Organic Fertilization In A "Tomato – Pea" Rotation In Southern Italy

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Abstract

The use of alternative to mineral fertilizers is an important issue in organic systems. A four-year field experiment to evaluate the effects of organic fertilizers on yield and quality of processing tomato and proteic pea in rotation, was carried out in Southern Italy. The fertilization treatments aimed to supply 100 kg ha^{-1} of N for tomato and 60 kg ha^{-1} of P_2O_5 for pea and were: 1) an organic biological fertilizer (BIO); 2) an experimental compost obtained by olive residues, sludge and straw mixture (COMP); 3) a control managed with traditional chemical fertilizers (ammonium nitrate and perphosphate, MIN). At harvest, the main productive and qualitative parameters were assessed.

Tomato fruit yield did not differ among the fertilization treatments, but unripe fruit yield was higher in the MIN and BIO treatment; MIN showed also smaller fruit than BIO and COMP. The N availability during crop cycle influenced the mean fruit weight and maturity date. No difference among treatments was observed for pea in rotation with tomato and, similarly, on the wheat cropped without fertilization following the two crops.

The possibility to use organic fertilizer for processing tomato and proteic pea has been evaluated and the conclusion is that organic fertilization is comparable to mineral one from a productive and qualitative point of view.

Introduction

Fertilization and, in particular, organic one, is an important key in plant nutrition and especially in organic systems. Alternative to mineral sources of nitrogen and phosphorus have been studied and positive effects have been showed on growth, yield, chemical and physical soil properties (Bouranis et al., 1995; Convertini et al., 2003; Elia et al., 2006**a**). Organic sources such as agricultural and agro-industrial wastes, after processing treatments, could be valuable alternatives in organic systems fertilization. The compost technique can further improve quality of fertilizer product.

The objectives of this research were: 1) to evaluate the effect of different organic fertilizers on yield and quality of processing tomato and proteic pea by comparison with the traditional mineral fertilizer and 2) to study the residual soil fertility effect of repeated applications on the productivity of a following durum wheat crop.

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Materials and methods

A field experiment was carried out in 2002-2006 period at experimental farm of the Institute (Foggia, Southern Italy). The soil was classified as a vertisol of alluvial origin, Aridic Haploxerert (USDA 9th, 2003), fine, mixed, thermic, silty-clay. The climate is "accentuated thermomediterranean" (UNESCO-FAO), with minimum temperatures below 0°C in the winter and maximum above 40°C in the summer. Annual rainfall (average 550 mm) is mostly concentrated during winter months.

A rotation "processing tomato-proteic pea" was fertilized for four years using two organic fertilizers compared to a control, a mineral one. The treatments and the amount of fertilizer were assessed considering nitrogen content for tomato and phosphorus for pea, in order to apply a rate of 100 kg of total N ha^{-1} for tomato and 60 kg of P_2O_5 ha^{-1} for pea. The treatments were: **COMP** = experimental compost derived from olive mill residues and leaves, sludge, straw and orange wastes; **BIO** = biological fertilizer, used in organic agriculture, coming from slaughterhouses wastes (Tab. 1); **MIN** = ammonium nitrate (34.5% of N), broadcasted half before transplanting and half at fruit formation in the first truss for tomato; mineral triple perphosphate (46%) in pre-sowing for pea. A completely randomised block design with four replications and a plot size of 50 m^2 (5 x 10 m) were adopted, with both crops in rotation sown at the same time every year, to minimize yearly variability.

The tomato plantlets (cv. Perfectpeel) were transplanted at the end of April using a density of 3 plants m^{-2} with a twin-row distribution. Irrigation was applied with the drip method. At harvest (August), the tomato fruits were weighed and graded in: 1) mature, 2) overripe and 3) unripe. Total soluble solids (° Brix) and citric acid (%) as qualitative parameters on fruit's juice were also measured. The proteic pea (Aravis, semileafless variety), was sown in December at the density of 100 seeds per m^2. At harvest, plant population, straw and seed yield, protein content were measured. In the 5th year (2005-06), on the same plots a not-fertilized durum wheat (cv. Simeto) crop was sown, and main productive and qualitative parameters at harvest were assessed, with the aim to evaluate residual soil fertility. Data were analysed using ANOVA for the four years, considering the "*year*" as a random effect; mean comparison was performed by using LSD test (SAS Inst., 1987).

Table 1. Main chemical characteristics of fertilizers used in the experiment (averages of four years).

Fertilizer	Fertilization	Total N	P_2O_5	C ($g \cdot kg^{-1}$)	C/N ratio	Amount for tomato ($t\ ha^{-1}$)	Amount for pea ($t\ ha^{-1}$)
		(%)					
Compost	COMP	2.0	3.1	38.3	19	5.0	2.1
Organic biological	BIO (Tomato)	12.7	3.2	48.7	4	0.8	-
Organic biological	BIO (Pea)	4.0	15.0	19.0	5	-	0.4

Results

The statistical analysis showed a not significant "*year x fertilization*" interaction and a "*year*" effect always significant for both crops and examined variables. The yearly variability, due to rainfall, temperature and pests, is not analysed in this paper. Only the results of "*fertilization*" effect are reported and discussed. It resulted significant for unripe fruit yield at tomato harvest, showing a superiority of MIN (for the late N availability) and BIO (for the slow mineralization of N) respects to COMP (Tab. 2). Commercial, overripe and total yield did not differ among treatments, showing the equivalence of organic and mineral fertilizations from a productive point of view. Similarly, important qualitative parameters for processing tomato, soluble solids and citric acid content, resulted the same for the three fertilization scenarios. The fruit weight was the only productive parameter that differed, in the MIN treatment resulted lower than COMP and BIO, probably for an availability of nutrients better in organic than in mineral treatments (Tab. 2). For pea, no fertilization effect has been detected for all the examined variables (Tab. 3). The soil mineral N content did not change after four years of COMP and BIO treatments, but increased in MIN one (from 19.5 to 24.2 mg kg^{-1}) (Rinaldi et al., 2006). This residual fertility due to four years of fertilizers application, did not influence the following durum wheat, neither for productive nor qualitative aspects (Tab. 4).

Table 2. Main productive and qualitative parameters of processing tomato.

Fertilization treatments	Fruit					Total soluble solids (° Brix)	Acidity (% of citric acid
	Mean weight	Total	Mature	Unripe	Overripe		
	(g)	($t\ ha^{-1}$)					
BIO	67.3 a	111.9	91.6	16.5 a	3.8	4.8	0.84
COMP	67.9 a	109.1	94.1	10.9 b	4.1	4.8	0.82
MIN	63.5 b	109.2	89.4	16.2 a	3.6	4.7	0.86

Numbers in column followed by different letters are different at $P < 0.05$ (LSD test).

Table 3. Main productive and qualitative parameters of proteic pea.

Fertilization treatments	Plant population	Straw biomass	Seed yield at 10% moisture	Seed protein content	Protein yield
	($p\ m^{-2}$)	($t\ ha^{-1}$)	($t\ ha^{-1}$)	(%)	($t\ ha^{-1}$)
BIO	57.5	2.7	3.5	31.8	1.10
COMP	59.2	2.9	3.5	32.3	1.13
MIN	56.4	2.7	3.4	31.2	1.06

Discussion

The significant result of unripe fruits, greater for BIO and MIN than COMP, indicated a delayed maturity date explainable for BIO for the slow N mineralization and for MIN for the late N availability with split application, respect to COMP treatment, that released nutrients matching better the plant requirements. This latter treatment, also for the larger amount of material applied to the soil (Tab. 1), showed beneficial effects on the soil hydrological properties, increasing soil water retention capacity (Elia et al., 2006**b**). For pea, the organic fertilization did not modify plant growth and yield and protein accumulation in the seed, for the greater dependence of this processes by nitrogen supply, sufficient in this species for atmospheric N-fixation capability.

Table 4. Main productive and qualitative parameters of durum wheat cropped without fertilization after 4 years of fertilization experiment.

Fertilization treatments	Seed yield at 13% moisture	Volumetric seed weight	Seed protein content	Glutin content
	(t ha^{-1})	(kg hl^{-1})	(%)	(%)
BIO	4.74	81.7	12.93	26.7
COMP	5.09	81.0	12.68	26.2
MIN	5.29	80.1	12.74	26.4

Conclusions

The organic fertilization of a “tomato-pea” rotation has been evaluated during a 4-year field experiment; the results indicated that the pre-sowing application of organic fertilizers and composted materials did not influence negatively fruit yield and quality. In addition, the slow and more regular release of nutrients, the distribution of other nutritive elements other than nitrogen and the single application using organic fertilization can involves several important benefits for tomato crop management. For a N-symbiotic crop like pea, no difference was observed. The first year of evaluation of residual fertility effect resulted not significant, but further years could be necessary to show some effects.

In conclusion, organic fertilization showed to be competitive with mineral for tomato and pea yield; in addition, this type of fertilization should be supported for two reasons: to reuse and dispose vegetal and animal wastes and to maintain or/and increase soil fertility.

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