Sustainability of Strawberry Production Systems in the Absence of Methyl Bromide

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INTRODUCTION

Growers and researchers in the mid-Atlantic and northeast regions of North America have long recognized inefficiencies in the conventional matted row production system and have searched for viable alternative production systems (Hancock et al. 1997, Black et al. 2002b). Problems with the conventional matted row system include high water use, inefficient fertilizer application, and high labor costs for weed control. Some growers have experimented with a cold-climate plasticulture system that offers the benefits of better weed control, more efficient irrigation and fertilizer application, and larger and earlier-ripening fruit (O'Dell and Williams, 2000). However, this system has higher establishment costs and increased risk of frost and freeze damage, for potentially marginal increases in returns (Larson, 1996). The advanced matted row system was developed by researchers at the USDA in Beltsville, MD as a potential alternative to conventional matted row and plasticulture. The advanced matted row is a raised bed system with drip irrigation, which uses a vetch-clover-rye cover crop residue as mulch (Black et al. 2002b).

Sustainability has been defined as consisting of the following criteria: economic viability and efficiency, minimal environmental impacts, and public acceptance (Merwin and Pritts, 1993). Among these criteria, the impact of agricultural systems on the environment has received the most attention. Many states have passed or are considering legislation to assess and regulate non-point sources of pollutants, including nutrient run-off from farms (Lea-Cox and Ross, 2001). The fate of pesticides is also of concern, particularly in early spring when pre-bloom fungicide sprays may coincide with heavy irrigation for frost protection. Many growers in the mid-Atlantic region grow multiple crops for the pick-your-own market. In order for a strawberry production system to be sustainable for this region, it would need to be economically viable, and acceptable to pick-your-own customers.

We conducted a three-year study to compare three strawberry production systems, conventional matted row, advanced matted row, and cold-climate plasticulture, for all aspects of sustainability.

MATERIALS AND METHODS

Three strawberry production systems, conventional matted row, advanced matted row, and cold-climate plasticulture, were established in three replicate plots measuring 6 x 15 m each. The conventional matted row system consisted of flat beds with overhead irrigation, cultivation for weed control, and broadcast fertilizer application. The cold-climate plasticulture system consisted of a double staggered row of plants on raised beds with plastic mulch, drip irrigation laid below the plastic, and weekly application of fertilizer through the irrigation system. The advanced matted row system is a raised bed matted row system, with a killed cover crop residue for initial weed control, and

subsurface drip irrigation (see Black et al., 2002b). Plots were established in 2002, and fruited through two harvest seasons (2003-2004). 'Allstar' was used in all three systems because of its exceptional performance in each system, as well as its resistance to verticillium wilt. By choosing a cultivar that was well adapted to all three systems, we were able to eliminate potential bias among the systems due to cultivar performance. Because the strawberry plots were following tomatoes, resistance to verticillium was paramount.

All management inputs, including weeding, runner removal, fertilizer and chemical application, and cultivations were recorded for each system to compare economic viability. From these, crop budgets are being developed. Fruit yield was determined through twice weekly harvests in two harvest years, using both volunteers simulating pick-your-own customers, and researchers measuring both marketable yields and unmarketable yield (culls).

Environmental impacts during the establishment year and first fruiting season were quantified by collecting surface runoff and sub surface water samples. Surface runoff samples were collected with automated runoff samplers installed in each plot and soil leachate samples were drawn by vacuum from suction lysimeters. Runoff samples were analyzed for soil content to estimate erosion. Analysis of surface and leachate samples for nutrient, and pesticide content is currently underway.

Volunteer harvesters were recruited and surveyed to evaluate consumer preference. Each volunteer harvested a 12-foot section of one row from each system and completed a survey giving opinions of each system. The project was terminated after the second harvest.

RESULTS AND DISCUSSION

Economics/Efficiency

Spring of 2003 was very wet due to above average rainfall, and yields were decreased due to high incidence of fruit rot despite a regular fungicide program. However, the crop was sufficient to allow for system comparisons. A total of eight harvests were conducted over the 4-week season. The conventional matted row had the highest total marketable yield of the three systems, at 19,500 lbs/acre, compared to 13,200 and 14,800 for plasticulture and advanced matted row, respectively (Table 1). Fruit size was significantly higher in plasticulture compared to the other systems and percentage of unmarketable fruit significantly lower in plasticulture compared to conventional matted row. In a spring with more optimal weather conditions, damage to fruit would likely be lower and marketable yields would be higher across all systems. Annual breeding trials at the Beltsville Agricultural Research Station from 1997-2001 have shown 5-year average yields of 24,300 lbs/acre and 30,800 lbs/acre, for 'Allstar' in the advanced matted row and plasticulture systems, respectively (Black et al 2002a).

The 2004 season was characterized by a period of very hot weather immediately preceding and during the harvest period, causing much of the fruit to ripen quickly. As a result, the harvest season lasted for 6 harvests over a three-week period. Marketable yields from the second harvest year were small across all systems, as was fruit size. Percentage of unmarketable fruit was lower in 2004 than in 2003 for conventional matted

row and advanced matted row, but was higher in 2004 for plasticulture. For 2004, both the conventional matted row and advanced matted row yielded higher than the plasticulture. There was no significant difference in the mean fruit size among treatments. The plasticulture system had the highest percentage of unmarketable fruit, and the conventional matted row had the lowest, while the advanced matted row was intermediate (see Table 1).

In order to compare profitability, enterprise budgets are being developed for each system. These will take into account all establishment costs, costs for hand and machine labor, material costs of pesticides, fertilizers, water use, and other relevant inputs, yield and estimated fruit value.

Environmental Impacts

During the establishment season (2002), the region experienced drought conditions with few rain events. Above average rainfall during the first fruiting year allowed for the collection of samples from 36 total rain events through 2003. Duration and intensity of each rain event was recorded by a weather station at the research site Conventional matted row had 2.9 times more soil loss from rain-induced surface runoff than the plasticulture and 4.2 times more than advanced matted row. The plasticulture had 1.5 times more soil lost than the advanced matted row despite being planted 3 months later. The increased soil loss in conventional matted row likely resulted from several intense rainfall events that occurred shortly after cultivation for weed control. Average volume of runoff water was similar across all systems during this time, although the plasticulture had lower cumulative water runoff due to its later planting date. Adding straw in the winter of 2002, a typical management practice to protect strawberry plants from winter cold, proved to be an effective means of lowering runoff volume and initial soil loss.

Late in 2003, we experienced several intense rain events within the period of a month, including Hurricane Isabel. As a result, there were large spikes in soil loss and water runoff volume, particularly in the conventional matted row and advanced matted row. At this point the straw had begun to deteriorate and in some cases was carried off the plots by wind and heavy rain. A possible explanation for the low volume of water runoff and erosion in the plasticulture system**,** particularly in the events on 11-August, 2003 and 18-September, 2003 (Figure 1), is that the straw in the plasticulture did not deteriorate as quickly, therefore helping to limit flow of water off the plots. This is likely due to the fact that there was less traffic in the plasticulture plots due to less hand weeding, pesticide spraying and no cultivation compared to the other systems, and therefore less disruption to the straw mulch. It may be practical for growers to replenish straw mulch during the summer or fall, not only as a weed control measure but to help limit runoff and erosion. Total soil loss from rain-induced surface runoff through the end of the first bearing year was 1079 kg/ha for conventional matted row, compared to 583 and 294 for advanced matted row and plasticulture respectively.

In addition to the loss of topsoil, surface runoff results in nutrient and chemical runoff. Data for nitrogen and pesticide runoff are not available at this time, as sample analysis is ongoing. Except for a few baseline samples at the beginning of the study, runoff samples were not tested for phosphorus, as no phosphorus was applied to any

treatment. Tissue samples were taken through destructive harvest following each fruit harvest, and are currently being analyzed for nitrogen partitioning among tissue types.

Public Acceptance

The goal of the survey was to determine whether there were any clear consumer preferences among systems, and whether preferences were based on such factors as quality of fruit, ease of harvest, or appearance. Representative results are shown in Figure 3. In 2003, consumers showed a preference toward the plasticulture, largely due to earlier ripening fruit, larger and more marketable fruit, and ease of harvest. Later in the season there was no clear preference among consumers for one system over another, despite the fact that plasticulture was later in its season than the other systems. Due to the shorter harvest period in 2004, only 3 harvests were conducted where volunteers were surveyed. In 2004, survey participants showed a preference for advanced matted row above either of the other systems. The plasticulture system had advantages of larger fruit size and a slightly earlier crop in 2003, but those advantages were not present in 2004. Many consumers who preferred the advanced matted row cited fruit quality, quantity of berries, and ease of harvest as reasons for their choice. Fruit samples were collected to compare fruit quality characteristics such as firmness, soluble solids, and titrable acidity. Analysis of these data is currently underway.

Combining the results of the two years, the plasticulture remained the most popular system. The plasticulture would seem to offer benefits to growers looking to get an early start to the season, but was rated comparable to the advanced matted row later in the season. The conventional matted row system was clearly the least preferred of the three, with many consumers citing the difficulty in finding fruit and of bending over further to reach the plants in the flat beds as negative factors.

At this stage of the project, it appears that both the plasticulture and advanced matted row systems offer advantages over the conventional matted row in both customer acceptance and environmental impacts. How these advantages weigh against the higher yields of the conventional matted row system, will be addressed by aspects of this study that are not yet complete.

The final report on this project will be submitted in May 2005 as a M.S. thesis by Matthew Stevens, a University of Maryland graduate student.

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TABLES AND FIGURES

Table 1. Comparison of harvest data among conventional matted row, advanced matted row and plasticulture. Marketable yield represents total amount of marketable fruit harvested in kg/ha. Fruit size is weight of fruit in g averaged over harvests. Percentage of Unmarketable Fruit represents the percentage of fruit not suitable for harvest, averaged over harvest dates. There were 8 total harvests in 2003, and 6 in 2004. (1000 lbs/acre = 1121 kg/ha)

Treatment	Marketable Yield (lbs/acre)	Mean Fruit Size (g)	Unmarketable Fruit (%)
		2003	
Conventional Matted Row	19,500a[z]	18.3a	33.1a
Advanced Matted Row	14,800b	16.8a	32.0ab
Plasticulture	13,200b	22.9b	21.4b
		2004	
Conventional Matted Row	11,200a	11.9a	23.9a
Advanced Matted Row	10,100a	11.0a	25.9ab
Plasticulture	6,800b	11.0a	32.5b

[z]Means followed by different letters are significantly different at 5% level

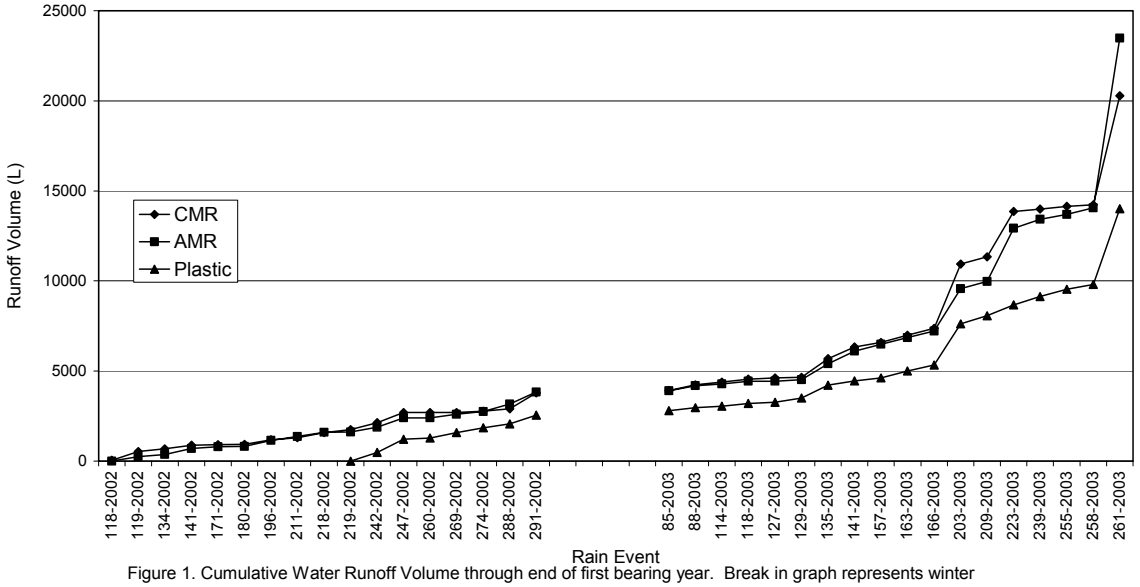

Figure 1. Cumulative Water Runoff Volume through end of first bearing year. Break in graph represents winter months when sampling was not performed. Straw covered the plants at this time and was moved in between rows in March 2003

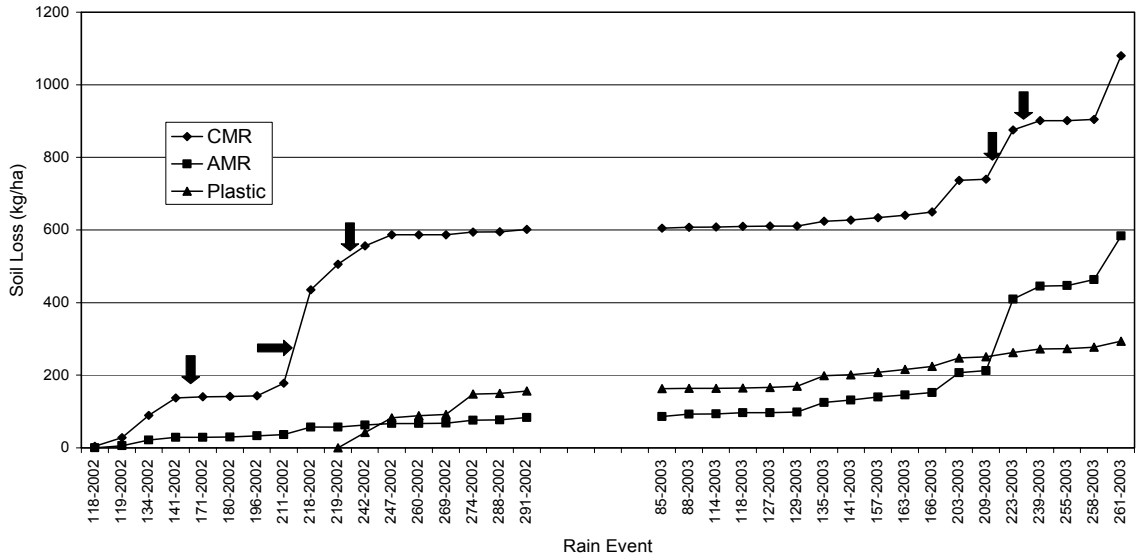

Figure 2. Cumulative Soil Loss through end of first bearing year. Break in graph represents winter months when sampling was not performed. Straw covered the plants and was moved in between the rows in March 2003. Arrows represent cultivation dates

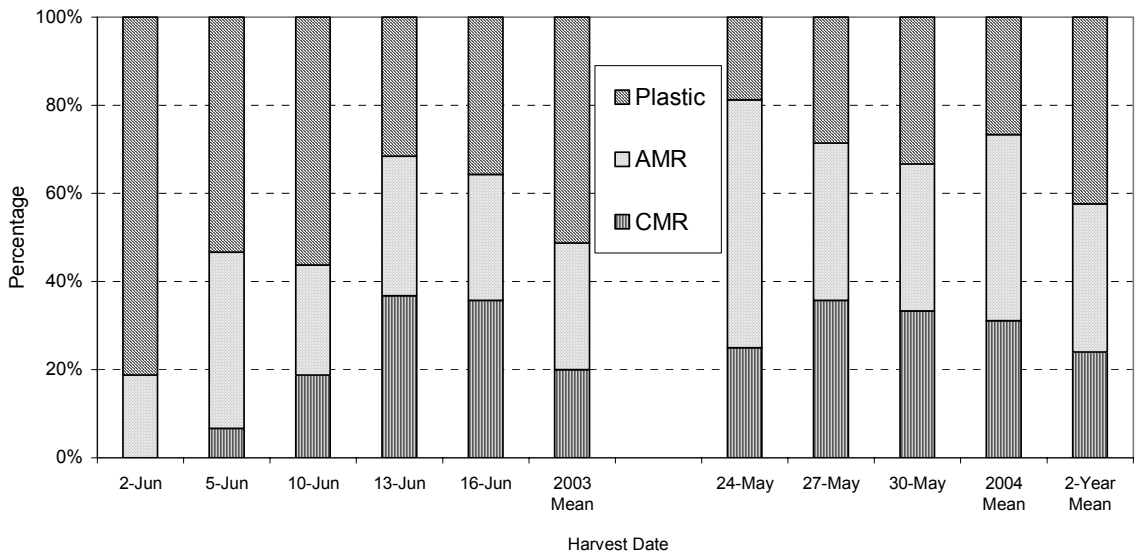

Figure 3. Consumer preference of strawberry production systems. Consumers were asked which system they would most like to pick from again. Responses are shown as a percentage of the total number of surveyed consumers for each harvest date.