

Investigating the feasibility of berry production in central Oregon under protected and unprotected culture – Second year results (2020)

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Introduction

Central Oregon growing conditions are challenging for horticultural production due to the short growing season, low annual precipitation, drastic swings in diurnal temperatures, and possibility of frost any time of year. Despite the challenging growing conditions, there are a number of farms growing vegetables in central Oregon, but very little in the way of fruit production. This report is from the second year of a project aiming to determine whether berry production in central Oregon is a viable enterprise, and if high tunnels are a justified expense to increase profitability and fruit quality. The main objective was to compare strawberry and raspberry production in high tunnels (indoor) vs. open field (outdoor).

Materials and Methods

Day neutral strawberries and primocane-bearing raspberries were planted in high tunnels and the open field in May 2019. Production data were collected for two growing seasons (2019-2020). Establishment of the berry trial, crop maintenance, and results from the 2019 growing season are explained in the [first-year report](#). The four strawberry varieties included in the trial were: ‘Albion’, ‘Evie 2’, ‘Mara des Bois’, and ‘Seascape’. The four raspberries varieties included in the trial were: ‘Anne’, ‘Caroline’, ‘Heritage’, and ‘Joan J’. The plots were managed using organic practices.

Trial Maintenance

The green leaves of the strawberry plants were left on plants through the fall of 2019 to contribute to the carbohydrate reserves in the plant. In early February, all dead and green leaves were cut away from the strawberry crowns. New crown growth started in March, and berries were fertigated once the irrigation season started in mid-April. Strawberries continued to be fertigated bi-weekly through the growing season with 5-0-0 liquid fish fertilizer, aiming for a total of 80lbs N/ac for the season. Runners were removed once a month in May, June, and July.

Raspberry canes were cut back to ground level in early February when plants were dormant. Raspberries were fertilized with feather meal at 40lbs N/ac before canes emerged, and mulched with yard debris compost. Once raspberry canes emerged, rows were narrowed to 18 inches. At flowering, indoor raspberries received an additional 20 lbs N/ac with 5-0-0 fish fertilizer. Raspberry rows were narrowed again to 18 inches in mid-July.

Pest Management

Rodent and bird damage to strawberry fruit was notable over the growing season, particularly in the high tunnel. Distinguishing between rodent and bird damage was not always possible but rodent damage seemed more apparent early in the growing season. Bird damage started a bit later and remained more constant over the growing season. No steps were taken to reduce the fruit damage due to rodent and bird pressure.

Spider mites were observed in the indoor raspberry planting in late June. They spread

significantly in July leading to some defoliation. There was minimal spider mite pressure in the outdoor planting. Cinnerate was applied in late July and early August at a rate of 32 oz/100 gallons. Spider mite pressure seemed somewhat reduced after these applications.

2020 Harvest

Berries were harvested once a week when production began, and then twice a week when berries were in full production. Hazardous smoke conditions across central Oregon resulted in a harvest gap of approximately 10 days in September. Harvested berries were separated into ‘marketable’ and ‘unmarketable’ fruit in order to calculate percent cull. Marketable and unmarketable berries per plot were weighed and counted to calculate yield per plot and fruit size (weight/berry). In order to compare yield across treatments, marketable weight was normalized per 10 plants. Total marketable yield per treatment was the accumulated yield over the growing season, normalized per 10 plants. Following the planting scheme used in this trial, 10 plants is the equivalent of five row feet of strawberries, and 20 row feet of raspberries. Some data are shown as pounds per 100 plants, which represents 50 row feet of strawberries and 200 row feet of raspberries. Data were subjected to analysis of variance, and treatment means were compared using Tukey’s honest significant difference test ($P < 0.05$).

Results and Discussion

Strawberry Trial 2020

Winter survival of strawberry plants was determined by comparing September 2019 plant totals to April 2020 plant totals for each variety. In the outdoor planting, Mara des Bois had the highest plant survival percentage at 100% while Albion had the lowest at 82%. In the indoor planting, Seascape (100%), Evie 2 (98%), and Mara des Bois (97%) had high plant survival over winter while the survival of Albion plants was lower (79%). Evie 2 and Seascape plant survival was higher indoors when compared to outdoors while Mara des Bois and Albion plant survival indoors was slightly lower when compared to outdoors (Table 1).

Starting in mid-April, weekly vigor rankings were taken for all plots. For each replication, the four strawberry varieties were ranked relative to the other varieties. These rankings were recorded for 12 weeks. The vigor rankings remained consistent over that time period. Mara des Bois was the most vigorous variety across all reps in both the indoor and outdoor plantings. Albion was the least vigorous across all reps in both the indoor and outdoor plantings. Seascape and Evie 2 were similar to each other in vigor ranking behind Mara des Bois and ahead of Albion.

Production system (indoor vs. outdoor) impacted both strawberry yield and growing season length. Total marketable yield for the season was significantly higher for indoor production (22lbs/10 plants) than outdoor production (14lbs/10 plants), and the indoor season was about a month longer. Indoor strawberry production began May 25 for Evie 2, Mara des Bois and Seascape, and started picking up by early July (Figure 1). Albion was several weeks behind the other varieties, and indoor production did not start picking up until late July. Indoor production was highest in July and September, with a dip in August, and a gradual decline in October as temperatures dropped (Figure 1). Outdoor production began in mid-July for Mara des Bois, and the end of July/early August for the other three varieties (Figure 2). Outdoor production picked

up in August and September, but dropped significantly at the end of September. All berry production stopped with freezing temperatures at the end of October.

Percent cull by berry weight was higher for indoor production (average 16%) than outdoor production (average 11%). Herbivory from mice and birds was the main culprit for designating fruit unmarketable, and herbivory pressure was observed to be much greater in the high tunnel. We did not put nets over the berry plants, but it is a recommended practice to reduce bird damage.

Strawberry fruit size differed by variety and also by production system (Table 2). Average fruit size was greater under indoor production (13 g/berry) than outdoor production (11 g/berry). Fruit size for Albion, Evie 2 and Seascape was comparable, while fruit from Mara des Bois averaged ~40% the size of other varieties (Table 1). Mara des Bois is known to be a smaller berry, so the reduced fruit size was expected. Fruit size is significant for a grower because the larger the berry, the fewer berries needed to fill a pint, resulting in lower labor requirements.

Overall, by variety, Evie 2 and Mara des Bois were the highest yielding (~21lbs/10 plants), followed by Seascape (18lbs/10 plants); Albion had a significantly lower yield (11lbs/10 plants) over the growing season. The interaction between production system and variety was not significant, as yield for all four varieties increased under indoor production as compared to outdoor production (Table 2). Indoor production of Mara des Bois in particular stood out, with yield increasing 70% indoor vs. outdoor. Taste tests were not performed in 2020, but berry quality was fairly similar between 2019 and 2020. Albion had large, firm berries that made picking and transportation easy, but yield was significantly lower. Evie 2 produced well but had a softer berry that was easily bruised while handling, making it more difficult for transportation to markets. Mara des Bois was an early producer and had a larger berry size in 2020 as compared to 2019, but the fruit was still small and had a short shelf life. Seascape was not as firm as Albion, but produced decently under both indoor and outdoor production systems.

Raspberry Trial 2020

New raspberry primocanes began to emerge in April. Indoor cane growth started towards the beginning of April while outdoor cane growth began towards the end of April. In April, there were nights during which air temperatures in the field and the high tunnel fell below 20°F. In mid-April, some damage was noted on the indoor raspberry plants after these cold nights but the plants recovered. The outdoor plants had not yet emerged for the mid-April cold events. In early May, on two separated nights, temperatures outside fell below 20°F. After these events, there was significant dieback in the outdoor trial. The percentage of plant loss varied between varieties with 79% loss of all Heritage plants, 32% loss of all Caroline plants, and 29% loss of all Anne and Joan J plants. There was not any plant loss in the high tunnel from the early May cold events (Table 3). The indoor plants were more mature and temperatures were about 2°F to 3°F higher in the high tunnel which may have accounted for the differences in plant survival.

Weekly vigor rankings were taken for all plots from mid-April through mid-July. The rankings were relative within each replication. In the outdoor planting, Joan J plants displayed the most vigor while Heritage plants were the least vigorous. In the indoor planting, Caroline was the most vigorous and Anne was the least vigorous.

Due to plant loss and stunted growth outside, raspberry production was nearly non-existent for the outdoor planting in 2020. Total marketable yield averaged across all live plants was 11lb/10 plants, whereas indoor production averaged 27lbs/10 plants over the growing season. Joan J raspberries started fruiting in the high tunnel in mid-August, but indoor production for the other three varieties did not start until early September (Figure 3). Raspberry production peaked in mid to late September for all of the varieties, and continued to produce well until mid-October. The extremely high raspberry harvest of September 20 came at the end of a 10-day gap in picking due to hazardous smoke conditions in the region. Raspberry production ended October 21 with freezing temperatures.

Percent cull by berry weight was higher for outdoor production (~30%) than indoor production (~5%), reflecting the very poor quality of outdoor fruit in 2020. Raspberry fruit size differed by variety and production system (Table 4). Average fruit size was greater under indoor production (2.6 g/berry) than outdoor production (1.7 g/berry). Joan J and Anne had overall larger fruit, followed by Caroline, and Heritage had significantly smaller berries.

Joan J stood out as the highest yielding raspberry variety, especially when grown in the high tunnel (Table 4). Total indoor marketable yield for Joan J was more than double the yield of Anne and Heritage, and 40% greater than Caroline. Fruit production came on late for Caroline, but it has nice, large berries and produced well late in the season. Anne had large, yellow berries and produced fairly well, but the fruit was more delicate and prone to being culled. Heritage is an heirloom variety and yielded lower than the other modern varieties due to its small fruit size and late maturity.

Strawberry Comparison Between Growing Seasons

Overall strawberry yield was significantly higher in the second growing season than the first, but there was no difference in fruit size. Total marketable yield averaged across all strawberry varieties and production systems was 18lbs/10 plants in 2020, and only 9lbs/10 plants in 2019. Increased yield in 2020 is likely due to the plants being established and putting on growth earlier than 2019, and having larger crowns that produced more fruit. The 2020 growing season started earlier and went later than the 2019 growing season. Early freezing temperatures at the end of September 2019 cut the first berry season short, but the additional berry picks in October 2020 only added another 2lbs/10 plants to the second year results.

Indoor strawberry production was consistently higher than outdoor production for both growing seasons. Overall indoor fruit size was also larger than outdoor fruit size. The yield pattern for varieties was fairly consistent between growing seasons (Figure 4), but there were some notable differences: Albion yield did not see much improvement in the second growing season, and yield was significantly lower than the other three varieties in 2020; and Mara des Bois was a top performer in 2020 as compared to 2019.

Raspberry Comparison Between Growing Seasons

It was expected that raspberry yield would increase in the second season due to the plants being more established, and that proved to be the case. Even with the outdoor crop failure, average raspberry yield was significantly greater in 2020 (13.9lbs/10 plants) than in 2019 (5.5lbs/10

plants). Average fruit size was lower in 2020 compared to 2019, suggesting increased yield was the result of increased berry numbers in 2020.

Indoor raspberry production was greater than outdoor production for both growing seasons. The outdoor crop failure in 2020 was unexpected, but revealed the importance of season extension in protecting sensitive plants from frost damage. Joan J consistently yielded the most in both years and in both production systems (Figure 5). Caroline was a very vegetative variety and fruit production occurred late in the season both years. In the first growing season, this was detrimental to Caroline's yield, but Caroline's performance improved in 2020 with the longer growing season and a larger berry size.

Preliminary Conclusions from 2019 & 2020

In 2019, berry variety had the largest influence on the factors measured rather than indoor vs. outdoor production. Evie 2 was the highest yielding strawberry, although berry quality (flavor and handling) was lower than other varieties. Joan J was the highest yielding raspberry and berry quality was quite good. In 2020, production system exerted a greater influence on berry yield, likely because the plants were already established and able to take advantage of a longer growing season inside the high tunnels.

Mara des Bois came out of the winter with greater vigor than the other varieties and started producing fruit earlier, making it a good choice for outdoor production. Evie 2 and Seascape offer viable options for strawberry production, and have different flavor and texture profiles. In our study, Albion fruit production came on much later and underperformed in terms of yield. Based on our two-year study, the central Oregon strawberry season peaks from late July through September, which may be later than expected by many consumers.

Joan J was the clear winner for both indoor and outdoor raspberry production across the trial years; fruit production came on the earliest and overall yield was the highest. Additional considerations for Joan J are that it is thornless (benefit), but the canes are not very rigid and are difficult to keep upright in a trellis (drawback). Caroline and Heritage had more upright growth habits that were easier to manage with a trellis, but they were both late-maturing and therefore not ideal options for central Oregon where early fall frosts are possible.

Results from this study indicate that some form of frost protection/season extension is needed to have a successful raspberry crop in Alfalfa, OR. As reported, the outdoor crop failed in the second growing season due to early spring freezes killing newly emerged growth, and the indoor crop clearly benefitted from protection of the high tunnel. It may have been possible to use low tunnels or row cover to protect early shoot emergence outdoors, but this was not trialed in our study. It is important to note that temperature swings in Alfalfa can be more extreme than other growing regions in central Oregon, and other farms in Deschutes County did not experience outdoor crop failure.

A later, more in-depth report will include an economic evaluation of production system, to help determine whether high tunnel berry production is a viable enterprise.

Acknowledgements

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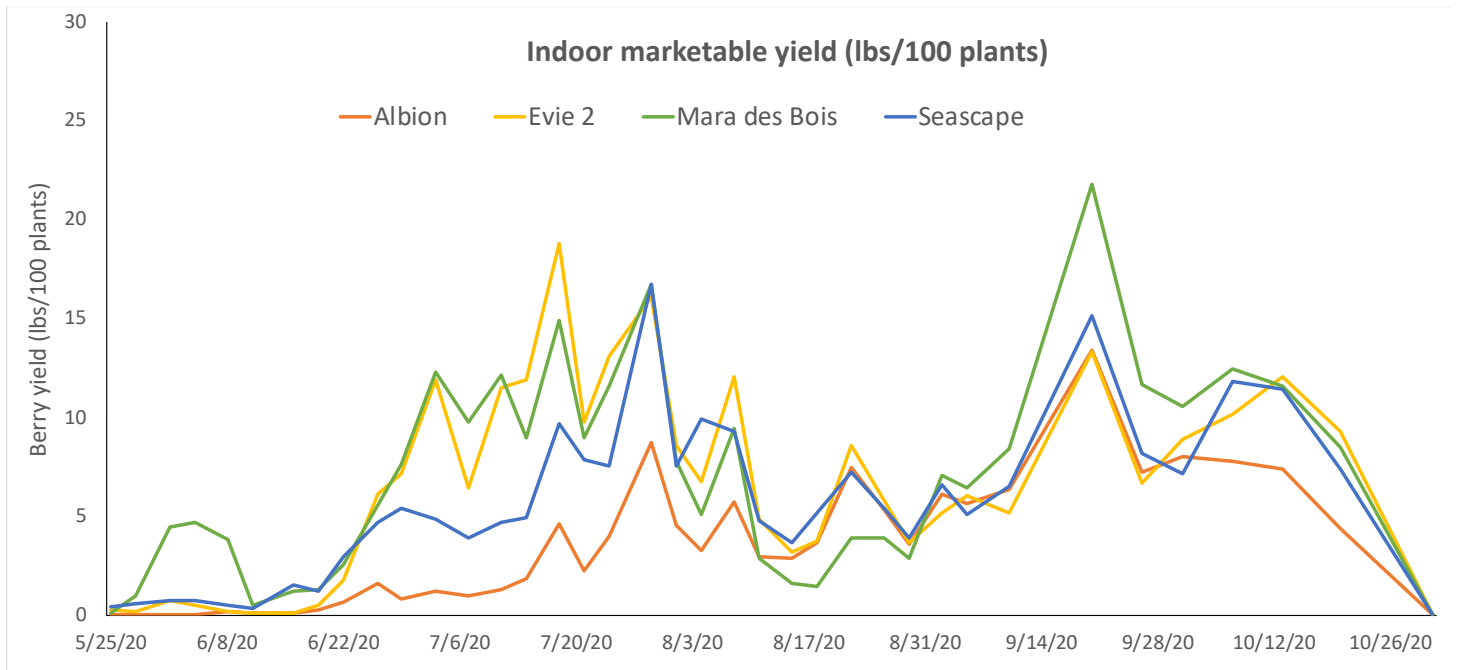


Figure 1. Indoor strawberry marketable yield (lbs/100 plants) by variety, measured over the growing season. Unit (100 plants) represents 50-row feet of strawberry plants.

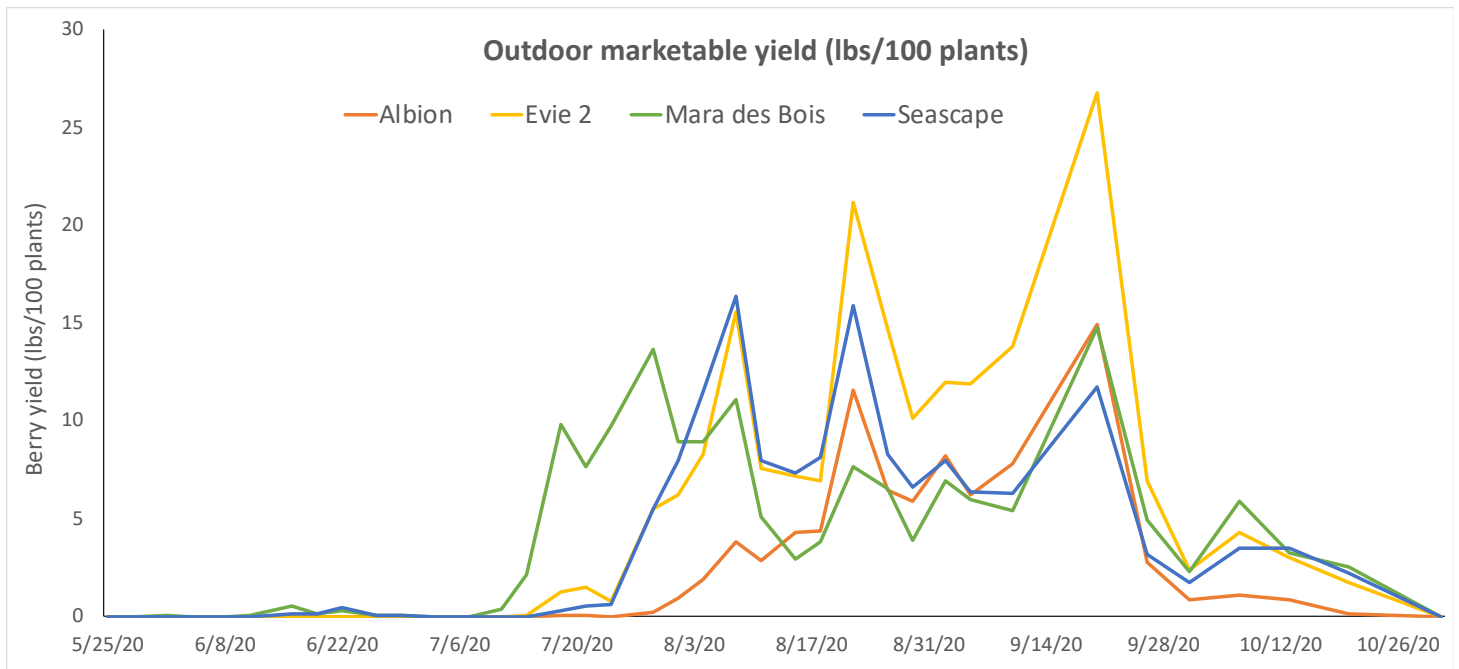


Figure 2. Outdoor strawberry marketable yield (lbs/100 plants) by variety, measured over the growing season. Unit (100 plants) represents 50-row feet of strawberry plants.

Table 1. Overwinter survival of strawberry plants. Percent survival calculated using plant totals from September 2019 and April 2020.

Variety	Plant survival from September 2019 through April 2020.	
	Outdoor	Indoor
Albion	82%	79%
Evie 2	88%	98%
Mara des Bois	100%	97%
Seascape	93%	100%

Table 2. Strawberry data comparing four varieties grown outdoor (field) vs. indoor (high tunnel) for the 2020 growing season. Picking started May 25 and ended Oct 20. Data is an average of three replicates.

Variety	Average fruit size(g/berry)		Total marketable yield (lbs/10 plants)		Total % yield increase indoor	Total % cull (by weight)	
	Outdoor	Indoor	Outdoor	Indoor		Outdoor	Indoor
Albion	13 a ¹	14 ab	8.5 b	13.4 b	57%	8	13
Evie 2	12 a	15 a	18.7 a	25.1 a	32%	10	21
Mara des Bois	7 b	8 c	15.6 ab	26.5 a	70%	15	16
Seascape	12 a	13 b	14.5 ab	21.5 a	49%	12	15

¹ Results in the same column followed by a different letter are significantly different at $P < 0.05$

Table 3. Overwinter/early spring survival of raspberry plants. Percent survival calculated using plant totals from September 2019 and May 2020.

Variety	Plant survival from September 2019 through May 2020.	
	Outdoor	Indoor
Anne	71%	100%
Caroline	68%	100%
Heritage	21%	100%
Joan J	71%	100%

Table 4. Raspberry data comparing four varieties grown outdoor (field) vs. indoor (high tunnel) for the 2020 growing season. Picking started Aug 8 (indoor) and ended Oct 21. Data is an average of four replicates.

Variety	Average fruit size(g/berry)		Total marketable yield (lbs/10 plants)		Total % yield increase indoor	Total % cull (by weight)	
	Outdoor	Indoor	Outdoor	Indoor		Outdoor	Indoor
Anne	1.3 ab ¹	2.9 a	0.2 b	20.3 b	Very high	27 ab	11 a
Caroline	0.8 ab	3.0 a	0.0 b	26.2 b	Very high	7 b	3 ab
Heritage	-	1.9 c	0.0 b	16.6 b	Very high	-	2 b
Joan J	3.0 a	2.6 b	3.5 a	44.6 a	>800%	55 a	5 ab

¹ Results in the same column followed by a different letter are significantly different at $P < 0.05$

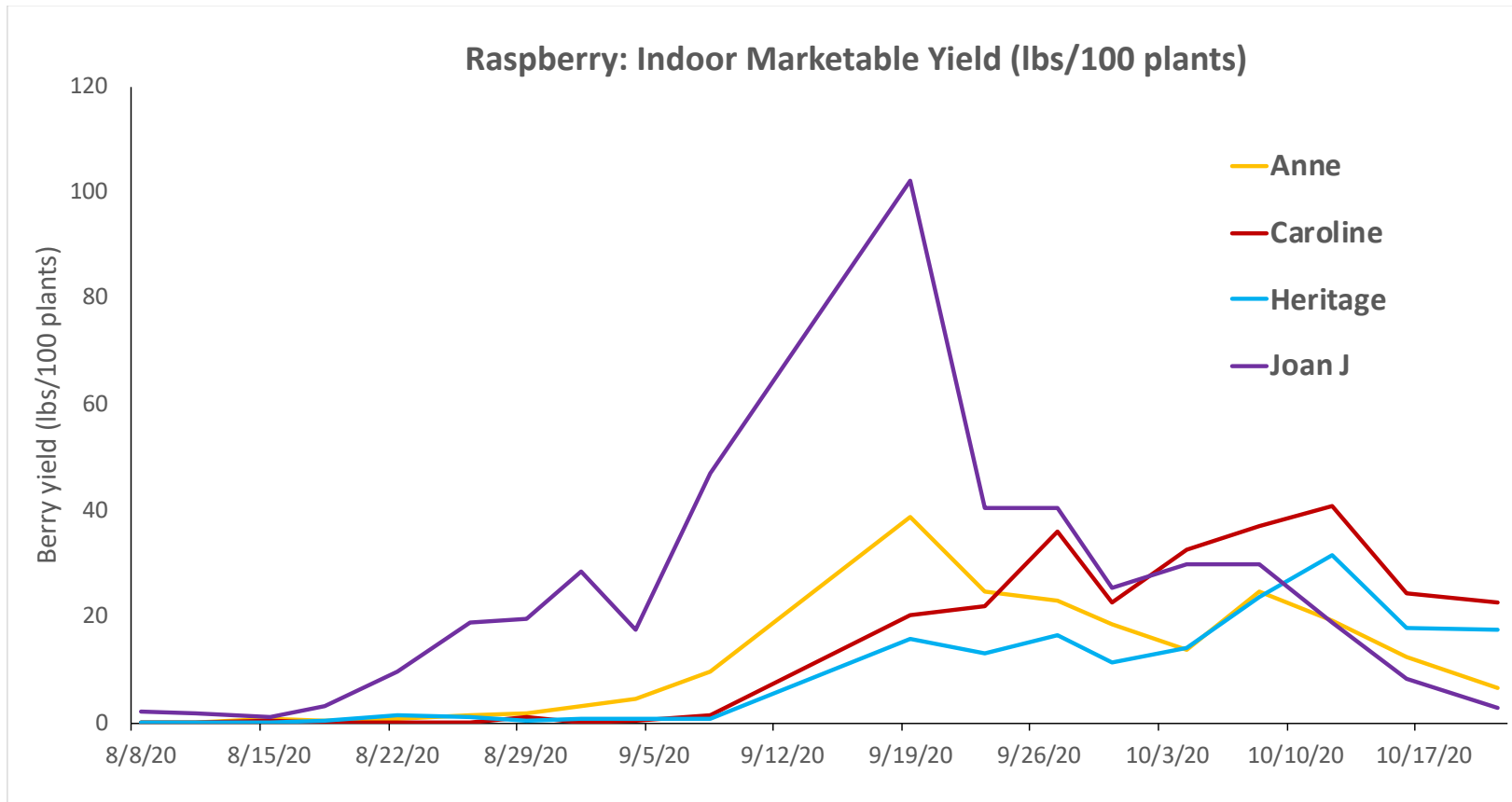


Figure 3. Indoor raspberry marketable yield (lbs/100 plants) by variety, measured over the growing season. Unit (100 plants) represents 200-row feet of raspberry plants.

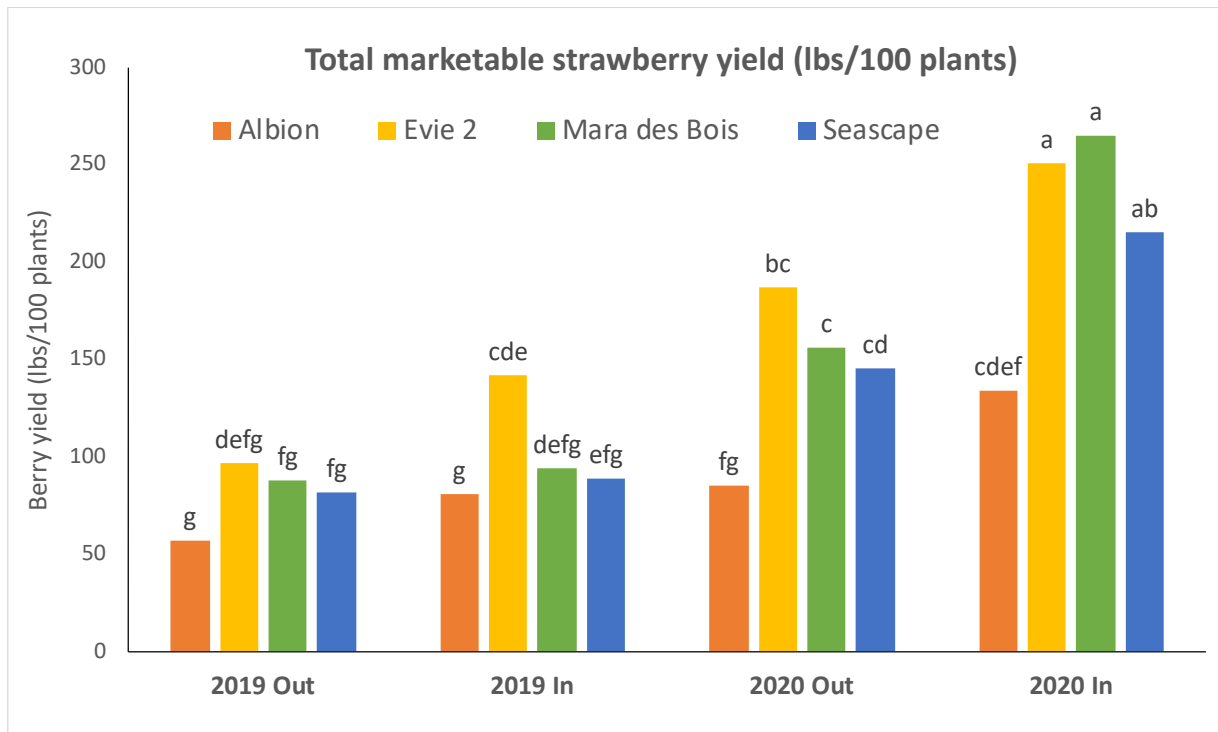


Figure 4. Total strawberry marketable yield (lbs/100 plants) for 2019 and 2020 growing seasons. Four varieties and two production systems (indoor vs. outdoor) are depicted. Bars with different letters are significantly different at $P < 0.05$. Unit (100 plants) represents 50 row feet of plants.

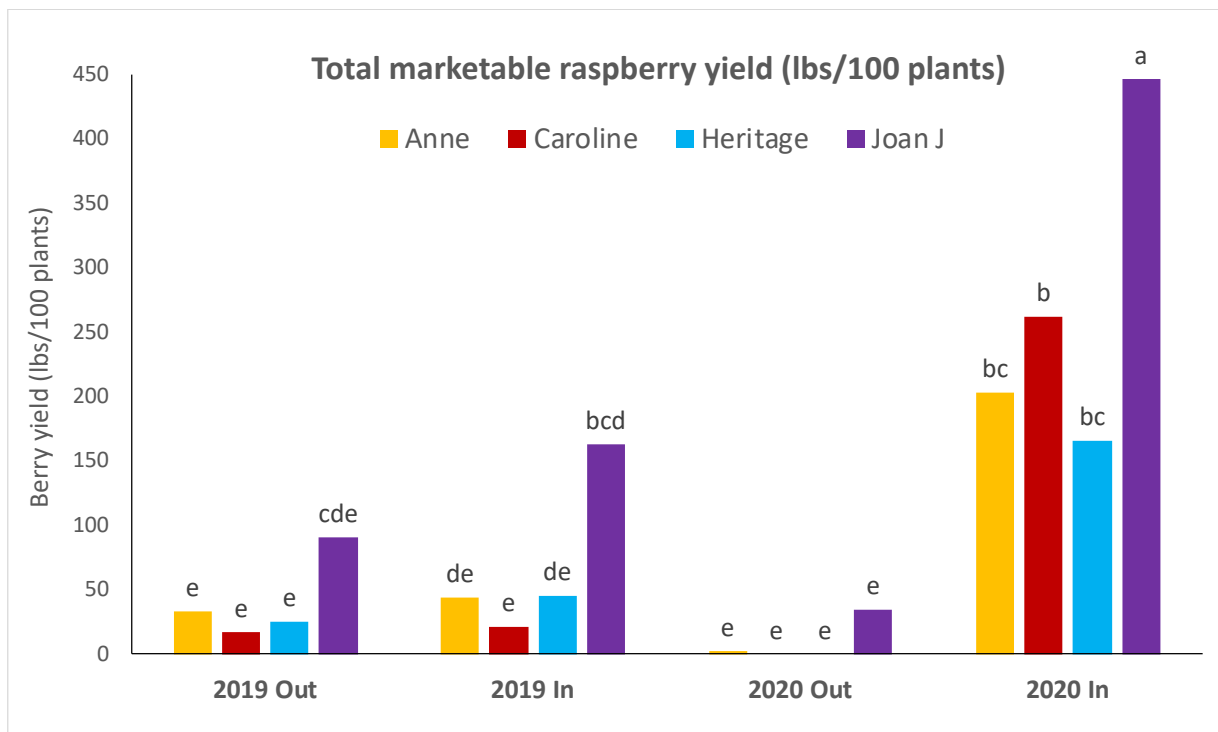


Figure 5. Total raspberry marketable yield (lbs/100 plants) for 2019 and 2020 growing seasons. Four varieties and two production systems (indoor vs. outdoor) are depicted. Bars with different letters are significantly different at $P < 0.05$. Unit (100 plants) represents 200 row feet of plants.