Effect of slow release organic nitrogen fertilizer combined with compost on soil fertility, yield and quality of organic zucchini in sandy soil

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Abstract
The lack of synchrony between vegetables needs and amount of nitrogen released by compost within sandy soils constitutes a significant restriction to organic vegetables growers. The aim of this experiment was to study the effect of a slow releasing organic nitrogen fertilizer (SRF) combined with compost (COM) on soil fertility, growth and yield of organic zucchini under greenhouse. Results showed significant improvement of soil organic matter (SOM) content (from 1.55 to 2%) after compost amendment. Soil nitrate release was high during first 2 months for all treatments and has decreased till the end of the cycle. Addition of compost to soil has increased SOM and has optimized nitrogen releasing which means that COM was more efficient than SRF witch didn't give the required advantage of optimum nitrogen supply, but has caused yield decrease due to vegetative promoting effect to the detriment of quality and productivity of the crop.
Keywords: compost, arid, sandy soil, slow release fertilizer, soil fertility, organic zucchini.

Introduction
In Morocco, as in many other arid zones, the management of soil fertility and plant nutrition under organic systems still a big challenge. In fact, very few studies have dealt with this issue under Mediterranean arid and semi-arid climate. Timing and amount of mineralized nitrogen often do not coincide with crop need, making in-season fertilization necessary. This lack of synchrony between mineralized nitrogen from organic matter and crop nitrogen uptake is a major challenge for fertility management under organic systems (Gaskell et al., 2006). Soil organic matter (SOM) content and its mineralization rate can influence levels of potassium (K), phosphorus (P) and micronutrients in soil (Martin-Rueda et al., 2007) and this will affect directly crop's productivity. Maintaining SOM through compost amendment is important not only for sequestration and greenhouse gas mitigation, it also has a significant influence on the physical, chemical, and biological properties of soil (Ashagrie et al. 2007). It may modify the pH of the final mix and has the ability to buffer or stabilize soil pH (Hazem, 2001). Compost provides a supply of nutrients in significant quantities to the benefit of soils and plants, some in slow release forms, reducing the need for future fertilizer applications: (i) Approximately 36 % of the total nitrogen (N) is available from compost in the first year; (ii) The release of nitrogen may be at a lower rate in subsequent years; (iii) Nitrogen efficiency increases through organic N accumulation when compost is regularly applied; (iv) Phosphorus, magnesium, iron and other nutrients are also slowly released and; (v) Potassium in compost is in more readily available forms compared with organic N and P (Vern Grubinger, 2005). The aim of this experiment was to study the effect of a slow releasing organic nitrogen fertilizer (SRF) combined with compost (COM) on soil fertility, growth and yield of organic zucchini. The mineralization rate and availability of nutrients in the soil during the crop cycle were investigated.

Materials and methods

Pedo-climatic conditions of the experimental site

Souss-Massa plain has a favourable climate for winter production with mild winters and relatively hot and dry summers. The study was carried out at the experimental field of the National Institute of Agronomic Research (INRA) 40 Km to the south of Agadir (Latitude=30.6; Longitude=9.36; Altitude= 75m). The region is characterized by an arid climate with climatic mean values as follows: $T°_{min}$=11.5°C; $T°_{max}$=24.8°C; Relative $Moisture_{max}$=85%; Relative $Moisture_{min}$=85%; Sunshine period=3600hr.$year^{-1}$ and Rainfall=173mm. Soils in the region are generally sandy with alkaline pH and very poor in terms of total nitrogen content. Soil characteristics are presented in (table 1).

Table 1. Soil characteristics of the field experiment

Elements	Unit	Value	Observation
Organic Matter	%	0,46	Low
pH	-	8,01	Alkaline
EC	dS/cm	0.138	Low
C/N		5,56	Low
Total N	%	0,0947	Very low
P_{ass}	ppm	46	Low
K_{Exch}	ppm	176,23	Low

Experimental design & Treatments description

A Completely Randomized Blocs design was adopted with 4 replicates following north-south and irrigation direction senses in order to minimize heterogeneities due respectively to radiation and drip irrigation pressure. The experimental field measured 500m², blocs 11.25m² (12.5 m * 9 m), plots 8.1 m2 (9m X 0.9 m). Quantities of COM and SRF were applied following nitrogen needs (NN) of the crop cycle witch are 160 Kg-N.ha-1.crop cycle-1 (Si Bennaseur Alaoui, 2005): T1 (100% of NN as COM incorporated before planting date [IBPD]); T2 (50% of NN as COM [IBPD] and 50% of NN as SRF divided into 3 amendments in crop cycle [4 weeks after planting, 8 weeks after planting and 11 weeks after planting]); T3 (25% of NN as COM and 75% of NN as SRF divided similarly as T2) and T4 (100% of NN as SRF divided into 4 amendments: first before planting and 3 amendments similarly as T2). The incorporation of compost and organic fertilizer were done 10 days before planting date (tables 2). Compost and the SRF chemical analysis are presented in the table 3:

Table 2. Treatments description of the experiment

Treatments	10 days before planting (DBP)		4 weeks after planting (WAP)	8 WAP	11 WAP
T1	160 Kg of NN (100%) as COM	**Plantation**	-	-	-
T2	80 Kg of NN (50%) as COM		26.3 Kg of NN (16.6%) as SRF	26.3 Kg of NN (16.6%) as SRF	26.3 Kg of NN (16.6%) as SRF
T3	40 Kg of NN (25%) as COM		40 Kg of NN (25%) as SRF	40 Kg of NN (25%) as SRF	40 Kg of NN (25%) as SRF
T4	40 Kg of NN (25%) as SRF		40 Kg of NN (25%) as SRF	40 Kg of NN (25%) as SRF	40 Kg of NN (25%) as SRF

Measurements and sampling method

Composite soil samples were taken with an auger (Ø=2.5 cm), just before compost and SRF amendment and monthly 4; 8; 12 and 16 WAP from top soil (0-30cm depth) by mixing four or five soil samples in one sample by plot. **Height** of five representative plants per plot was measured each fortnight from the plant crown to the plant apex. **Plant biomass** was recorded after the end of the crop cycle through five representative plants per plot which were weighed for fresh and dry plant biomasses; then, oven dried (65 ºC for 3 days) ground, and prepared for chemical analysis. **Crop yield parameter** were assessed by quantifying total weight (Kg) of the fruits in each harvest, and was added on to the previous quantity in order to determine the cumulative yield during the harvest period. **Fruit harvesting** was performed as fruit maturity progress and data were consolidated at weekly basis.

Soil and plant chemical analysis

Soil chemical analysis: Soil samples were sieved (Ø=2 mm) and analyzed for pH in 1:2.5 soil/water (w/v) suspensions using a glass electrode pH-meter (BioBlock pH-mètre Microprocessor 99621) at room temperature (Rhoades, 1982). EC (µS/cm) was measured using electrical conductivity meter (WTW Inolab-Cond Level-2P, Germany [at T°=25°C]) in 1:5 soil/water (w/v) solutions. Soil organic matter (SOM) was determined by Walkley-Black method (Jakson, 1967). Soil Total Nitrogen (STN) content analysis was performed using standard semi micro-Kjeldahl procedure (Jackson, 1967). Mineral nitrogen (N-NO3 and N-NH4) was measured using standard Kjeldahl procedure (Gerhardt: Kjeldatherm-Vapodest 20, Germany). Available phosphorus (P) was determined by Olsen method described by (Jackson, 1967). Potassium contents were determined using flame photometer according to Black et *al.* (1982). As for calcium and magnesium, they were analyzed by shaking 1 g of soil with sodium acetate for 1 hour prior to the atomic absorption spectroscopy detection (Varian Spectra AA 220FS, USA). **Plant chemical analysis:** Total nitrogen content was determined using Kjeldahl apparatus. Colorimetric spectrophotometer was used (Erma AE400, Japan) to determine phosphorus content at a wave length of 420 nm and plant tissue content of K, Mg and Ca starting with the mother solution prepared for phosphorus..

Statistical analysis

All statistical analyses were performed using Minitab 13.0Fr software. The multiple comparisons of means were confirmed by Tukey's test (at $P < 0.05$).

Results & Discussion

Soil and foliar Total nitrogen content

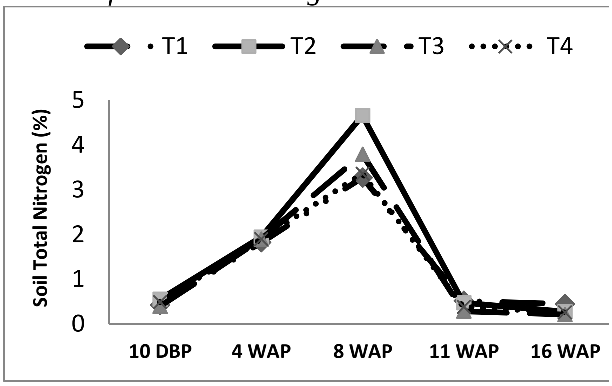

Figure 1. Evolution of Soil Total Nitrogen Content

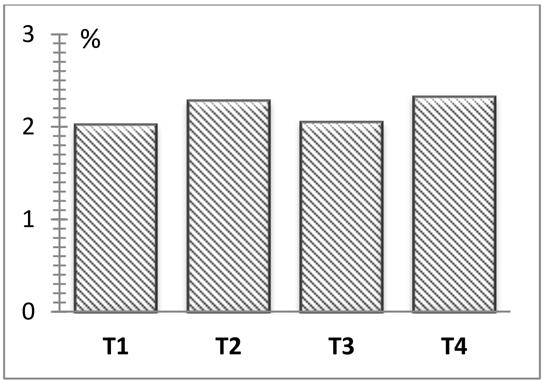

Figure 2. Foliar Total Nitrogen Content

Figure 1 presents the evolution of the STN over crop cycle and according to this graph, after application of the first amendment total STN increased in all treatments, until 8 weeks after planting date then a decrease is recorded until rest of the crop cycle. For all treatments in the first month when the plants were small, their NN were less than the nitrogen released by SRF and COM, consequently STN increased. Nevertheless, the crop needs increased in the following months, and mineralization rate decreased, so that STN decreased in the rest of crop cycle showing an unbalance between mineralization rate and NN. The low content of STN can be explained by nitrate leaching due to sandy soil nature. There is no significant statistical difference among treatments, and all treatments followed the same tendency during the whole crop cycle. Figure 2 represents the foliar analyses to confirm soil analysis results and field observation. There is no significant statistical difference among treatments in terms of foliar total nitrogen content in all treatments.

Yield of organic zucchini

Statistical analysis (Table 3) revealed a significant difference between treatments, and the highest yield recorded was under treatment T2 where 50% of NN was applied as COM and 50% as SRF, followed by treatment T1 than treatment T3 and T4 with lower yield. T2 gave the highest yield, and this can be explained by fertilization program which was adopted. This program may reduce nutrient losses, and respond to crop requirement over time.

Table 3. Yield of organic zucchini with respect to different treatments

Treatment	Yield($t.ha^{-1}$)	Standard error
T1 (100% COM)	32.26 **B**	5.70
T2 (50 % COM+50% as SRF)	29.41 **A**	2.68
T3 (25% COM+75% SRF)	27.49 **C**	2.51
T4 (100% SRF)	26.75 **C**	3.54

Conclusion

Based on obtained results about the effect of COM and SRF on soil fertility, growth and yield of zucchini grown under greenhouse in Souss Massa, the adequate combination between COM and SRF is T2, where 50% of NN was applied as COM and 50% as SRF. Fertilization approach should take into consideration the integration of phosphorus and potassium needs under an improvement of organic matter content in a midterm program.

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