Investigating the feasibility of berry production in central Oregon under protected and unprotected culture

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Introduction

Central Oregon growing conditions are challenging for horticultural production for myriad reasons: short growing season (70-100 days); average annual precipitation of ~11 inches; drastic swings in diurnal temperatures; possibility of frost any time of year; and sandy soils low in organic matter (Detweiler, 2016). Despite the challenging growing conditions, there is fresh-market produce grown in Central Oregon, and there is strong demand from the community through farmer markets, CSAs, restaurant buyers, and wholesale accounts. While some vegetables grow well in the region, there is almost no fruit being produced in central Oregon, despite strong demand. Raspberries and strawberries are the most suitable berries for Central Oregon due to their cold hardiness, but yield loss due to winter injury and frosts are a major concern. Elsewhere in the US, protected culture (i.e. high tunnels) has been used to extend the berry growing season and improve yields (Rowley et al., 2009 & 2010). In central Oregon, high tunnels are currently used to grow multiple high-value vegetable crops in a season; therefore, farmers are not likely to plant a perennial crop in a high tunnel unless proven profitable. This project aims to determine whether berry production in central OR is an economically viable enterprise, and if high tunnels are a justified expense to increase profitability and fruit quality. The main objective is to compare strawberry and raspberry production in high tunnels (indoor) vs. open field (outdoor).

Materials and Methods

Two berry trials were established on a farm in Alfalfa, OR in May 2019. Each trial was arranged using a split-plot design. The main factor was production system (high tunnel vs. open field) and the replicated, subplot factor was berry variety. Strawberry subplots were replicated three times, and raspberry subplots were replicated four times.

Four strawberry varieties were planted as bare rootstock in a high tunnel (14x45ft structure, Fig 1) and the open field on May 6. All of the varieties were cold-hardy and day-neutral types: ‘Albion’, ‘Evie 2’, ‘Mara des Bois’, and ‘Seascape’. Strawberries were planted directly into landscape fabric at 1ft-spacing in double rows, with beds spaced 4ft apart. Individual plot size measured 10ft indoor, and 20ft outdoor. First inflorescences were removed until early June to allow strawberry plants establish vegetatively before entering the reproductive phase. Runners were removed all season to maintain each strawberry plant as one mother plant.

Four raspberry varieties were planted as bare rootstock in a separate high tunnel (30x45ft structure, Fig 2) and the open field on May 8. All of the raspberry varieties chosen were cold-hardy and primocane-bearing types: ‘Anne’, ‘Caroline’, ‘Heritage’, and ‘Joan J’. Raspberries were planted at 2ft-spacing within rows that were planted 8ft apart, and landscape fabric was used between the rows for weed suppression. Individual plot size measured 10ft indoor, and 15ft

outdoor. Trellis systems were installed to support the raspberries once they were tall enough.

The plots were managed using organic practices. Pre-plant soil test revealed high levels of P and K, and low levels of nitrate-N, S and Ca. Pre-plant fertility was met with broadcasted poultry manure (30lbs N/ac, 24lbs P/ac, 16lbs K/ac), feather meal (40lbs N/ac), gypsum (130lbs/ac), and compost (20ton/ac). All plots were fertilized twice over the growing season with liquid fish fertilizer (5-1-1) at a rate of 10gal/ac. Liquid fertilizer was applied to the soil at the base of the plants using a backpack sprayer. Thrip pressure was very high in mid-July and the plots were sprayed once with Mycotrol (1quart/ac), an organic insecticide (active ingredient *Beauveria bassiana*). Plots were irrigated every other day May through September using drip irrigation lines with 12" emitter spacing. Strawberry plots had two drip lines per bed, and raspberry plots had one drip line per bed.

Berries were harvested once a week when production began, and then twice a week when berries were in full production. Harvested berries were separated into 'marketable' and 'unmarketable' in order to calculate percent cull. Marketable and unmarketable berries per plot were then counted and weighed 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. 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

The first pick of fruit for both outdoor and indoor production was July 19, 2019. It was not until mid-August the strawberries started producing consistently, and indoor production increased at a faster rate than outdoor production (Fig 3). Three of the strawberry varieties peaked in production August 20, but Albion peaked in September (Fig 3). Rain and cold temperatures in mid-September resulted in dirty and mushy fruit, which is reflected by a drop in marketable yield (Fig 3). Freezing temperatures at the end of September/early October ended the season's harvest. Overall, marketable yield was significantly higher for indoor production (10lbs/10 plants) than outdoor production (8lbs/10 plants), and in some varieties total yield increase indoor was more than 40% (Table 1).

Strawberry fruit size differed by variety and also by production system (Table 1). Strawberry fruit size was on average 18% greater for indoor production (13 g/berry) than outdoor production (11 g/berry). Albion and Evie 2 had significantly larger fruit size than Seascape and Mara des Bois (Table 1). Mara des Bois is known to be a smaller berry, and in our trials it averaged ~50% weight of the other berries. Fruit size is significant for a grower because the larger the berry fruit size the fewer berries needed to fill a pint, and the lower the labor requirements.

Evie 2 stood out as the highest yielding variety (12lbs/10 plants), especially grown indoor. However, Evie 2 had a softer berry that was easily bruised while handling, and had a significantly higher cull rate than other varieties (average 23% cull vs. 12-17%). Also, many

taste test participants found the flavor of Evie 2 to be bland. Albion had firm fruit and was a favorite in many taste tests, but the first-year yield was significantly lower than other berries. Seascape was not as firm as Albion, but had a very nice flavor and a consistent yield indoor and outdoor (Table 1). While many people liked the flavor of Maras des Bois, its small size made harvest too time consuming to be profitable.

Raspberry Trial

Raspberries started fruiting mid-August, but harvest was not consistent until the end of August. As with the strawberries, raspberry production increased more quickly in the high tunnel plots than the outdoor plots (Fig 4). Raspberry production was steadily increasing in late September, but harvest was cut short by freezing temperatures. The last harvest outdoor was September 25, and was also the highest yield for all varieties (Fig 4). The indoor plots survived the freezing temperatures a little longer, and indoor production peaked September 25. The October 2 harvest indoor occurred after a heavy freeze, and nearly all of the berries were culled. Overall, marketable yield of raspberries tended to be higher for indoor production (6.8lbs/10 plants) than outdoor production (4.1lbs/10 plants). In some varieties total yield increase indoor was more than 75% (Table 2).

Raspberry fruit size increased over the growing season in the outdoor plots, from an average of 2.3 g/berry on Aug 12, to 3.7 g/berry on Sep 25. In contrast, fruit size indoor remained fairly steady over the growing season. On average, there was a 12% increase in berry size from outdoor to indoor production (Table 2). Variety had a greater effect on fruit size than production system; Heritage was significantly smaller than other berries, and Joan J was noticeably larger.

Joan J stood out as the highest yielding raspberry variety (12.7lbs/10 plants), especially grown indoor (Table 2). Over the growing season, Joan J out-yielded the other varieties outdoor by 250%, and indoor by 350%. Caroline had the smallest yield, which was surprising because it is marketed as one of the "most productive primocane-bearing raspberries" and is supposed to fruit earlier than Heritage. In our trials, Caroline remained vegetative most of the growing season and yield did not start increasing until mid-September. Heritage is an heirloom variety and yielded lower than the other modern varieties due to its small fruit size. Anne had large, yellow berries and produced fairly well, but the fruit was more delicate and prone to being culled. There was not a clear winner in terms of taste for the berry varieties, but most taste testers liked the flavor of the outdoor raspberries more than the indoor berries.

Conclusion

First year results revealed berry yield and quality differences between varieties and production systems. 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 berries. Joan J was the highest yielding raspberry and berry quality was quite good. Strawberry and raspberry yields tended to improve in high tunnels as compared to the field, but data from a second year will help determine whether the high tunnel investment is worthwhile. There did appear to be an interaction between production system (high tunnel vs. open field) and variety for both crops, which will be followed closely in the second year. It is expected that production system will have more of an effect on berry yield and season length for second year plants, relative to the first-year results.

Acknowledgements

This project was funded by a Western Sustainable Agriculture Research and Education (SARE) Professional + Producer Grant. The author thanks Windflower Farm for hosting the main trial site, the seven other farms involved in this study, and Kara Young for project management.

References

Detweiler, A.J. 2016. Central Oregon climate and how it relates to gardening. Deschutes County Extension.

Rowley, D., B. Black, D. Drost. 2010. High Tunnel Strawberry Production. https://extension.usu.edu/files/publications/publication/Horticulture_HighTunnels_2010-01pr.pdf

Rowley, D., B. Black, D. Drost. 2009. Fall-bearing raspberries in high tunnels. https://extension.usu.edu/files/publications/publication/Horticulture_HighTunnels_2009-01pr.pdf

Figure 1. Inside the strawberry high tunnel, structure is 14 x 45ft.

Figure 2. Raspberry high tunnel on the left (30 x 45ft gothic-style), strawberry high tunnel on the right. Outdoor raspberries top left, outdoor strawberries foreground of photo.

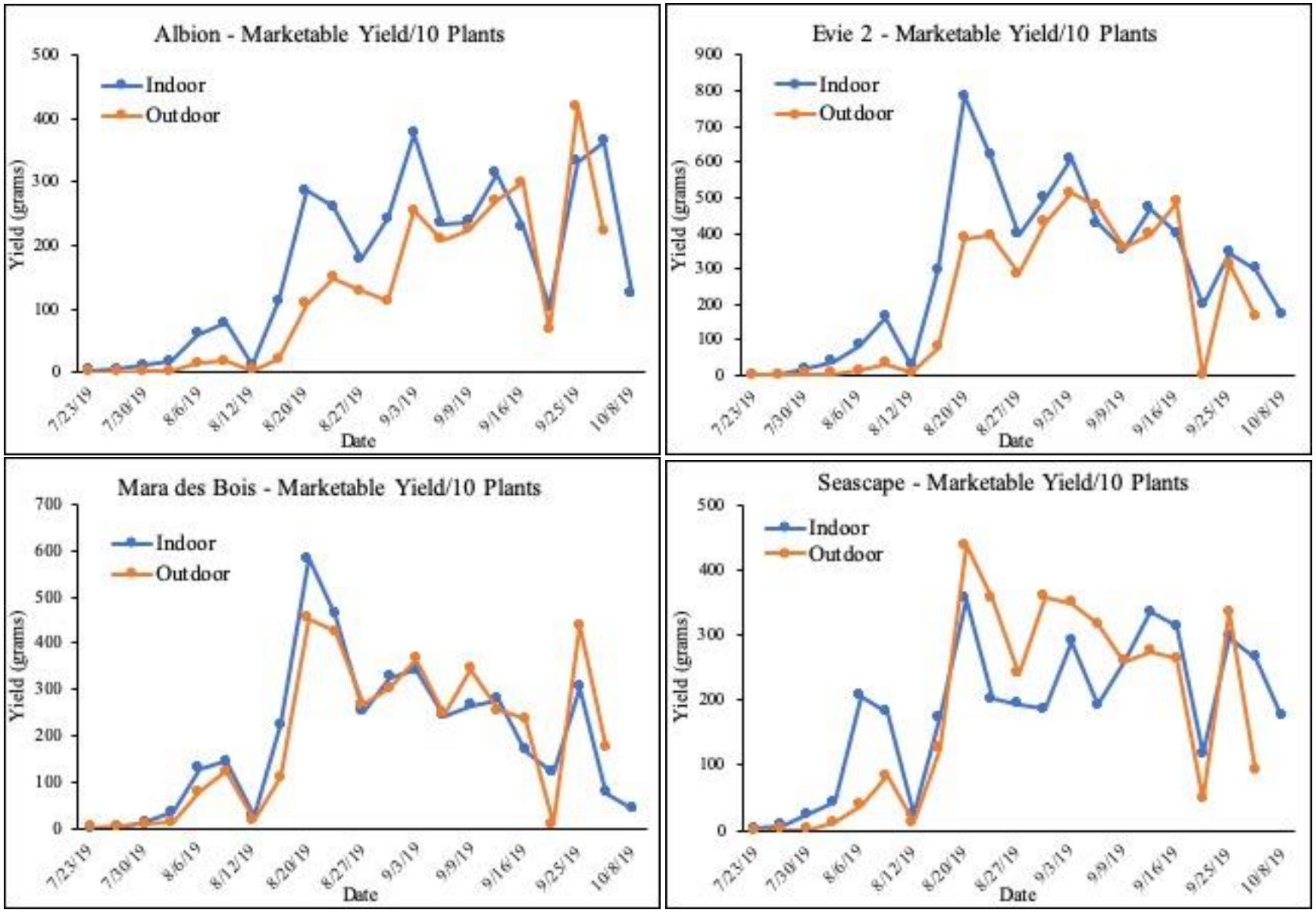

Figure 3. Strawberry marketable yield (g/10 plants) over growing season. Indoor vs. outdoor production by variety.

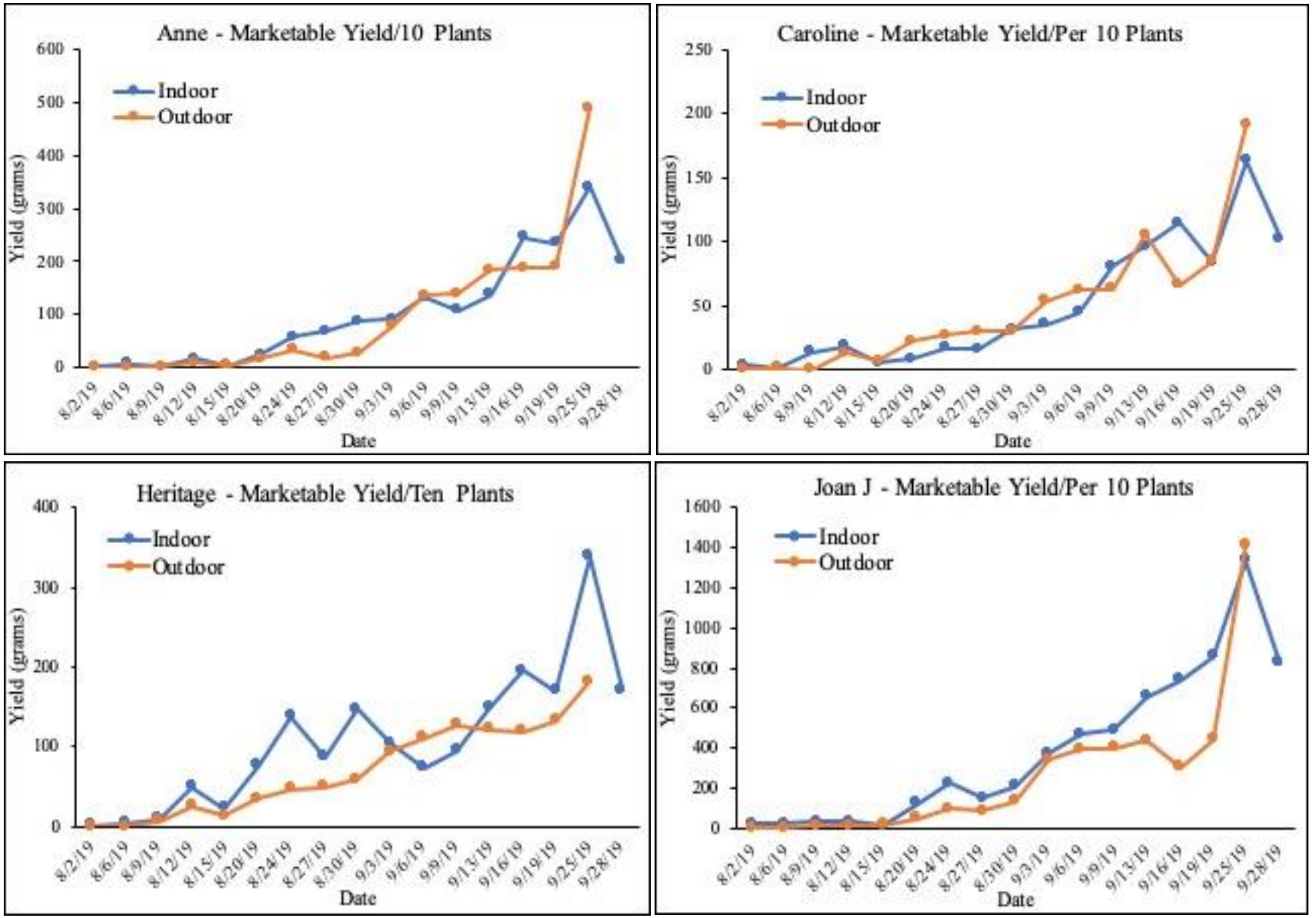

Figure 4. Raspberry marketable yield (g/10 plants) over growing season. Indoor vs. outdoor production by variety.

Table 1. Strawberry data comparing four varieties grown outdoor (field) vs. indoor (high tunnel). Data is an average of three replicates.

Variety	Average fruit size(g/berry)		Total marketable yield (lbs/10 plants)		Total % yield increase indoor	Highest single yield (lbs/10 plants)		Total % cull (by weight)[1]	
	Outdoor	Indoor	Outdoor	Indoor		Outdoor	Indoor	Outdoor	Indoor
Albion	14 a[2]	16 a	5.6 b	8.1 b	44%	0.9	0.8	8	5
Evie 2	13 a	15 a	9.7 a	14.2 a	46%	1.1	1.7	10	7
Mara des Bois	6 c	8 c	8.8 a	9.4 b	7%	1.0	1.3	10	8
Seascape	12 b	13 b	8.2 a	8.9 b	9%	1.0	0.8	10	5

[1] % cull until Sep 16 harvest, % cull rose dramatically after Sep 16 due to rain and freeze

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

Table 2. Raspberry data comparing four varieties grown outdoor (field) vs. indoor (high tunnel). Data is an average of four replicates.

Variety	Average fruit size(g/berry)		Total marketable yield (lbs/10 plants)		Total % yield increase indoor	Highest single yield (lbs/10 plants)		Total % cull (by weight)	
	Outdoor	Indoor	Outdoor	Indoor		Outdoor	Indoor	Outdoor	Indoor
Anne	4.1 ab[1]	4.3 a	3.3 b	4.4 b	33%	1.1	0.9	20	13
Caroline	3.0 ab	3.9 a	1.7 b	2.1 b	24%	0.4	0.5	13	7
Heritage	2.3 b	2.4 b	2.5 b	4.5 b	80%	0.4	0.8	10	8
Joan J	4.8 a	4.7 a	9.1 a	16.3 a	79%	3.1	3.6	23	10

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