Title: Vegetation-free Strip Width in Young Blackberry

Progress Report

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Objectives:
1) To determine the influence of vegetation-free strip width on the establishment and development of newly planted blackberry in Western N.C.

2) To determine the optimum vegetation-free strip width for established blackberry with regards to plant vigor, primocane thinning, yield, fruit quality, and income potential. Initial VFSW studies were initiated in 2011 at the Sandhills Research Station in Jackson Spring, N.C. to evaluate the influence of six VFSWs (0, 1, 2, 4, 6, and 8 ft) on 'Navaho' blackberry establishment and development. Strip widths were established in late summer-early fall and baseline data (primocane number, diameter, length) collected. Vegetation between rows consisted of existing weed species (annual and perennial grasses, sandbur, yellow nutsedge, and broadleaf weeds). Plant growth parameters will continue to be monitored and fruit yield and quality parameters will begin in 2012.

In September 2012 a grower location was identified in western NC. Grass seed (fescue) will be planted in the row middles the week of October 29th. This study will be part of a Master of Science thesis project for Nick Basinger, a student who will begin January 2013.

Results are included in this report from two studies conducted by Steve Meyers (PhD student) at the Sandhills Research Station. Steve initiated the studies in 2010 and completed his research in 2012. These studies will be maintained by Nick Basinger as part of his Master of Science research.

Materials and Methods:

Field studies were initiated in 2011 at two locations at the Sandhills Research Station near Jackson Springs, NC to determine the influence of vegetation-free strip width (VFSW) on the growth of newly planted 'Navaho' blackberry plants, and the yield and quality of blackberry fruit. Soil at Location 1 consisted of Candor (sandy, siliceous, thermic Arenic

Paleudults) and Fuquay sands (loamy, siliceous, thermic Arenic Plinthic Kandiudults). Soil at Location 2 was a Candor sand. Both locations had a field history consisting of sorghum-Sudangrass (*Sorghum* x *drummondii*) in 2009 and peanut (*Arachis hypogaea* L.) in 2010. A fall rye cover crop was planted on 10 Nov. 2010. Rye was killed on 8 Mar. 2011 with an application of glyphosate (Buccaneer Plus, Tenkoz, Inc., Alpharetta, GA) at 830 g acid equivalent ha^{-1}. 'Navaho' blackberry plugs (50 per flat) (North American Plants Inc., Lafayette, OR) were planted on 29 Mar. 2011 with in-row and between-row spacing of 1.2 and 3.7 m, respectively. Plots were maintained weed-free by shallow cultivation within 0.6 m of both sides of the planted row until 9 June 2011. A V-trellis was installed on 14 June 2011. VFSW treatments were established on 5 Aug. 2011 at Location 1 and 18 Oct. 2011 at Location 2. Between-row vegetation consisted of existing weed and turf-grass species and included Bermudagrass [*Cynodon dactylon* (L.) Pers.], carpetweed (*Mollugo verticillata* L.), cutleaf evening primrose (*Oenothera laciniata* Hill), horseweed [*Conyza canadensis* (L.) Cronquist], large crabgrass [*Digitaria sanguinalis* (L.) Scop.], long-spined sandbur [*Cenchrus longispinus* (Hack.) Fernald], spotted spurge [*Chamaesyce maculate* (L.) Small], volunteer peanut (*Arachis hypogaea* L.), and yellow nutsedge (*Cyperus esculentus* L.).

Treatments consisted of 0, 0.3, 0.6, 1.2, 1.8, and 2.4 m (0, 1, 2, 4, 6, and 8 feet) VFSW with half of each VFSW distributed on either side of the planted row. Plots consisted of four plants at Location 1 and three plants at Location 2. Vegetation-free strips were maintained weed-free with the applications of a paraquat (Gramoxone Inteon®, Syngenta Crop Protection, Inc., Greensboro, NC) solution of 5 g ai L^{-1} plus 0.25% v/v nonionic surfactant or a glufosinate (Rely 280®, Bayer CropScience LP, Research Triangle Park, NC) solution of 8.4 g ai L^{-1}. On 12 July 2012, 310 g ha^{-1} sethoxydim (Poast®, BASF Corp., Research Triangle Park, NC) was applied to control emerged large crabgrass within the designated VFSW area at both locations. All herbicides were applied with a CO_2 pressurized backpack sprayer calibrated to deliver 187 L ha^{-1} with a single 8003EVS nozzle tip (Teejet 8003EVS, Teejet® Technologies) at 140 kPa. All applications contained an inert blue spray indicator dye.

Data recorded included primocane and floricane number, length, and caliper; post-harvest floricane weight; blackberry fruit yield; individual fruit weight; and fruit pH, soluble solids content (SSC), and titratable acidity (TA). Blackberry fruit reaching the minimum stage of "shiny black" were hand-harvested weekly 14 June to 12 July 2012. After each harvest, 25 fruit per plot were weighed to determine individual fruit weight. During the final harvest, the remaining non-ripened blackberry fruit in each plot were counted. The season-long mean individual fruit weight was multiplied by the number of fruit remaining within each plot and the total added to the weekly harvest data to determine total fruit yield.

Blackberry fruit from the first two harvests were segregated into dull and shiny black fruit. Within 3 h of harvest, blackberry fruit were placed in a freezer at -19 °C until the fruit could be analyzed. Each fruit type (shiny black and dull black) was analyzed separately for pH, SSC, and TA on 9 Aug. 2012 at the Plants for Human Health Institute, Kannapolis, NC. Frozen blackberry fruit were thawed at room temperature, then grinded at 15,000 rpm (Brinkmann Polytron PT-35 GT) until berries became a homogenized puree. A 2 g aliquot of puree was mixed with 60 ml of distilled water and titrated to an endpoint of 8.2 using an automated titrimeter (Metrohm 862 Compact Titrosampler) and 0.1 NaOH as the titrant. Results were expressed as percent citric acid (the predominant organic acid in blackberry). SSC was determined by placing approximately 1 ml of puree on the stage of a digital refractometer (Atago Pocket Refractometer PAL-1) at 21 C.

Data were subjected to ANOVA and analyzed by SAS Proc Mixed (SAS 9.2, SAS Institute, Cary, NC). LS means for each dependent variable derived from Proc Mixed were subjected to regression analysis by SAS Proc Reg with the independent variable of VFSW. The experimental design was a randomized complete block with four replications.

Results:

Primocane number and weight and floricane number. Primocane number and length did not differ by VFSW in fall 2011. Each plot averaged two heavily branched, semi-erect primocanes 110 cm in length (data not shown). In 2012, post-harvest floricane weight differed by location. At Location 1, floricane weight per plant displayed a positive quadratic response to VFSW (Fig. 1). Predicted post-harvest floricane fresh weight per plant increased from 0.19 to 0.30 kg at VFSW of 0 to 1.5 m and decreased from 0.30 to 0.26 kg at VFSW of 1.5 to 2.4 m. Post-harvest floricane weight at Location 2 could not be fit to a linear, quadratic, or higher-order regression model. Mean post-harvest floricane fresh weight at Location 2 was 0.22, 0.18, 0.20, 0.22, 0.19, and 0.17 kg per plant at VFSW of 0, 0.3, 0.6, 1.2, 1.8, and 2.4 m, respectively.

Primocane number, length, and stem caliper in fall 2012 did not display a response to VFSW. Mean primocane number m^{-1} and length were 8.9, 7.8, 9.0, 9.2, 9.5, and 9.1 canes and 141, 144, 156, 158, 151, and 149 cm for VFSW of 0, 0.3, 0.6, 1.2, 1.8, and 2.4 m. Primocane stem caliper average 12 mm per cane across all treatments and locations.

Blackberry yield. Season-long blackberry yield in 2012 displayed a positive quadratic response to VFSW (Fig. 2). Predicted blackberry yield increased from 711 to 1,030 kg ha^{-1} at VFSW of 0 to 1.8 m and decreased from 1,030 to 960 kg ha^{-1} at VFSW of 1.8 to 2.4 m. In the present study, a VFSW of 1.8 m maximized blackberry fruit yield.

Blackberry fruit weight. Season-long individual fruit weight displayed a positive linear response to VFSW (Fig. 3). Predicted blackberry fruit weight increased from 3.1 to 3.6 g per fruit at VFSW of 0 to 2.4 m. Blackberry fruit from the present study are smaller than those reported by others. Perkins-Veazie et al. (1996) reported shiny and dull black Navaho fruit weighed 4.7 and 5.3 g, respectively. Milosevic et al. (2012) reported a mean Navaho blackberry fruit weight of 5.4 and 5.9 in two different years. Blackberry fruit size can be influenced by a number of production practices including cane thinning (Takeda et al., 2003). Takeda et al. (2003) reported that 'Chester Thornless' blackberry thinned to two floricanes produced larger racemes and slightly larger fruit than those thinned to five or six floricanes. Smaller fruit weight may be a reflection of the first bearing season. The inclusion of secondary and tertiary fruit in the calculation of fruit weight may also contribute to a smaller reported mean fruit weight than if only primary fruit were used.

Blackberry Fruit SSC, TA, SSC:TA, and pH. SSC of dull black blackberry fruit displayed a negative quadratic response to VFSW (Fig. 4). SSC decreased from 15.0 to 14.4 °Brix at VFSW of 0 to 1.4 m and increased from 14.4 to 14.7°Brix at VFSW of 1.4 to 2.4 m. SSC of shiny blackberry fruit could not be fit to linear, quadratic, or higher order regression models. Mean SSC for shiny blackberry fruit was 13.9, 13.7, 13.3, 13.6, 13.9, and 13.7°Brix for VFSW of 0, 0.3, 0.6, 1.2, 1.8, and 2.4 m, respectively. SSC in the present study was greater than those reported by others. Perkins-Veazie et al. (1996) reported SSC of 8.4 and 9.6% for shiny and dull black Navaho blackberry fruit, respectively. Similarly, Milosevic et al. (2012) reported SSC of 9.4 and 9.7% for Navaho blackberry in two different years. However, Fan-Chiang (1999) reported SSC of 13.6% for Navaho blackberry. Cultural practices can influence blackberry SSC. Alleyne and Clark (1996) reported increasing nitrogen rate (0, 56, 112 kg N ha^{-1}) resulted in increased fruit SSC in 'Arapaho' blackberry.

Blackberry fruit TA was not influenced by VFSW (data not shown). Mean TA was 0.96, 0.97, 0.96, 1.02, 0.95, and 1.04% for shiny blackberry fruit and 0.90, 0.87, 0.89, 0.93, 0.96, and 0.86% for dull blackberry fruit at VFSW of 0, 0.3, 0.6, 1.2, 1.8, and 2.4 m, respectively. While a statistical comparison of dull and shiny black fruit was not conducted in the present study, trends were generally similar to those reported by Perkins-Veazie et al. (1996) in that TA of shiny black fruit was numerically greater than TA of dull black fruit. Perkins-Veazie et al. (1996) reported TA of 1.2 and 0.8% for shiny and dull black fruit, respectively. Overall, TA values in the present study were lower than those reported by Milosevic et al. (2012), 1.08 to 1.33% in two separate years. SSC:TA was not influenced by VFSW. Mean SSC:TA was 14 and 17 for shiny and dull blackberry fruit, respectively. Blackberry fruit pH was not influenced by VFSW. Mean Mean pH was 3.6 and 3.8 for dull and shiny fruit, respectively.

Fruit quality was largely unaffected by VFSW. Even though predicted dull black blackberry fruit SSC displayed a response to VFSW, the range of predicted SSC (14.4 to 15°Brix) would likely go undetected by a consumer. These data suggest that a 1.8 m VFSW maximized yield in the first bearing year and results in greater blackberry yield than the current recommendation of 1.2 m.

Blackberry plant growth was also largely unaffected by VFSW. This may be attributed to numerous factors. The type of vegetation allowed to grow on the production floor may influence blackberry growth. Bowen and Freyman (1995) reported that 'Willamette' primocane-bearing raspberry field floors consisting of white clover (*Trifolium repens* L.) had greater yield (27 T/ha), cane height (207 cm), and cane diameter (8.9 mm) than perennial ryegrass (*Lolium perenne* L.) (24.9 T/ha, 188 cm, and 7.8 mm, respectively). Tworkoski and Glenn (2001) reported that yield of mature peach trees was reduced 3% by orchardgrass (*Dactylis glomerata* L.). However, perennial ryegrass (*Lolium perenne* L.) did not affect yield (Tworkoski and Glenn, 2001). As the plantings in the present study mature, the diversity of species comprising the between row space may change, thus potentially altering the influence of VFSW.

Water availability may have also contributed to the lack of influence of VFSW on blackberry growth. Vegetation in narrow VFSW would be expected to compete with the crop for water and nutrients. However, in the present study blackberry plants were supplemented with 1.3 cm of irrigation per week when rainfall was lacking. Doing so likely reduced the competition between crop and between-row vegetation for this resource. The interaction of irrigation and VFSW has been reported in peach. Buckelew (2009) reported that a 1.5 m VFSW with irrigation and fertilization resulted in peach tree growth and yield comparable to non-irrigation VFSW of 3.6 m.

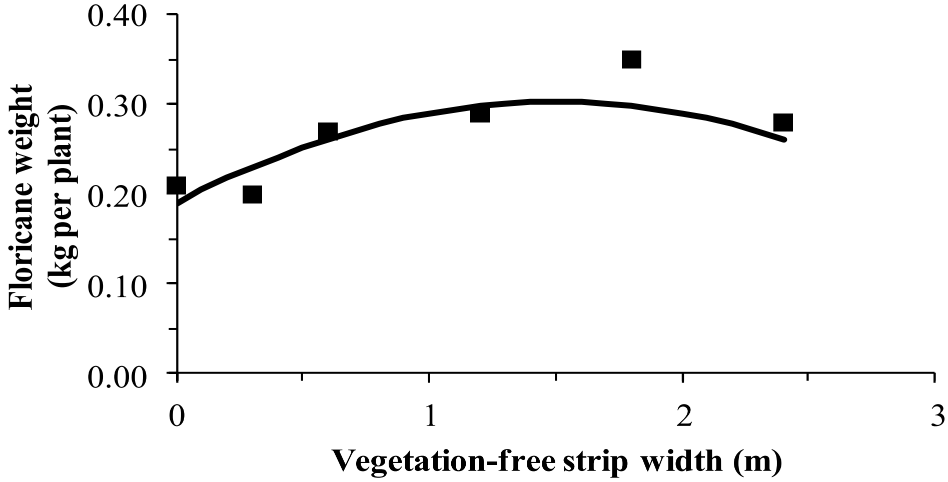

Figure 1. Relationship between blackberry fruit weight and VFSW at Jackson Springs, NC in 2012. Points represent observed mean data. The line represents predicted values.

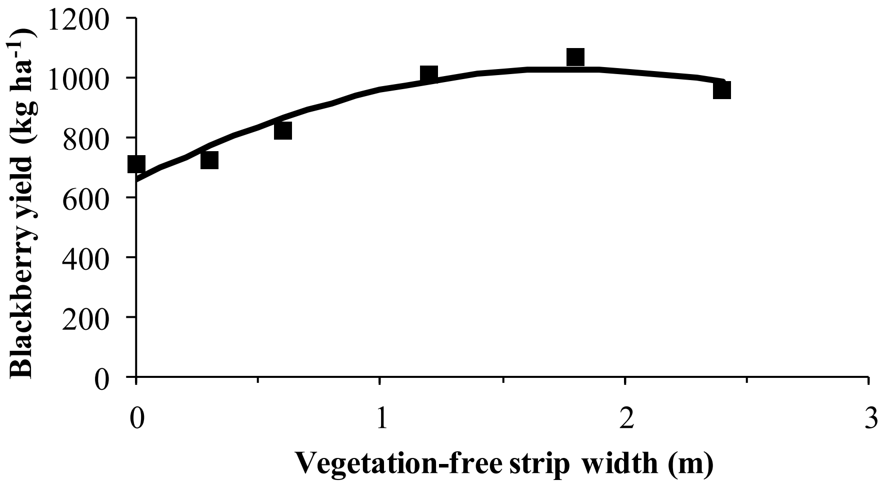

Figure 2. Relationship between of vegetation-free strip width and 'Navaho' blackberry yield at Jackson Springs, NC in 2012. Points represent observed mean data. The line represents predicted values.

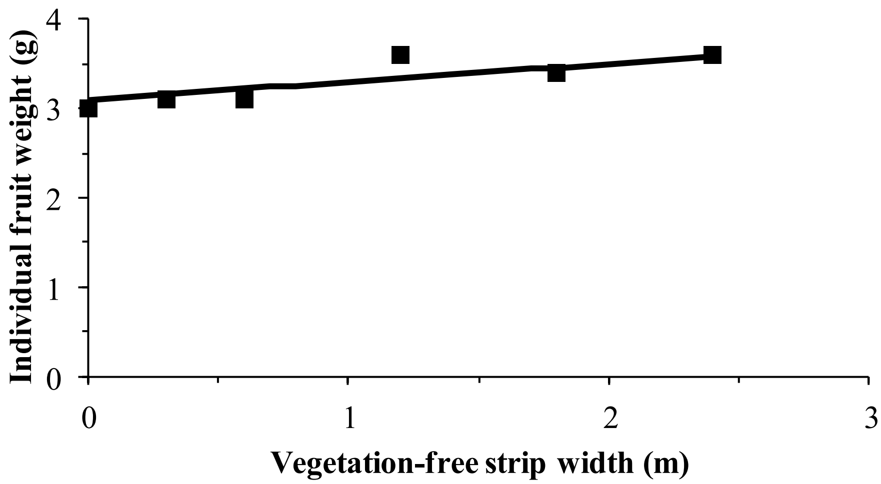

Figure 3. Relationship between blackberry fruit weight and VFSW at Jackson Springs, NC in 2012. Points represent observed mean data. The line represents predicted values.

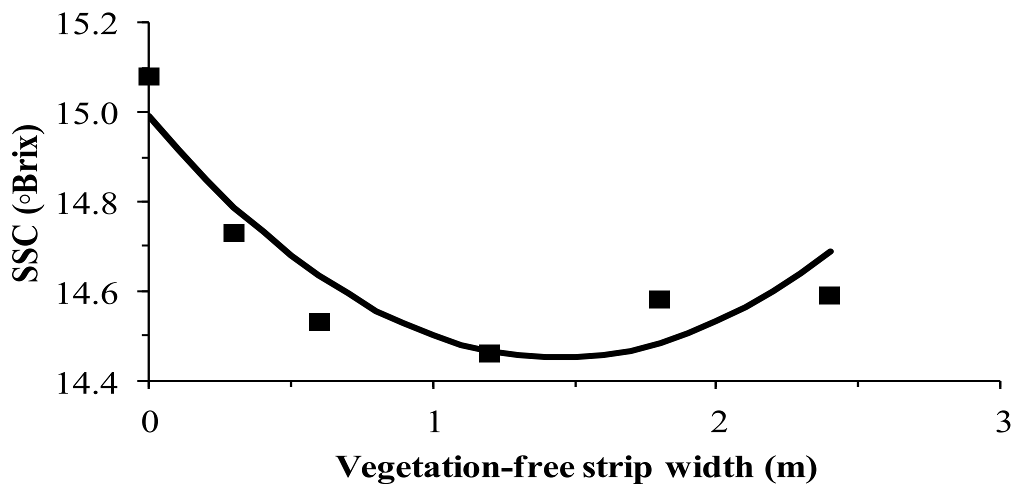

Figure 4. Relationship between soluble solids content of dull blackberry fruit and vegetation-free strip width. Points represent observed mean data. The line represents predicted values.