Virtishear, model 225318, Gardiner, NY) at a speed setting of 70 for 1 minute. The homogenate was transferred to Oak Ridge Centrifuge Tubes (Nalge Nunc International Corporation, Rochester, NY), followed by a 10 minute sonication (Branson, model 5510 Branson Ultrasonic Corporation, Danbury, CT). Sonicated samples were clarified by centrifugation (Beckman Centrifuge, model J2-21, San Antonio, TX) at 13,000 rpm for 15 min at 4°C, filtered with Miracloth (Calbiochem, La Jolla, CA), and diluted to a final volume of 120 mL.

Vitamin C was determined according to a procedure reported by Gossett et al. (1994) with modifications (Hodges et al., 1996) which permits adaptations for micro-plate determinations. For ascorbate (AsA) determination, a 2.0- mL microcentrifuge tube 50µl of Milli-Q water, 100µl of appropriately diluted clarified sample was added to 250µl of KH_2PO_4 (150mM, pH 7.4 and 5 mM EDTA), with a 10 minute room temperature incubation and 50µl of Milli–Q water was added. To which 200µl of trichloroacetic acid (TCA), 200µl of O-phosphoric acid, 200µl of 4% (w/v) 2, 2-bipyridyl dissolved in 70% HPLC grade ethanol, 100µl of 3% (w/v) $FeCl_3$. Generation of a standard curve was achieved by constructing six different concentrations of L- AsA (0, 20, 40, 60, 80, and 100 µM) which were performed in parallel with appropriate diluted samples. Microcentrifuge tubes were capped, inserted into polypropylene floating microcentrifuge tube racks and incubated in a water bath (Fisher Scientific model ISOTEMP 210, Dubuque, Iowa) maintained at 40^{o}C for 60 minutes. In the event of the need to clarify samples following incubation due to the incidence of particulates formed, samples and standards were clarified by centrifugation (Thermo, Micromax Centrifuge, Milford, MA) at 10,000 g for 15 min at 4°C. Clarified extracts and standards were immediately transferred to multichannel pipette reservoir and 200µl were pipetted into 96 well flat bottom plates (Costar cat # 3370, Corning Inc., Corning, NY). The absorbance was read at 525 nm in a microplate reader (Synergy HT, BIO-TEK Instruments, Inc., Winooski, Vermont) maintained at 25^{o}C. Vitamin C content was expressed as mg/100gfw.

Statistical Analysis

Data were analyzed using analysis of variance (ANOVA; SAS version 9.1; SAS Institute, Cary, NC) and means were separated using Duncan's multiple range tests at $P < 0.05$. Treatments were arranged in a Randomized Complete Block Design. The main effects consisted of mulch color and row cover on selected physical attributes (above mulch temperature AMT; below mulch temperature, BMT; yield components, grades, and dry weight), physicochemical properties (pH, soluble solids content, titratable acidity and total soluble sugar content), and antioxidant properties (total carotenoid content, TC; total phenolics content, TP and antioxidant activities). Within each of the experiments, data were combined across treatments and Pearson's correlation coefficients were used to investigate relationships between selected variables.

CHAPTER IV. RESULTS AND DISCUSSION

Early Harvest Sweet Potato Total Yield and Grades – 2008

SPM + RC, SPM, and RPM produced higher yields in Jumbo weight than BPM + RC, BS + RC, BS, BLUPM + RC, and BLUPM 83 days after planting during summer 2008 (Table 1). All other treatment yields were similar in Jumbo weight. SPM + RC produced the greatest yields in U.S. #1 weight in comparison to all treatments except RPM. There were no differences among the treatments in U.S. #2 weight. BPM treatment was higher than the BPM + RC treatments in canner weight, while other treatments were similar. RPM + RC produced higher yields in cull weight than RPM, while other treatments were similar. SPM + RC and RPM treatments were higher than BPM + RC, RPM + RC, BS + RC, and BLUPM + RC treatments in total yield, while there were no differences among other treatments..

Late Harvest Sweet Potato Total Yield and Grades – 2008

SPM + RC and RPM treatments produced higher Jumbo weight than BPM + RC, RPM + RC, BS + RC, BS, SPM, and BLUPM + RC treatments 104 days after planting during summer 2008 (Table 2). All other treatments were similar in Jumbo weight. U.S. #1 weight, SPM + RC produced higher yields than BS + RC, while other treatments were similar. U.S. #2 weight, BLUPM + RC produced higher yields than all treatments except BS, SPM, WPM, and BLUPM + RC treatments. There were no differences among treatments in canner weight and cull weight. SPM + RC, WPM, and RPM treatments yields were higher in total weight than BPM + RC, RPM + RC, BS + RC, and BS treatments while all other treatments showed no differences in total yield.

Early Harvest and Late Harvest Sweet Potato Total Marketable Yield – 2008

SPM + RC treatment yields were higher in early marketable weight than BPM + RC, RPM + RC, BS + RC, BS, BLUPM + RC, and BLUPM treatments while all other treatments exhibited similar early marketable weight following 83 and 104 days after planting during summer 2008 (Table 3). In late total marketable yield weight, SPM + RC and WPM treatments produced higher yields than BPM + RC, RPM + RC, BS + RC, and BS treatments while there were no differences among other treatments.

Sweet Potato Sample Vine Length and Vine Weight – 2008

Vine length for RPM and BPM treatments were higher than BPM +RC, SPM + RC, SPM, and WPM + RC, while all other treatments were similar during summer 2008 (Table 4). Vine weight of BPM, SPM + RC, RPM + RC, WPM, and RPM were higher than BPM + RC, but there were not different among other treatments.

Environmental Conditions at E.V. Smith Experiment Station in Shorter, AL. – 2008

E.V. Smith Research and Extension Center in Shorter, Alabama environmental air temperatures were recorded 1.52 m above the soil surface during summer 2008 (Table 5). The absolute high and low air temperatures represent the single most highest and lowest temperature recorded every hour over a 24 hour a day time frame for 7 days. The average high and low air temperatures represent the average of the day to day highest and lowest temperatures recorded over a period of 7 days. The overall average air temperature represents the average of all temperatures recorded daily for a 24 hour a day, 7 day period (week). Precipitation represents the total rainfall recorded during a 7 day period. The absolute high air temperatures recorded ranged from 30.00°C to 37.22°C, while the absolute low air temperatures recorded ranged from 7.78°C to 22.78°C during the 2008 growing season. The average high air temperatures recorded ranged from 27.70°C to 36.11°C, and the average low air temperatures recorded ranged from 11.91°C to 23.49°C. The overall average air temperatures recorded ranged from 19.92°C to 29.05°C. The total rainfall recorded ranged from 0 cm to 19.63 cm from planting until harvest.

E.V. Smith Research and Extension Center in Shorter, Alabama environmental soil temperatures were recorded 10.16 cm beneath the soil surface during summer 2008 (Table 6). The absolute high and low soil temperatures represent the single most highest and lowest temperature recorded every hour over a 24 hour a day time frame for 7 days. The average high and low soil temperatures represent the average of the day to day highest and lowest temperatures recorded over a period of 7 days. The overall average soil temperature represents the average of all temperatures recorded daily for a 24 hour a day, 7 day period (week). The absolute high soil temperatures recorded values were between 32.22°C to 41.67°C, while the absolute low soil temperatures recorded values were between 17.22°C to 29.44°C. The average high soil temperatures recorded values were between 29.37°C to 39.76°C, and the average low soil temperatures recorded values were between 18.81°C to 29.84°C. The overall average air temperatures recorded values were between 24.21°C to 34.92°C.

Sweet Potato Above Mulch Air and Below Mulch Soil Temperature – 2008

BPM + RC and WPM + RC were higher in above mulch temperature when compared to all treatments except for the RPM treatment during summer 2008 (Table7). Below mulch temperatures for BPM + RC treatment were higher when compared to all treatments except for RPM, BLUPM + RC, and BLUPM treatments.

Sweet Potato Physical and Physiochemical Components – 2008

Dry matter content of sweet potatoes grown on SPM, SPM + RC, WPM, and RPM + RC treatments were higher than BPM + RC, BPM, and BS treatments for 2008 growing season (Table 8). Sweet potatoes grown on all other treatments were similar in dry matter weight. There was no difference among treatments in canner content. The pH of sweet potatoes grown on BS + RC was higher than all other treatments. Total soluble solids content was higher in sweet potatoes grown on BLUPM + RC and BLUPM treatments when compared to other treatments except for BPM + RC and BS treatments. Total sugar content was higher in sweet potatoes grown on BPM + RC when compared to all other treatments except for the BS + RC treatment. Titratable acidity content was higher in sweet potatoes grown on BS when compared to other treatments except for the BPM + RC treatment.

Sweet Potato Antioxidant Capacity – 2008

ABTS VCEAC content of sweet potatoes grown on WPM was higher compared to other treatments with SPM being the exception (Table 9). Sweet potatoes grown on BS + RC and WPM + RC treatments VCEAC content were higher when compared to other treatments when determined by DPPH assay. Sweet potatoes grown in RPM were higher compared to all other treatments in TEAC when determined by DPPH assay. Sweet potatoes grown on RPM and WPM + RC treatments were higher in Vitamin C equivalent antioxidant capacity, Chlorogenic acid equivalent, and Trolox equivalent antioxidant capacity when compared to all other treatments and determined by FRAP assay.

Sweet Potato Antioxidant Content – 2008

Sweet potatoes grown on the SPM + RC treatment were higher in total carotenoid content when compared to BPM + RC, BPM, RPM, BS, SPM, WPM, and BLUPM, while sweet potatoes grown on all other treatments were similar in total carotenoid content (Table 10). Vitamin C content was higher in sweet potatoes grown on BPM treatment when compared to all other treatments except for the SPM RPM treatments. Sweet potatoes grown on the RPM treatment were higher in Chlorogenic acid content when compared to all other treatments. In contrast, sweet potatoes grown on the RPM when compared to all treatments except for the RPM + RC, WPM + RC, and BLUPM treatments were higher in gallic acid.

Correlation Among Sweet Potato Physical and Physiochemical Components – 2008

Below mulch (soil) temperature was found to have negative correlations with dry matter content (r = -0.44105) and canner weight (r = -0.37349), which implies as below mulch temperature increased dry matter content and canner weight decreased (Table 11). However, below mulch temperature was found to have a positive correlation with total sugar content (r = 0.30469). In regards to titratable acidity, negative correlations associated with dry matter content (r = -0.34741) and pH (r = -0.75976) content are reported. The pH content was found to have positive correlations with dry matter content (r = 0.42653) and total soluble solids (r = 0.32716) content. Total soluble solids content was found to have a negative correlation with total sugar (r = -0.31178) content.

Correlation Among Sweet Potato Antioxidant Capacity and Content Components – 2008

Vitamin C content negatively correlates with above mulch (air) temperature (r = -0.64139) and DPPH Vitamin C equivalent antioxidant capacity (r = -0.35954) (Table 12). Below mulch (soil) temperature was found to have a negative correlation with ABTS-VCEAC (r = -0.31783), but had a positive correlation with DPPH Trolox equivalent antioxidant capacity (r = 0.38465). FRAP-VCEAC was found to have a positive correlation with DPPH-TEAC (r = 0.68425). There were several positive correlations with FRAP Chlorogenic acid equivalent content which included DPPH-VCEAC (r = 0.29533), DPPH-TEAC (r = 0.67062), and FRAP-VCEAC (r = 0.98992). There were several positive correlations with FRAP-TEAC which included DPPH-TEAC (r = 0.68443), FRAP-VCEAC (r = 0.98387), and FRAP-CAE (r = 0.99138) content. Total phenolics CAE was found to have positive correlations with DPPH-TEAC (r = 0.64255), FRAP-VCEAC (r = 0.80945), FRAP-CAE (r = 0.81382) content, and FRAP-TEAC (r = 0.82518). There were several positive correlations with total phenolics gallic acid equivalent content which include DPPH TEAC (r = 0.47401), FRAP-VCEAC (r = 0.69569), FRAP-CAE (r = 0.66446) content, FRAP-TEAC (r = 0.67400), total carotenoid content (r = 0.35026), and total phenolics CAE (r = 0.60410) content.

Sweet Potato Total Yield and Grades – 2009

In regards to Jumbo weight, SPM + RC, BPM + RC, and RPM + RC treatments produced higher yields than BS + RC, BS, WPM + RC, and BPM while all other treatments were not different 147 days after planting during summer 2009 (Table 13). WPM treatment produced higher yields in U.S. #1 weight compared to BPM, BS + RC, BS, SPM, WPM + RC, and BLUPM while all other treatments were similar in U.S. #1 weight. The SPM + RC treatment produced higher U.S. #2 weight compared to BS + RC, BS, and WPM, while all other treatments were similar. Highest yield producers of canner sweet potatoes were SPM, WPM, and SPM + RC treatments, while all other treatments were not differences. Cull weights for, BS, BS + RC, and BPM were the lowest producing treatments when compared to all other treatments. Total yields for SPM + RC treatments produced higher yields than BS + RC treatment while there were no differences among all other treatments.

Sweet Potato Harvest Total Marketable Yield – 2009

The SPM treatment produced higher total marketable weight when compare to BPM, BS + RC, BS, and WPM treatments 147 days after planting during 2009 growing season; however, there were no differences among all other row cover and color mulch treatments (Table 14).

Sweet Potato Sample Vine Length and Vine Weight – 2009

Vine length were higher for BLUPM + RC and RPM treatments when compared to BS + RC, BS, SPM + RC, and WPM treatments while all other treatments had similar vine length during 2009 growing season (Table 15). Vine weights were similar for all treatments with the exception noted for BS + RC and BS, which had the lowest weights.

Environmental Conditions at E.V. Smith Research and Extension Center in Shorter, AL. – 2009

The results for the 2009 environmental air conditions at E.V. Smith Research and Extension Center in Shorter, Alabama environmental air temperatures were recorded 1.52 m above the soil surface (Table 16). The absolute high and low air temperatures represent the single most highest and lowest temperature recorded every hour over a 24 hour a day time frame for 7 days. The average high and low air temperatures represent the average of the day to day highest and lowest temperatures recorded over a period of 7 days. The overall average air temperature represents the average of all temperatures recorded daily for a 24 hour a day, 7 day period (week). Total rainfall was recorded during a 7 day period. The absolute high air temperatures recorded ranged from 30.00°C to 36.11°C, while the absolute low air temperatures recorded ranged from 2.78°C to 22.78°C during the 2009 growing season. The average high air temperatures recorded ranged from 21.27°C to 35.32°C, and the average low air temperatures recorded ranged from 8.02°C to 23.33°C. The overall average air temperatures recorded ranged from 15.00°C to 29.44°C. The total rainfall recorded ranged from 0 cm to 6.58 cm from planting until harvest.

The results from the 2009 environmental soil conditions at E.V. Smith Research and Extension Center in Shorter, Alabama environmental soil temperatures were recorded 10.16 cm beneath the soil surface (Table 17). The absolute high and low soil temperatures represent the single most highest and lowest temperature recorded every hour over a 24 hour a day time frame for 7 days. The average high and low soil temperatures represent the average of the day to day highest and lowest temperatures recorded over a period of 7 days. The overall average soil temperature represents the average of all temperatures recorded daily for a 24 hour, 7 day period (week). The absolute high soil temperatures values recorded were between 23.89°C to 40.56°C, while the absolute low soil temperature values recorded were between 12.22°C to 29.44°C. The average high soil temperatures values recorded were between 20.56°C to 39.92°C, and the average low soil temperatures recorded ranged from 14.21°C to 30.00°C. The overall average air temperatures recorded values were between 17.62°C to 35.08°C.

Sweet Potato Above Mulch Air and Below Mulch Soil Temperature – 2009

WPM + RC, BPM + RC, RPM + RC, and SPM + RC treatments had the highest temperature while no difference occurred among all other treatments (Table 18). BPM + RC treatment was higher in below mulch temperature when compared to all treatments with the exception of the RPM + RC, RPM, BLUPM + RC, and BLUPM.

Discussion Summary

In 2009, SPM was higher in total marketable weight than the BPM, BS + RC, BS and WPM treatments (Table 14). These results are in agreement with other research (Brown et al., 2008). Kim et al. (2008) reported that reflective plastic film mulch increased marketable fruit yields in plums. White (2003) reported that four different watermelon highest yields were recorded on red plastic mulch. In the present study, BS and BS + RC treatments were among the lowest in sweet potato production in 2008 and 2009 (Tables 1, 2, 3, 13, and 14). Plastic mulch enhancement of yield were also reported in strawberries (Mathod and Jholgiker, 2005) and sweet corn (Kwabiah, 2004) when compared to bare soil.

Diaz-Perez and Batal (2002) reported root zone temperature influenced biomass vegetables. In the present study, treatments without row covers appeared to have increased vine lengths and vine weights when compared to treatments with row cover.

Ham et al. (1993) reported soil temperatures were highest beneath mulches. According to Diaz-Perez and Batal (2002), the degree of soil warming is correlated with reflectivity of the mulch; black mulch had the lowest light reflectance while silver had the highest. Diaz-Perez et al. (2007) also reported that root zone temperature was highest under black mulch. In the present study, row cover treatments during 2008 and 2009 had higher above mulch and below mulch temperatures when compared to treatments without row cover (Tables 7 and 18).

In the present study, below mulch (soil) temperatures were negatively influenced canner weight and dry matter content which explains the decrease in canner weight. Diaz-Perez and Batal (2002) noted that with certain plastic mulch treatments, high temperatures during the summer, especially in the southeastern United States, may critically reduce to plant growth. However, Ban et al. (2009) found a positive correlation of early yield and total yield with average soil temperatures in watermelon production. The effects of colored mulches on plant response depend on the mulch root zone temperature according to Diaz-Perez and Batal (2002). Diaz-Perez and Batal (2002) also noted plant growth and yield were highest as root zone temperature approached the optimal root zone temperature for tomatoes using red mulch. Diaz-

Perez (2009) found that broccoli plant growth and yield responded more favorably to dark-colored mulches than to light-colored mulches, suggesting that broccoli benefited from increased soil warming, but only during cool conditions.

In the present study, field experiments for 2009 season matured much later than 2008 sweet potatoes. Ahn (1993) reported sweet potatoes are sensitive to water-logging conditions which may cause storage root rot, reduce growth, and storage of roots.

In 2008, RPM treatment was among the highest in Beauregard sweet potato extracts with respect to DPPH, FRAP, and total phenolics content compared to other treatments. However, there were no other common trends among treatments for sweet potato physical components, physiochemical components, and antioxidant content.

Table 1. Beauregard sweet potato yields as affected by colored plastic mulch and row covers determined 83 days after planting in summer of 2008 in Shorter, Alabama.

Treatment	**Marketable Yield (kg/plot)**				**Cull**[u]	**Total Yield**
	Jumbo[y]	**U.S. #1**[x]	**U.S. #2**[w]	**Canner**[v]		
BPM+RC[z]	0.00b[t]	3.64b	4.24a	6.45b	4.01ab	18.34d
BPM	1.22ab	8.38b	10.10a	14.01a	2.09b	35.80abcd
RPM+RC	1.19ab	5.63b	5.27a	7.70ab	4.89a	24.68cd
RPM	4.80a	17.77ab	10.36a	8.52ab	4.39ab	45.84ab
BS+RC	0.00b	3.40b	4.41a	8.93ab	3.62ab	20.36cd
BS	0.00b	6.95b	9.74a	10.91ab	4.24ab	31.84bcd
SPM+RC	5.32a	26.99a	3.95a	11.80ab	4.21ab	52.27a
SPM	4.84a	8.39b	8.69a	11.07ab	4.64ab	37.63abc
WPM+RC	4.39ab	4.89b	13.61a	9.51ab	3.14ab	35.54abcd
WPM	2.53ab	6.00b	11.45a	11.67ab	4.47ab	36.12abcd
BLUPM+RC	0.00b	10.62b	5.68a	8.56ab	4.14ab	29.00bcd
BLUPM	0.00b	7.81b	4.91a	8.68ab	4.62ab	26.02cd

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]Jumbo – roots 8.75cm or greater in diameter

[x]U.S. #1 – roots 8.75cm to 5.63cm in diameter

[w]U.S. #2 – roots 5.63cm to 4.38cm in diameter

[v]Canner – roots 4.38cm to 3.75 in diameter

[u]Cull – roots 3.75cm or less in diameter

[t]Mean separation in columns by Duncan's multiple range test, 5% level with four replications

Study conducted at Auburn University E.V. Smith Research and Extension Center

Table 2. Beauregard sweet potato yields as affected by colored plastic mulch and row covers determined 104 days after planting in summer of 2008 in Shorter, Alabama.

Treatment	Marketable Yield (kg/plot)				Cull[u]	Total Yield
	Jumbo[y]	U.S. #1[x]	U.S. #2[w]	Canner[v]		
BPM+RC[z]	6.29bcd[t]	23.05ab	6.36b	4.44a	1.47a	41.61c
BPM	15.04abc	36.88ab	6.47b	6.20a	1.31a	65.90abc
RPM+RC	7.30bcd	26.05ab	4.10b	8.20a	2.39a	48.04bc
RPM	23.49a	44.83ab	6.16b	5.98a	1.87a	82.33a
BS+RC	2.68cd	19.48b	5.58b	6.99a	0.92a	35.65c
BS	0.73d	26.42ab	8.64ab	6.44a	0.93a	43.16c
SPM+RC	23.56a	48.41a	6.69b	8.21a	1.72a	88.59a
SPM	8.37bcd	45.38ab	11.12ab	8.43a	2.82a	76.12ab
WPM+RC	17.48ab	31.79ab	6.53b	4.54a	2.78a	63.12abc
WPM	18.42ab	46.85ab	8.50ab	8.29a	2.05a	84.11a
BLUPM+RC	10.04bcd	26.95ab	9.60ab	7.00a	2.93a	56.52abc
BLUPM	18.58ab	36.87ab	15.58a	3.25a	2.11a	76.39ab

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]Jumbo – roots 8.75cm or greater in diameter

[x]U.S. #1 – roots 8.75cm to 5.63cm in diameter

[w]U.S. #2 – roots 5.63cm to 4.38cm in diameter

[v]Canner – roots 4.38cm to 3.75 in diameter

[u]Cull – roots 3.75cm or less in diameter

[t]Mean separation in columns by Duncan's multiple range test, 5% level with four replications

Study conducted at Auburn University E.V. Smith Research and Extension Center

Table 3. Comparison of colored plastic mulch and row covers effects on Beauregard sweet potato total marketable yields determined 83 and 104 days after planting in summer of 2008 in Shorter, Alabama.

Treatment	Early Total Marketable Yield (kg/plot) 83 days after planting	Late Total Marketable Yield (kg/plot) 104 days after planting
BPM+RC[z]	14.33d[y]	40.14d
BPM	33.71abc	64.59abcd
RPM+RC	19.79cd	45.65cd
RPM	41.45ab	80.46ab
BS+RC	16.74cd	34.73c
BS	27.60bcd	42.23c
SPM+RC	48.06a	86.87a
SPM	32.99abc	73.30ab
WPM+RC	32.40abcd	60.34abc
WPM	31.65abcd	82.06a
BLUPM+RC	24.89bcd	53.59abc
BLUPM	21.40cd	74.28ab

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]Mean separation in columns by Duncan's multiple range test, 5% level with four replications

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Table 4. Beauregard sweet potato vine length and vine weight as affected by colored plastic mulch and row covers determined 35 days after planting in summer of 2008 in Shorter, Alabama.

Treatment	Vine Length (cm)	Vine Weight (kg)
BPM+RC[z]	91.68c[y]	0.29b
BPM	138.55a	0.92a
RPM+RC	117.30ab	0.80a
RPM	140.00a	0.77a
BS+RC	116.55ab	0.55ab
BS	132.70ab	0.62ab
SPM+RC	96.05bc	0.86a
SPM	95.00bc	0.50ab
WPM+RC	96.68bc	0.58ab
WPM	124.58ab	0.78a
BLUPM+RC	108.55ab	0.74ab
BLUPM	120.63ab	0.63ab

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]Mean separation in columns by Duncan's multiple range test, 5% level with four replications

Study conducted at Auburn University E.V. Smith Research and Extension Center

Table 5. Seasonal air temperature and rainfall data recorded in Shorter, Alabama during summer of 2008 Beauregard sweet potato production[z].

Week	absolute high temp (°C)	absolute low temp (°C)	average high temp (°C)	average low temp (°C)	overall average temp (°C)	total rainfall (cm)
1	30.00	8.33	27.70	11.91	19.92	1.63
2	31.11	7.78	28.89	16.19	22.78	4.78
3	32.22	10.56	27.86	16.35	22.22	0.00
4	32.78	15.56	31.03	18.17	24.76	0.00
5	35.56	18.33	33.26	19.84	26.67	0.51
6	37.22	20.00	36.11	21.67	29.05	2.57
7	34.44	16.11	33.65	19.84	26.91	0.91
8	35.56	14.44	33.09	18.57	25.95	0.00
9	36.67	13.89	33.02	19.21	26.19	1.50
10	35.00	18.89	33.81	20.48	27.30	5.77
11	35.56	17.78	33.73	21.19	27.54	2.08
12	36.67	19.44	34.76	21.11	28.02	2.82
13	35.56	21.67	33.09	23.02	28.17	1.96
14	35.00	22.78	34.37	23.49	29.05	1.70
15	37.22	15.56	32.30	20.24	26.35	3.86
16	33.33	19.44	31.83	20.72	26.43	0.00
17	33.89	21.67	29.52	22.86	26.35	19.63

[z]Temperatures reported from E.V. Smith Research and Extension Center (Shorter, AL) represent absolute high, absolute low, average high, average low, and overall average in °C during the 2008 season from planting (May 8, 2008) to final harvest (August 21, 2008). Temperatures recorded 1.524m above soil surface. Total rainfall is reported in centimeters.

Table 6. Seasonal soil temperature and rainfall data recorded in Shorter, Alabama during summer of 2008 Beauregard sweet potato production[z].

Week	absolute high temp (°C)	absolute low temp (°C)	average high temp (°C)	average low temp (°C)	overall average temp (°C)	total rainfall (cm)
1	32.22	17.22	29.37	18.81	24.21	1.63
2	32.78	18.89	30.95	21.43	26.35	4.78
3	33.89	17.78	29.13	20.48	25.00	0.00
4	36.67	23.89	34.37	24.92	29.84	0.00
5	38.89	26.67	37.46	27.70	32.78	0.51
6	41.11	29.44	39.76	29.84	34.92	2.57
7	38.89	24.44	35.79	26.11	31.19	0.91
8	39.44	24.44	37.38	26.67	32.22	0.00
9	40.00	25.00	36.43	27.62	32.14	1.50
10	40.00	25.56	38.41	28.49	33.49	5.77
11	39.44	24.44	35.00	26.35	30.87	2.08
12	40.00	25.56	38.02	27.62	32.94	2.82
13	37.22	26.11	34.52	27.06	30.95	1.96
14	40.56	28.33	38.73	28.97	33.97	1.70
15	41.67	25.00	36.27	26.91	31.74	3.86
16	36.67	24.44	33.41	25.24	29.44	0.00
17	37.22	24.44	30.95	25.63	28.41	19.63

[z]Temperatures reported from E.V. Smith Research and Extension Center (Shorter, AL) represent absolute high, absolute low, average high, average low, and overall average in °C during the 2008 season from planting (May 8, 2008) to final harvest (August 21, 2008). Temperatures recorded 10.16cm below soil surface. Precipitation is reported in centimeters.

Table 7. Recorded temperatures for Beauregard sweet potato production above mulch air and below soil mulch temperatures as affected by colored plastic mulch and row covers in summer of 2008 in Shorter, Alabama.

Treatment	Above Mulch Air Temperature (°C)[x]	Below Mulch Soil Temperature (°C)[w]
BPM+RC[z]	45.08a[y]	34.64a
BPM	38.17d	32.74bcd
RPM+RC	43.35ab	33.02bcd
RPM	38.42d	34.02ab
BS+RC	40.38c	32.47bcd
BS	37.19d	31.94cde
SPM+RC	44.11ab	29.46f
SPM	38.22d	29.32f
WPM+RC	44.92a	31.57de
WPM	38.03d	30.57ef
BLUPM+RC	42.49b	33.82ab
BLUPM	38.38d	33.33abc

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]Mean separation in columns by Duncan's multiple range test, 5% level with four replications; temperatures recorded twice a week from May 8, 2008 to June 12, 2008 – 35 days.

[x]Above mulch air temperature was recorded 15.24 cm above the mulch

[w]Below mulch soil temperature was recorded 15.24 cm below the soil surface

Study conducted at Auburn University E.V. Smith Research and Extension Center

Table 8. Dry matter content (DM), canner weight (CW), pH, total soluble solid (TSS), total sugar (TS) and titratable acidity (TA) content of Beauregard sweet potato as effected by colored plastic mulch and row covers during summer of 2008 in Shorter, Alabama.

Treatment	DM[y] (g)	CW (kg/plot)	pH	TSS (%)	TS (mg/gfw)	TA (citric acid %)
BPM+RC[z]	2.19bcd[x]	4.44a	6.34e	17.63ab	240.18a	3.51ab
BPM	2.14cd	6.20a	6.46de	17.00c	206.55bc	2.81cd
RPM+RC	2.39a	8.20a	6.43e	16.88c	184.89cd	3.04bc
RPM	2.28abcd	5.98a	6.53cde	16.63d	189.24cd	2.74cd
BS+RC	2.32abc	6.99a	7.02a	17.38b	217.26ab	2.23d
BS	2.13d	6.44a	6.43e	17.63ab	169.61de	3.66a
SPM+RC	2.40a	8.21a	6.72bc	17.50b	184.18cd	2.89cd
SPM	2.48a	8.43a	6.71bc	17.50b	163.17def	2.49cd
WPM+RC	2.35ab	4.54a	6.82b	17.50b	147.27efg	2.74cd
WPM	2.40a	8.29a	6.66bcd	17.50b	122.28g	2.64cd
BLUPM+RC	2.35ab	7.00a	6.75b	17.88a	136.10fg	2.74cd
BLUPM	2.33abc	3.25a	6.77b	17.88a	135.52fg	2.48cd

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]DM – dry matter, CW – canner weight, pH, TSS – total soluble solids (BRIX), TS – total sugars, TA – titratable acidity

[x]Mean separation in columns by Duncan's multiple range test, 5% level with four replications

Table 9. Effect of colored plastic mulch and row covers on Beauregard sweet potato antioxidant capacity as determined by ABTS, DPPH and FRAP assays.

Treatment	ABTS	DPPH		FRAP		
	VCEAC[y] (mg/100gfw)	VCEAC (mg/100gfw)	TEAC (µM/100gfw)	VCEAC (mg/100gfw)	CAE (mg/100gfw)	TEAC (µM/100gfw)
BPM+RC[z]	406.20bc[w]	113.66ef	164.24de	41.78de	83.46de	228.30cd
BPM	296.33d	113.09f	163.06def	33.36ef	67.96ef	199.25d
RPM+RC	369.11cd	114.02ef	170.83c	64.51b	121.60b	332.26b
RPM	323.05cd	117.97b	177.81a	76.30a	143.84a	386.00a
BS+RC	362.36cd	120.20a	157.45g	37.64ef	73.89e	200.59d
BS	319.56cd	117.47bc	161.78f	40.90de	79.57de	212.69d
SPM+RC	337.35cd	116.46c	148.20h	39.32de	78.99de	215.04d
SPM	467.78ab	108.92g	162.56ef	48.89cd	93.67cd	254.50c
WPM+RC	366.95cd	119.55a	174.86b	76.23a	151.83a	413.04a
WPM	502.61a	115.24d	165.02d	28.03f	55.53f	153.25e
BLUPM+RC	377.82cd	114.59e	164.04de	34.90ef	68.41ef	191.52d
BLUPM	375.41cd	117.39bc	163.06def	54.52c	108.59bc	299.01b

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]VCEAC – vitamin C equivalent antioxidant capacity, CAE – Chlorogenic acid equivalent, TEAC – Trolox equivalent antioxidant capacity

[x]ABTS = 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid), DPPH = 2, 2-Diphenyl-1-picrylhydrazyl, FRAP = Ferric Reducing Antioxidant Power

[w]Mean separation in columns by Duncan's multiple range test, 5% level with four replications

Table 10. Total carotenoid (TC), vitamin C, and total phenolic (TP) content of Beauregard sweet potato as affected by colored plastic mulch and row covers during summer of 2008 in Shorter, Alabama.

Treatment	Total Carotenoid[y] (mg/100gfw)	VITAMIN C (mg/100gfw)	TOTAL PHENOLICS CAE (mg/100gfw)	GAE (mg/100gfw)
BPM+RC[z]	15.03c[x]	4.82e	71.88d	19.76d
BPM	15.94bc	6.64a	64.15d	17.13d
RPM+RC	16.86abc	4.83e	100.18c	57.69ab
RPM	15.96bc	6.15ab	141.36a	60.06a
BS+RC	18.75ab	4.94de	71.88d	27.65cd
BS	15.99bc	5.43cd	70.59d	25.56d
SPM+RC	19.50a	4.87e	66.73d	26.44d
SPM	16.01bc	6.20ab	96.32c	33.46bcd
WPM+RC	19.33ab	4.98de	122.06b	53.47abc
WPM	16.04bc	5.68bc	59.01d	10.28d
BLUPM+RC	17.15abc	5.37cde	59.01d	20.82d
BLUPM	16.06bc	5.75bc	106.62bc	35.57abcd

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]Total Carotenoid, Vitamin C,CAE – Chlorogenic acid equivalent, GAE – gallic acid equivalent

[x]Mean separation in columns by Duncan's multiple range test, 5% level with four replications

Table 11. Correlation coefficients for above mulch air temperature and below soil mulch temperatures and physicochemical parameters for Beauregard sweet potato as affected by colored plastic mulch and row covers during summer of 2008 in Shorter, Alabama.

Components[z]	ST	DM	CW	pH	TSS	TS	TA
AT	0.15141	0.08302	0.11570	0.04287	0.07079	0.21817	0.09145
ST		-0.44105*	-0.37349*	0.23109	0.15817	+0.30469*	0.10271
DM			0.21182	+0.42653*	0.10120	0.26239	-0.34741*
CW				0.00582	0.05133	0.03241	0.04667
pH					+0.32716*	0.14089	-0.75976*
TSS						-0.31178*	0.04589
TS							0.08017

[z]Components: AT – above mulch air temperature, ST – below mulch soil temperature, DM – dry matter, CW – canner weight, pH, TSS – total soluble solids, TS – total sugar, TA – titratable acidity

*Significant at $p \leq 0.05$ with four replications

+Positive correlation

-Negative correlation

Table 12. Correlation coefficients for antioxidant capacity and antioxidant content for Beauregard sweet potato as affected by colored plastic mulch and row covers during summer of 2008 in Shorter, Alabama.

Components[z]	ST	AB-VCEAC	DP-VCEAC	DP-TEAC	FR-VCEAC	FR-CAE	FR-TEAC	TC	VIT-C	TP-CAE	TP-GAE
AT	0.15141	0.14721	0.07743	0.03356	0.15593	0.17732	0.19573	0.01840	-0.64139*	0.02422	0.22466
ST		-0.31783*	0.17096	+0.38465*	0.14791	0.15523	0.16434	0.19744	0.07301	0.18344	0.06174
AB-VCEAC			0.27050	0.01863	0.06141	0.08079	0.11693	0.24579	0.11626	0.19244	0.24030
DP-VCEAC				0.09230	0.27546	+0.29533*	0.277798	0.08305	-0.35954*	0.19705	0.18639
DP-TEAC					+0.68425*	+0.67062*	+0.68443*	0.01680	0.17520	+0.64255*	+0.47401*
FR-VCEAC						+0.98992*	+0.98387*	0.03153	0.07638	+0.80945*	+0.69569*
FR-CAE							+0.99138*	0.03344	0.07776	+0.81382*	+0.66446*
FR-TEAC								0.00545	0.07020	+0.82518*	+0.67400*
TC									0.00622	0.13131	+0.35026*
VIT-C										0.11715	0.10457
TP-CAE											+0.60410*

[z]Components: AT – above mulch air temperature, ST – below mulch soil temperature, AB-VCEAC – ABTS Vitamin C equivalent antioxidant capacity, DP-VCEAC – DPPH Vitamin C equivalent antioxidant capacity, DP-TEAC – DPPH Trolox equivalent antioxidant capacity, FR-VCEAC – FRAP Vitamin C equivalent antioxidant capacity, FR-CAE – FRAP Chlorogenic acid equivalent, FR-TEAC – FRAP Trolox equivalent antioxidant capacity, TC – total carotenoid, VIT-C – Vitamin C, TP-CAE – total phenolics Chlorogenic acid equivalent, TP-GAE – total phenolics Gallc acid equivalent

*Significant at $p \leq 0.05$ with four replications

+Positive correlation

-Negative correlation

Table 13. Beauregard sweet potato yields as affected by colored plastic mulch and row covers determined 147 days after planting in fall of 2009 in Shorter, Alabama.

Treatment	**Marketable Yield (kg/plot)**				**Cull**[u]	**Total Yield**
	Jumbo[y]	**U.S. #1**[x]	**U.S. #2**[w]	**Canner**[v]		
BPM+RC[z]	62.08a[t]	43.24abc	14.29abc	28.65b	28.71abc	176.97abcd
BPM	10.42d	20.86bc	13.28abc	18.41b	16.38bc	79.35bcd
RPM+RC	47.19b	42.42abc	11.94abc	24.14b	36.60a	162.29abcd
RPM	32.36abc	55.25abc	17.20abc	30.39b	32.95ab	168.15abcd
BS+RC	2.39d	7.51c	0.00d	20.85b	15.54bc	46.29d
BS	6.32d	13.74bc	2.82d	21.88b	13.52c	58.28cd
SPM+RC	67.04a	71.70ab	44.27a	53.57a	24.94abc	261.52a
SPM	25.52bcd	36.72abc	40.21ab	61.29a	33.16ab	196.9abc
WPM+RC	3.53d	13.70bc	8.69bc	30.86b	27.00abc	83.78bcd
WPM	19.34cd	94.21a	19.83abc	56.25a	32.72ab	222.35ab
BLUPM+RC	8.60bcd	52.62abc	12.10abc	31.70b	25.03abc	130.05abcd
BLUPM	16.29cd	32.17bc	18.34abc	28.03b	33.33ab	128.16abcd

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover
[y]Jumbo – roots 8.75cm or greater in diameter
[x]U.S. #1 – roots 8.75cm to 5.63cm in diameter
[w]U.S. #2 – roots 5.63cm to 4.38cm in diameter
[v]Canner – roots 4.38cm to 3.75 in diameter
[u]Cull – roots 3.75cm or less in diameter
[t]Mean separation in columns by Duncan's multiple range test, 5% level with four replications
Study conducted at Auburn University E.V. Smith Research and Extension Center

Table 14. Beauregard sweet potato total marketable yield as affected by colored plastic mulch and row covers determined 147 days after planting in fall of 2009 in Shorter, Alabama.

Treatment	Total Marketable Yield (kg/plot)
BPM+RC[z]	148.26abc[y]
BPM	62.97bc
RPM+RC	125.69abc
RPM	135.20abc
BS+RC	30.75c
BS	44.76c
SPM+RC	236.58a
SPM	163.74abc
WPM+RC	56.78bc
WPM	189.63ab
BLUPM+RC	105.02abc
BLUPM	94.83abc

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]Mean separation in columns by Duncan's multiple range test, 5% level with four replications

Study conducted at Auburn University E.V. Smith Research and Extension Center

Table 15. Beauregard sweet potato vine length and vine weight as affected by colored plastic mulch and row covers determined 35 days after planting in summer of 2009 in Shorter, Alabama.

Treatment	Vine Length (cm)	Vine Weight (kg)
BPM+RC[z]	81.58bcde[y]	0.44cd
BPM	106.88abc	0.73abc
RPM+RC	112.50abc	0.94ab
RPM	125.33a	1.02a
BS+RC	47.83e	0.10d
BS	52.20de	0.11d
SPM+RC	74.08cde	0.51bcd
SPM	89.38abcd	0.64abc
WPM+RC	83.13bcde	0.53bcd
WPM	86.25bcd	0.72abc
BLUPM+RC	125.95a	0.76abc
BLUPM	114.38ab	0.82abc

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]Mean separation in columns by Duncan's multiple range test, 5% level with four replications

Study conducted at Auburn University E.V. Smith Research and Extension Center

Table 16. Seasonal air temperature and rainfall data recorded in Shorter, Alabama during summer of 2009 Beauregard sweet potato production[z].

Week	absolute high temp (°C)	absolute low temp (°C)	average high temp (°C)	average low temp (°C)	overall average temp (°C)	total rainfall (cm)
1	33.89	15.56	29.92	18.73	24.52	3.43
2	33.89	18.89	32.06	20.56	26.43	0.33
3	36.11	20.56	34.52	22.06	28.41	1.19
4	36.11	22.78	35.32	23.33	29.44	0.00
5	36.11	16.11	35.00	19.21	27.22	2.84
6	33.89	20.56	31.43	21.59	26.59	2.82
7	34.44	16.11	32.94	21.35	27.38	0.03
8	33.33	14.44	31.59	18.25	25.08	2.26
9	33.89	20.00	32.06	22.06	27.22	4.88
10	34.44	20.56	33.57	21.51	27.62	1.24
11	35.56	21.11	33.65	22.06	28.10	6.48
12	32.78	16.11	31.27	21.11	26.35	4.32
13	32.78	15.56	30.48	19.29	25.00	2.67
14	31.11	18.89	28.49	20.24	24.44	4.42
15	32.78	18.89	30.24	20.48	25.56	6.48
16	30.56	21.67	29.29	22.38	25.95	1.52
17	32.78	20.56	31.43	21.98	26.90	1.55
18	30.00	10.00	26.90	12.62	19.84	5.54
19	32.22	16.67	27.38	18.41	23.10	6.58
20	27.22	3.89	21.35	14.05	17.94	0.38
21	27.78	2.78	21.67	8.02	15.00	3.86
22	28.33	5.56	21.27	11.67	16.59	0.10

[z]Temperatures reported from E.V. Smith Research and Extension Center (Shorter, AL) represent absolute high, absolute low, average high, average low, and overall average in °C during the 2009 season from planting (June 9, 2009) to harvest (November 4, 2009). Temperatures recorded 1.524m above soil surface. Total rainfall is reported in centimeters.

Table 17. Seasonal soil temperature and rainfall data recorded in Shorter, Alabama during summer of 2009 Beauregard sweet potato production[z].

Week	absolute high temp (°C)	absolute low temp (°C)	average high temp (°C)	average low temp (°C)	overall average temp (°C)	total rainfall (cm)
1	35.56	21.67	31.83	23.73	27.86	3.43
2	37.22	23.89	33.25	25.48	29.44	0.33
3	39.44	25.00	36.19	27.46	31.98	1.19
4	40.56	28.89	39.21	30.00	34.76	0.00
5	40.56	29.44	39.92	29.84	35.08	2.84
6	36.11	25.56	33.49	26.59	30.16	2.82
7	36.11	24.44	34.52	26.51	30.56	0.03
8	37.78	23.33	35.79	25.95	30.95	2.26
9	38.33	26.11	33.97	26.90	30.63	4.88
10	37.22	25.56	34.21	26.19	30.40	1.24
11	38.89	27.22	36.67	28.10	32.46	6.48
12	36.11	23.89	32.62	25.79	29.37	4.32
13	34.44	22.78	31.67	24.52	28.33	2.67
14	31.67	23.89	29.68	24.52	27.22	4.42
15	33.89	24.44	31.35	24.92	28.25	6.48
16	30.00	24.44	29.29	25.00	27.22	1.52
17	32.22	25.00	30.87	25.63	28.41	1.55
18	30.56	19.44	27.62	20.63	24.29	5.54
19	30.00	20.56	27.06	22.30	24.76	6.58
20	27.78	12.78	23.57	19.76	21.75	0.38
21	23.89	12.22	20.63	14.21	17.62	3.86
22	23.89	14.44	20.56	16.35	18.57	0.10

[z]Temperatures reported from Auburn University E.V. Smith Research and Extension Center (Shorter, AL) represent absolute high, absolute low, average high, average low, and overall average in °C during the 2009 season from planting (June 9, 2009) to harvest (November 4, 2009). Temperatures recorded 10.16cm below soil surface. Total rainfall is reported in centimeters.

Table 18. Recorded temperatures for Beauregard sweet potato production above mulch air and below soil mulch temperatures as affected by colored plastic mulch and row covers in summer of 2009 in Shorter, Alabama.

Treatment	Above Mulch Air Temperature (°C)[x]	Below Mulch Soil Temperature (°C)[w]
BPM+RC[z]	47.67a[y]	37.14a
BPM	40.36cd	35.06bcde
RPM+RC	45.5ab	35.61abcd
RPM	41.08cd	36.36abc
BS+RC	40.89cd	34.47cde
BS	39.89d	34.00def
SPM+RC	46.00ab	32.17fg
SPM	41.00cd	31.97g
WPM+RC	47.75a	34.53cde
WPM	40.58cd	33.19efg
BLUPM+RC	43.39bc	36.53ab
BLUPM	41.14cd	36.5ab

[z]BPM – black plastic mulch, RPM – red plastic mulch, BS – bare soil, SPM – silver plastic mulch, WPM – white plastic mulch, BLUPM – blue plastic mulch, RC – row cover

[y]Mean separation in columns by Duncan's multiple range test, 5% level with four replications; temperatures recorded twice a week from June 10, 2009 to July 15, 2009 – 35 days.

[x]Above mulch air temperature was recorded 15.24 cm above the mulch

[w]Below mulch soil temperature was recorded 15.24 cm below the soil surface

Study conducted at Auburn University E.V. Smith Research and Extension Center

CHAPTER V. CONCLUSION

Results from this study indicate that the use of plasticulture on sweet potato has potential benefits in modifying growth and nutritional status of sweet potato under Alabama growing conditions. Spun-bonded row enhanced air temperatures but appeared to have no effect on soil root zone temperatures. Dark colored plastic mulches increased soil temperatures compared to lighter colored plastic mulches. The silver plastic mulch plus row cover and red plastic mulch treatments had higher early yields, marketable yields, and total yields, followed by red plastic mulch, compared to other colored mulch and row cover treatments. Overall, red plastic mulch had the most favorable sweet potato growth and nutritional content response compared to other colored plastic mulch and spun-bonded row cover treatments. Also, red plastic mulch yields had the highest overall nutritional properties content analyze. It was hypothesized, that a higher FR:R ratio was due to light reflectance from the plastic mulch which may have activated the plants' phytochrome response, signaling plants physical, chemical, and antioxidant properties. Further investigation is needed to determine the exact mechanisms involved in order to fully exploit this technology (plasticulture) intended to enhance early market yield, quality and nutritional values of sweet potato.

LITERATURE CITED

Ahn, P.M., 1993, "Tropical soils and fertilizer use", Intermediate Trop. Agric. Series. Longman Sci. and Tech. Ltd. UK.

Antonious, G.F. and M.J. Kasperbauer. 2002. Color of Light Reflected to Leaves Modifies Nutrient Content of Carrot Roots. Crop Science 42:1211-1216.

Ban, D., K. Zanic, G. Dumicic, T.G. Culjak, S.G. Ban. 2009. The type of polyethylene mulch impacts vegetative growth, yield, and aphid populations in watermelon production. Journal of Food, Agriculture & Environment Volume 7(3&4): 543-550.

Benzie, I.F.F. and J.J. Strain. 1996. The ferric reducing ability of plasma (FRAP) as a measure of “antioxidant power”: The FRAP assay. Analytical Biochemistry 239:70-76.

Bextine, B., A. Wayadand, B.D. Bruton, S.D. Pair, F. Mitchell, and J. Fletcher. 2001. Effect of insect exclusion on the incidence of yellow vine disease and of the associated bacterium in squash. Plant Disease. 85(8):875-878.

Bonanno, A.R. and W.J. Lamont. 1987. Effect of polyethylene mulches, irrigation method, and row cover on soil and air temperature and yield of muskmelon. J. Amer. Soc. Hort. Sci. 112(5):735-738.

Britz S.J. and A.W. Galston. 1983. Physiology of Movements in the Stems of Seedling Pisum sativum L. cv Alaska : III. Phototropism in Relation to Gravitropism, Nutation, and Growth, Plant Physiol. 71(2):313-318

Brown, J.E., F.W. Woods, and C. Channell-Butcher. 1998. Effect of black plastic mulch and row cover on sweet potato production. J. Veg. Crop. Prod. 4(1):49-55.

Brown, J.E. and Channell-Butcher. 1999. Effect of three row covers and black plastic mulch on the growth and yield of ‘Clemson Spineless’ okra. J. Veg. Crop Prod. 5(2): 67-71.

Brown, J.E. and C. Channell-Butcher. 2001. Black plastic mulch and drip irrigation affect growth and performance of bell pepper. J. Veg. Crop Prod. 7(2): 109-112.

Clarke, A.D. 1987. Some plastic industry development; their impact on plastic films for agricultural application. Plasticulture. 74:15-26.

Coventry, J.M., K.H. Fisher, J.N. Strommer, and A.G. Reynolds. 2003. Reflective mulch to Enhance Berry Quality in Ontario Wine Grapes. ISHS Acta Horticulturae 689: VII International Symposium on Grapevine Physiology and Biotechnology.

Costa, G., L.C. Grappadelli, M. Noferini, and G. Fiori. 2003. Use of Light Reflective Mulch to Affect Yield and Fruit Quality. Acta Hort 610, ISHS 2003.

Csizinszky, A.A., D.J. Schuster, and J.B. King. 1995. Color mulches influence yield and pest populations in tomatoes. J. Amer. Soc. Hort. Sci. 120:778-784.

Decoteau, D.R. 2000. Vegetable Crops, pg. 312. Prentice Hall, Inc., Upper Saddle River, New Jersey.

Decoteau, D.R., M.J. Kasperbauer, D.D. Daniels, and P.G. Hunt. 1989. Mulch surface color affects yield of fresh-market tomatoes. J. Amer, Soc. Hort. Sci. 114(2):216-219.

Diaz-Perez, J.C. 2009. Root zone temperature, plant growth and yield of broccoli [*Brassica oleracea* (Plenck) var. *italic*] as affected by plastic film mulches. Scientia Horticulturae 123 (2009) 156-163.

Diaz-Perez, J.C. and K.D. Batal. 2002. Colored plastic film mulches affect tomato growth and yield via changes in root-zone temperature. J. Amer. Soc. Hort. Sci. 127(1) 127-136.

Diaz-Perez, J.C., R. Gitaitis, and B. Mandal. 2007. Effects of plastic mulches on root zone temperature and on the manifestation of tomato spotted wilt symptoms and yield of tomato. Scientia Horticulturae 114 (2007) 90-95.

Dubois, M., K. A. Giles, J.K. Hamilton, P.A. Rebers, and F. Smith. 1956. Colorimetric method for determination of sugars and related substances. Anal. Chem. 28, 350-356.

Emmert, E.M. 1957. Black polyethylene for mulching vegetables. Proc. Amer. Soc. Hort. Sci. 69:464-469.

Farias-Larios, J. M. Orozco-Santos, and J. Perez. 1998. Effect of plastic mulch, floating row covers and microtunnels on insect population and yield of muskmelon. Proc. Natl. Agr. Plast. Congr. 27:76-83.

Goc, M. 1985. Spunbonded row covers. An easy-to-tend plastic brings a nursery like atmosphere to the garden. Rodale’s Organic Gardening 32(12):82-84, 86-92.

Gordon, G.G., W.G. Foshee, S.T. Reed, J.E. Brown, E.L. Vinson, and F.M. Woods. 2008. Plastic Mulches and Row Covers on Growth and Production of Summer Squash. International Journal of Vegetable Science 14(4):322-338.

Gordon, G.G., W.G. Foshee, S.T. Reed, J.E. Brown, and E.L. Vinson. 2010. The Effects of Colored Plastic Mulches and Row Covers on the Growth and Yield of Okra. Hort Technology 20(1): 224-223.

Gossett, D.R., E.P. Millhollon, and M.C. Lucas. 1994. Antioxidant response to NaCl stress in salt-tolerant and salt-sensitive cultivars of cotton. Crop Sci. 34:706-714.

Gross, J. 1991. Pigments in Vegetables: Chlorophylls and Carotenoids; Van Nostrand Reinhold: New York

Hall, B.J. 1963. Continuous polyethylene tube covers for cucumbers. Proc. Natl. Agr. Plast. Congr. 4:112-132.

Ham, J.M., G.J. Kluitenberg, and W.J. Lamont. 1993. Optical Properties of Plastic Mulches Affect the Field Temperature Regime. J. Amer. Soc. Hort. 118(2): 188-193.

Hodges, D.M., C.J. Andrews, D.A. Johnson, and R.I. Hamilton. 1996. Antioxidant compound responses to chilling stress in differentially sensitive inbred maize lines. Physiologia Plantarum 98:685-692.

Ibarra, L., J. Flores, and J.C. Diaz-Perez. 2001. Grow and yield of muskmelon in response to plastic mulch and row covers. Scientia Horticulturae 87:139-145.

Islam, S., E. Izekor, and J.O. Garner. 2009. Development of selection procedures of Sweetpotato genotypes according to chilling tolerance. Journal of Food, Agriculture & Environment Vol. 7(2): 329-331.

Jensen, M.H. 2000. Plasticulture in the global community – view of the past and future. Proc. Natl. Agr. Plast. Congr. 29: Appendix 1-10.

Kasperbauer, M.J. and P.G. Hunt. 1990. Bell Pepper Plant Development over Mulches of Diverse Colors. HortScience 25(4):460-462.

Kasperbauer, M.J. and J.H. Loughrin. 2004. Crop Ecology, Management and Quality: Butterbean Seed Yield, Color, and Protein Content Are Affected by Photomorphogensis. Crop Science 22:2123-2126.

Kays, S.J. 2005. Sweetpotato. In: Gross, K.C., C.Y. Wand and M. Saltveit (Eds). The commercial storage of fruits, vegetables, and florist and nursery stocks, US Department of Agriculture, Agriculture Handbook 66. Retrieved 22, May 2008 from http://www.ba.ars.usda.gov/hb66/132sweetpotato.pdf

Kemble, J.M., E.J. Sikora, D. Fields, M.G. Patterson, and E. Vinson. 2006. *Guide to Commercial Sweetpotato Production in Alabama, ANR-982*. The Alabama Cooperative Extension System , Alabama A&M University and Auburn University.

Kim, D., K. W. Lee, H.J. Lee, and C.Y. Lee. 2002. Vitamin C equivalent antioxidant capacity (VCEAC) of phenolic phytochemicals. *Journal of Agricultural and Food Chemistry*, 50, 3713-3717.

Kim, E.J., D.G. Choi, and S.N. Jin. 2008. Effect of Pre-Harvest Reflective Mulch on Growth and Fruit of Plum (*Prunus Domestica L.*). ISHS Acta Horticulturae 772: XXVII International Horticultural Congress – IHC2006: International Symposium on Enhancing Economic and Environmental Sustainability of Fruit Production in a Global Economy.

Kwabiah, A.B. 2004. Growth and yield of sweet corn (*Zea mays* L.) cultivars in response to planting date and plastic mulch in a short-season environment. Scientia Horiculturae 102 -(2004) 147-166.

Lamont, W.J. 1993. Plastic mulch for the production of vegetables crops. HortTechnology. 3:35-39.

Lamont, W.J. 1996. What are the components of a Plasticulture vegetable system? HortTechnology. 6(3):150-154.

Lamont, W.J., M.D. Przolek, L.Otjen, and T. Simpson. 2000. Production of potatoes using plasticulture. Proc. Natl. Agr. Plast. Congr. 29:599-601.

Lamont, W.J. 2004. Production of Vegetables, Strawberries, and Cut Flowers Using Plasticulture, NRAES-133. Natural Resource, Agriculture, and Engineering Service Cooperative Extension.

Lopez, M.V. 1998. Growth, yield and leaf NPK concentrations in crop-covered squash. J. of Sustainable Agr. 12(4):25-38.

Loy, J.B. and O.S. Wells. 1975. Response of hybrid muskmelons to polyethylene row covers and black polyethylene mulch. Scientia Horticulturae. 3(3):223-230.

Loy, J.B. and O.S. Wells. 1982. A comparison of slitted polyethylene and spunbonded polyester for plant row covers. Hort Science. 17(3):405-407.

Loy, J.B. and B. Bushnell. 1984. Comparison of polyethylene and spunbonded fabric row covers over muskmelon and summer squash. Proc. Natl. Agr. Plast. Congr. 18:63-66.

Mahbud, A. and R. Zimmerman 2006. Kansas State University Research and Extension. 20 March 2006. http://www.oznet.ksu.edu/swao/Irrigation/Kabocha%20Study%report%20Latest.pdf

Mathod J.C and P. Jholgiker. 2005. Effect of Synthetic and Organic Mulches in Improving Growth, Yield and Quality of Strawberry under Subtropical Ecosystem. Acta Hort 696, ISHS 2005.

Melendez-Martinez, A.J., I.M. Vicario, and F.J. Heredia. 2004. Stability of carotenoid pigments in foods. Archivos Latinoamericanos de nutricion. 54(2):209-215.

Munguia, J., R. Quezada, A. Zermeno, and V. Pena. 1998. Plastic mulch effect on the special distribution of solutes and water in the soil profile and relationship with growth and yield of muskmelon crop. Proc. Natl. Agr. Plast. Congr. 27:173-177.

Orzolek, M.D., J. Murphy, and J. Ciardi. 2003. The effect of colored polyethylene mulch on the yield of squash, tomato and cauliflower. Penn State Center for Plasticulture. 31 January 2006. http://plasticulture.cas.psu.edu/cmulch-93.htm.

Penn State. 2003. Row covers. Center for Plasticulture. 5 April 2005. http://plasticulture.cas.psu.edu/RowCovers.htm

Powell, N.L. 2000. Watermelon production with red and black plastic mulch in southeast Virginia. Proc. Natl. Agr. Plast. Congr. 29:622-627.

Qureshi, M.S., D.J Midmore, S.S. Syeda, and C.L Playford. 2007. Floating row covers and pyriproxyfen help control silverleaf whitefly Bemisia tabaci (Gennadius) Biotype B (Homoptera: Aleyrodidae) in zucchini. Australian Journal of Entomology, 46(4) p. 313-319.

Rangarajan, A. and B. Ingall. 2001. Mulch color effects radicchio quality and yield. HortScience 36(7):1240-1243.

Ray, R.C. and R. Ravi. 2005. Post Harvest Spoilage of Sweetpotato in Tropics and Control Measures. Critical Reviews in Food Science and Nutrition, 45:623-644.

Schales, F.D. and R. Sheldrake. 1963. Mulch effects on soil conditions and tomato plant response. Proc. Natl. Agr. Plast. Congr. 4:78-90.

Schlesier, K., M. Harwat, V. Bohm, and R. Bitsch. 2002. Assessment of antioxidant activity by using different in vitro methods. *Free Radical Research*, 36, 177-187.

Shadbolt, C.A., O.D. McCoy, and F.L. Whiting. 1962. The microclimate of plastic shelters used for vegetables production. Hilgardia. 32(4):251-266.

Slinkard, K., and V.L. Singleton. 1997. Total phenol analysis: automation and comparison with manual methods. American Journal of Enology and Viticulture, 28:49-55.

Stapleton, J.J. and R.A. Duncan. 1994. Preliminary evaluation of red-pigmented spray mulch for enhanced yield of zucchini squash in the San Joaquin Valley. Proc. Natl. Agr. Plast. Congr. 25:221-225.

Stevens, C., V.A. Khan, J.E. Brown, G.J. Hochmuth, W.E. Splittstoesser, and D.M. Granberry. 1991. Plastic chemistry and technology as related to Plasticulture and solar heating of soil. P. 141-158. In: J. Katan and J.E. Devey (eds.) Soil solarization. CRC Press. Boca Raton, FL.

Swiader, J.M. and G.W. Ware. 2002. Producing Vegetable Crops Fifth Edition, pg. 521. Interstate Publishers, Inc. Danville, Illinois.

Talcott, S.T., and L. Howard. 1999. Phenolic autooxidation is responsible for color degradation in processed carrot puree. J. Agric. Food Chem. 47: 2109-2115.

Tarara, J.M. 2000. Microclimate modifications with plastic mulch. HortScience. 35(2):169-180.

United States Department of Agriculture – Agriculture Research Service. 2010. Sweet potato, raw, unprepared. http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/list_nut_edit.pl

Unites States Department of Agriculture – Economic, Statistics, and Marketing Information (2010). U.S. Sweet Potato Statistics - 03001. http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1492

Valdez-Fields, F.F. Radillo-Juarez, and J. Farias-Larios. 2002. Effects of colored plastic on growth and yield of tow cultivars of eggplant (*Solanum melongena* L.) Proc. Natl. Agr. Plast. Congr. 30:128-132.

Wall, M.M. 2006. Ascorbic acid, vitamin A, and mineral composition of banana (*Musa sp*.) and papaya (*Carica papaya*) cultivars grown in Hawaii. Journal of Food Composition and Analysis 19:434-445.

Wells, O.S. and J.B. Loy. 1985. Intensive vegetable production with row covers. HortScience. 20(5):822-825.

Wells, O.S. 2000. Season extension technology. Proc. Natl. Agr. Plast. Congr. 29:1-7 Appendix B.

White, J.M. 2003. Watermelon Yield and Size When Grown On Four Mulch Colors. Proc. Fla. State Hort. Soc. 116:138-139.

Wittwer, S.H. and R.E. Lucas. 1956. Celery production in Michigan. Michigan Agr. Ext. Bul. 339.

Wolfe, D.W., L.D. Albright, and J. Wyland. 1989. Modeling row cover effects on microclimate and yield: I. growth response of tomato and cucumber. J. Amer. Soc. Hort. Sci. 114(4):562-568.

Woods, F.M., J.O. Garner, Jr., J.L. Silva and C. Phromtong. 1991a. Estimation of chilling sensitivity in leaves of sweet potato by chlorophyll fluorescence and electrolyte leakage. Inter. J. of Expt. Bot. 52(1):33-37.

Woods, F.M., and J. O. Garner, Jr., and J.L. Silva. 1991b. Chilling tolerance in sweet potatoes. Inter. J. of Expt. Bot. 521(1):39-41. (**b)**