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Harvest Yields for Brussels Sprouts Cultivar Trials in Northeast Florida

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A brussels sprout cultivar trial was conducted in Northeast Florida at the University of Florida/IFAS (UF/IFAS) Hastings Agriculture Extension Center (HAEC) in Fall 2020. Brussels sprouts are considered a specialty crop in the United States with a reported 9445 harvested acres in 2017, according to the USDA–NASS Census of Agriculture. Brussels sprouts are becoming a trendy treat in upscale restaurants. Over 95% of the harvested acreage goes to fresh market. Currently, 85% of the acreage is grown in California, but Northeast Florida may have a competitive window in the fall. Cultivar trials were planted for two consecutive seasons and marketable yields were measured according to USDA grading standards. Three green varieties ('Marte', 'Speedia', and 'Divino') were planted on 13 November 2019 in Year 1 (Y1) and on 5 Oct. 2020 in Year 2 (Y2). Transplants were planted on 40-inch rows with 16-inch interrow spacing in a randomized complete-plot design with four replications. Average marketable harvest yields (lb/acre) for all four replications in Y1 and Y2 were 4248 and 5275 lb/acre for 'Marte', 3625 and 4670 lb/acre for 'Speedia', and 2694 and 3101 for 'Divino'. The primary differences in production year include days to maturity (i.e., 127–131 in Y1 and 120 in Y2) and in-season pruning in Y1 (i.e. the tops were removed within the first 60 days of planting to allow for fuller sprout production). Three additional red varieties were added to the trial in Y2, namely 'Redarling', 'Rubine', and 'Red Ball'. The only red cultivar that produced any measurable marketable yield was 'Redarling' (2651 lb/acre), but the maturity date was later (135 days after transplanting) and the average yield was significantly lower than the three green varieties. Nutritional benefits in the form of anthocyanin concentrations were detected in 'Redarling' at 13 g/100 g (fresh weight), while none were detected in 'Divino'.

Given the current state of supply chain hindrances and increasing transportation costs, Florida growers and regulators must preserve agricultural land use for food production and economic security. Florida must continue to strive to produce high-value commodities and establish local markets to keep a competitive edge with other high productivity states. In the most recent Census of Agriculture, Florida ranked 5th in vegetable harvested acres after California, Idaho, Washington, and Wisconsin (USDA, 2017a). California is clearly the top producer of brussels sprouts with over 85% of the harvested acreage. A majority (96%) of the harvested acreage is sold on the fresh market (USDA, 2017b).

The Tri-County Agriculture Area (TCAA) in Northeast Florida consists of St. John's, Putnam, and Flagler Counties. The primary cash crops are potatoes and cabbage. Brussels sprouts are a valuable commodity that could be incorporated as 5-acre plots alongside relatively large acreage (> 100 acres) cabbage fields to diversify crop schemes and boost economic viability as a secondary cash crop. Research is currently underway to determine the most productive varieties of brussels sprouts that can be grown in the sandy soils of the TCAA. Specific objectives were to: 1) identify days to maturity for each cultivar grown in a specific season and climate; 2) measure marketable harvest yields for each cultivar; and 3) to determine economic feasibility of brussels sprout production in Northeast Florida.

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Materials and Methods

Field experiments were conducted using three consistent green varieties, namely 'Marte', 'Speedia', and 'Divino' for two consecutive growing seasons at the Hastings Agriculture Extension Center. Additional varieties including 'Dagan' (planted only in Year 1) and 'Red Ball', 'Rubino', and 'Redarling' (planted only in Year 2) were evaluated. Transplants were planted in raised beds using a mechanical transplanter on 40-inch centers with 16-inch in-row spacing, resulting in a planting density of 9803 plants per acre (A). Four replications of each cultivar were planted in a randomized complete block design; each subplot consisted of four 20-ft rows. The brussels sprouts were planted in seepage irrigation fields on 13 Nov. 2019 during Year 1 and 5 Oct. 2020 during Year 2. The nutrient scheme consisted of preplant and two side dressings totaling N–P–K (lb/A) of 200–100–200. Specifics associated with soil preparation, irrigation and management of pest, weeds and diseases followed grower standard practices. A major production variable that differed from Year 1 to Year 2 was topping the sprouts (physically removing the top of the plant to promote sprout growth) approximately 60 days after transplanting in Year 1.

The harvest date was determined for each cultivar when the majority of the sprouts on the stalk had reached marketable size. At harvest, the inner two rows in each subplot were cut and destemmed by hand and graded according to USDA Standard Grades (USDA, 2016). Marketable sprouts, (U.S. No. 1 and No. 2), were

well-colored, firm, and not withered with a minimum diameter of 1 inch and a maximum length of 2.75 inches (USDA, 2016). Results were statistically analyzed within each year using least squares means differences followed by mean separation using Tukey's honestly significant difference (HSD) test at $P < 0.05$.

Postharvest evaluation of anthocyanin concentrations was conducted on two varieties of brussels sprouts as part of the Year 2 trial. Anthocyanins are natural phytochemicals, more specifically flavonoids, with a reddish purple pigment that act as antioxidants and offer health benefits. Seven individual sprouts were removed from each stalk and three sections were cut from a single red cabbage head for comparison purposes then blended ('Redarling' sprouts; n = 6 samples, 'Divino' sprouts; n = 4 samples, and 'Rio Grande' red cabbage; n = 3). Ground tissue (0.3 g) was weighed into three individual extraction tubes and from each tube three replicate subsamples were measured. The total number of measurements read were 54 for 'Redarling', 36 for 'Divino', and 9 for 'Rio Grande'. Total anthocyanins were extracted and measured according to Lee et al. (2005).

Results and Discussion

Maturity dates ranged from 127 to 131 days after transplanting (DAT) in Year 1 and 120 to 135 DAT in Year 2 (Table 1).

Marketable harvest yields for each cultivar in pounds per acre (lb/acre) are shown in Fig. 1 (Year 1) and Fig. 2 (Year 2). The graphical depiction of harvest yields incorporates eight replications since each of the two inner rows in each of the four replicated plots were harvested, graded and weighed separately. During Year 1, the yields from 'Divino' were statistically different and significantly lower than 'Dagan', 'Marte', and 'Speedia' (Fig. 1). During Year 2, yields from both 'Divino' and 'Redarling' were statistically different and significantly lower than 'Marte' and 'Speedia' (Fig. 2). No significant differences were observed within the same cultivar when comparing Year 1 and Year 2.

Year 2 of the trial involved three red cultivars, namely 'Rubine', 'Red Ball', and 'Redarling', that are unique in color and flavor. They have a reddish-purple color. In the case of 'Redarling', that color penetrates through the entire sprout (Fig. 3). 'Rubine' was bred over 30 years ago by C.N. Vreeken by crossing red cabbage with brussels sprouts, but it is not known which particular

Table 1. Length of growing season for each cultivar by year.

Trial Year	Cultivar	Maturity (days after transplanting)
Year 1	Dagan	131
Year 1	Marte	127
Year 1	Speedia	127
Year 1	Divino	131
Year 2	Marte	120
Year 2	Speedia	120
Year 2	Divino	120
Year 2	Redarling	135

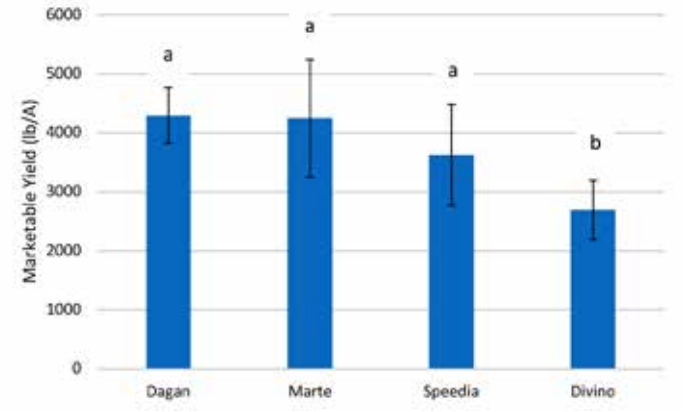

Fig. 1. Marketable Harvest Yields for Brussels Sprout Varieties Grown in Year 1 (bar graph represents averages of eight replications; error bars represent standard deviation; letters on top represent significant differences according to the Tukey test at the 0.05 confidence level)

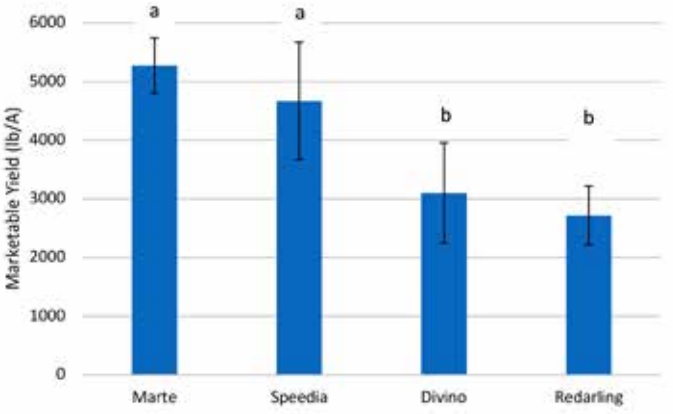

Fig. 2. Marketable Harvest Yields for Brussels Sprout Varieties Grown in Year 2 (bar graph represents averages of eight replications; error bars represent standard deviation; letters on top represent significant differences according to the Tukey test at the 0.05 confidence level)

Fig. 3. Cross-section view of Redarling brussels sprout still on the stalk, immediately following harvest.

cultivars were used as parents (Ockendon, 1977). The only red cultivar that produced marketable results was 'Redarling'. The anthocyanin results are included in Table 2, along with concentrations detected in other fruits and vegetables for comparison purposes (Kalt, 2020). Although anthocyanins are clearly present in 'Redarling' sprouts, the concentrations are relatively low compared to red cabbage.

A brief discussion on economics is warranted since price point would be the major driving force for Florida growers to adopt this alternative crop as a secondary cash crop. Since California is the major producer, the free on board shipping point (FOB) reference value was based on prices from California at the time of harvest. Figure 4 shows the FOBs generated by the USDA Agricultural Marketing Service for both production years. Marketable harvest yield and specific harvest dates for 'Marte' were used to estimate the crop value to the farmer for each year. The key harvest week was 21 Mar. 2020 for Year 1 when FOB prices were $24/box and 2 Feb. 21 for Year 2 when FOB prices were $15/box. Each box weighs 25 lb, so the value for 'Marte' is estimated to be $4078/acre in Year 1 and $3165/acre in Year 2. Although a thorough economic analysis was not part of the trial, these estimated earnings would not cover all the input costs associated with production, harvest and shipment of the produce to wholesale markets.

Table 2. Anthocyanin concentrations of different fruits and vegetables (Kalt, 2020).

Fruit or Vegetable	Anthocyanins (mg/100g fresh)
Blackberry	245
Blueberry (highbush)	387
Blueberry (lowbush)	487
Raspberry	92
Red Plum	20
Apple (red peel)	12
Redarling Sprouts	13 ± 3[z]
Rio Grande Cabbage	60 ± 11[z]
Divino Sprouts	0[z]

[z]Evaluated as part of this research trial.

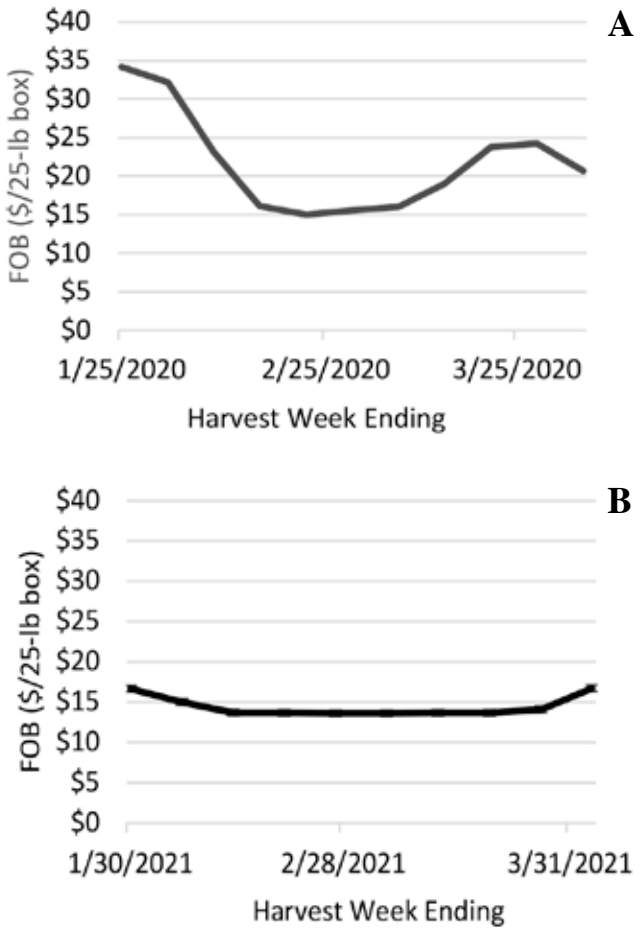

Fig. 4. Free on Board Shipping Point Prices from California for the harvest season in Year 1 (**A**) and Year 2 (**B**). Custom reports were generated by the USDA Agriculture Marketing Service <https://www.ams.usda.gov/market-news/custom-reports>.

Conclusion

'Marte' and 'Speedia' had consistently higher yields than 'Divino' in both years, and were fairly early maturing varieties (127 DAT in Year 1; 120 DAT in Year 2). Although there were some major production differences (later planting date and topping the sprouts in Year 1), no significant differences in yields were observed in Year 1 compared to Year 2. 'Redarling' was the only red cultivar that produced marketable yields; however, they were significantly lower than the green varieties. 'Redarling' had anthocyanin concentrations of 13 mg/100 g fresh, which is comparable to those measured in a red apple or a red plum. Although a thorough economic analysis was not completed as part of this trial, a rough estimation based on real-time shipping price points from California indicated that higher production yields would be necessary to generate profits from this alternative crop in Northeast Florida.

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