BERRIED TREASURES: OFF-SEASON PRODUCTION OF STRAWBERRIES AND RASPBERRIES

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In North America, greenhouse production of edible products has been limited primarily to tomatoes, cucumbers, greens and herbs. But what about the other half of the horticultural pie? Although fruits are available year around in supermarkets, those available in winter in the North are not freshly picked - rather they are usually harvested before peak ripeness and shipped great distances. And although it may be impractical to produce apples in April, it is possible to produce strawberries in January and raspberries in February.

Supermarkets brim with inexpensive strawberries in February and March, but according to consumer surveys, strawberries are second only to peaches in rankings of poor and inconsistent quality. Surely a niche exists for consistently flavorful berries picked at the peak of ripeness and available to the consumer the day after harvest. Such fruit may be more expensive than field grown berries from Florida, but the quality will be unrivaled.

We have been working on the techniques that would enable greenhouse owners to produce strawberries and raspberries during the off-season. Methods already exist for this type of production, and the Belgians and Dutch are heavily into greenhouse strawberry production. However, until recently, they have had the advantage of import restrictions imposed on fruit from southern producers, resulting in a favorable economic situation. Also, they have developed a strawberry variety specific to greenhouse production (Elsanta), but which American consumers would find of mediocre eating quality. Our objectives were to take readily available technologies and familiar varieties, and implement them under typical greenhouse conditions in the northeastern US.

Strawberries

A Cornell extension bulletin from 1897 written by Liberty Hyde Bailey discusses the forcing of strawberries in greenhouses. He states that "the attempt was so successful that the methods which were employed in raising the crop are here detailed." Strawberries were rooted in pots outdoors. The potted plants were kept in a cold frame, then moved into a heated greenhouse in intervals, beginning in late December. Flowers were pollinated by hand, and the first crop was harvested from May 6th through May 16th. Each plant produced an average of 6 large berries, or one quart per 3 ft2 of bench space. Interestingly, the price they obtained in 1897 ($2.00/quart) was approximately the same as the seasonal price today.

The varieties available today are more productive than those of 100 years ago. We identified one of the most productive and flavorful varieties available today (Jewel, a short - day type) and focused our research on getting it to fruit during the off-season. We reasoned that we could not compete with Florida and California on the basis of price, but perhaps we could compete on the basis of quality.

We place dormant crowns into 6 inch pots filled with equal parts peat, perlite and vermiculite in May and June, and allow them to grow outdoors until early November. Runners and flowers are removed at regular intervals. Plants then are either moved into the greenhouse, or stored in a cold room at about 28 - 30F. Plants will still fruit if leaves are removed to make handling easier.

Cold - stored plants are moved into the greenhouse at staggered intervals, about 12 - 13 weeks before fruit is desired. When plants are placed at a pot - to - pot spacing on a bench and provided with supplemental HID lighting, we obtain marketable yields of 12 ounces/ft2 during a 3 week fruiting period.

The use of dayneutral varieties is an alternative to the system just described because this type is insensitive to day length, and will flower soon after initiate flowers as Jewel does. Therefore, a special nursery for spring transplants is not required. Dormant dayneutral runner plants can be obtained from commercial nurseries in late autumn, planted directly into the greenhouse, and they will continuously flower and fruit even under long photoperiods. The fruiting season for individual plants can be several months in length as opposed to several weeks.

We deflowered day neutral strawberries for 2 weeks to allow for good establishment. Plants were derunnered as well. We evaluated 5 varieties (3 from the West Coast and 2 from the East Coast) and found that Tristar (developed in Maryland) not only produced the highest yields, but it was the most flavorful as well. We obtained 7 to 10 oz/ft2 per month once fruiting began, and we averaged 8 g per berry (a typical supermarket berry from the West Coast might average 25 g).

The major disadvantage of the dayneutrals was that pests were difficult to manage after the same plants had been in the greenhouse for a few months. We have had more success with Jewel than with Tristar, despite the additional number of Jewel plants that have to be moved and manipulated.

Lighting/Heating. Because the weather is cloudy for much of the winter in the Northeast, we used supplemental lighting at night to provide about 150 µmol/m2s1 of PAR. Since strawberries thrive at lower temperatures than most plants, heating the greenhouse is likely to be required only at night, and the heat from the lamps often is adequate to provide sufficiently high temperatures. We use a 75 /55 F day - night temperature cycle.

Fertilization /Irrigation. We examined various nutrient solutions and found that 50-100 ppm N is adequate for strawberries. We used a stock solution of soluble 5-11-26 , plus ammonium nitrate and calcium nitrate. The calcium and ammonium nitrate were made into a 10 gal stock solution using 615 g and 130 g, respectively. The 5-11-26 is made into a separate stock solution using 1230 g. The proportioned (1/50) adds equal amounts of both to maintain a constant conductivity equal to 100 ppm (later dropping to 50 ppm once flowering begins). A 100 ppm solution consists of 2.46 g/gal 5-11-26, 0.26g/gal ammonium nitrate, and 1.23 g/gal calcium nitrate- providing 88 ppm N as NO3-N and 12 ppm as NH4-N.

Micronutrients were added to the soil mix. We used leaf analyses to monitor nutrient levels, and phosphoric acid to maintain the solution pH at 6.5. Additional boron was required when leaf levels dropped below 30 ppm, and iron chelate was added to the solution when leaf levels dropped below 50ppm. Care was taken when mixing the stock solution. The phosphoric acid and iron chelate were added to the dilute solution-not to the stock solution - to avoid precipitation.

Pollination. Strawberry flowers requires some type of assistance to move pollen from the anthers to stigma. Bumble bees provide good pollination for strawberry plants. They perform much better than honey bees or hand pollination, and now we use them exclusively. Bumble bees are not aggressive, and we have never been stung by them - in contrast to the honey bees! Bumble bee hives are short-lived, about 6 - 8 weeks, so they have to be replaced regularly. Bumble bees can be obtained from numerous vendors who import them from Holland or Canada. They are flown to a nearby airport for pick - up. (GB Systems P .O. Box 19497, Boulder, CO 80308 or P.O.Box 300, Locke, NY 13092 [315-497-3129] or The Green Spot, 93 Priest Rd., Nottingham, NH 03290 [603 - 942-8925]).

Pest management. One advantage of greenhouse production is the absence of weeds. However, the controlled climate is ideal for other arthropod and fungal pests, if they are introduced. The following pests might be encountered growing strawberries in greenhouses: shore flies, fungus gnats, two - spotted spider mites, aphids, thrips, powdery mildew, and gray mold. If one uses bees in

the greenhouse, then pesticides are not recommended. We release *Geolaelaps*, *Orius* or *Amblyseius cucumeris* at the first sign of thrips, lacewing larvae and Aphidoletes midge for aphids, and Phytoseiulus persimilis for mites. We found it essential to have biological control agents in place before a pest outbreak begins. Scouting for pests is important, because population can increase rapidly under the favorable, greenhouse conditions. Root diseases (e.g. red stele) can become serious if we have never had a problem. Ensure that plant material is disease - free prior to planting.

We allowed the plants to grow through plastic mulch in order to keep fruit from lying on the soil mix. This barrier prevented insect larvae in the soil mix from burrowing into the ripening fruit, and reduced the incidence of gray mold on the fruit.

Economics. Producing off-season strawberries is expensive, and the break- even price for us was $3.00/pint. However, a small , but significant number of consumers are willing to pay top dollar for a fresh berry picked at the peak of ripeness and delivered to the store within a few hours. Size may not be a major factor for marketing these berries since they have such an intense flavor. They should be promoted as a special type for strawberry connoisseurs.

Raspberries

Raspberries are a high value crop that sell for $ 3.00 to $6.00 per1/2 pint during the winter and early spring. No domestic sources of winter raspberries exist, with the exception of a few producers in a small region in southern California along the coast. The vast majority of winter raspberries are flown in from the southern Hemisphere. Quality is generally poor because raspberries have an extremely short postharvest life, and the varieties grown there are unexceptional. A tremendous opportunity exists during the winter months for North American growers to sell high quality raspberries to restaurants, supermarkets or directly to the consumer if techniques could be identified and developed that would allow off- season production.

In the United States, there are many greenhouses that are empty during the winter months because they are used for bedding plants and vegetable seedlings in Spring. These greenhouses could be used to grow high quality raspberries during the winter months, providing greenhouse owners with an opportunity to produce an extremely high value crop during a time of the year when they are realizing no return on their capital investment. In our first attempt at growing greenhouse raspberries, we have obtained the equivalent of $500 - $1000 of exceptionally high quality fruit from as little as 25 feet of row (15 plants) between mid-Feb. - mid-April. In addition, by holding dormant raspberry plants in cold storage during the winter and bringing them into the greenhouse at staggered intervals, they can be made to ripen for several months prior and up to the normal raspberry season, dramatically extending the season of availability.

There is no other crop that appears to be so uniquely suited to winter greenhouse production, yet very little literature exists on this practice. Off- season raspberry production has been attempted in mild growing areas of Europe where primocane-fruiting types (those types that produce fruit on the tips of first- year canes at the end of the season) are mowed in spring to delay fruiting to autumn. Prior attempts at winter raspberry production have failed due to lack of acceptable pollination. However, in the last few years, entomologists have commercially developed bumble bee hives, and bumble bees are superior pollinators to honey bees in the greenhouse. In addition, biological control agents have been developed recently to manage greenhouse pests, making the spraying of pesticides unnecessary and allowing the bumble bee pollinators to thrive. So, several factors are in place for the first time that can make winter raspberry production successful: - extremely high prices for fruit, empty greenhouses throughout the country during winter, domesticated bumble bees, and effective biological control. In addition, with deregulation of electric power, costs for heating and lighting should decrease while the cost of fuel for transportation continues to rise. These changing economic conditions are favorable for local off- season production of fruits and vegetables, as well as year around production.

Procedure

We planted summer- bearing (floricane-fruiting) tissue- cultured raspberry plugs into 9 inch (1 gals) pots filled with equal parts sand:peat:perlite:vermiculite in early spring, allowed them to grow outdoors until late December, then brought them into the greenhouse. We trellised the canes, and watered with a 100 ppm N fertilizer as described for strawberries. Off- peak supplemental lighting was used between 2200 and 600 HR. Household fans were used to circulate air down the rows. Our " best-guess" as to temperature is 60-65F day and 40-45F night.

After 6 weeks the plants flowered, and bumble bees were used to pollinate the flowers. Fruiting began in late February. Primocanes were removed at regular intervals during the fruiting period. We also grew plants without supplemental lighting. The effects was a 2 week delay in fruiting, but total yields were not much different than when lights were used.

With the one-year-old plants, we used double rows (with row centers 5 ft. apart) and a pot-to-pot spacing so that approx. 26 plants were contained in each 10 ft. length of row. Each plant produced about one pint of fruit.

We removed all of the canes after harvest, and transplanted into 7 gallon pots for the second year. Plants were placed outside for the growing season after harvest in April, and they were returned to the greenhouse in mid-December- after the chilling requirement had been fulfilled. Rapidly satisfying the chilling requirement is one advantage that northern growers have over more southern producers. Outdoors, plants were watered regularly and fertilized once a week with a soluble balanced fertilizer (100 ppm N). Canes were held upright with trellises as they grew, and were exposed to full sun.

In the second year, we spaced plants 22 inches apart in the row (single rows), with 5.5 feet between rows. Plants were trellised in an upright position. In one variety, Chilliwack, we harvested an average of 11 half- pints of fruit per plant. In the stores during winter, half-pints sell for $ 3.00 - $ 6.00 each. Therefore, we were harvesting between $30 and $60 worth of fruit per plant over the 4 month period.

We did attempt to bring fall- bearing (promocane- fruiting) raspberries into the greenhouse in October to prolong the September fruiting season. Although we pick fruit well into November, new flowers are not produced and the production is quite low. In 1997, we will be experimenting with techniques to produce raspberries in late fall by delaying flowering until September.

Varieties and fruit quality. We have fruited a number of different varieties over the 2 year period. Furthermore, we invited chefs and produce buyers to sample our fruit and pass judgment on its quality. The favorite variety of most people is Tulameen, followed by Chilliwack and NY 7. Titan also produces flavorful and extremely large fruit. Early in the season, fruit size averaged 6 grams(some berries were 12 grams!) and it fell to 3 grams over the 8 week harvest period.

Jewel black raspberry also produced excellent fruit of large size, but yields were quite a bit lower than those of the red raspberries because the harvest season is much shorter (3 weeks).

Royalty purple raspberry and Heritage red raspberry ("summer crop") did not produce fruit of acceptable flavor. We will be examining additional varieties over the coming year.

Overall, with the exception of Royalty and Heritage, fruit quality was superb. Size was very large and the fruit did not rot because it is not exposed to rain. Flavor is outstanding. Only 6% of the berries were crumbly or otherwise unmarketable.

We found that Titan has a longer chilling requirement than Tulameen or Chilliwack, so must be brought into the greenhouse later. For us, mid-December was sufficient for Tulameen and Chilliwack, whereas early January was best for Titan. If plants are to be kept outdoors until late December, the pots must be protected from the cold weather. Otherwise, plants can be brought into a cooler in early December and the remainder of their chilling requirement can be fulfilled there.

Pests. Our major pest problem was twospotted spider mites which occurred in one house during the

last two weeks of harvest. We think that by keeping the night temperature at 45F, this pest will be less of a problem. Also, we released predators to reduce mite populations(see strawberries).

Economics. At our orchard store, we sold greenhouse strawberries for $3.50 per pint during late winter and early spring, but we sold raspberries for $3.00 per 1/2 pint. Although we sell everything that we can grow at our store, there is much less resistance to the price of raspberries. We are currently working on a detailed cost-of- production analysis for the greenhouse raspberries.

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Graduate Student Project Descriptions | Research Interests
Professional Societies/Editorial and Committee Activities
Extension Program | Personal Interests