Strawberry fruit production and quality under conventional, integrated and organic management.

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Abstract

The aim of the present research was to study the effects of strawberry (*Fragaria x ananassa* Duch) farm management (organic, conventional, and integrated) on fruit quality. Under the organic and integrated production system, the soil was supplemented with two organic amendments and was also inoculated with nitrogen fixing bacteria of the genus Azospirrillum and Azotobacter, right after planting. Plants were grown in pots in a glasshouse for a period of seven months. Fertilization begun two weeks after planting and the three farm managements were distinguished by the use of only chemical fertilizers (conventional), only organic ones (organic) or combination of the two former types of fertilizers (integrated), along with the prohibition (organic) or not (integrated, conventional) of pesticides. Two samplings took place; each one lasted approximately one month. During each sampling event the fruit weight, diameter, length, dry weight, color, firmness, titratable acidity, total soluble sugars and pH along with the antioxidant capacity of the juice (according to DPPH and FRAP assays) were measured. Based on the statistical analysis, there were not any significant differences between the three farming systems concerning pH, titratable acidity, firmness, color parameters, fruit diameter and length as well as mean fruit weight. Organically and integrated produced fruits presented higher values of total soluble solids. There was not any significant difference observed concerning the antioxidant capacity of the juice based on the DPPH assay, but FRAP assay revealed significant differences, as the integrated farm management resulted in significantly lower ferric reducing power of the juice produced, compared to the conventional and organic farm management. Fruit production was significantly higher under integrated farming system, while both organic and integrated farm managements resulted in the higher weight of fruits classified in Extra category. In conclusion, integrated management system resulted in the higher yield of high quality fruits.

INTRODUCTION

Epidemiological evidence suggests that consumption of fruit and vegetables reduces the risk of cancer, degenerative and cardiovascular diseases, potentially through the biological actions of phytochemicals such as vitamin C, flavonoids and carotenoids (Valavanidis et al., 2009). Strawberry consumption appears to be associated with such reduction in those diseases through the phytochemicals found in these fruits, and especially anthocyanins. Organic agriculture is one of the fastest developing sectors in agricultural industry. With respect to product quality, surveys indicate that consumers consider organic foods to be more beneficial to both human health and environment, and with better flavour than their conventionally-integrated grown counterparts (Valavanidis et al., 2009). However, consumers' expectations and beliefs must be properly confirmed by more scientific studies. The aim of the present experiment was to compare strawberry fruit quality produced under three different farm managements, thus under conventional, integrated and organic farm management.

MATERIALS AND METHODS

Commercial fresh strawberry plants cv. Camarosa were planted in a glasshouse in 5L plastic pots filled with a substrate comprised from orchard soil, peat and perlite at a ratio 5:1:2 in late October. At planting, the plants of organic and integrated management were treated with the commercial organic soil amendments Guanito (6-15-3 plus 2 MgO) and Sicobio (6-8-15 + 3 MgO) while right after planting the same plants were inoculated with nitrogen fixing bacteria, by the commercial formulation Azospir (*Azospirillum* sp and *Azotobacter* sp.). Further fertilization took place in all treatments two weeks after planting. Plants of the conventional and integrated management were fertilized with a water soluble fertilizer in the form of 21-21-21 (N-P-K) along with iron chelate (Fe-EDDHA). Plants of integrated as well as those of organic management were further fertilized with the commercial organic soil amendment Activit (3.6-2.8-2.2 plus 1.5MgO). This fertilization program continued till the end of the trial (late May) at 15-20 days intervals. In overall, the three farm managements were distinguished by the use of only chemical fertilizers (conventional), only organic ones (organic) or combination of the two former types of fertilizers (integrated), along with the prohibition (organic) or not (integrated, conventional) of pesticides. Two fruit samplings took place, each one lasting approximately one month, in order to evaluate fruit fresh and dry weight, diameter, length and firmness, total soluble solids (TSS), pH and total acidity (TA) of the juice, fruit color and antioxidant capacity of the juice, by 1.1-diphenyl-2-picrylhydrazyl (DPPH) discoloration assay and by the ferric reducing power (FRAP) assay. Based on the European Community legislation (843/2002) on the strawberry fruit trade, the overall fruit production per treatment was classified into two categories (based on fruit diameter), i.e. "Extra", fruits with diameter above 25mm and "I and II" for fruits with diameter at least 18mm.

RESULTS

Fruit quality characteristics were similar between the three management systems (Table 1). The mean fruit weight did not exhibit significant differences between the different managements, although under conventional management fruits presented higher weight. The mean diameter as well as the mean length and their ratio was similar under all managements. The ratio of fresh to dry weight, although lower under integrated management did not present significant differences. The same stood for fruit firmness too. Juice quality characteristics (pH, titratable acidity and the ratio total soluble solids to titratable acidity) were similar under the three management types, while TSS was higher in juice of fruits produced under integrated and organic management (Table 2). Significant differences were recorded concerning the overall yield per plot (Table 3). Plants grown under integrated management produced the highest yield, and almost double that produced under conventional management. The entire production of conventional management was graded at Extra quality fruits, but the weight of these fruits was significantly lower than that achieved under integrated management. The color of fruits did not exhibit significant differences between management types, based on L, Hue and Chroma indexes (Table 4). The antioxidant capacity of the juice was similar under all management types when this was expressed by the DPPH assay, while when this was expressed by the FRAP assay it resulted in significant differences (Fig. 1). Integrated produced fruits presented the lowest antioxidant capacity while the highest was recorded in organically produced juice.

Table 1. Effect of farm management on strawberry fruit quality characteristics.

Farm management	Fruit quality characteristics					
	Mean weight (g)	Mean diameter (mm)	Mean length (mm)	Diameter /length	FW/DW	Firmness (N)
Conventional	18.2 a	32.41 a	40.9 a	0.8 a	13.5 a	4.22 a
Integrated	15.6 a	30.67 a	36.4 a	0.84 a	11.7 a	3.67 a
Organic	16.2 a	31.47 a	38.1 a	0.83 a	13.5 a	4.07 a

Means within the same column followed by the same letter do not differ significantly based on Tukey's HSD test, on α=0.05.

Table 2. Effect of farm management on strawberry juice quality characteristics.

Farm management	Quality characteristics			
	pH	TSS	TA	TSS:TA
Conventional	3.58 a	6.34 b	0.75 a	8.64 a
Integrated	3.6 a	7.5 a	0.91 a	8.42 a
Organic	3.47 a	7.08 a	0.89 a	8.13 a

Means within the same column followed by the same letter do not differ significantly based on Tukey's HSD test, on α=0.05.

Table 3. Effect of farm management on strawberry yield.

Farm management	Yield parameters		
	Mean plot weight (g)	Extra category fruits (%)	Extra category fruit weight (g)
Conventional	1265.1 b	100 a	1265.1 b
Integrated	2102.1 a	85.4 b	1796.1 a
Organic	1569.7 b	93.1 ab	1460.9 ab

Means within the same column followed by the same letter do not differ significantly based on Tukey's HSD test, on α=0.05.

Table 4. Effect of farm management on strawberry fruit color.

Farm management	Color parameters		
	L	Chroma	Hue
Conventional	35.2 a	40.5 a	27.6 a
Integrated	34.3 a	38.9 a	28.3 a
Organic	34.8 a	39.6 a	29.2 a

Means within the same column followed by the same letter do not differ significantly based on Tukey's HSD test, on α=0.05.

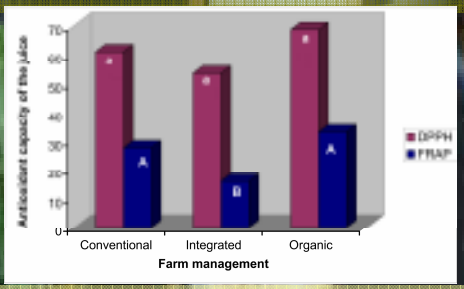

Figure 1. Antioxidant capacity of the juice measured by DPPH (% inhibition compared to control) and FRAP (mM Trolox equivalents ml^{-1} juice) assays.

DISCUSSION

The farm management influenced neither the fruit weight nor its dimensions. It seems that the influence of genotype is stronger than that of farm management. Several studies have shown that organic fruits may be larger in size but smaller ones have also been recorded (Peck et al. 2006). On the other hand, the total fruit production under integrated management was significantly higher than those under organic and conventional ones, which could be ascribed to the more efficient plant nutrition through the combination of chemical and organic fertilizers.

The quality characteristics of the juice were similar between the farm managements except that of total soluble solids, where the conventional management resulted in lower values. Similar results have been reported by Cayuela et al. (1997). The color of the fruits was not influenced by the farm management, as it seems to be a characteristic of the genotype which is less sensitive to agricultural management techniques. On the other hand though, the antioxidant capacity expressed as ferric reducing power was found to be higher in organic fruits. There are numerous reports where organically produced strawberry fruits have been found to contain higher concentrations of phytochemicals which contribute to antioxidant capacity, such as phenolic compounds and ascorbic acid (Hakkinen and Torronen 2000; Olsson et al. 2006). In conclusion, it seems that all farm managements resulted in satisfactory fruit production, with integrated management producing more strawberry fruits of high quality, while organically produced fruits exhibited slightly higher antioxidant capacity.

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