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Effect of cover crop management and compost application on soil N fertility of organic melon

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Key words: green manure, roller crimper, soil mineral nitrogen, nitrogen budget

Abstract

A field experiment was carried out in Central Italy on growing melon (Cucumis melo L.) after barley (Hordeum vulgare L.). Three different systems of cover crop termination (green manure, roller crimper and fallow, as control) were combined with three doses of compost (0, 15 and 30 t ha^{-1} d.m.) in a strip plot design. The main objective of the research was to evaluate their effects on organic melon production and on soil nitrogen (N) fertility. Marketable yield and quality and soil N availability along the melon cycle were determined and a simplified N budget calculated. Green manure (GM) treatment showed the highest total and marketable yield, followed by fallow (FA), while roller crimper (RC) was characterized by a significant lower yield respect to the other two treatments (45% and 62% of the marketable yield of GM and FA, respectively). Soil N fertility of GM and FA were characterized by N deficit unless combined with compost application at the dose of 15 t ha^{-1} d.m.

Introduction

Soil fertility management in organic farming is mainly based on organic sources of nutrients. Unfortunately, timing of soil mineralization of organic materials and the consequent nutrients availability is often asynchronous respect to plants needs. Cover crops grown for their nutrient value are mainly incorporated into soil as green manure (GM), but there is a wide literature on the benefit of killing cover crops by the use of roller crimper (RC) mainly for weed control also on vegetable production (Canali et al., 2013). However, information about the combined effect of alternative cover crop management strategies and compost application on soil fertility and N availability to vegetable crops are scarce (Montemurro et al., 2013). The main objective of this research was to evaluate the effects of alternative methods of termination of barley (*Hordeum vulgare* L.) combined with different doses of compost, on organic melon (*Cucumis melo* L.) production and on soil N fertility.

Material and methods

The research was carried out at the Monsampolo Vegetable (MOVE) long term experiment, located at the Vegetable Research Unit of the Research Council for Agriculture (CRA-ORA) in Monsampolo del Tronto (AP) (latitude 42° 53' N, longitude 13° 48' E), in Marche Region (Central Italy). The type of soil is a Fluventic Haploxerept, fine silty, mesic (USDA, 2006), with hydric regime xeric. In a strip plot experimental design, melon (*Cucumis melo L.*) was cultivated after barley (*Hordeum vulgare L.*), utilized as cover crop in the rotation. The first factor was barley management and the following treatments were compared: (i) FA: fallow (control), in which barley was not cultivated and soil tilled before melon planting; (ii) GM: green manure, in which, at flowering, barley biomass was chopped and ploughed into the soil and (iii) RC: roller crimper, in which the barley biomass was flattened in order to obtain a natural soil mulching layer made of the barley biomass. The second factor was the compost dose which was applied, on a dry matter basis, as follow: (i) 0 (control), in which compost was not added; (ii) 15; in which compost was applied at the dose of 15 tons d.m. ha^{-1}; (iii) 30; in which compost was applied at the dose of 30 tons d.m. ha^{-1}. Melon was harvested according to fruit ripening. Total yield was calculated as the sum of the different harvest. Marketable and not marketable yield were evaluated according to local market standards. In order to evaluate mineral nitrogen availability to plants, soil samples were collected four times (at 0, 28, 63 and 85 days after transplanting) for soil mineral nitrogen determination. Moreover, a simplified N budget was calculated in order to evaluate either short and long term soil N fertility of compared treatments.

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Results

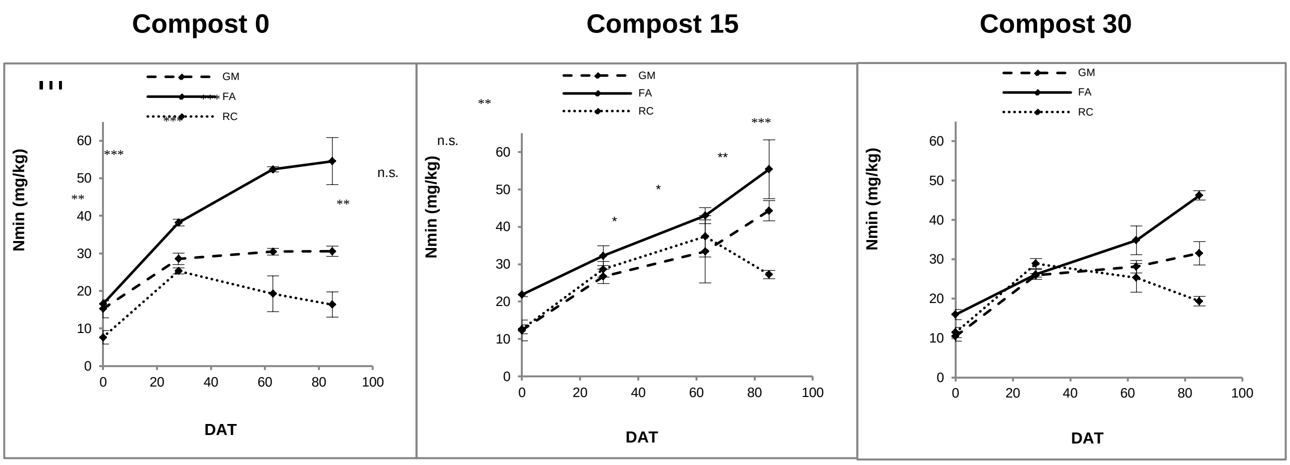
The total and marketable yield are reported in Table 1.

Table 1: Total and marketable yield of melon

	Total				Marketable				Not marketable			
Cover crop management	**kg plant $^{-1}$**		**fruits plant $^{-1}$**		**kg plant $^{-1}$**		**fruits plant $^{-1}$**		**kg plant $^{-1}$**		**fruits plant $^{-1}$**	
GM	4.0	a	3.0	a	3.3	a	2.4	a	0.7	a	0.7	a
FA	2.8	b	2.3	b	2.4	b	1.8	b	0.4	b	0.5	ab
RC	1.6	c	1.6	c	1.5	c	1.4	c	0.1	c	0.2	b
Compost dose												
30	3.0	a	3.5	a	2.5	a	1.8	a	0.6	a	0.7	a
15	3.0	a	2.4	a	2.6	a	2.0	a	0.4	ab	0.4	ab
0	2.0	b	2.0	a	2.1	a	1.7	a	0.3	b	0.3	b

The mean values in each column followed by a different letter are significantly different according to LSD and DMRT (two and more than two comparisons, respectively) at the reported probability level.

GM treatment showed the highest total and marketable yield, followed by FA. RC was characterized by a significant lower yield respect to the other two treatments. The doses of compost showed less evident results, with similar yields for treatments 15 and 30 tons of compost and lower yield for compost dose 0. In Figure 1 (a,b,c) are shown the curves of available soil mineral nitrogen (at different compost doses) during the melon cycle, divided by cover crop management. The FA treatment showed always the highest values followed by GM and RC. Nevertheless, compost dose affected the significance of the differences. As far as the comparison between the two systems of cover crop termination (GM and RC) is concerned, the RC treatment showed the lowest amount of soil available nitrogen at any dose of compost applied.



n.s. = not significant differences; * = P ≤ 0.05; ** = P ≤ 0.01;*** = P ≤ 0.001, according to DMRT. Bars = ± Standard Deviation.

Figure 1: Soil mineral nitrogen (at different doses of compost) during the melon crop cycle, divided by cover crop management

A simplified budget of nitrogen for melon is reported in Table 2.

Table 2: N simplified budget for melon (kg ha^{-1})

			FA			RC			GM		
		Source	0	15	30	0	15	30	0	15	30
Input	**Off farm**	**Min Avail N**	66 b	87 a	64 b	30 e	50 cd	46 d	61bc	49 d	42 d
		Barley	0	0	0	127 b	114 bc	85 c	173 a	105 bc	108bc
	In farm	**Organic fertilizers**	47	47	47	47	47	47	47	47	47
		Compost	0	303	606	0	303	606	0	303	606
		Total	113 g	437 d	717 d	204 f	514 c	784 a	281 e	504 c	803 a
Output		**Yield**	159 cd	224 c	174 cd	114 d	85 d	70 d	323 b	376 ab	438 a
		Not mark. yield	0	4	4	0	0	2	0	0	0
		Crop residues	52 bc	54 b	60 b	36 bc	33 bc	24 c	63 b	59 b	105 a
		Min Avail N	218 a	221 a	185 a	65 c	109 bc	77 bc	122 b	177 a	84 bc
		Total	429 c	503 bc	423 c	215 d	227 d	173 d	508 bc	612 ab	627 a
Difference (Input - output)			-316 e	-66 d	294 c	-11 d	287 b	611 a	-227 e	-108 d	176 c

The mean values in each column followed by a different letter are significantly different according to LSD and DMRT (two and more than two comparisons, respectively) at the reported probability level. n.s., not significant; ***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$.

Available mineral nitrogen is considered as an input when measured on soil samples collected at transplanting and as an output when measured at harvest. In both cases, available soil mineral N was significantly higher in FA compared to RC and GM. In particular, at harvest, soil mineral N in FA, at different compost doses, was from 100 to 230% higher than RC and from 25 to 120% higher than GM. On the other side, at compost dose 0 and 15, total N input was significantly higher in GM and RC respect to FA due to the amount of nitrogen supplied by the cover crop either incorporated to soil (GM) and flattened (RC). Total N output was significantly higher in GM compared to FA, while the lowest values were shown by RC. The difference (input - output) of the compared treatments put in evidence a N surplus for RC at compost dose 15 and 30, while a N deficit for both FA and GM at compost dose 0 and 15. The low melon yield of RC could be due to the low amount of available soil mineral N along the crop cycle. Both GM and RC showed, at transplanting, a lower soil mineral N respect to FA, probably as consequence of N barley uptake in the previous months. During melon cropping cycle, the mineralization rate of native soil organic matter allowed an increasing availability of soil mineral N for FA, while a prevailing process of N immobilization was probably at the basis of the lower soil mineral N for GM and RC. In particular, for RC, an important role in soil N mineralization was possibly played by the significant lower soil temperature due to the natural mulch (about 5 °C lower than GM and FA along the whole cropping cycle) (data not reported). Lower soil temperatures influenced also the phenological phase of melon, which is a macrotherm crop, with significant delay in fruit ripening and harvest (data not reported). The analysis of the simplified N budget allows some considerations regarding short and long-term soil N fertility. The high amount of available soil mineral N of FA, at harvest, could represent an advantage in case melon is followed by another crop in few days time (as in our rotation, where melon is followed by fennel transplanting in two weeks time). On the other hand, the risk of nitrate leaching increases if melon were not followed immediately by another crop. The analysis of the data regarding the difference (input - output) put in evidence the high N deficit of FA and GM at compost dose 0. These results underline that soil N fertility cannot be managed in the long term without the incorporation to soil of exogenous organic matter and that green manuring of barley is not sufficient *per se* to supply the nitrogen needs of the crop. RC treatment, at all compost doses, seems the more equilibrated in terms of N input - output.

Discussion

The combination of different systems of cover crop termination and compost dose had significant effects on organic melon production and on short and long term soil N fertility management. Barley green manuring determined the highest yield and a sufficient amount of soil mineral N available for the next crop (short term effect), but a deficit of N reduced the sustainability of this system of cover crop management if not associated with a compost application (compost dose 15). Roller crimped barley was not competitive in terms of yield, probably because melon, as a macrotherm plant, needs high soil temperature, while the fallow system (control) showed the worst N deficit. Also in this case, the sustainability of the system was increased by the application of compost dose 15.

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