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High Tunnel Performance of Seven Floricane Red Raspberry Cultivars in Western NY

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Abstract

Seven floricane fruiting red raspberry (*Rubus idaeus* L.) cultivars ('Canby', 'Encore', K81-6, 'Killarney', 'Moutere', 'Prelude', and 'Titan') were grown under high tunnels to assess their relative performance in a protected agriculture system in western New York. Yield among the cultivars was not significantly different in the first two harvest seasons nor cumulatively over the three harvests. 'Moutere' tended to have the highest yield over three seasons averaging over 9 $t \cdot ha^{-1}$ per year. 'Killarney', K81-6, and 'Encore' produced very similar yields to 'Moutere'. Generally, 'Prelude' and 'Canby' produced intermediate yields and 'Titan' was lower yielding with mean annual yields of 5.7 $t \cdot ha^{-1}$ per year. K81-6 had the greatest mean annual fruit weight (3.55 g per fruit over 3 seasons) with 'Titan' matching it in season 1 and 2 and 'Encore' in seasons 2 and 3. The other four cultivars tended to be smaller with 'Killarney', and 'Prelude' having the lowest mean fruit weight. In each of the 3 seasons, 'Prelude' was the first cultivar to begin harvest and K81-6 the last. The season started as early as June 13 and as late as June 20 and averaged 43 days in length across the 7 cultivars over the 3 seasons, ending at the end of July to early Aug. With the largest fruit weights, K81-6 and 'Encore' both showed promise in the later summer season and 'Prelude' had the best quality among the early cultivars so that growing a combination of these cultivars which would allow for the longest harvest period in New York and regions of similar climate. Poor fruit quality in 'Moutere', 'Killarney' and 'Titan' made them less desirable cultivars, and susceptibility to powdery mildew in 'Canby' limited its utility under high tunnels where conditions are ideal for the disease.

Floricane red raspberry (*Rubus idaeus* L.) production has fallen out of favor due to the development of high quality primocane cultivars that allow reduced labor for pruning as well as production in warm climate conditions without winter chilling. However, since the spread of the invasive spotted wing drosophila fruit fly (*Drosophila suzukii*) into the northeastern United States which was first detected NY in 2011 (Carroll et al. 2012), interest in floricane raspberry production has increased in the region as a method to avoid or reduce the potential infestation period. Detection of this pest in northern states occurs in late June to early Aug. in most years and peaks in late Aug. to early Oct. (Cornell Fruit Resources www.fruit.cornell.edu/spottedwing/) which coincides with peak primocane raspberry production. A return to floricane raspberry production to the historical levels of early 1900's in NY when over 4,200 ha was under cultivation (Hedrick, 1925) is unlikely, but floricane production provides growers the ability to reduce the dependence on insecticides and also to extend the raspberry season in NY by 6 weeks when combined with primocane raspberry production.

The increased availability of fresh raspberries in supermarkets has driven interest in local sources of fresh raspberries for farm-direct retail outlets and farmers' markets as well as regional wholesale outlets in the Northeast. Increased demand for locally grown fruit for use in local processing for the tourist trade has also provided more opportunities for growers in the temperate regions in the Midwest and Northeastern U.S. to market fruit directly. Floricane raspberries fit into the peak summer fruit marketing window when demand for local product is high.

The introduction of high tunnels for raspberry production has been instrumental in

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the expansion of the fresh market raspberry industry in the U.S. and around the world (Gaskell, 2004). Fruit quality improvements due to post-harvest handling advances combined with new primocane fruiting cultivars enabled the widespread shipment of fresh raspberries from production areas in the west to the entirety of the U.S. This technology has also made widespread production in temperate regions more feasible, and possibly competitive to California production of fresh raspberries, when all cost and productivity factors are considered. Multiple reports on performance of open field (Goulart and Demchak, 1999; Hanson et al., 2005; Weber et al. 2005) and high tunnel (Demchak, 2009; Hanson et al., 2011; Weber, 2018; Yao and Rosen, 2011) trials with primocane cultivars in temperate climate conditions have been published. However, while the floricane cultivars available to growers in the region are well characterized in open field trials (Weber et al., 2004a, 2004b, 2005), few trials using floricane cultivars have been conducted in high tunnels and little information is available to growers on their performance in high tunnels.

The goal of this project was to compare the performance of seven commonly grown floricane fruiting raspberry cultivars in the region in a high tunnel production system to aid in evaluating their suitability for the system and to demonstrate the potential for fresh floricane red raspberry production in New York. Yield components and fruit quality observations were made to evaluate the potential of the cultivars for NY production and their utility for use in the Cornell berry breeding program for the development of improved cultivars for protected production in temperate climate regions.

Materials and Methods

A trial of seven floricane fruiting red raspberry cultivars was established in a randomized complete block design at Cornell AgriTech at the New York State Agricultural Experiment Station (NYSAES) in Geneva, NY (lat. 42°8’N, long. 77°0’W). The cultivars included ‘Canby’, ‘Encore’, K81-6, ‘Killarney’, ‘Moutere’, ‘Prelude’, and ‘Titan’ which represent standard floricane cultivars in the region from multiple breeding programs around the world (Weber, 2013). Bare root canes of each cultivar were sourced from commercial nurseries and planted in 30.5 cm high raised beds in a Honeoye loam soil with less than 3% slope in a 3-bay (7.32 m width per bay) high tunnel structure (Haygrove Ltd., Ledbury, UK). Each bay was treated as a block in a randomized complete block design with one 6-plant plot (5.49 m per plot) of each cultivar randomly located in each block (bay). Initial in-row spacing was 0.9 m within row and 2.44 m between row centers with 3 rows in each bay.

A three-level V-trellis with a width of 46 cm at the base and 60 cm at 1.5 m height was installed after planting and drip irrigation was provided to deliver approximately 25 mm of water per week after the tunnels were covered prior to bloom and approximately 51 mm of water per week during the fruit development period through harvest after which the tunnel covers were removed for the winter. Fertilization was based on recommendations for high tunnel (Heidenreich et al., 2012) and field production practices (Bushway et al., 2008) and was applied through the drip irrigation. Weed barrier fabric (GreenhouseMegastore, International Greenhouse Co., Danville, IL) was applied between the rows and supplemental hand weeding was utilized within the rows. Predator mites (*Phytoseiulus persimilis*) (Biobest USA, Inc., McFarland, CA) were released prophylactically 3 times each summer to suppress two-spotted spider mite (*Tetranychus urticae* Koch) populations. To ensure good pollination, a quad-hive of bumble bees (*Bombus impatiens* Cresson) (Biobest USA, Inc., McFarland, CA) was placed at the end of the tunnel at the beginning of bloom each year.

In floricane raspberry types, few canes develop in the planting year making an additional year for plot maturation necessary.

The plants were grown for approximately 25 months before the first harvest was recorded in the second summer after planting. Fruit was harvested for the same 2 m of row within each block for three seasons for annual and cumulative yield calculations. Yield was converted to $t \cdot ha^{-1}$ based 4099 m of row$\cdot ha^{-1}$ at the spacing stated above. Fruit were harvested on Mondays, Wednesdays and Fridays, for each plot throughout the harvest period. For mean fruit weight calculations, a random 10-fruit sample was taken at each harvest date per block per cultivar being harvested. Mean fruit weight values over the whole season were calculated for each year, and total mean fruit weight values across all three years were calculated. All mean yield and fruit weight values for each cultivar were subjected to one-way analysis of variance (ANOVA) and mean separation by Duncan's multiple range test ($P \leq 0.05$) when appropriate using Microsoft Excel software (Microsoft Corp., Redmond, WA) following the procedures of Gomez and Gomez (1984). Harvest began when any plot had ripe fruit and ended when the last plot had fruit. The date of first harvest, peak harvest, and last harvest were recorded each year for each cultivar with peak harvest being the date with the greatest 3-plot cumulative daily yield. Air temperature and rainfall measurements were recorded at the NYSAES North Farm weather station approximately 1.5 km from the trial site to identify any gross differences in annual weather conditions between years that may have affected the trial results.

Results and Discussion

Yield in this trial was very similar to open field trials previously conducted at the NYSAES (Weber et al., 2004a; 2004b; 2005) when adjusted to yield per meter of row to account for different row spacing. Yield of individual cultivars within the trial was not significantly different in the first two harvest seasons nor cumulatively over the three year period (Table 1). Yield differed significantly only in the third season, most likely due to reduced vigor for the more root disease susceptible cultivars 'Titan' and 'Canby' compared to the very resistant 'Prelude'. The reduction in yield in the later cultivars in the third season, especially 'Titan', also shifted the overall peak harvest period for the planting

Table 1. Mean yields of seven floricane red raspberry cultivars in a high tunnel field trial at Geneva, NY over three harvest seasons. Field spacing was equivalent to 4099 m of row per ha at 3.44 m center to center row spacing.

Cultivar	Mean yield[z, y] ($t \cdot ha^{-1}$)[x]			Mean cumulative yield[y] ($t \cdot ha^{-1}$)[x]
	Year 1	Year 2	Year 3	
Moutere	10.2	10.1	5.6 ab	27.2
Killarney	9.9	9.6	5.9 ab	26.7
K81-6	8.7	13.0	4.1 bc	26.7
Encore	8.4	10.4	5.5 ab	25.4
Canby	7.6	10.4	3.8 bc	22.7
Prelude	7.6	6.5	8.6 a	23.6
Titan	6.8	7.9	1.7 c	17.2
Mean[w]	8.47	9.69	5.02	

[z] There were 3 replications per cultivar per year.
[y] Means within columns followed by common letters do not differ significantly different as determined by Duncan's multiple range test at $P \leq 0.05$. Means in Years 1 and 2, and cumulatively over 3 years were not significantly different among the cultivars.
[x] Multiply $t \cdot ha^{-1}$ by 890 for equivalent $lb \cdot ac^{-1}$.
[w] Yearly mean across all cultivars.

considerably earlier (Table 3). This difference between cultivar productivity and peak planting harvest would likely be more pronounced in future seasons as the less vigorous cultivars continued to decline. This contrasts to the significant improvement in yield observed by Hanson et al. (2011) in a Michigan trial which compared tunnel production with open field production concurrently but with fewer cultivars. The yield advantage in the Michigan trial was significant even when accounting for row spacing differences. While these studies cannot be compared directly because they were completed in different years and locations, it indicates that environmental conditions during the summer season may play an important role in productivity. Photosynthetic activity in red raspberries declines at temperatures above 25°C (Fernandez and Pritts, 1994; Percival et al., 1996) which is more likely to occur during the floricane fruit development and ripening periods from late June through July than in the late Aug. to Oct. period when most primocane cultivars ripen in western NY. Root damage from *Phytophthora rubi* or other pathogens on overwintered floricanes would exacerbate this reduction in productivity.

However, overall fruit weights were higher in this trial compared to the same cultivars grown in the open field trials (Weber et al., 2004a; 2004b; 2005). This was especially true for the cultivars with larger fruit like K81-6, 'Titan' and 'Encore' but less so for the smaller cultivars like 'Killarney' and 'Prelude'. This dichotomy was similar to that observed in the Michigan trial with concurrent tunnel and open field production (Hanson et al., 2011), though fewer floricane cultivars were tested. This trend of larger/heavier fruit was consistent over subsequent seasons but the overall mean weight declined with each successive season (Table 2) although the maximum weights were more consistent in the first two seasons before dropping off in the third season. The mean fruit weight of the individual cultivars also decreased with each successive season but the relative size among them was consistent. K81-6, 'Titan' and 'Encore' were consistently the largest fruiting cultivars with 'Canby' and 'Moutere' being intermediate in size and 'Killarney' and

Table 2. Mean fruit weight for seven floricane red raspberry cultivars over three harvest seasons at Geneva, NY.

Cultivar	Mean fruit weight[z,y] (g)			Three-year mean fruit weight[y,x] (g)	Maximum 10-fruit Mean weight (g)			Minimum 10-fruit Mean weight (g)		
					Season			Season		
	Year 1	Year 2	Year 3		1	2	3	1	2	3
K81-6	4.11 a	3.96 a	2.58 a	3.55 a	5.5	5.8	4.0	2.7	2.1	1.7
Titan	3.88 ab	3.39 ab	2.20 b	3.16 a	4.9	5.7	3.6	3.1	1.4	1.4
Encore	3.66 b	3.33 ab	2.68 a	3.22 a	4.8	5.3	3.6	2.7	1.7	2.0
Canby	2.92 c	2.40 cd	2.00 bc	2.46 b	3.8	2.9	2.9	2.3	1.5	1.2
Moutere	2.86 c	2.78 bc	2.21 b	2.62 b	5.1	4.2	3.5	1.9	1.9	1.6
Killarney	2.64 cd	2.55 cd	1.98 c	2.39 b	3.4	4.1	2.6	1.9	1.8	1.2
Prelude	2.40 d	1.91 d	2.03 bc	2.11 b	3.1	2.5	2.6	1.9	1.6	1.3
Mean[w]	3.21	2.91	2.24							

[z] There were 3 replications per cultivar per harvest seasons.
[y] Means within columns followed by common letters are not significantly different as determined by Duncan's multiple range test at $P \leq 0.05$.
[x] Mean across all three harvest season.
[w] Seasonal mean across all cultivars.

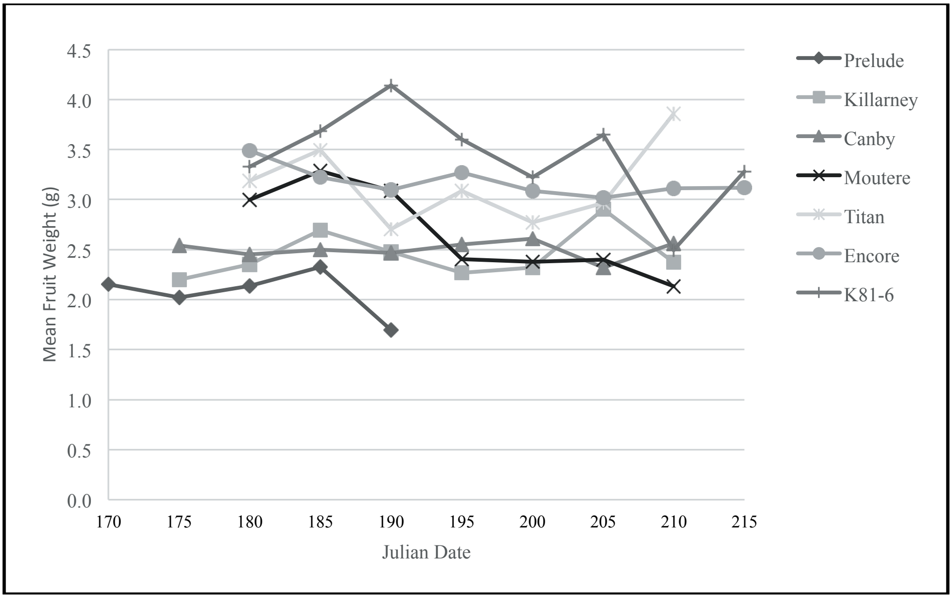

Figure 1. Mean fruit weight over three seasons for 7 floricane raspberry cultivars through the harvest season. (Julian date 170 corresponds to June19 and 215 to August 3).

'Prelude' being generally small in size (Table 2). Fruit weights also tended to decline as the seasons progressed (Figure 1) with the heaviest fruit harvested in the beginning of the season. However, in the latest cultivars, the fruit at the end of the season increased in size when few fruit were present (Figure 1). 'Encore' was the most uniform in weight over the harvest periods with 'Canby' and 'Killarney' also being relatively uniform albeit smaller (Fig. 1).

The fruit in this trial often started relatively small and increased in mean weight until peak harvest at which point there was a drop-off in fruit weight. This was followed by another increase in size, often with maximum fruit size recorded after the peak harvest date when the crop load was low followed by a steep drop-off at the very end of the season. This pattern differed in the primocane raspberry where the largest fruit was observed at the beginning of the season with a decline in mean size as the season progressed (Yao and Rosen, 2011), sometimes with a spike after peak harvest which would then diminish as the season concluded (Weber, 2018). The fruit weights among plots was much more variable in floricane cultivars than that observed in primocane fruiting cultivars. It may be more highly influenced by the relatively higher July temperatures and varying water status of the plants as irrigation was needed more frequently to maintain adequate soil moisture.

Variation in mean fruit size during the season was greatest for 'Moutere' with mean reduction from maximum to minimum mean fruit weights of 44% over the 3 year period. 'Prelude' produced the most consistent fruit weights over the three seasons, averaging only a 21% decrease from the maximum to minimum mean weight. The other cultivars varied between 34% and 40% reduction in fruit weight between the maximum and minimum (data not shown). This wide difference in fruit weight uniformity among the cultivars suggests a strong genetic effect on this character. Therefore, improving this uniformity is likely to be possible through breeding but may be more difficult as the maximum fruit weight increases. Additionally, the largest fruiting cultivars were larger than the largest primocane cultivars from previous trials (Weber, 2018, Hanson et al., 2011) suggesting that large fruiting floricane cultivars can be a source for large fruit size for breeding larger primocane cultivars. This has been demonstrated in the development of the cultivars 'Watson' (US Plant Patent 7,067P) (Sanford et al., 1988) and 'Crimson Giant' (US Plant Patent 23,375P3) in the Cornell program, both utilizing 'Titan' as the large fruit contributing parent.

The length of the floricane harvest season is relatively short, lasting only six weeks (Table 3). 'Prelude' was the earliest fruiting cultivar in each season, starting harvest seven days earlier than the next earliest, 'Killarney' (Table 3). K81-6 and 'Encore' were the latest fruiting each year with 'Titan' and 'Moutere' producing in a very similar time frame. Each individual cultivar's harvest season lasted as little as 17 days for 'Prelude' in season one to as long as 36 days for 'Killarney' in season three (Table 3). By comparison, harvest periods of 40 to 60 days have been observed for primocane cultivars with a season across cultivars lasting 10 weeks or longer (Weber,

Table 3: Harvest dates for 7 floricane raspberry cultivars grown under high tunnels over three harvest seasons in Geneva, NY.

Cultivar	Harvest Season	1st Harvest Date	Last Harves Date	Peak Harvest Date	Season Length (days)
Prelude	1	Jun 14	Jun 30	Jun 21	17
	2	Jun 22	Jul 11	Jun 27	20
	3	Jun 13	Jul 9	Jun 18	27
Killarney	1	Jun 21	Jul 19	Jun 28	29
	2	Jun 29	Jul 28	Jul 11	31
	3	Jun 20	Jul 25	Jul 2	36
Canby	1	Jun 21	Jul 19	Jun 28	29
	2	Jul 1	Jul 28	Jul 11	28
	3	Jun 25	Jul 25	Jun 27	31
Moutere	1	Jun 22	Jul 26	Jul 8	35
	2	Jul 7	Jul 26	Jul 13	20
	3	Jun 25	Jul 23	Jul 2	29
Titan	1	Jun 24	Jul 26	Jul 2	33
	2	Jul 5	Jul 29	Jul 7	25
	3	Jun 22	Jul 25	Jul 5	34
Encore	1	Jun 24	Jul 26	Jul 12	33
	2	Jul 5	Aug 2	Jul 12	29
	3	Jun 25	Jul 23	Jul 9	29
K81-6	1	Jun 25	Jul 26	Jul 12	32
	2	Jul 7	Aug 2	Jul 13	27
	3	Jun 25	Jul 25	Jul 9	31
Whole Planting	1	Jun 14	Jul 26	Jul 12	43
	2	Jun 22	Aug 2	Jul 12	42
	3	Jun 13	Jul 25	Jul 1	43

2018). The flowering period of floricane cultivars is much more concentrated than primocane cultivars since the whole plant is emerging from dormancy simultaneously so that the fruiting laterals form much more uniformly than in primocane cultivars where new laterals are produced progressively down the cane for many weeks. This flowering pattern makes for a much more concentrated harvest in floricane cultivars.

The late cultivars in this trial stretched the season to late July or early Aug. in each year (Table 3). There is at least one cultivar, 'Octavia' (Solomon, 2013), not included in this trial that continues to fruit beyond the window of K81-6 and 'Encore' but it seems that breeders are nearing the limits of what can be accomplished through genetics to lengthen the floricane season. However, by combining optimal production practices with late floricane and early primocane fruiting cultivars, continuous production of red raspberries for up to 6 months in cool climate locations such as western NY is possible. The development of improved cultivars is needed to take advantage of this long window, especially large fruited cultivars for the early season and firmer cultivars overall.

While the overall yield performance of the floricane cultivars under high tunnels was similar to what has been recorded in outdoor trials in NY (Weber et al., 2004a; 2004b; 2005), the trial in Michigan showed considerable yield advantage (Hanson et al., 2011). Additionally, fruit quality aspects of the fruit in this trial, especially size, were considerable so that the advantages of high tunnel production when optimized likely justify the increase input costs. Pest control requirements in this trial were significantly reduced compared to outdoor trials with no fungicides applied and only minimal hand weeding. Even without fungicide treatments, no appreciable fruit rots were observed. In most years, spotted winged drosophila (SWD) (*Drosophila suzukii*) does not become a pest problem in the region until late July to early Aug. so that most of the floricane production avoids infestation. Monitoring for SWD was only done in the general area during this trial so specific cultivar infestation is unknown. Cultivar preference studies have had mixed results as far as infestation rates in specific cultivars (Burrack et al., 2012; Lee et al., 2011) but high rates of infestation have generally been observed in raspberries. In order to reduce the impact of this pest, a diligent monitoring program should be followed, especially late in the season, to identity any fly infestation and to implement an appropriate insecticide program if needed, rotating recommended chemical classes (Pritts et al., 2015) if needed. Alternatively, complete exclusion with netting (http://blogs.cornell.edu/swd1/2016/04/19/exclusion-netting-against-swd/) could be used to control the insect, but this may not be cost effective unless earlier infestation dates are observed in the future.

While a direct comparison to open field production was not done in this trial, many of the cultivars had improved fruit size compared to previous open field trials (Weber et al., 2004a, 2004b, 2005). However, some displayed characteristics that may limit their suitability for production under tunnels or for marketing. The canes of 'Killarney' grew in a very curvy, uncontrolled manner and were less upright than observed in outdoor trials, making them difficult to prune and train. The fruit of 'Killarney' was also darker red, especially after storage, than is generally desirable for fresh raspberries but may be acceptable for local markets. This cultivar is typically darker red, but the color intensity may have been affected by the higher temperatures experienced in the high tunnels. 'Moutere' had very attractive fruit with good firmness and uniformity, but the flavor was very poor and generally unacceptable for fresh consumption. This could possibly be attributed to the conditions under the high tunnels but is more likely a regular characteristic of this cultivar (H. Hall, pers. comm.). 'Titan' displayed the same susceptibility to Phytophthora root rot observed in open field conditions (Maloney et al., 1993). The noticeable drop off in vigor and productivity observed in the third season may even have been exacerbated by the higher temperatures experienced in the high tunnels. The fruit of 'Prelude' was consistently smallest in the trial which is generally undesirable, however, it still has a place in the marketplace since it is a week earlier than other cultivars so has little competition from other local raspberries in this market window. Care should also be taken, especially with the latest cultivars, to pick during the coolest period of the day and to refrigerate quickly after harvest because they tended to soften in the high temperatures experienced in mid-afternoons in July.

On the whole, even with some shortcomings in the cultivars, very high quality fruit was produced that was superior to much of what is offered in local markets from outdoor production, and it proved to be acceptable to local wholesale buyers. The adoption of high tunnels for raspberry production in cool climate regions should be encouraged as a quick way to improve the quality of local fruit. However, production practices to hasten the establishment of floricane plantings are also needed to reduce the payback period for growers. It may be possible to use tissue culture plugs planted at a high density to produce enough fruiting canes for harvest in the first summer after planting. An economic evaluation of the added cost of plants versus the potential yield in such a system would be needed. Additionally, the development of improved cultivars specifically for high tunnel production in cool climate regions will amplify the benefits over time, allowing the industry to grow and take advantage of the expanding local markets where growers can receive high retail prices for greater profitability.

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Literature Cited

Burrack, H.J., G.E. Fernandez, T. Spivey and D.A. Kraus. 2013. Variation in selection and utilization of host crops in the field and laboratory by Drosophila suzukii Matsumara (Diptera: Drosophilidae), an invasive frugivore. Pest Manag. Sci. 69:1173-1180.

Bushway, L., M. Pritts, and D. Handley. 2008. Raspberry and blackberry production guide for the Northeast, Midwest, and eastern Canada. NRAES-35. Natural Resource, Agriculture, and Engineering Service, Ithaca, NY.

Carroll, J. F. Zaman and G. Loeb. 2012. This "Ninja" fruit fly cuts into perfect fruits- spotted wing Drosophila. 2012. NY Fruit Quart. 20(2):17-20.

Demchak, K. 2009. Small fruit production in high tunnels. HortTechnology 19(1):44-49.

Fernandez, G.E. and M.P. Pritts. 1994. Growth, carbon acquisition, and source-sink relationships in 'Titan' red raspberry. J. Amer. Soc. Hort. Sci. 119(6):1163-1168.

Gaskell, M. 2004. Field tunnels permit extended season harvest of small fruits in California. Acta Hort. 659:425-430.

Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures for agricultural research. 2nd ed. Wiley, New York.

Goulart, B. and K. Demchak. 1999. Performance of primocane fruiting red raspberries. Fruit Var. J. 53:32-40.

Hanson, E., S. Berkheimer, A. Schilder, R. Isaacs and S. Kravchenko. 2005. Raspberry variety performance in southern Michigan. HortTechnology 15(3):716-721.

Hanson, E., M. Von Weihe, A.C. Schilder, A.M. Chanon and J.C. Scheerens. 2011. High tunnel and open field production of floricane- and primocane-fruiting raspberry cultivars. HortTechnology 21(4):412-418.

Hedrick, U.P. 1925. The small fruits of New York. NY State Agr. Expt. Sta. J.B. Lyon, Albany, NY.

Heidenreich, C., M. Pritts, K. Demchak, E. Hanson, C. Weber and M.J. Kelly. 2012. High tunnel raspberries and blackberries. Dept. Hort., Cornell Univ., Ithaca, NY Pub. #47. https://blogs.cornell.edu/newfruit/files/2017/01/hightunnelsrasp2012-vfy3di.pdf

Lee, J.C., D.J. Bruck, H. Curry, D. Edwards, D.R. Haviland, R.A. Van Steenwyk and B.M. Yorgey. 2011. The susceptibility of small fruits and cherries to the spotted-wing drosophila, Drosophila suzukii. Pest Mgt. Sci. 67:1358-1367.

Maloney, K.E., W.F. Wilcox and J.C. Sanford. 1993. Raised beds and metalaxyl for controlling Phythophtora root rot of raspberry. HortScience 28(11):1106-1108.

Percival, D.C., J.T.A. Proctor and M.J. Tsujita. 1996. Whole-plant net CO2 exchange of raspberry as influenced by air and root-zone temperature, CO2 concentration, irradiation, and humidity. J. Amer. Soc. Hort. Sci. 121(5):838-845.

Pritts, M., M.C. Heidenreich, R.D. Gardner, M.J. Helms, G.M. Loeb, C.A. Weber, J. Carroll, K. Cox, R.R. Bellinder, L. McDermott, A. Landers and E. Bihn. 2015. Cornell Pest Management Guidelines for Berry Crops. M.P. Pritts and M.C. Heidenreich (eds.). Cornell Coop. Ext. Cornell Univ., Ithaca, NY. 200 pp.

Solomon, M. 2013. A century of research at East Malling: 1913-2013. East Malling Research, New Rd., East Malling, Kent, UK. 89 pp.

Sanford, J.C., K.E. Maloney and J. Reich. 1988. RubyTM (cultivar 'Watson') red raspberry. New York's Food and Life Sci. Bul. 125. NY State Ag. Exp. Sta., Cornell University, Geneva, NY.

Weber, C.A., K.E. Maloney and J.C. Sanford. 2004a. 'Encore' floricane raspberry. HortScience 39(3):63-636.

Weber, C.A., K.E. Maloney and J.C. Sanford. 2004b. 'Prelude' everbearing raspberry. HortScience 39(3):633-634.

Weber, C.A., K.E. Maloney, and J.C. Sanford. 2005. Performance of eleven floricane fruiting red raspberry cultivars in New York. Small Fruits Rev. 4(2):49-56.

Weber, C., 2013. Cultivar development and selection, p.55-72. In: Raspberries. R.C. Funt and H.K. Hall (eds.) CAB International, Boston, MA, USA.

Weber, C.A. 2018. High tunnel performance of seven primocane red raspberry cultivars in western NY. J. Amer. Pomol. Soc. 72(3):194-200.

Yao, S. and C.J. Rosen. 2011. Primocane-fruiting raspberry production in high tunnels in a cold region of the upper Midwestern United States. HortTechnology 21(4):429-434.