Title: <u>Evaluation of the effects of photo-selective shading nets on vegetative growth, and fruit growth and quality in southern highbush blueberry</u>

Progress Report

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Research Proposal

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Objective:
The main objective of the proposed research is to *determine the effects of various photo-selective shading nets on the growth and quality of southern highbush blueberry*

Justification and Description:

Over the last decade, blueberry (*Vaccinium* sp.) has developed into a major fruit crop of high economic significance in the southeast, especially in Georgia which has emerged as a leading producer of this crop in the United States (US). Around 24,000 acres are currently under blueberry cultivation in Georgia and the crop was valued at around 230 million US dollars in 2012 (2012 Georgia Farm Gate Value Report). To sustain such tremendous growth in blueberry production, various aspects of its biology and cultivation such as growth and development, horticultural manipulation, nutrient management, pest and disease management, harvesting, and ripening and postharvest handling need to be addressed through continued research efforts. Improving productivity of blueberry cultivation is essential to maintain its profitability and for the economic sustainability of this crop.

Blueberries are native to, and are better adapted to soils and environmental conditions that are often distinctly different from typical conditions of their cultivation (Retamales and Hancock, 2012). Blueberry plants are native to shaded environmental conditions. However, production in many blueberry growing regions such as that in southern Georgia as well as other parts of the southeast occurs in regions where the plants are exposed to high levels of solar radiation during much of the growing season. Under such conditions, blueberry plants may experience physiological stress which may reduce their productivity. Alleviation of such stress can enhance their growth and development leading to higher yields.

Shading nets can significantly alter the micro-climate around the plants (Stamps, 2009; Bastias and Corelli-Grappadelli, 2012). Shading nets reduce the extent of net solar radiation and also increase the extent of diffused or scattered light incident on plants (Stamps, 2009). In fact, diffused light may increase the extent of light penetration and distribution within the plant canopy thereby altering the efficiency of photosynthesis (Stamps, 2009; Bastias and Corelli-Grappadelli, 2012). These nets may also help mitigate the damage caused to the fruit from other factors such as birds and insects (Stamps, 2009). Further, photo-selective (colored) shading nets alter the spectral quality of light perceived by the plants. Plant growth and development is often responsive to changes in the spectral quality of light, and the use of photo-selective nets can alter plant responses such as vegetative and reproductive growth and development, and fruit quality (Shahak et al., 2004; Bastias and Corelli-Grappadelli, 2012). In apple and peach, the use of photo-selective nets altered flowering and fruit set, enhanced fruit size, and improved quality attributes such as fruit color (Shahak et al., 2008). Due to the above reasons, photo-selective shading nets are becoming increasingly popular in fruit production (Stamps, 2009; Bastias and Corelli-Grappadelli, 2012).

Based on results from other fruit crops as described above, it may be hypothesized that the use of photo-selective shading nets can alter vegetative and reproductive growth, and fruit quality in blueberry. However, reports on the evaluation of the effects of shading nets in blueberry production are limited. Only recently, the effects of photo-selective shading nets on blueberry growth, physiology and productivity were evaluated in northern highbush blueberry (*V. corymbosum*) in Michigan and Chile (Retamales et al., 2008; Lobos et al., 2009; 2012; 2013). In an initial study in Chile, Retamales et al., 2008 reported an increase in fruit yields under wavelength neutral (white) and colored shade nets (red) in the highbush blueberry cultivar, Miraflores. However, further evaluation using the cultivar, Elliot in Michigan indicated that yields were not affected by the shading nets, although a delay in harvest time was observed (Lobos et al., 2013). These studies indicate that the effects of these nets may be dependent at least in part on the location and the cultivar. Evaluation of photo-selective shading nets has not yet been reported in southern highbush blueberry. Southern highbush blueberries are extensively grown in southern Georgia and other parts of the southeastern US where climatic conditions are significantly different from that in Michigan. It has been suggested that in locations such as southern Georgia, early installation of photo-selective shading nets may have a beneficial and reproducible effect on fruit growth and quality (Retamales et al., 2008; Lobos et al., 2013). Further, it may be expected that the shading nets serve as a physical barrier for birds thereby reducing the extent of fruit loss due to bird damage. Hence, the main goal of the proposed study was to evaluate the effects of photo-selective shading nets on vegetative and fruit characteristics of southern highbush blueberry in southern Georgia.

Methods:

The experiment was initiated in the spring of 2016. The southern highbush blueberry cultivar, Star, was used in this study. Plants grown and maintained at the Blueberry Research and Demonstration Farm in Alma, GA were used. Three photo-selective shade materials used in this study were donated by PAK Unlimited, Cornelia, GA. The photo-selective material consisted of colored fabric (Chromatinet) that was rated for 50% shading. Three colors, Red, Blue and Pearl (White) of photo-selective shade netting were evaluated.

Each of the photo-selective shading nets was installed over three rows of the ‘Star’ blueberry plants. The central row was subsequently used for sample and data collection. Installation of the shading nets and initiation of the shading treatments was performed on March 15, 2016 following fruit set. A section of plants contiguous with those used for the shading treatment was also included as an unshaded control and involved direct exposure to ambient light and temperature conditions. In all, four treatments were applied: 1. Control; 2. Red shading net; 3. Blue shading net; and 4. White shading net. Wood posts and wire were used to provide structural support for the shading nets. The shade material was erected at a height of around 8′ from the ground by securely fastening the nets to the structural support as shown below (Fig. 1). Temperature was monitored on a regular basis in the control and shading treatments. Light levels were measured in all treatments under the canopy of the plants.

Fig 1. Structural support and the installation of shading nets over ‘Star’ blueberry plants in Alma, GA.

Fruit from at least four blueberry plants within the central row were harvested twice at maturity, harvest 1 (H1; 5 May, 2016) and harvest 2 (H2; 12 May, 2016). At each of the harvests, the following fruit quality characteristics were measured: fruit yield (g); individual fruit weight (g); fruit firmness (with FirmTech 2, BioWorks, Inc., Wamego, KS); Soluble solids content (SSC, ° brix); pH; titratable acidity (% citric acid equivalent); and fruit color. Shoot growth after summer pruning was measured on five plants from each treatment (10 shoots per plant) on 14 October, 2016. All data were analyzed using the general linear model (PROC GLM) in SAS (Cary, NC). Fisher's least significant difference (LSD) was used for mean separation ($\alpha = 0.05$). In all the data tables presented below, same letters next to the values indicate no significant difference between the means.

Results:

Temperature under the 50% red and blue shading nets appeared to be lower than that under the control treatment by up to 3° C, indicating significant cooling during late spring and at the time of fruit harvests (Table 1). However, these shading treatments did not lower temperature significantly during later stages of the summer. Temperature under the white shading net was not significantly different from the control during late spring but was significantly higher during summer. Light levels under the red and blue photo-selective shading net treatments were significantly lower than that the unshaded control by more than 40% (Table 2). However, light levels under the white shading nets were not significantly different from that under the control.

Table 1. Temperature under control and photo-selective shading net treatments.

	Temperature (° C)^{x}		
	5 May	**12 May**	**21 July**
Control	24.5 f	34.6 c	38.4 b
Red	22.5 g	31.7 de	37.4 b
Blue	22.9 fg	31.3 e	37.2 b
White	24.4 f	33.2 cd	42.2 a

^{x} *P value: <0.0001; LSD = 3.15*

Table 2. Light levels (Photosynthetic Photon Flux Density; PPFD) under control and photo-selective shading net treatments.

	PPFD (µmol m^{-2} s^{-1})
	21 July
Control	912.3 ab
Red	530.9 c
Blue	644.7 bc
White	1184.2 a

^{x} *P value: <0.0001*

Blueberry fruit yield was significantly reduced at the first harvest in the red and blue shading net treatments by as high as 80% in comparison to that in the control (Table 3). White shading net treatment did not have significantly lower yields at this harvest stage even though it was numerically lower than in the unshaded control. Fruit yields at the second harvest were not significantly different among the treatments.

Table 3. Blueberry fruit yield under control and photo-selective shading net treatments.

	Yield (g)^{x}	
	Harvest 1	**Harvest 2**
Control	1835.7 a	1568.9 a
Red	486.1 bc	1655.9 a
Blue	323.0 c	1410.2 ab
White	1257 abc	2036.9 a

^{x} *P value: 0.007; LSD = 935.3*

Individual fruit weight differed between the two harvests but was not significantly different among the treatments (Table 4). At the first harvest, fruit sampled from the shading treatments displayed lower fruit firmness in comparison to the unshaded control (Table 4). However, at the second harvest, the red shading net treatment displayed slightly higher firmness than the control fruit. The SSC was generally lower in the photo-selective shading net treatments, especially at the second harvest by up to 13% (Table 4). Titratable acidity was higher in the red shading net treatment at the first harvest and lower at the second harvest in the white shading net treatments in comparison to the controls (Table 4). The ratio of the soluble solids to titratable acidity, which is an indicator of fruit flavor, was significantly reduced in the red and blue shading treatments by as much as 26% (Table 4). Also, pH of juice extracted from the fruit tended to be slightly higher in the shading net treatments in comparison to the control, especially under the white photo-selective shading net treatment (Table 4). Overall, these data indicate significant effects of photo-selective shading net treatments on fruit quality. The data suggest that colored shading nets may delay fruit maturity.

Table 4. Fruit quality characteristics at first (H1) and second harvests (H2) under control, red, blue and white photo-selective shading net treatments.

	Fruit weight (g)	Firmnes (g/mm)	SSC (brix)	Titratable acidity (TA; % CA[x])	SSC/TA	pH
Control H1	2.6 ab	145 a	10.6 b	1.65 bc	6.43 ab	2.98 bc
Control H2	2.0 cd	124 e	11.5 a	1.99 a	6.40 ab	2.89 c
Red H1	2.6 a	126 e	9.8 bc	1.98 a	5.10 cd	3.06 b
Red H2	2.2 bcd	131 bcd	10.1 bc	1.89 ab	5.36 cd	3.05 b
Blue H1	2.3 abc	132 bc	9.7 c	1.89 ab	5.16 cd	3.01 b
Blue H2	2.0 bcd	128 cde	10.0 bc	2.14 a	4.70 d	2.99 bc
White H1	2.4 ab	134 b	10.5 b	1.49 c	6.40 ab	3.17 a
White H2	1.9 d	127 de	10.3 bc	1.62 bc	7.13 a	3.18 a
P value	*0.007*	*<0.0001*	*0.004*	*0.001*	*0.001*	*< 0.0001*
LSD	*935.3*	*4.18*	*0.83*	*0.29*	*1.04*	*0.10*

[x] Citric acid equivalent

Interestingly, shoot length following summer pruning was significantly higher in the photo-selective shading net treatments by up to 17.5% (Table 5). These data suggest greater shoot extension under the shading net treatments.

Table 5. Shoot growth under control and photo-selective shading net treatments in blueberry.

	Length (mm)[x]
Control	428 b
Red	495 a
Blue	490 a
White	503 a

[x] *P value: < 0.005; LSD = 1.79*

Conclusions:

In the one-year of study conducted on 'Star' blueberries in Alma, GA, photo-selective shading nets were found to decrease yields especially in the first harvest and under red and blue colored shading. In addition, significant effects of photo-selective shading nets were observed on various fruit quality parameters suggesting a delay in fruit maturity. However, an increase in shoot growth was observed. This may increase the potential for floral bud production in the subsequent year and will be further evaluated in 2017. If it is found that shading increases floral bud production, installation and use of these shading nets after harvest and summer pruning may be an effective approach to prevent losses in yields and fruit quality. Further research needs to be conducted to evaluate such potential of photo-selective shading net use.

Impact:

Photo-selective shading net use in blueberry production was evaluated to determine if it can enhance yields and fruit quality. These parameters were found to be negatively affected in the current study where the nets were used from early spring onwards. It may still be likely that targeted use of the shading nets at later stages after summer pruning may enhance shoot growth and result in greater flower bud production, a hypothesis that will be evaluated in 2017. Such a potential increase in flower bud production may enhance yields in the following year and increase profitability for the growers.

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