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Sunflower under conventional and organic farming systems : results from a long term experiment in Central Italy

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Summary

Sunflower productivity under organic and conventional agricultural systems was studied between 2002 and 2004 in the frame of the MASCOT experiment (Mediterranean Arable Systems COmparison Trial), established in 2001. The aim was to compare organic and conventional management systems for a typical arable crop rotation of Central Italy in the long-term. Sunflower was cultivated as a part of a five-year stockless arable crop rotation (sugar beet-common wheat-sunflower-pigeon bean-durum wheat). In the organic system, red clover (*Trifolium pratense*) is interseeded in common and durum wheat and used as a green manure for sunflower or sugar beet. Grain yield of organically-grown sunflower was lower by 41%, 17% and 44% in 2002, 2003 and 2004 respectively, but no significant differences in percent seed oil content were found between the conventional and organic sunflower in two years out of three.

Key words: Long-term system experiment, organic sunflower, MASCOT.

Introduction

In terms of agricultural land cultivated organically, Italy is the third country in the world and the first in Europe. Despite the great interest of both Italian growers and consumers in organic agriculture, organic farming research in Italy has, so far, been very fragmented and has seen very little commitment from the public sector. As a consequence there is a shortage of technical information about the management of vegetable and arable crops to disseminate to organic farmers. In Central Italy, characterised by clayey soils and dry summers, sunflower is often the most important summer crop both in conventional and organic farms, where it represents the main cash crop in several common crop rotations.

Due to its deep rooting system, sunflower is able to use natural resources such as soil moisture and soil nitrogen better than other species (e.g. maize and soyabean). For these reasons and for the high quality of its residues and its competitiveness against weeds, sunflower could represent a good opportunity in organic farming systems.

The aim of this study was to evaluate the effects of conventional vs organic cultivation on yield and grain quality of sunflower grown in the MASCOT long-term experiment (Bàrberi &

Mazzoncini, 2006) in the years 2002 to 2004.

Materials and Methods

The MASCOT experiment (Mediterranean Arable Systems COmparison Trial) was established in 2001 at the Interdepartmental Centre for Agro-environmental Research "Enrico Avanzi" (CIRAA) of the University of Pisa. CIRAA is located on the northern coast of Tuscany, 8 km SW of Pisa and 1 km E of the Tyrrhenian sea on the southern side of the Arno river (lat. 42°41' N, long. 10°23' E) and it is included within the borders of the Migliarino-San Rossore-Massaciuccoli Regional Natural Park.

Within MASCOT, sunflower was cultivated as a part of a five-year stockless arable crop rotation (sugar beet-common wheat-sunflower-pigeon bean-durum wheat) comparing a conventional and an organic management system. Systems are replicated three times according to a Randomized Complete Block design, each experimental plot having a field size of 0.35 to 1 ha. In the organic system, red clover (*Trifolium pratense*) was interseeded in common and durum wheat and used as a green manure for sunflower or sugar beet. The MASCOT experiment was established on loamy soil, whose main characteristics are reported in Table 1.

Table 1. *Average soil characteristics measured at the beginning of the MASCOT experiment*

	Soil layer (cm)	
	0 to 15	15 to 30
Sand (%)	43.7	43.5
Silt (%)	33.3	33.8
Clay (%)	23.0	22.7
pH	8.47	8.40
Organic matter (%) (1)	1.62	1.60
Total nitrogen (%) (2)	0.11	0.11
Assimilable phosphorus (ppm) (3)	12.9	13.7
Field capacity (% dry weight)	26.5	
Wilting point (% dry weight)	11.5	

(1)Walkley-Black method; (2) Kjeldahl method; (3) Olsen method

Climatic conditions are typical of Mediterranean areas. Mean monthly air temperature varies from 11°C in February to 30°C in August. Rainfall is mainly concentrated in autumn (October-November) and spring (March-April). In the last 20 years, mean total rainfall ranged from 550 to 1180 mm $year^{-1}$. Due to elevated air temperatures, potential evapotranspiration is generally high in late spring and summer (up to 6-7 mm day^{-1}). As a consequence, summer soil water deficit (from 120 to 150 mm $month^{-1}$) normally occurs. However, crops and natural vegetation rarely undergo water stress because of the presence of a high water table, whose depth ranges from 40-50 cm in winter to 100-120 cm at the end of the dry season (mid September).

In the organic system, red clover (*Trifolium pratense*) was interseeded by broadcasting into the common and durum wheat crops during cereal tillering stage (February) and was used as a green manure the following spring for sunflower and sugar beet (April), by ploughing its biomass into the soil 1-2 weeks before sunflower or sugar beet sowing. In February 2002, at the beginning of the experiment, *Trifolium pratense* was interseeded into the wheat, but sunflower cultivated in the same year did not receive this green manure treatment because the experiment was in its initial stage. The average quantity of nitrogen supplied by red clover ploughed into the was estimated to

be 161 and 38 kg·ha^{-1} in 2003 and 2004 respectively.

During sunflower seedbed preparation, 30 kg of N, P_2O_5 and K_2O (as organic fertiliser) were incorporated into the soil by harrowing, while 124 kg of N and 96 of P_2O_5 and K_2O were applied under the conventional system as chemical fertiliser. Mechanical weed control was performed in the organic system, whilst both chemical (pre-emergence herbicide application) and mechanical weed control was performed in the conventional system. The sunflower hybrid used was the same in both systems in 2003 and 2004 (Carlos), while in 2002 Carlos was used in the organic system and Ketil in the conventional. In both the conventional and organic systems, the seed rate and the row spacing were the same (7.5 seeds m^{-2} and 50 cm respectively).

Results and Discussion

The conventional system showed an enhanced weed control especially by means of the combined use of chemical and mechanical methods. Use of pre-emergence herbicide application on average resulted in 60% lower total weed density in the conventional than in the organic system (Table 2). Use of mechanical weed control positively affected weed density reducing this by about 50% in both systems (Raffaelli & Peruzzi, 2001). Weed flora composition was characterized mainly by *Anagallis arvensis, Polygonum aviculare, Equisetum arvense, Chenopodium* spp. and *Lolium* spp.

Table 2. *Weed density (plants m^{-2}) recorded in sunflower before (BH) and after (AH) hoeing in the conventional and organic systems in 2002, 2003 and 2004*

	2002		2003		2004	
Systems	BH	AH	BH	AH	BH	AH
Conventional	2.1	2.6	8.1	3.6	10.9	5.7
Organic	12.0	12.9	17.3	9.1	18.6	9.2
Significance	*	*ns*	*ns*	*	*ns*	*ns*

*, ns = significant at $P \leq 0.05$ and not significant respectively

Table 3. *Sunflower yield characters as measured in 2002, 2003 and 2004*

System	Plants (n° m^{-2})	Grain yield dry matter (t ha^{-1})	Crop residue dry matter (t ha^{-1})	Total dry matter (t ha^{-1})	1000 seeds weight (g)
			Year 2002		
Conventional	6.8	5.8	8.2	14.0	60.6
Organic	6.9	3.4	5.6	9.0	44.6
Significance	*ns*	*	*	*	**
			Year 2003		
Conventional	6.2	2.3	4.0	6.3	39.1
Organic	6.2	1.9	3.6	5.5	31.9
Significance	*ns*	*ns*	*ns*	*ns*	*ns*
			Year 2004		
Conventional	4.9	3.9	5.9	9.7	54.5
Organic	5.3	2.2	3.5	5.7	41.0
Significance	*ns*	**	*	*	*ns*

**,*, ns = significant at $P \leq 0.01$, $P \leq 0.05$ and not significant respectively

On average, sunflower biomass yield was 40% lower in the organic than in conventional system (Table 3): these findings confirm previous experimental evidence (Bonnemort, 2001). These differences were mainly due to grain yield (-30 % in the organic system) and crop residues (-41%); as a consequence, total dry matter biomass was lower in the organic system by 41%. These findings suggest that sunflower under organic management was negatively influenced both by the greater weed presence (estimated at the middle of its biological cycle) with respect to the conventional system and by the lower nitrogen availability.

A lower nitrogen concentration in the sunflower plant tissues under the organic system was observed on average with respect to the conventional one (1.62% *vs* 1.39 in 2002; 1.27% *vs* 1.18% in 2003 and 1.38% *vs* 1.24 in 2004). In the organic system, sunflower seeds showed a slightly higher fatty acids content in two years out of three (Table 4). These results could be connected with the different nitrogen supply typical of the two cropping systems (Lotti, 1985). In contrast, the crop management system did not effect fatty acid composition of sunflower oil. This result confirms the earlier findings of Perretti et al. (2004), who showed no significant trends in oil for TAG and FA (triglycerides and fatty acids) composition.

Table 4. *Oil content (%) and fatty acids composition in sunflower in 2002, 2003 and 2004*

Systems	Oil (%)	Fatty acids (g g^{-1} total fatty acids)				
		C16:0	C18:0	C18:1	C18:2	C18:3
		Year 2002				
Conventional	44.1	5.9	2.6	29.8	60.3	1.3
Organic	48.0	6.0	4.0	32.5	55.9	1.6
Significance	*	ns	ns	ns	ns	ns
		Year 2003				
Conventional	46.1	5.6	3.2	39.8	50.3	1.2
Organic	45.8	6.0	3.2	28.9	50.4	1.6
Significance	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
		Year 2004				
Conventional	50.1					
Organic	52.4					
Significance	*ns*					

*, ns = significant at $P \leq 0.05$ and not significant respectively

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References

Bàrberi P, Mazzoncini M. 2006. The MASCOT (Mediterranean Arable Systems Comparison Trial) long-term experiment (Pisa, Italy). In *Long-term Field Experiments in Organic Farming*, pp. 1-14. Eds J. Raupp, C. Pekrun, M. Oltmanns and U. Köpke. Verlag, Berlin (DE): ISOFAR Scientific Series.

Bonnemort C. 2001. Tournesol biologique: avancées techniques dans le domaine de la production agricole. *Alter Agri* **47**:18–20.
Lotti G. 1985. *Principi di chimica e biochimica vegetale.* Vol. II. ETS Pisa.
Perretti G, Finotti E, Adamuccio S, Della Sera R, Montanari L. 2004. Composition of organic and conventionally produced sunflower seed oil. *Journal of the American Oil Chemist's Society* **81**:1119–1123.
Raffaelli M, Peruzzi A, Di Ciolo S. 2001. Controllo meccanico delle infestanti nella coltura del girasole e della soia mediante erpice strigliatore: risultati di due anni di sperimentazione. *Proceeding of A.I.I.A. National Conference "Ingegneria Agraria per lo sviluppo dei paesi del mediterrane"*. Vieste (FG).11–14 Settembre.