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SPECIALTY PEPPER TRIALS 2011, 2012, 2014

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ABSTRACT

In 2011, 2012, and 2014, ten cultivars of specialty bell peppers were grown on a sandy terrace soil (Windsor, CT) and a loamy upland soil (Hamden, CT). Average yield was 15.6 t/A or 4.3 lbs/plant. Early Sunsation (yellow) averaged the greatest yields (6.2 lbs/plant) while Lilac (lavender) and King Arthur (red) averaged 4.9 lbs/plant. The lowest yielding cultivar was Baron (red) at 2.8 lbs/plant. King Arthur (red) (6.3 oz/fruit), Super Heavyweight (yellow) (6.2 oz/fruit), and Early Sunsation (6.1 oz/fruit) produced the largest fruit while Chablis (red) (2.1 oz/fruit) and Lilac (2.8 oz/fruit) were the smallest. Chablis (31.7 fruit/plant), Lilac (25.0 fruit/plant), and Merlot (red) (20.0 fruit/plant) all produced at least 20 fruit/plant while Baron (8.0 fruit/plant), Super Heavyweight (8.2 fruit/plant), and Chocolate Beauty (brown) (8.3 fruit/plant) averaged less than 9 fruit/plant. Chablis and Merlot were the fastest maturing red varieties while Super Heavyweight and Early Sunsation were the fastest maturing yellow varieties. By harvesting some immature peppers when green and harvesting others with their mature color, growers can market both green and colored bell peppers at the same time.

INTRODUCTION

Peppers (*Capsicum annum*), members of the Solanaceae (nightshade family), are native to the tropics and are related to potatoes, tomatoes, and eggplant. The origin of peppers is believed to be Central and South America (Eshbaugh 1993). Christopher Columbus found the natives of the West Indies growing and using very hot forms of *Capsicum*. He assumed they were some form of pepper (*Piper nigrum*, i.e. black pepper) because of their extremely pungent flavor. Thereafter, peppers became adopted immediately and their use spread worldwide.

Peppers are tender, warm-season vegetables that thrive in hot temperatures. They require 3 to 4 months of frost-free weather for good yields. Peppers may be "hot" or "sweet". Hot peppers are pungent due to the presence of capsaicin, a chemical concentrated in the cross walls of the fruit surrounding the developing seeds. Peppers that do not contain capsaicin are considered "sweet".

Specialty peppers include both hot and sweet varieties of unusual shape, size, or color. Colored peppers command a higher market price because they have extra flavor, nutrition, and aesthetic appeal. Most colored peppers are obtained by leaving the fruits on the bush until they reach mature color (e.g., red, yellow, orange). Others, such as banana pepper, are pale yellow even when immature. Green bell peppers are high in vitamin C (one medium green bell pepper contains 177 percent of the RDA for vitamin C). As they mature and sweeten (turn color), the vitamin A content rises 9-fold while the vitamin C content doubles (Jegtvig 2007).

The per capita consumption of bell peppers in 2015 was 10.2 pounds compared to 7.5 pounds in 2000 or a 36% increase (Anon 2018). One quarter of Americans consume at least one food containing bell peppers daily (Anon 2001). Many factors have contributed to their increased popularity including availability of greenhouse fruit in winter, development of colored peppers, and increased ethnic diversity in the nation's population. Many ethnic restaurants (e.g., Italian, Chinese, Lebanese, Korean, Indian, and Mexican) use peppers in their cuisine.

Every state in the U.S. grows peppers with California and Florida together accounting for 63% of the total acreage (USDA 2014). While 67% of California's pepper growers average less than 1 acre/farm, one percent of the pepper growers account for 87% of acreage with an average of 314 acres of pepper production/farm. Number of acres of peppers/farm in Florida averages over 100 acres while in New England each farm averages less than an acre. Connecticut leads New England with 421 farms growing 425 acres of bell peppers in 2012 (USDA 2014). In addition, 261 farms grew 141 acres of other peppers. Because of the great varietal differences, peppers offer the grower a diversity of products for their operation.

The economic potential of this crop is estimated to be very high for growers who sell directly to the consumer. Based on production in our preliminary trials, average yield was 4.9 lb/plant or over 42,000 lb/A (Maynard, unpublished data). Gross returns, based on an average retail price of $1.49/lb for green bell peppers, approached $62,580/A. With production costs estimated to be $4,800/A (University of Massachusetts), net returns would exceed $57,000/A, providing that the entire crop was harvested and sold.

MATERIALS AND METHODS

Sites and soils. Trials of bell peppers were conducted for three years at the Valley Laboratory in Windsor, CT on Merrimac sandy loam (Entic Haplorthod), an inland sandy terrace soil with somewhat limited moisture holding capacity (Shearin and Hill 1962); and at Lockwood Farm in Hamden, CT on Cheshire fine sandy loam (Typic Dystrochrept), a coastal loamy upland soil with moderate moisture holding capacity (Reynolds 1979).

Cultivars. Cultivars grown in 2011 and 2014 included Chablis, Chocolate Beauty, Baron, Golden California Wonder, King Arthur, Lilac, Mandarin, Merlot, Super Heavyweight, and Early Sunsation. The same cultivars were grown in 2012 with the exception of California Wonder whose seeds did not germinate in the greenhouse. Trials were also conducted in 2013 but the data could not be used because of pilferage on the experimental plot. Color characteristics, days to maturity, and seed source are described in Table 1.

Culture. Peppers were seeded in the greenhouse on April 5 to 8. Seedlings were grown in Promix BX (Premier, Red Hill PA) in 3x3x3-inch Jiffystrips and placed in a greenhouse maintained at 75^{o}-90^{o}F. After germination, plants were thinned to one per pot. Seedlings were moved to a cold frame for hardening before transplanting in the field. Water-soluble 20-20-20 fertilizer (one tbsp/gal) was added to the seedlings before they were transplanted in the field in mid-June. Rows 3 ft apart were covered with black plastic mulch (3’ wide) applied by a tractor-pulled plastic-layer. At Hamden, drip irrigation tubing was laid as the plastic was applied. Transplants were planted 2 feet apart through the plastic with the plastic punctured during the planting process. There were 15 plants per cultivar, with three blocks of five plants per cultivar.

Fertilization. The field soils (pH 6.5) were fertilized at a rate of 1300 lb/A 10-10-10 just before seeding or transplanting. Different experimental fields at each location were used each year to minimize potential disease build-up.

Weed control. Weeds around each plant were controlled by the black plastic mulch. Weeds in the aisles were mechanically controlled by rototilling.

Insect and disease control. Insects and diseases were controlled by Manzate (mancozeb), Quadris (azostobin), Asana (esferivaterate), and Bravo (chlorothalmil) applied per labeled directions as needed throughout the growing season.

Irrigation. Water was supplied by drip irrigation at Hamden. At Windsor, water was supplied by overhead sprinklers as needed. Plots were irrigated at both sites to ensure that plants received at least 1 inch of water per week either through rainfall or irrigation.

Harvest. Peppers showing at least some of their final color (see Table 1) were harvested from July to the first frost in October. Fruits were counted, weighed, and evaluated for quality.

Statistical Analysis. A two-factor (cultivar, site) analysis of variance (ANOVA) with year as replicate was used to compare the yield (lbs per plant) and fruit size (oz/fruit). Tukey's HSD test was used to test for significant differences between the cultivar yields and fruit size at $p < 0.05$.

RESULTS AND DISCUSSION

Yields did not differ between the two experimental sites (Hamden and Windsor), but did differ among cultivars. Early Sunsation averaged the greatest yields (6.2 lbs/plant) over the three years and was statistically equal to King Arthur (4.9 lbs/plant) and Lilac (4.9 lbs/plant) (Table 2). King Arthur and Lilac were also statistically equal to Chablis (4.9 lbs/plant), Merlot (4.1 lbs/plant), Mandarin (3.8 lbs/plant), and Super Heavyweight (3.6 lbs/plant).

Yields in pounds per plant are due to a combination of fruit size and a number of fruit per plant. Number of fruit per plant varies according to the growing season with large variations from year to year and from site to site (Table 4). Favorable growing conditions produce larger plants which produce more fruit. The year 2011 averaged the greatest number of peppers (22 peppers/plant), compared with 2012 (13 peppers/plant) and 2014 (10 peppers/plant). That year (2011) had the greatest number of growing degree days (GDD) from June 1 to October 31 (Table 5).

Pepper flowers abort when the temperature rises above 90^{o}F or remains above 70^{o}F at night (LeBoeuf 2004). As peppers require about 60 days (for red peppers) from pollination to market maturity (Maynard and Hockmuth 1997), the key time for flowering would be mid-June to mid-August. The year 2012 had the most days (10) over 90^{o}F during the critical flowering period compared to 2011 (7), and 2014 (1) (Table 5). There were also four additional days in 2012 from July 5 to July 8 where the high temperature reached 89^{o}F (data not shown). In addition, there were 13 nights in 2012 during the critical flowering period where the low temperature remained above 70^{o}F compared to 5 nights in both 2011 and 2014. So even though the GDD's in 2011 and 2012 were similar, the timing of the hot weather in 2012 appears to have been problematic for optimum pepper production. On the other hand, the year 2014 was a much cooler year as shown by the lower GDD and this decreased plant growth and subsequent pepper yields.

Cultivars producing the greatest number of fruit had the smallest fruit (Chablis, Lilac, and Merlot) (Tables 3 and 4). Overall, King Arthur averaged the largest size (6.3 oz/pepper) but was statistically equal to all the other cultivars except for the smaller Chablis, Lilac, and Merlot (Table 3).

Days to maturity (Table 1) is an especially important characteristic for colored peppers. Once peppers reach the desired size, usually a green pepper, it then takes several additional days (usually about 15 days) for the peppers to change color. These additional days on the plant, that leave the fruit more susceptible to diseases, sunscald, and insects, are one of the reasons why colored peppers demand a higher market price. In these trials, days to maturity is defined as the number of days from seeding to when half the mature crop has been harvested. This was determined by calculating cumulative yield from the weekly harvest data until half the total yield had been reached. The days to maturity for each of the three years was then averaged. For red peppers, Chablis (148 days) and Merlot (150 days) had shorter days to maturity compared to Baron and King Arthur (both 162 days). This is not surprising as Chablis and Merlot are smaller in size and so take a shorter amount of time to mature. For yellow peppers, Early Sunsation

and Super Heavyweight ripen about a week earlier than California Wonder but, in general, are about 2 weeks later than the larger red peppers.

Specialty colored peppers have a higher marketplace price compared to green peppers. Wholesale prices of green bell peppers were $24 per 1 1/9 bushel (average 20 lbs) compared to $28 for red bell peppers, and $30 for both yellow and orange bell peppers (Anon 2018). At a spacing of 3 X 2 ft spacing (7260 plants/acre), a grower could gross over $68,000/acre by growing Early Sunsation and selling when yellow compared to $54,000/acre if the same crop is sold when green. If the grower is selling directly to the consumer, advertised retail prices averaged $2.72 per pound nationally for field grown red peppers and $2.80 per pound for field grown yellow peppers. This compares to $1.68 per pound for green peppers or a 62% increase for red peppers and a 67% increase for yellow peppers (USDA 2018). Orange peppers commanded the highest wholesale price ($2.90 per pound) or 73% greater than green peppers.

The differences in yields between cultivars highlight the importance of cultivar selection to maximize profits for a grower. For yellow peppers, Early Sunsation averaged 3.0 lbs/plant more than the standard California Wonder. This is equivalent to 21,780 more pounds (1,089 bushels) per acre or $32,670 more per acre. For red peppers, King Arthur averaged 2.1lbs/plant more than Baron. This is equivalent to 16,128 more pounds (806 bushels) per acre or $24,192 more per acre. These increases in gross profits per acre are due solely to cultivar selection. All other growing expenses remain the same.

One advantage to growing specialty bell peppers is that there can be two commodities marketed at the same time. A grower can choose to leave the entire crop to fully mature (colored) or can choose to harvest a portion of the crop early to be sold immature or green. Even off the same plant, both green and colored peppers can be harvested at the same time. In addition, at the end of the season when frost is imminent, the immature green peppers can be harvested and sold. In this trial, Chablis and Merlot were unique in that they are not green when immature but are yellow and purple, respectively, so could be harvested earlier and still be sold as a colored pepper. Packaging, which includes multiple colors or “stoplight packs” has proven to be an important marketing strategy that takes advantage of the color options now available in peppers.

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Table 1. Color characteristics (Days to Maturity) (Seed Source) of pepper cultivars used in trials

Red when mature

Chablis – Yellow to Red (148 days) (Totally Tomatoes)

Merlot – Black Purple to Red (150 days) (Totally Tomatoes)

Baron – Green to Red (162 days) (Totally Tomatoes)

King Arthur – Green to Red (162 days) (Totally Tomatoes)

Yellow when mature

Super Heavyweight – Green to Yellow (174 days) (Totally Tomatoes)

Early Sunsation – Green to Yellow (176 days) (Totally Tomatoes)

Golden California Wonder – Green to Yellow (182 days) (Totally Tomatoes)

Other colors when mature

Lilac – Ivory to Lavender/Red (148 days) (Reimer)

Chocolate Beauty – Green to Brown (158 days) (Totally Tomatoes)

Mandarin – Green to Orange (166 days) (Holmes)

Table 2. Average yields of mature colored peppers grown in 2011, 2012, and 2014 in Connecticut. Average yield (lbs/A) assumes 36 X 24 inch spacing of 7260 plants per acre.

	Pounds per plant				
	2011	2012	2014	Average*	(lbs/A)
Early Sunsation	8.8	6.7	4.2	6.2a	45,012
King Arthur	7.1	3.4	4.5	4.9ab	35,574
Lilac	7.8	3.4	3.7	4.9ab	35,574
Chablis Hybrid	8.4	2.8	2.8	4.4bc	31,944
Merlot	6.5	3.2	3.0	4.1bcd	29,766
Mandarin	7.0	2.8	2.8	3.8bcd	27,588
Super Heavyweight	7.0	1.6	2.6	3.6bcd	26,136
Golden California Wonder	4.5	-	2.8	3.2cd	23,232
Chocolate Beauty	5.1	1.2	2.4	3.0cd	21,780
Baron	5.0	1.6	2.6	2.8d	20,328
Average	6.7	3.0	3.1	4.3	31,218

* Average year column values with same letter were not significantly different at $p < 0.05$

Table 3. Average fruit size (ounces) of mature colored peppers cultivars grown in 2011, 2012, and 2014 in Connecticut.

	Ounces per fruit			
	2011	2012	2014	Average*
King Arthur	6.3	5.8	6.8	6.3a
Super Heavyweight	7.0	4.2	7.4	6.2a
Early Sunsation	5.8	6.3	6.6	6.1a
Golden cal wonder	5.4	-	6.2	5.8a
Mandarin	5.6	5.2	5.2	5.1ab
Chocolate beauty	5.7	3.9	5.4	5.1ab
Baron	4.0	4.4	5.6	5.0ab
Merlot	3.4	3.0	3.4	3.3bc
Lilac	3.2	2.4	3.0	2.8c
Chablis	2.6	1.8	2.2	2.1c
Average	4.9	4.1	5.2	4.8

* Average year column values with same letter were not significantly different at $p < 0.05$

Table 4. Average number of mature colored fruit per plant for pepper cultivars grown in 2011, 2012, and 2014 in Connecticut.

	Number of fruit per plant			
	2011	2012	2014	Average
Chablis	48.5	25.5	21.0	31.7
Lilac	34.0	22.0	19.0	25.0
Merlot	30.0	17.5	12.5	20.0
Early Sunsation	17.0	17.5	10.0	14.8
King Arthur	17.0	9.5	8.5	11.7
Mandarin	15.0	8.5	8.5	10.7
Golden Cal Wonder	12.5	-	6.5	9.5
Chocolate Beauty	13.5	5.0	6.5	8.3
Super heavyweight	14.0	4.5	6.0	8.2
Baron	14.5	5.5	4.0	8.0
Average	21.6	12.8	10.2	14.8

Table 5. Growing Degree Days (GDD)* (June 1-October 31), number of days over 90°F, and number of nights above 70°F during critical flowering period (June 15-August 15) at in 2011, 2012, and 2014.

	2011	2012	2014
GDD	2771	2715	2590
Days over 90°F	7	10	1
Nights above 70°F	5	13	5

* Growing Degree Days based on 50 degrees Fahrenheit