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URI Fall Broccoli Trial – 2020 Report

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Trial Conditions

The 2020 trial used a randomized complete block design with four replication and two planting dates. The trial included 17 entries (table 1). Seeds were sown in 128-cell plug trays and transplanted into the field as five week old seedlings. The first planting was seeded June 17 and transplanted July 22. Problems with the soilless mix used in the plug trays resulted in high seedling mortality; as a result the plot size for the first planting was only 10 plants. The second planting was seeded July 1 and transplanted August 4. A different soilless mix was used, with better results, and plot size was 18 plants.

Broccoli seedlings were transplanted into the field in Kingston, Rhode Island. Prior to broccoli transplanting the field was cover cropped with buckwheat. Soil is Bridgehampton silt loam; fertility followed recommendations in the New England Vegetable Management Guide. Spacing was 30 inches between rows and 18 inches between plants in the row. Plots in planting 1 were single row while plots in Planting 2 were double rows. Weeds were managed with mechanical cultivation. Planting 1 was sprayed once for cross-striped cabbage worm. The summer of 2020 was atypically warm and dry. Soil moisture levels were good when the first planting was transplanted, but total precipitation was only 2.5 inches between July 22 and September 30. The trial was sprinkler-irrigated but we were not able to completely prevent drought stress. Planting 1 was harvested September 18 through October 9. Planting 2 was harvested October 9 through November 5. Dry weather prevented foliar disease in the first planting, but wet weather beginning in mid-October triggered



Figure 1. The second planting date on October 9, first day of harvest.

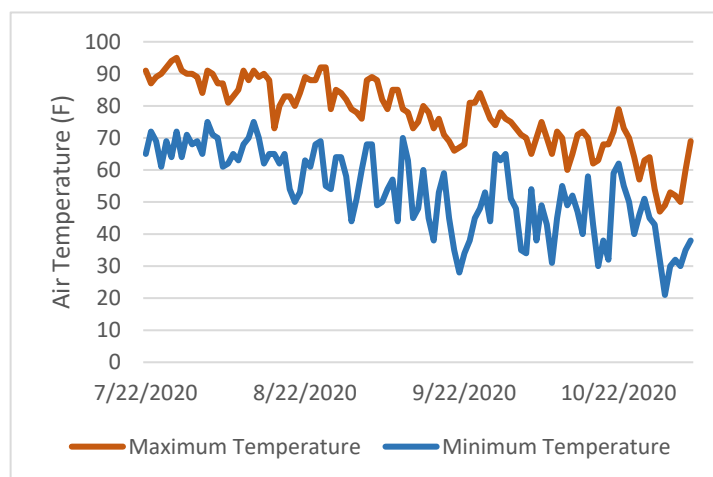


Figure 2. Daily air temperature data during the broccoli trial. Planting 1 was transplanted on July 22, and Planting 2 on August 4.

extensive *Alternaria* infection in the second planting.

Maturity

One question of interest in this trial was how broccoli varieties respond to changing Fall conditions. Climate change has resulted in warmer than normal temperatures, encouraging broccoli growth, but day lengths still decrease from 14 hrs 40 min in late July to just over 10 hours in early November. Mature heads were harvested weekly and a maturity index was calculated for each plot by multiplying the harvest week by the percent of total heads harvested in that week, and then summing across all weeks of the harvest. A plot in which all heads were harvested in the first week would have an index value of 1.0, while a plot in which 50% of the heads were harvested in the first week and 50% in the second week would have a harvest index of 1.5. For Planting 1 harvest began 58 days after transplanting and lasted until 79 days after transplanting, when all heads had been harvested. In Planting 2 harvest began 66 days after transplanting and lasted until 94 days after transplanting, when a hard freeze severely damaged all plants.

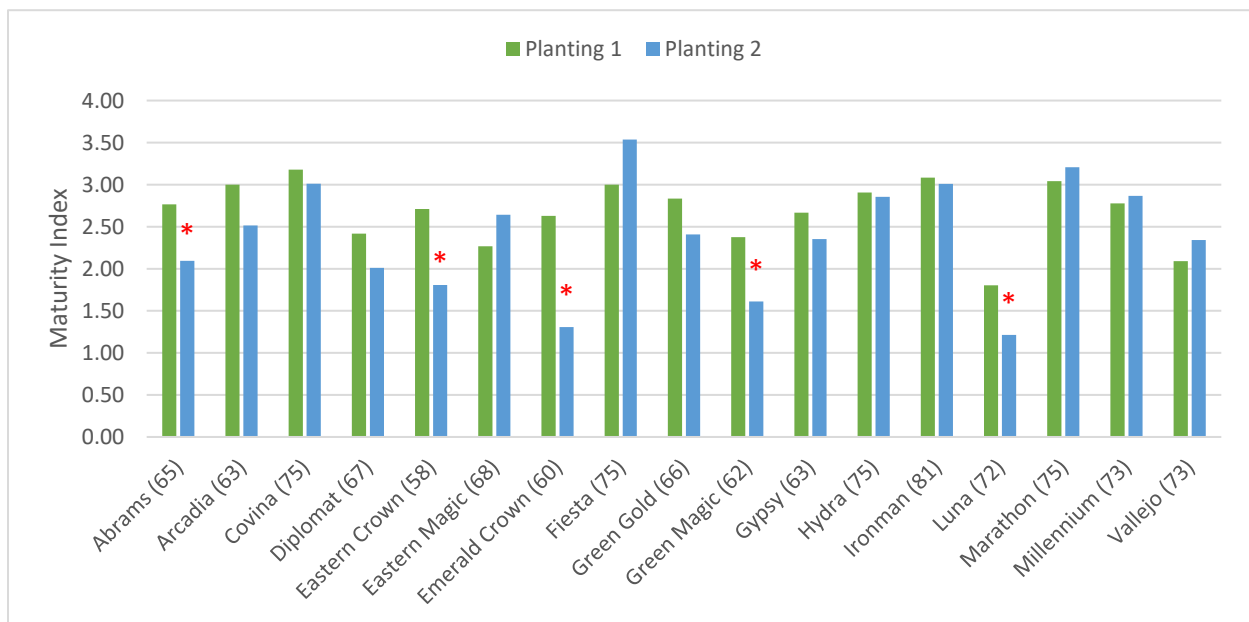


Figure 3. Relative maturities for all trial entries in plantings 1 and 2. Values in parentheses after variety names are days to harvest from variety descriptions. For Planting 1 a maturity index value of 1 indicates that all heads were harvested at 58 days after transplanting; for Planting 2 a value of 1 indicates that all heads were harvested 66 days after transplanting. * indicates that maturity differed significantly at $\alpha=0.05$. Within a planting date varieties differed significantly if maturity index values differed by more than 0.4 in Planting 1 and 0.8 in Planting 2.

Luna was the first variety to mature in both planting dates. This was not expected, as Luna is listed as a mid-season variety. In Planting 1 Vallejo was similar to Luna and all other entries were significantly later maturing. In Planting 2 Eastern Crown, Emerald Crown and Green Magic were similar to Luna. Interestingly, all four varieties were also significantly earlier in Planting 2 than in Planting 1, indicating that the actual days from transplant to maturity remained constant despite shorter days and cooler temperatures for Planting 2. Covina was the only other variety with a significant difference in maturity between planting dates.

Entry	Diameter (in.)	Head Weight (lbs)	Yield
Abrams	5.9	1.1	96%
Arcadia	4.8	0.7	83%
Covina	5.4	1.0	92%
Diplomat	5.0	0.7	88%
Eastern Crown	5.8	1.1	86%
Eastern Magic	6.0	1.3	89%
Emerald Crown	5.5	1.0	96%
Fiesta	3.9	0.4	35%
Green Gold	5.9	1.3	50%
Green Magic	5.1	0.6	92%
Gypsy	5.5	0.9	79%
Hydra	5.5	1.1	100%
Ironman	4.9	0.6	41%
Luna	5.2	0.5	100%
Marathon	4.8	0.8	62%
Millennium	6.2	1.4	100%
Vallejo	5.7	1.0	100%
LSD (95%)	1.8	0.4	26%
LSD (90%)	1.2	0.3	23%

Table 1. Yield data for first planting date. Yield is the percentage of plants producing a marketable head. Values are means across four replications. Means which differ by the LSD (95%) value have a 95% chance of being truly different.

Green Gold, Ironman and Marathon which had many plants which had not headed by the end of the harvest period, or which produced only small, unmarketable heads. Luna and Green Magic produced numerous marketable side shoots after the primary heads were harvested; these were not included in the yield data.

Planting 2

Data for Planting 2 are shown in Table 2. Emerald Crown had the largest heads, averaging 6.78 inches in diameter. Vallejo produced the smallest heads, averaging only 5.22 inches. Fiesta was only slightly larger than Vallejo, and both were significantly smaller than Emerald Crown. Millennium head size was noticeably smaller than in Planting 1 and at 5.6 inches was similar to Fiesta and Vallejo but not to Emerald Crown. Emerald Crown had the heaviest heads at 1.3 lbs, and Vallejo had the lightest at only 0.6 lbs. The standard variety Arcadia was similar to Vallejo in size, while the standard variety Diplomat was significantly larger than Vallejo but significantly smaller than Emerald Crown.

Yields

All entries were harvested for primary heads only, and only heads exceeding 4 inches in diameter were harvested. Data were collected on time to maturity, percentage of plants yielding harvestable heads, head weight, and head diameter. Data for the two plantings were analyzed separately due to significant differences in relative performance among entries. In general heads were smaller and lighter in planting 1. Across all entries 82% of plants yielded marketable heads in planting 1, and 87% percent yielded heads in planting 2. The difference was not statistically significant.

Planting 1

Data for planting 1 is presented in Table 1. Millennium had the largest heads and Fiesta the smallest, but only Fiesta was significantly different from Millennium for head diameter. There was more variation for head weight. The standard varieties Arcadia and Diplomat had significantly smaller heads than many of the newer varieties. Most varieties produced a head on most plants. The exceptions were Fiesta,

Entry	Diameter (in.)	Head Weight (lbs)	Yield	Alternaria Damage
Abrams	6.0	1.2	92%	3.0
Arcadia	5.5	0.7	85%	1.75
Covina	5.4	1.0	79%	3.0
Diplomat	5.9	1.0	81%	2.75
Eastern Crown	6.1	1.2	94%	4.5
Eastern Magic	6.2	1.2	87%	3.25
Emerald Crown	6.8	1.3	98%	4.75
Fiesta	5.3	0.9	78%	2.75
Green Gold	5.9	1.2	88%	4.5
Green Magic	6.4	1.1	98%	3.25
Gypsy	6.4	1.1	85%	2.25
Hydra	5.4	0.9	90%	3.0
Ironman	5.3	0.7	88%	2.0
Luna	6.3	1.1	96%	3.75
Marathon	6.2	1.0	84%	1.0
Millennium	5.6	1.0	65%	2.75
Vallejo	5.2	0.6	88%	1.5
LSD (95%)	0.8	0.3	16%	1.0
LSD (90%)	0.7	0.2	14%	0.75

Table 2. Yield data for second planting date. Yield is the percentage of plants producing a marketable head. Values are means across four replications. Means which differ by the LSD (95%) value have a 95% chance of being truly different. Alternaria damage was rated on a 1 to 5 scale with 1 indicating the least damage.

damaged and heads completely rotten. Emerald Crown was the most heavily damaged, followed by Eastern Crown and Green Gold. In general the earliest maturing varieties were most heavily damaged although Luna and Green Magic had significantly less damage than Emerald Crown. Marathon, Vallejo and Arcadia had the least damage. However, none of the varieties was resistant, and by the end of the trial all plants were severely damaged.

Vegetative Growth

Another question of interest was whether broccoli varieties differed in canopy diameter, and the speed at which canopy diameter increased. Canopy diameter is influenced by overall plant size and growth rate (vigor), but also by the angle between the leaves and the stem, with more horizontal leaves resulting

Millennium had the lowest yield, with only 65% of plants producing mature heads. Fiesta and Covina were similar. All three varieties were relatively late maturing, and it is possible that they may have produced more heads if harvest had extended for another week. However, Ironman and Marathon had

significantly higher yields, similar to those of the top performers, despite having larger maturity index values than Millennium and lower yields in the first planting.

Alternaria leafspot and head rot (*Alternaria brassicicola*) rapidly infected the second planting following heavy rains on October 13. Damage was rated on October 16 using a 1 to 5 scale where 1 indicated some spotting on lower leaves but no crown infection and 5 indicated all leaves were severely



Figure 4. Measuring canopy diameter of broccoli plants three weeks after transplanting.

Entry	Diameter at 3 weeks	Diameter at 5 weeks	Growth Rate (inches/day)
Abrams	14.0	25.0	0.79
Arcadia	12.9	29.0	1.16
Covina	12.4	27.0	1.05
Diplomat	15.1	27.1	0.86
Eastern Crown	9.6	19.5	0.71
Eastern Magic	18.1	34.1	1.14
Emerald Crown	11.1	19.6	0.63
Fiesta	11.2	24.5	0.95
Green Gold	10.7	18.6	0.59
Green Magic	11.3	23.3	0.85
Gypsy	11.5	23.6	0.87
Hydra	13.4	26.8	0.96
Ironman	9.8	22.4	0.90
Luna	12.0	22.4	0.77
Marathon	13.4	25.8	0.89
Millennium	14.6	25.0	0.76
Vallejo	15.2	27.7	0.89
<i>Trial Average</i>	12.7	24.8	0.87
<i>LSD</i>	3.3	4.4	0.25

Table 3. Canopy size data for Planting 1. Means which differ by the LSD value have a 90% chance of being truly different. Each entry was represented by 8 individual plants.

in a larger diameter. Canopy diameter affects how quickly the canopy will close. This in turn affects the variety's ability to compete against weeds, and also the window for interseeding a winter cover crop into a fall broccoli planting. Interseeding cover crops is an increasingly common practice with Fall brassicas, but multiple studies have shown that competition (from cover crop or weeds) in the first three to five weeks after transplanting will reduce head size and yields of brassica vegetables.

Interseeded cover crops establish most successfully when seed is drilled or rolled (i.e. with a culti-seeder) rather than being broadcast over the top of the cash crop. There is a narrow window between when the broccoli crop is large enough to avoid competition and when the plants are so large that they will suffer

mechanical damage during interseeding.

We evaluated all entries in the broccoli trial for lateral growth rate. Plant diameter was measured weekly using digital images taken from directly above the plant. Two plants were randomly selected in each plot; edge plants were excluded. The same plants were photographed every week, allowing us to measure change over time. Planting date 1 was measured on August 12, August 19 and August 26. Planting date 2 was measured August 19 through September 17. Sampling stopped when all entries had reached canopy close within the row and the largest entries had closed canopies between rows. Entries were compared to determine differences in plant diameter, and differences in growth rate.

In Planting 1 Eastern Magic was the only variety with a canopy diameter significantly larger than the trial average on all three sampling dates. Eastern Magic and Arcadia were the fastest-growing entries, significantly faster than the average. None of the entries had a canopy diameter significantly smaller than average at three weeks after transplanting, and only Eastern Crown, Emerald Crown and Green Gold had a canopy diameter significantly smaller than the average at five weeks after transplanting. These three varieties also had the slowest growth rates, with Green Gold growing significantly more slowly than the trial average. All three of these varieties produced large heads, suggesting that the small canopy size was due to vertically-oriented leaves and that these might be good varietal choices for interseeding into.

Entry	Diameter at 3 weeks	Diameter at 5 weeks	Growth Rate (inches/day)	Change from Planting 1
Abrams	12.5	26.0	0.88	0.09
Arcadia	13.3	29.7	1.04	-0.12
Covina	12.4	28.7	1.03	-0.03
Diplomat	10.5	28.4	1.07	0.21
Eastern Crown	12.4	24.9	0.83	0.12
Eastern Magic	11.3	26.2	0.93	-0.21
Emerald Crown	13.4	31.9	1.14	0.51
Fiesta	12.2	26.8	0.89	-0.06
Green Gold	12.1	29.1	0.97	0.38
Green Magic	12.3	26.9	0.91	0.06
Gypsy	8.9	27.7	1.00	0.13
Hydra	11.6	28.8	1.02	0.06
Ironman	11.1	30.5	1.13	0.23
Luna	14.0	28.1	0.88	0.11
Marathon	13.5	30.8	1.11	0.23
Millennium	11.0	25.6	0.89	0.13
Vallejo	10.1	25.0	0.91	0.02
<i>Trial Average</i>	11.9	27.9	1.0	0.11
<i>LSD</i>	NS	NS	3.80	

Table 4. Canopy diameter data for Planting 2. Negative change values indicate that the variety grew more slowly in Planting 2 than in Planting 1.

In Planting 2 background variability in plant size was larger, and there were no significant differences in canopy size between varieties. There were significant differences in growth rate. Emerald Crown had the fastest growth rate at 1.14 inches per day, nearly double its growth rate in Planting 1. Ironman, Marathon, Diplomat, Arcadia, Covina and Hydra were similar, with growth rates exceeding 1 inch per day. Eastern Crown had the slowest growth rate at 0.83 inches per day.

Growth rate for weeks 3 to 5 in Planting 2 was only weakly correlated with growth rate in Planting 1 ($R^2 = 0.34$). We expected growth rate to be slower in Planting 2, as days were shorter and temperatures generally cooler. However, the trial average rate was actually 0.1 inch per day faster than the growth rate in Planting 1, and only Arcadia and Eastern Magic grew noticeably more slowly.

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