Durum wheat in olive orchard: more income for the farmers?

Anne Panozzo, Dominique Desclaux

DURUM WHEAT IN OLIVE ORCHARD: MORE INCOME FOR THE FARMERS?

Panozzo A[1], Desclaux D[1*]

(1) DiaScope- Inra–Domaine de Melgueil-34130 Mauguio, France

*Corresponding author: dominique.desclaux@inra.fr

Abstract

The present study arises from the difficult sustainability of organic olive orchards in Mediterranean areas that present usually a low productivity. Literature provides examples of increased olive productivity when associated to understorey crops but mainly cover crops. This study highlights that, (i) it is possible to grow field crops in an abandoned olive orchard without ploughing to avoid olive root damages, (ii) agroforestry can improve the olive orchard profitability by implementing a crop rotation based on durum wheat and legumes. Since they are yearly pruned, Olive trees increased progressively their productivity and the associated durum wheat provides an additional source of income to the farmer. Furthermore, if durum wheat varieties adapted to agroforestry conditions would be provided by breeders, they could reach higher yield when associated with olives and thus increasing the orchard sustainability.

Keywords: agroforestry; oil market, breeding; sustainability

Introduction

Olives and olive oil are the key basis in the healthy Mediterranean diet and the demand is increasing for such products coming from sustainable and organic farming (Afidol 2015). Most often organic orchards are zero input ancient orchards located in extensive hilly and mountainous areas susceptible to soil erosion (Taguas et al. 2010). These low-density olive orchards present a low productivity and therefore are progressively abandoned (as described in the EU Olivero project: Duarte et al. 2008). High-density olive orchards have been spreading over flat Mediterranean regions in order to get advantages from fertile lands and better condition for agricultural practices (Pastor et al. 2007). But, they usually need the use of chemical treatments and are therefore not totally compatible with the organic regulation. Moreover, despite the increasing production, this system does not always ensure better farm profitability because of the increasing volatility of olive oil market prices and because of the fruit-bearing alternance.

Traditional or high-yielding Olive orchards present most often large space between tree rows (5m to 9m). To face the above issues and also the growing needs for (i) arable land use optimization, (ii) sun radiation use maximisation and (iii) erosion limitation, sowing an associated crop in the olive tree inter-rows could be a relevant solution. As organic durum wheat and chickpea are also typical Mediterranean crops, cultivated over the same environmental conditions than olive trees, they represent interesting alternatives to be the associated crops. The aim of this paper is to answer the following questions: (i) Is-it possible to grow field crops in an abandoned olive orchard without ploughing to avoid olive root damages? (ii) What is the impact on the olives production? (iii) May this agroforestry system produce additional income for farmers?

Materials and methods

Experimental design

The olive orchard, located at INRA station DiaScope in Mauguio, France (43º35'N, 3º45'E), was planted in 2002 in a 6 x 6m design (Figure 1- left). The olive trees CV. Picholine) have never been pruned neither treated until the year 2012 when the orchard has been officially converted into organic. Then trees were seriously pruned for the first time to reconstruct the canopy structure. From 2014 to 2017 trees have been yearly pruned during the spring period and olives have been hand-harvested at the beginning of November each year.

A part of this orchard was in association with durum wheat or legumes (Agroforestry treatment) (Figure 1- left) and another part was covered by natural grasses ("forest" control), as the soil has never been ploughed neither drilled.

Crop association management

From October 2014 to 2017, 25 varieties of durum wheat have been sown in an annual rotation with legumes (chickpea, fababean, forage mix) between olive trees rows (Figure 1-right, yellow parts) just after olive fruit harvest. The soil was drilled only in the first 10 cm followed by a rotary harrow passage. Weeds were controlled with a rotary hoe during early season. By respecting organic regulation, no treatment has been done to the crop and the tree for the whole period, neither protection neither fertilization products were added. Wheat plots have been sown annually during autumn (November /December) and harvested at the end of June. The straws were grounded in September and incorporated into the soil.

Each year and for each tree, the total amount of olive was weighed, the number of olives fallen on the soil surface was estimated visually and samples of 100 counted olives were weighed.

Figure 1: Olive tree orchard (google earth capture – left photo) and same orchard with durum wheat crop associated (right photo). Left photo legend: yellow areas = agroforestry (AF) treatment; green areas = "Forest" control.

Economic impact of association

Profitability of introducing durum wheat crop cultivation into an organic olive orchard has been evaluated. The economic analysis has been carried on for the two components of the system: additional income given by durum wheat selling and olive trees productivity.

The gross profit of durum wheat production was calculated by multiplying the average yield of the 25 genotypes with the average (2014-2017 period) organic durum wheat selling prices in the South of France. Direct profit has been deduced by eliminating the production charges. It was compared with the average yield reached in the open-field control. Concerning the olive production, the average yield registered in some zone of the yellow part (AF treatment as shown in fig.1) was compared with those registered in some zones showing same fertility level in the green part (natural grass – Forest control). The price references used in the analysis arises from South of France organic olive market (MarketOlea 2016).

Results and discussion

Impact on olive production

The olive orchard showed a heterogeneous production according to space and time. In 2014, while intercropping (AF) was not yet implemented, olive production was highly variable between rows (from 220 g for row A to 1416 g for row H) and generally very low. Two zones showing differentiated olives productivity in 2014 were highlighted (Figure 2) and their evolutions over time were compared according to the treatment (Agroforestry or "Forest" control) (Table 1).

A	B	C	D	E	F	G	H
P71	P30	P08	P35	P35	P21	P28	P28
P71	P71	P18	P28	P21	P49	P18	P21
P71	P30	P28	P35	P49	P30	P30	P18
P08	P18	P08	P35	P21	P28	P21	P35
P18	P21	P18	P28	P49	P08	P30	P08
P08	P71	P28	P71	P71	X	P66	P35
P18	P28	P30	P66	P30	P08	P18	P66
P71	P49	P21	P71	P21	P66	P30	P49
P49	P35	P71	P66	P49	P30	P49	P35
P49	X	X	P35	P30	P66	P18	P35
P08	P21	P18	X	P28	P08		

Legend
Initial average productivity
Low (400 g/tree)
High(700 g/tree)
Inter-row management
Agroforestry
"Forest" control

Figure 2: Zones of fertility on the olive tree orchard determined in 2014 by weighing olive production tree per tree.

Considering the low fertility zones, the agroforestry zones reached a higher olive fruits yield in 2017 than the grassed zones (Forest control). However, in the high fertility zones, no difference was noticed. The average increase of productivity over the 2014-2017 period was + 393% when crop is associated and +294% in the grassed zones.

Table 1: Evolution of the olive trees productivity, according to the fertility zones and to the treatment.

Fertility Zones		**Yield of olive tree, g (mean)**				**Increasing yield, % (2014/2017)**
Productivity level (in 2014)	Treatment	2014	2015	2016	2017	
Low	Agroforestry	385 a	2673 a	3114 a	19987 a	+ 503 a
Low	Forest control	425 a	1585 b	1770 b	7605 b	+ 304 b
High	Agroforestry	671 a	1822 a	3208 a	12494 a	+ 282 a
High	Forest control	762 a	1791 a	2976 a	13494 a	+ 285 a

The weight of 100 olives decreased from 2015 to 2017, while the yield increased. In association with durum wheat, the weight of 100 olives went from 481 g in 2015 to 263 g in 2017, and a similar decrease is noted on the grasses zones: 457 g/100 olives in 2015 and 300 g/100 olives in 2017.

Economic impact of agroforestry

- **Organic olive orchard**

In high fertility zones, Olive production was not reduced by crop association. And in low fertility zones, a difference of 25% was noticed between the yield increase in agroforestry treatment and in forest control. A farmer can expect at least the same production or in some cases get an additional income (until 1250 €/ha) when intercropping an associated crop in the olive orchard.

Yield organic Picholine olive orchard t/ha	**Additional Yield in organic agroforestry** t/ha	**Olive oil from additional productivity** litres	**Organic olive oil market price** euros per litre	**Additional gross profit** euros/ha
4-10	**1-2.5**	**100-250**	**5€**	**500-1250€**
Average Yield obtained in non-irrigated or irrigated conditions in the South of France territory (Afidol 2015)	25% of increasing yield compared to control (our results period 2014-2017)	Additional litres produced (10 kg Picholine olives = 1 litre of olive oil) (Afidol 2015)		Yield x market price

- **Organic durum wheat**

Economic profitability arising from durum wheat in agroforestry system

Yield in organic full sun t/ha	**Yield in organic agroforestry** t/ha	**Organic durum wheat price** euros per ton	**Gross profit** euros/ha	**Production costs** euros/ha	**Direct profit** euros/ha
1.8	**1**	**390 €**	**390 €**	**260 €**	**130 €**
Average Yield of the 25 varieties grown as sole crop (2015-2017)	Average yield of the 25 varieties grown in agroforestry (2015- 2017) 44% of reduction comparing to full sun	335-445 €/ton Average price (2014/2017) revenuagricole.fr	Yield x price	130 €/ton inputs 130 €/ton mechanical operations threshold cost to be competitive (Arvalis 2013)	(= Gross profit- Production costs)

The yield of durum wheat cultivated between olive tree rows was estimated at 1t/ha, showing a reduction (44%) compared to sole durum wheat grown in full sun conditions. The production costs and the market prices come from local references in organic farming context. A direct profit of 130€/ha may be reached thanks to the durum wheat association. This estimation doesn't integrate the other crops of the rotation and the eventual need of workforce, and considers a level of yield reduction equal to 44%. But this reduction can be lower according to the choice of the durum wheat genotypes (less than 7% of reduction with agroforestry-adapted cvs) (Desclaux et al. 2016), and therefore the farmer may obtain higher income.

Finally, by adding the profitability arising from the additional olive tree productivity (500 to 1250 €/ha) and from the organic durum wheat sold (130 € per hectare, not considering the ground space hosting olive tree rows), we can estimate a potential adding profitability coming from the whole agroforestry system between 630 and 1380 €/h.

Conclusion

The present study arises from the difficult sustainability of organic olive orchards in Mediterranean areas, usually mainly associated to low productivity. Literature provides examples of increasing olive productivity when associated to understorey crops but mainly cover crops (Martínez Raya et al. in 2006; Correia et al. 2015). This study highlights that, by

implementing a crop rotation based on durum wheat and legumes, agroforestry can improve the olive orchard profitability. Since they are yearly pruned, Olive trees increased progressively their productivity and the associated durum wheat provides an additional source of income to the farmer. Furthermore, if durum wheat varieties adapted to agroforestry conditions would be provided by breeders, they could reach higher yield when associated with olives and thus increasing the orchard sustainability.

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