On-farm influence of production patterns on total polyphenol content in peach

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Abstract

Peach production in France is constantly confronted with marketing problems due to a decrease in fruit consumption and increasing competition with neighbouring Mediterranean countries. The production of higher quality products using production methods such as organic farming (OF) appears to be a tangible way of differentiating and enhancing peach production. To test this hypothesis, an on-farm study was conducted in one of the major production areas in South-eastern France. Focussing on the peach cultivar, cv. Spring Lady®, paired comparisons were conducted between plots in OF and conventional farming (CF). Farmers' practices were identified and checked against crop measurements and performances (yield, sugar content, size classes) in 2004 (12 plots) and in 2005 (10 plots). Polyphenol contents were assessed as an additional component of fruit quality, using the Folin-Ciocalteu colorimetric method. Organic peaches have a higher polyphenol content at harvest. Contents were 4.8 times higher in 2004, whereas the same phenomenon was not observed in 2005. Levels of nitrogen, yield and tree vigour management appeared to be the key elements responsible for the synthesis of total polyphenols and sugar content This implies new opportunities for improving the nutritional quality of peaches, based on production methods.

Introduction

French peach production is facing an economic crisis due to increased competition with other Mediterranean countries, higher labour costs, emerging pests and diseases and a decrease in fruit consumption. Can organic and low-input farming and food production methods contribute to the improvement of this situation by bettering fruit quality? To answer this question, we focussed our study on one of the major areas of peach production in France. We analysed the relationships between farmers' practices and crop performance. Although organic products have become increasingly popular with consumers, references to the health value of organic fresh fruits are scarce and remain to be clarified . Carbonaro & Mattera (2001) observed a higher level of polyphenols in OF peaches, but did not explain the results in agronomical terms. It is hoped that this study will shed some light on this issue.

After introducing the research protocol and subsequent measurements, we compare technical management and agronomic performances of the two production patterns, organic (OF) and conventional farming (CF), in this paper. In addition to discussing specifications specifications, we analyse relationships between annual nitrogen applications, tree vigour and crop performances assessed on the basis of yield and

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fruit quality (polyphenols and sugar content). Finally, we discuss these results in relation to low-input food and farming systems.

Material and methods

A two-year study was conducted (2004 and 2005) in commercial peach orchards located in the middle Rhône Valley (France). Individual fields were selected on the basis of paired comparisons whenever possible: for a given cultivar, an organic plot was located close to a conventional plot with similar soil and climate conditions. Organic orchards conformed to specifications and were third-party certified (EU regulation 2092/91). The study was implemented on 12 plots cultivated with Spring Lady® (an early cultivar of yellow peach) in 2004 (four in OF and eight in CF), and on ten plots in 2005 (five OF and five CF). This protocol was adjusted in 2005 in order to have paired plots (with similar site conditions in OF and CF); as a result, three plots were added (one in OF and two in CF). Fertilisation and irrigation practices were recorded on the basis of data provided by farmers and then complemented with interviews. In each plot, a sample area including six adjacent trees was pre-determined during winter in order to measure fruit load, vegetative growth and yield per tree. The distribution of fruit sizes - namely the percentage of grade A-plus fruit (≥ 67 mm diameter) - and fruit quality components were also assessed for these trees. Fruits were harvested during several operations whose scheduling was determined by the producer. A random sample of 30 fruits from the main fruit-size class was collected for lab analyses from the fruits of these six trees picked by seasonal workers. In addition to classical measurements on fruit quality, polyphenol contents were also evaluated. Total Soluble Solid Content (SSC, °Brix) and firmness were measured on all collected fruits with the automatic lab unit "Pimprenelle" within two days after harvest. Total polyphenols were determined during the second harvest operation on fruit pulp. This operation best represents peach production patterns and crop development conditions. The method used was that of Folin-Ciocalteu, as proposed by Georgé et al. (2005), and results were expressed in mg EGA/100g DM (EAG = Equivalent Gallic Acid and DM = Dry Matter). Between harvest and analysis, fruits were stored at –30°Celsius. Hydric and N status were determined in 2005 by measuring peach leaf hydric potential before harvest and foliar analysis 105 days after full bloom. To compare patterns features the Wilcoxon-Mann-Whitney non-parametric test (with a 5% threshold) was used and we used Principal Component Analysis (PCA) to analyse the relationship between levels of intensification and fruit quality.

Results

Input management was compared among production patterns (Table 1).

Table 1: Average levels of N fertilisation and irrigation. Indicators of nutritional status and number of shoots on Spring Lady® (2004-2005)

Pattern	Farm plot	Irrigation water amount (m3.ha-1)	Leaf hydric potential (2005, Mpa)	N supply (kg.ha-1)	N foliar content (2005, g per100 g DM)	Sucker (number per tree)
OF	9	3189	3.9	58.2	2.8	12.4
CF	13	3380	3.2	80.9	2.8	22.8

Nitrogen fertilisation and water irrigation levels tend to be lower in OF (non-significant differences). The number of suckers in the canopy exhibits a lower vigour in OF orchards, which can be attributed to lower input levels. OF yields are half of those in CF (13.8 T/ha versus 27.7 T/ha) and fruit sizes are also smaller (Table 2). Trees in OF have a limited productive potential, due to a lower initial number of shoots per tree (40.0% less shoots and 41.7% less fruits than in CF).

Table 2: Production and fruit polyphenol contents on Spring Lady® for each production pattern (2004-2005)

Pattern	Shoot beaming (number per tree)		Fruit load (nb per tree)		Yield (T/ha)		% of fruits size >A		SSC (RI in °Brix)		Polyphenol content (mg/100 g EAG)	
OF	77.6	*	252.2	*	13.8	*	27.4	*	8.9	ns	100.7	ns
CF	129.3	*	432.6	*	27.7	*	47.2	*	8.6	ns	68.9	ns

* significant for P<0.05

Taking both a positive correlation between fruit size and their sugar content (Génard, 1992) into account, and a trend for higher sugar content with small fruit sizes, we consider that OF fruits have a higher sugar content than CF-derived fruits. Although harvesting periods differ among farmers, firmness is similar between the two patterns (3.1 kg/cm^2 in OF and 3.2 in CF). Significantly lower yields in OF result from lower tree vigour due to competition with grass cover and lower input levels. The number of shoots bearing fruits and fruit load are therefore reduced. Generally speaking, our results confirm established facts and allow us to partially differentiate the two production patterns.

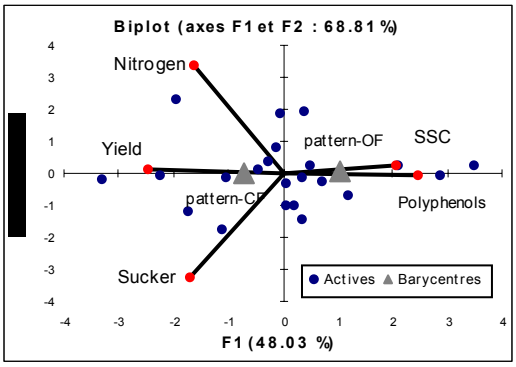

Figure 1: PCA representation on first factorial design with orchard intensification variables (N amount, suckers and yield) and fruit quality variables (SSC and polyphenol content) Biplot (F1 and F2 = 68.81%) F1 (4.8.03%)

Fruit polyphenol contents differ between the two production patterns, based on fresh matter of OF and CF fruits for both cultivars. Organic peaches display higher polyphenol content. The difference is significant for Spring Lady® in 2004 (147 mg EGA/100g DM in OF *vs.* 67.25 mg EAG/100g DM in CF; probability = 1.39%) (Fauriel et al., 2005). There are no significant differences in 2005. Between 2004 and 2005, input levels increased in OF plots, therefore reducing the gap between OF and CF in

terms of polyphenol content. The PCA (Figure 1) represents three variables of orchard intensification (N amount, suckers and yield) as opposed to fruit quality (SSC and polyphenol content). The patterns are illustrative variables. Plots in OF are generally cultivated with low inputs and exhibit higher fruit polyphenol content.

Discussion

The influence of the form and amount of fertilisers on polyphenol content has been demonstrated by several authors (Radi et al., 2003), and partly confirmed by our study.

In addition to the positive effects of organic production on nutritional quality and taste (ensuring higher sugar and polyphenol contents, no pesticide residues), the OF production pattern also results in less labour input (for pruning, thinning, harvesting) due to lower tree vigour. Conversely, orchards with low input levels, annual growth and yields are favourable to the synthesis of polyphenols. This may also be the case for low-input production patterns, therefore challenging organic fruit production, since no maximum input level is recommended in OF (except for copper utilisation), in keeping with the conventionalisation thesis (Guthman, 2000). Since the profitability of organic fruit production is at issue, organic producers tend to increase their production objectives and competitiveness, while adopting conventional technical management techniques. This could be detrimental to fruit nutritional quality and increase environmental risks as a result of increased inputs. Only the plots with sustained low-input practices would maintain a high polyphenol content.

Conclusion

As compared with conventional orchards, organic orchards exhibit differences both in harvest performances (yield, fruit size, °Brix, polyphenol content) and input management. Production levels are lower in OF orchards. Even if they generate higher quality fruits, this raises the problem of profitability in OF orchards when quality is not valued on the market. The relationship between production patterns and polyphenol content depends on management practices. An organic low-input production pattern would exceed current EU regulation standards and strike a balance between economic and environmental concerns.

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