A Comparison of Fruit Quality and Consumer Preferences Among Three Cold-climate Strawberry Production Systems

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SUMMARY. **In consumer-harvested marketing, crop management practices and production systems directly affect the experience of the customer. An experiment was designed to compare overall consumer preference and fruit quality characteristics among three perennial cold-climate strawberry (*Fragaria ×ananassa*) production systems: conventional matted row (CMR), advanced matted row (AMR), and cold-climate plasticulture (CCP). Replicate plots of each system were maintained for two harvest seasons. Volunteers harvested subplots in each system and completed a survey to evaluate pick-your-own consumer preferences. The CCP system was preferred by a majority of consumers in the first year, whereas the AMR system was rated highest in the second year. Preferences were positively correlated with ease of harvest and fruit appearance and negatively correlated with the percentage of fruit unfit for harvest. Fruit quality measurements made on marketable fruit in the second harvest season indicated that there were no treatment differences in titratable acidity or soluble solids concentration, but significantly lower fruit firmness in the CCP treatment compared with CMR and AMR.**

In the mid-Atlantic region of the United States, many growers produce crops for the consumer-harvested or pick-your-own (PYO) market, in which the end consumer harvests the crop directly from the field. A number of fruit and vegetable crops work well as PYO crops, and growers often produce a wide range of crops to offer fresh produce items for PYO through much of the season. Many growers use PYO crops to entice customers to shop in an onsite farm stand for jams, jellies, baked goods, and other value-added items. Strawberries have one of the earliest harvest seasons and are important to PYO market-based operations for beginning the flow of customers in the spring.

Some factors consistently affect the shopping experience of PYO customers. In a study of direct marketing of strawberries for North Carolina, Safley et al. (2004) found that the predominant reasons cited by PYO consumers for picking less fruit than they expected were poor fruit quality (31.1%), fields were picked over/not enough fruit (17.6%), uncomfortably hot weather (6.8%), small fruit size (4.0%), too hard to pick berries (4.0%), and fields were too muddy (1.4%). Other answers not listed constituted 35.1% of the responses. The same study cited reasons customers picked more fruit than expected: good fruit quality (57.7%), easier to pick than expected (25.3%), good fruit size (7.8%), and low prices (4.6%) with 4.6% listing other reasons.

Although some of these factors such as fruit size, yield, and ease of harvest are partly influenced by cultivar selection, production systems also affect these and other factors that determine the PYO consumer's overall experience. To that end, growers who want to maximize PYO sales should consider using a system that enhances characteristics that consumers value such as quality and quantity of fruit produced, fruit size, and ease of harvest. Field conditions were also cited by Safley et al. (2004) as playing a role in how long PYO customers chose to pick. Weather conditions cannot be controlled, but a production system that maximizes customer comfort may help increase PYO sales.

Although it is important for growers to consider the desires of the public when designing their production practices, economics also dictate which practices are implemented. Some studies have shown that consumers are willing to pay a premium for products that are pesticide-free (Boccaletti and Nardella, 2000), environmentally certified (Jensen et al., 2003), and not genetically modified (Chern et al., 2002). If PYO strawberry customers were willing to pay a higher price for the convenience and increased enjoyment of picking strawberries from a system they prefer, it could improve the economic viability of a higher input system.

Growers in temperate regions of North America with PYO strawberry operations have typically used the conventional matted row production

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
0.3048	ft	m	3.2808
2.5400	inch(es)	cm	0.3937
25.4000	inch(es)	mm	0.0394
4.4482	lbf	N	0.2248
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

system. Some growers have tested a cold-climate plasticulture system that is thought to offer better weed control and improved fruit size and quality as well as increased yields in some situations (Fiola et al., 1995). The cold-climate plasticulture (CCP) system may also improve ease of harvest. The CCP system is an adaptation of annual hill production practiced in milder climates but is frequently cropped over multiple years and thus is not a true annual system. A third system, the advanced matted row (AMR), has been developed by researchers at the U.S. Department of Agriculture (USDA) in Beltsville, MD, as a potential alternative production system (Black et al., 2002a). Although this system is not yet widely used, determining its acceptability to PYO customers is an important consideration for its implementation.

Some evidence suggests that management systems may influence overall fruit quality. For some cultivars, fruit from the CCP system have been shown to have increased soluble solids concentration, total sugar, fructose, glucose, ascorbic acid, titratable acid, and citric acid compared with the conventional matted row (Wang et al., 2002). It remains to be seen how closely related these measurable factors of fruit quality are to consumer perceptions.

A better understanding of how production practices affect consumer experience is important for aiding PYO-based growers in optimizing customer satisfaction. An experiment was carried out to compare three cold-climate strawberry production systems for overall consumer preference and for fruit quality.

Materials and methods

Cropping system. Three replicate plots of each of the three production systems (conventional matted row [CMR], AMR, and CCP) were established in 2001 to 2002 in a randomized complete block design at the USDA Henry A. Wallace Beltsville Agricultural Research Center in Beltsville, MD. Each plot was prepared in a north–south orientation, measuring 45 ft long and 20 ft wide (four rows), with strawberries planted in 2002 and cropped in 2003 and 2004 seasons. Each cropping system was managed according to recommended management practices for the production system and region (Black et al., 2002a; O'Dell and Williams, 2000; Pritts and Handley, 1998). For CMR, plants were grown on flat beds with overhead irrigation and periodic cultivation for between-row weed control. The AMR consisted of raised beds mulched with the residue of a preplant cover crop of hairy vetch (*Vicia villosa*), crimson clover (*Secale cereale*), and grain rye (*Trifolium incarnatum*). Irrigation was by subsurface drip, and between-row weed control was by directed herbicide application. Plants in the AMR system are allowed to produce and set runners like in the CMR system. The CCP system consisted of raised beds with plastic mulch and subsurface drip irrigation. Each system also had straw mulch in between rows at the time of harvest. This mulch was initially used on top of the rows to protect plants in the winter but was moved between rows in spring and provided additional weed control. The cultivar 'Allstar' was used in all systems because of a favorable disease resistance profile and adaptability to different production systems. 'Allstar' was originally selected for CMR production (Galletta et al., 1981) and has shown superior performance in both the CCP and AMR systems (Black et al., 2002b). Although growers would likely select a cultivar uniquely suited to their production system, using only 'Allstar' for this experiment allowed for separating cultivar from management system effects. Further detail on management of each production system is found in Stevens (2005).

Consumer preference. During the 2003 and 2004 harvest seasons, volunteers were recruited to harvest plots and complete questionnaires to assess preference among the production systems. Data were only collected from the two center rows of each plot, which were divided into three 12-ft-long subplots with a minimum of 3 ft of row between subplots. This resulted in a total of 54 harvest subplots (three replicate plots × three treatments × six subplots per replicate). Each of the nine replicate plots and 54 harvest plots were randomly assigned a three-digit number designation to avoid introducing bias through the use of descriptive treatment names. Number combinations of repeating digits such as 111 or ascending or descending sequential combinations such as 123 or 987 were eliminated as were combinations with the potential for known connotations such as 911. Once numbers were randomly assigned to all harvest plots, the harvest plot with the highest numerical value within each replicate was designated for harvest by research staff to determine biological yield. The remaining five plots in each replication were harvested by survey volunteers.

A questionnaire was developed to assess the reactions of volunteers to each production system before, during, and after their harvesting experience. A panel with both PYO and sensory evaluation experience discussed relevant questions, terminology, and scaling in developing the questionnaire. The questionnaire consisted of five pages, and each survey was anonymously labeled with a randomly assigned harvest plot from each treatment with treatments assigned in random order. The first page of the questionnaire was to be completed before entering the plots and consisted of background demographic information, prior experience at PYO farms, plans for use of the harvested fruit, and initial visual impressions of each of the systems. The second, third, and fourth pages corresponded to each of the three plots the volunteer was to harvest and were identical except for the plot designation. Questions on these pages were designed to give quantitative answers concerning the aspects of fruit quality, visual appearance of both the plot and the fruit, ease of harvest, and overall enjoyment of picking. Quantitative results were obtained by providing a 100-mm line with descriptive end points (Table 1) and asking survey participants to mark the line relative to their impressions. Research staff members were present at the time of harvest to help volunteers locate their assigned subplots and provide brief instructions for picking. Volunteers were instructed to pick any and all fruit that they deemed marketable within their assigned harvest plot and to complete the corresponding survey page before moving to the next assigned harvest plot to repeat the process. After harvesting each of their assigned harvest plots and completing the corresponding

Table 1. Attributes scored for each strawberry production system by volunteer harvesters.[z]

Attribute	Left label (score = 0)	Right label (score = 100)
Overall appearance	Poor	Excellent
Ease of harvest	Difficult	Easy
Appearance of fruit	Poor	Excellent
Amount of fruit not fit for harvest	None	100%
Overall enjoyment	Did not enjoy	Very enjoyable

[z]Each attribute was scored by making a pencil mark on a 100-mm (3.94 inches) line with descriptive end points.

questionnaire page, the volunteers completed the final survey page. The final page of the survey asked the volunteers to rank the three treatments with regard to their overall enjoyment and the quality of fruit. Volunteers were instructed to indicate which treatment they would most like to pick from again and whether they would be willing to pay more to pick from this treatment. This page also allowed the volunteers to describe the picking conditions on that particular day and make additional comments. At no point were the volunteers told specific information about any of the systems.

Before the harvest season of Spring 2003, volunteers were recruited through an e-mail sent to a listserve of ≈1300 clerical, administrative, technical, and scientific staff at Beltsville Agricultural Research Center and by word of mouth. A total of 75 volunteers were assigned to one of five scheduled harvest dates at one of three times per day (0800–1000 HR, 1000–1200 HR, or 1200–14:00 HR). Harvest dates were scheduled twice weekly after all three systems had ripe fruit available. All volunteers were told that they would be participating in experimental research and would be required to complete a questionnaire about the experience. In exchange for their participation, volunteers would be allowed to keep their harvested fruit at no charge. Volunteers met at a centralized site on the research station and were transported by van to the research field. Numbered buckets were provided as picking containers.

For the Spring 2004 harvest, a new group of volunteers was recruited through an e-mail sent to the same employee listserve as in 2003 and another sent to the graduate student, faculty, and staff e-mail distribution lists of the University of Maryland Department of Natural Resources and Landscape Architecture. Because of the shorter harvest season incited by unusually hot weather at harvest time, only three harvests were completed using volunteers. A total of 45 volunteers participated in the 2004 harvest. Slight modifications to the survey were made for 2004, because the wording of a few questions was changed slightly for clarity and an additional question ("What factors most influenced your opinions about each plot") was added to the postpicking survey. The complete survey can be found elsewhere (Stevens, 2005).

FRUIT QUALITY. In 2004, 20 fruit from each research plot were sampled to assess factors of fruit quality. Each fruit was cut in half vertically, and each half was compressed to determine firmness using a 0.25-inch spherical probe with a $1\text{-mm}\cdot\text{s}^{-1}$ speed of penetration to a depth of 6 mm. The maximum force values for both halves were averaged, giving 20 total observations. The berries were then blended using a household juicer, and the juice was filtered through cheesecloth. Soluble solids concentration of the juice was measured by placing four drops on a handheld refractometer. A 10-mL aliquot of each juice sample was stored at –30 °C for subsequent determination of titratable acidity. These samples were thawed, diluted (5 mL juice + 95 mL deionized water), and titrated with 0.1 N sodium hydroxide to a pH of 8.2. Acidity was expressed as milligrams of citric acid equivalent per 100 mL of juice.

Survey data were analyzed using a repeated measures subroutine in the Proc Mixed routine of SAS (version 8.2; SAS Institute, Cary, NC) with treatment and harvest date as factors. When significant interactions were found, treatment means separation was performed using the PDIFF option of the LSMEANS statement. Correlations between attributes and overall enjoyment were performed using the PROC REG routine and stepwise regression method in SAS. Stepwise regression allowed for examination of correlation between overall enjoyment and all attributes equally. Fruit quality measurement data were analyzed using the Proc Mixed routine with treatment means separation using the PDIFF option of the LSMEANS statement.

Results and discussion

DEMOGRAPHICS AND BACKGROUND INFORMATION. The majority of participants in both years of the study were female (74% in 2003 and 93% in 2004). The predominant age group among survey participants was 21 to 30 years (greater than 50%) followed by the age groups of 31 to 40 years and 41 to 50 years (Table 2). The two most common household income groups

Table 2. Demographic information for harvest volunteers participating in a comparison of strawberry production systems.[z]

Parameter	2003 (%)	2004 (%)	2-yr mean (%)
Gender			
Male	26	7	19
Female	74	93	81
Age (years)			
≤20	8	2	6
21–30	50	53	51
31–40	23	22	23
41–50	15	20	17
51–65	4	2	3
>65	8	2	6
Household income ($)			
<20,000	4	7	5
20,000–40,000	22	25	23
40,000–60,000	17	21	18
60,000–80,000	28	18	24
80,000–100,000	15	9	13
>100,000	15	21	17
Country of origin			
United States	81	87	83
India	5	0	3
China	4	0	2
Venezuela	1	4	2
Other[y]	9	9	9

[z]Total number of participants was 75 and 45 for 2003 and 2004, respectively.
[y]Germany, Lithuania, Brazil, Taiwan, Chile, Colombia, Korea, Serbia, and Montenegro.

were the $60,000–80,000 and the $20,000–40,000 group, but a wide range of household incomes was represented among survey participants. Over 80% of participants in each year were born in the United States (Table 2). Safley et al. (2004) reported that the typical PYO customer in their survey was between 25 and 44 years old, female, with a household income of $30,000–44,999, whereas the typical farm stand customer fell within the same age range and gender but had a higher level of income.

Approximately 72% of participants in both 2003 and 2004 had picked some crop at a PYO farm in the past. The most commonly picked crops were strawberries followed by apples (*Malus* × *domestica*), pumpkins (*Cucurbita maxima*), blueberries (*Vaccinium* spp.), peaches (*Prunus persica*), blackberries (*Rubus* spp.), and raspberries (*Rubus idaeus*). In 2003, 29% of respondents had picked strawberries at a PYO farm in the past 3 years compared with 19% in 2004. Nearly half of the respondents in 2003 had never picked strawberries at a PYO farm compared with approximately one-third of those in 2004. In each year, more than 60% of the respondents indicated that they did not pick strawberries in an average year with the remainder indicating somewhere between one and three PYO visits per year (Table 3). The participants in this study listed fresh consumption as the most common use for PYO strawberries (Table 4), similar to results previously reported (Safley et al., 2004).

Table 3. Pick-your-own (PYO) history of harvest volunteers participating in a comparison of strawberry production systems.[z]

Question	2003 (%)	2004 (%)	2-yr mean (%)
1) Have you ever picked fruit or vegetables from a PYO farm?			
Yes	72	72	72
No	28	28	28
2) If so, what crops have you picked			
Strawberries	50	67	56
Apple	26	37	30
Pumpkin	18	33	23
Blueberry	18	21	19
Peach	13	14	13
Raspberry	6	16	10
Blackberry	6	12	8
Other	40	21	33
3) How recently have you picked strawberries from a PYO farm?			
Within the last year	18	12	15
Within 2–3 years	11	7	10
More than 3 years	29	49	36
Never	43	33	39
4) How many times in an average year do you pick strawberries?			
0	64	61	63
1	18	29	22
2	9	2	7
3	2	0	1
Depends	8	7	7

[z]There were 75 volunteer harvesters in 2003 and 45 in 2004, for a total of 120 volunteer harvesters.

Table 4. Previous and intended use(s) of strawberries picked by volunteer harvesters participating in a comparison of strawberry production systems.[z]

	How have you previously used your pick-your-own strawberries?			How do you intend to use the strawberries you pick today?		
Use	2003 (%)	2004 (%)	Total (%)	2003 (%)	2004 (%)	Total (%)
Eat fresh	59	69	63	72	78	74
Freeze	32	51	39	33	49	39
Process	31	49	37	24	31	27

[z]Volunteers could list up to three uses for harvested fruit, if applicable.

Table 5. Consumer scores for attributes of three cold-climate strawberry production systems in 2003 and 2004.[z]

	2003			2004		
Attribute	CMR	AMR	CCP	CMR	AMR	CCP
Overall appearance	54 b[y]	68 a	71 a	55	58	60
Ease of harvest	54 c	67 b	83 a	57 b	74 a	78 a
Appearance of fruit	59 b	61 b	70 a	64 a	67 a	54 b
Amount of fruit not fit for harvest	50	53	48	37	38	43
Overall enjoyment	56 b	67 a	73 a	65	68	63

[z]Production systems were conventional matted row (CMR), advanced matted row (AMR), and cold-climate plasticulture (CCP).
[y]Means in a row within a year followed by different letters are significantly different at $\alpha = 0.05$ as compared by least significant difference. Where letters are not shown, means are not statistically different within a year. Participants scored each attribute by making a mark on a 100-mm (3.94 inches) line; the score was the position of the mark relative to the left end point.

Attributes of production systems affecting consumer preference. The 2003 season was characterized by unusually cool, wet weather from bloom to harvest with measurable precipitation occurring on 21 of 30 d during this period. Volunteers were asked to give each production system a quantitative score based on a number of attributes (Table 1). In 2003, consumers rated the AMR and CCP systems higher than the CMR for overall plot appearance (Table 5). The CCP system was the highest rated for ease of harvest, followed by AMR, with CMR receiving the lowest rating. The CCP system was the highest rated for appearance of fruit with no significant difference between the AMR and CMR systems. There was no significant harvest date or system × harvest date interaction for overall appearance of the plots (P = 0.50 and 0.49, respectively), ease of harvest (P = 0.052 and 0.72, respectively), or appearance of fruit (P = 0.62 and 0.11, respectively). The amount of fruit that volunteers rated not fit for harvest differed significantly among harvest dates (P < 0.0001) but not among production systems with no significant system × harvest date interaction. Because of the extended period of cool, wet weather surrounding the harvest period, the amount of fruit not fit for harvest, primarily as a result of increased fruit rot, was much higher in all systems than is typical of the location and production systems. In nearby cultivar trials, K.S. Lewers and J.S. Enns (unpublished data) found 'Allstar' yields for 2003 were 25% and 34% of average yields for the previous six seasons for AMR and CCP, respectively. Ratings for overall enjoyment were significantly higher in AMR and CCP, compared with the CMR system, and did not differ among harvests (Table 5).

At the end of their experience, the survey participants were asked to specify which of the systems they would like to pick from again. For this final measure of preference, there was a significant system × harvest date interaction ($P = 0.006$), in which early season preferences were for CCP shifting to AMR and CMR as the season progressed (Fig. 1). This seasonal shift in overall preference was likely a function of yields. The CCP typically begins fruiting earlier than the other systems. As a result, the first surveyed harvest in 2003 came at the peak of the season for the CCP and very early in the season for the other two systems.

The 2004 season was characterized by unseasonably warm temperatures that resulted in an abbreviated season with reduced yields and low quality fruit as a result of heat damage. Yields in the region were again lower than normal, but not as severely reduced as in 2003. Nearby research plots showed 'Allstar' yields that were 71% and 81% of average for AMR and CCP, respectively (K.S. Lewers and J.S. Enns, unpublished data). In 2004, significant differences between systems were detected in only two attributes, ease of harvest and appearance of fruit. AMR and CCP ranked highest in ease of harvest, above CMR. For appearance of fruit, AMR and CMR were the highest rated with CCP the lowest. Overall appearance, amount of fruit not fit for harvest, and overall enjoyment were not statistically different among treatments (Table 5). Harvest- and system-by-harvest-date interactions were nonsignificant for any attribute in 2004. Despite similar ratings between CCP and AMR for most characteristics, more respondents indicated they would most like to pick from the AMR again (Fig. 1). There was no significant harvest-by-system interaction. Because of the abnormally hot weather during the harvest period in 2004, the harvest season was much shorter than normal. In addition to lowering the overall yield and fruit size, this also caused the fruit to ripen faster across all systems, which would be accentuated on the black plastic mulch of the CCP system (Himelrick et al., 1996).

Correlation analysis using stepwise regression found that overall enjoyment was positively correlated to fruit appearance ($R^2 = 0.45$, $P < 0.0001$) and the ease of harvest ($R^2 = 0.60$, $P < 0.0001$) and negatively correlated to the amount of fruit not fit for harvest ($R^2 = -0.62$, $P = 0.001$). This is consistent with findings of Safley et al. (2004) in which customers who picked more fruit than they intended, an indication of enjoyment of the experience, did so primarily as a result of good fruit quality and ease of harvest. Overall enjoyment was not significantly correlated with fruit size or marketable yields.

In both years, AMR and CCP plots were favored over CMR plots, an indication that raised beds were a factor in harvesting enjoyment. This is likely a reason for the higher ratings in ease of harvest for AMR and CCP in each year compared with CMR. Growers have often related that the consumers' major complaints with the CMR system were that fruit clusters sat in the soil as a result of the flat beds and that picking was hard on the back. Multiple comments from survey volunteers reinforce this conclusion. One volunteer observed of the CMR "the lack of a raised hump means I will be hunching over more," whereas another said of the AMR "liked higher beds which made picking easier (less back pain)." Comments by the volunteers also revealed differences of opinion on the aesthetics of the systems. One volunteer indicated "black plastic mulch kind of detracts from my enjoyment of the 'natural' experience of picking berries," whereas another said "the weed cloth makes it look sterile and hot." However, another volunteer who liked the look of the CCP system best but enjoyed picking from the AMR most said she "was surprised to find out that ease of picking, fruit quality and size, had very little to do with my initial opinion based on aesthetics." A number of volunteers initially disliked the look of the plastic in the CCP system but enjoyed the system after picking from it: "I didn't like the look of the plastic, but the fruit was easy to see and pick;" "I'm philosophically opposed to plastic but it did make picking easier;" and "now I like the black plastic. It made the fruit easier to see." The majority of these comments came in the first year of the study. The CCP was rated much lower for the second year and was reflected by comments such as "bad quality strawberries, most had been bleached or damaged by sun" and "I don't like deteriorating plastic on surface, fruit laying on plastic parboiling in the sun."

The results of this study confirmed that CCP was preferred by PYO customers in the first year. However, this was not true in the second

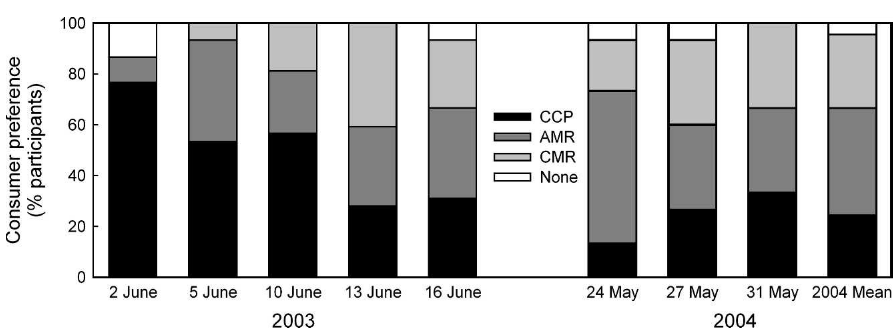

Fig. 1. Consumer preference of strawberry production systems for the 2003 and 2004 harvest seasons. Participants were asked to identify the system that they would most like to pick from again. Values are expressed as a percentage of the total number of participants. None indicates that the participant did not give a preference.

Table 6. Quality characteristics (titratable acidity, soluble solids concentration, and firmness by compression) of strawberry fruit harvested in 2004 from conventional matted row (CMR), advanced matted row (AMR), and cold-climate plasticulture (CCP) plots.

Treatment	CMR	AMR	CCP
Titratable acidity (citric acid equivalent)	0.70	0.74	0.69
Soluble solids concentration (%)	6.95	7.02	7.71
Compression F_{max} (N)[z]	2.21 a[y]	2.23 a	1.87 b

[z]1 N = 0.2248 lbf.
[y]Means within a row followed by different letters are significantly different at α = 0.05 as compared by least significant difference.

year. The difference between seasons may be attributed to carrying over an annual system for a second year and also could have been related to the hotter than normal weather conditions. Although fruit yield and size dropped, these factors were not directly correlated to the drop in overall enjoyment cited by consumers. Fruit appearance (which likely is judged in relation to fruit size), ease of harvest, and amount of fruit not fit to harvest were found to be most correlated to overall enjoyment by the PYO consumer. In addition, by the second year of fruit production and the third year of the experiment, the plastic mulch in the CCP system had begun to break down, with holes appearing in the plastic. This difference in aesthetics may have had some role in the decrease in satisfaction with the CCP system.

Fruit quality measurements. Fruit samples collected on four harvest dates in 2004 were analyzed for fruit quality characteristics. The sampling dates represented the last four of six total harvests for each system. No differences were found among treatments in either titratable acidity or soluble solids concentration (Table 6). This contradicts results previously reported by Wang et al. (2002) in which fruit from CCP had higher soluble solids concentration and titratable acidity. Fruit from both the CMR and AMR systems were firmer than fruit from the CCP system with an F_{max} value of 1.87 on a standard compression test compared with 2.21 and 2.23 for CMR and AMR, respectively (Table 6). These differences in firmness may have been the result of an increased proportion of overripe fruit resulting from higher ripening rates on the black plastic mulch (Himelrick et al., 1996) and 3 to 4-d harvest intervals.

In conclusion, the CCP system was highly favored by PYO customers in the first year of the study, but this effect did not carry over to the second harvest year. However, the CCP was no different from AMR for overall appearance, ease of harvest, and overall enjoyment in the second (carryover) year. AMR was the most popular system in the second harvest year, with volunteers ranking it as the one they would most like to pick from again. Appearance of fruit and ease of harvest were the attributes that were positively correlated to overall enjoyment, whereas amount of fruit not fit for harvest was negatively correlated to overall enjoyment. Although the CCP fruit were softer than fruit from the CMR and AMR systems in 2004, no other measurable fruit quality differences were noted. Among the respondents over the 2 years of the study, 63% expressed a willingness to pay more to pick from their preferred system compared with 27% that were not willing to pay more. This would indicate that when a producer is selecting a strawberry production system, higher establishment could be offset by charging higher prices of the PYO consumer. Producers should consider that they are selling an experience in addition to the fruit. Of course, growers will also need to consider labor, yield, and other economic differences between systems as well, which are discussed in Stevens (2005).

Literature cited

Black, B.L., J.M. Enns, and S.C. Hokanson. 2002a. Advancing the matted-row strawberry production system. 5th North Amer. Strawberry Conf. p. 112–115.

Black, B.L., J.M. Enns, and S.C. Hokanson. 2002b. A comparison of temperate-climate strawberry production systems using eastern genotypes. HortTechnology 12:670–675.

Boccaletti, S. and M. Nardella. 2000. Consumer willingness to pay for pesticide-free fresh fruit and vegetables in Italy. Intl. Food Agribusiness Mgt. Rev. 3: 297–310.

Chern, W.S., K. Rickertsen, N. Tsuboi, and T.-T. Fu. 2002. Consumer acceptance and willingness to pay for genetically modified vegetable oil and salmon: A multiple-country assessment. AgBioForum 5:105–112.

Fiola, J.A., R.J. Lengyen, and D.A. Reichert. 1995. Planting density and date affect productivity and profitability of 'Chandler', 'Tribute', and 'Tristar' in strawberry plasticulture. Adv. Strawberry Res. 14:49–52.

Galletta, G.J., A.D. Draper, and H.J. Schwartz. 1981. 'AllStar' strawberry. HortScience 16:792–794.

Himelrick, D.G., F.M. Woods, W.A. Dozier, Jr., and J.R. Akridge. 1996. Influence of mulch color on strawberry production in the annual hill plasticulture system. Adv. Strawberry Res. 15:42–48.

Jensen, K., P.M. Jakus, B. English, and J. Menard. 2003. Market participation and willingness to pay for environmentally certified products. For. Sci. 49:632–641.

O'Dell, C.R. and J. Williams. 2000. Hill system plastic mulched strawberry production guide for colder areas. Virginia Coop. Ext. 438–018, Virginia Tech, Blacksburg.

Pritts, M. and D. Handley. 1998. Strawberry production guide for the northeast, midwest, and eastern Canada. Northeast Regional Agr. Eng. Serv. 88, Ithaca, NY.

Safley, C.D., E.B. Poling, M.K. Wohlgenant, O. Sydorovych, and R.F. Williams. 2004. Producing and marketing strawberries for direct market operations. HortTechnology 14:124–135.

Stevens, M.D. 2005. Sustainability of cold-climate strawberry production systems. Univ. of Maryland, College Park, MS Thesis.

Wang, S.Y., W. Zheng, and G.J. Galletta. 2002. Cultural system affects fruit quality and antioxidant capacity in strawberries. J. Agr. Food Chem. 50:6534–6542.