Cotton fertilization with composts of (sugarbeet) vinasse and agricultural residues

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Abstract

A concentrated depotassified beet vinasse was mixed with each of ten solid agricultural residues. The ten mixtures were composted for 7 months. The composts obtained after this period were used to fertilize a cotton crop. A mineral treatment was used for comparison and a treatment without fertilization was used as control. The nitrate content of petiole determined before the first top dressing revealed significant differences between treatments. All treatments produced higher yields than the control. Analysis of fibre quality did not show significant differences between treatments.

Introduction

The recycling of certain organic wastes can jointly mitigate problems of both environmental pollution and soil degradation. Beet vinasse are beet molasses that are almost completely biochemically desugarized, distilled and sometimes concentrated. The high levels of N (3%), K (3%) and O.M. (35%) of the concentrated vinasse could be beneficial factors for the land application of this waste (López *et al.*, 1993; Murillo *et al.*, 1993). However, the vinasse has three major problems for direct application as fertilizer: (a) high salt content (up to 14% of total salt) (Murillo *et al.*, 1993), (b) low P content (0.012%) and (c) high density (1.23 g cm^{-3}).

One alternative to overcome these disadvantages is the co-composting of the vinasse with other agricultural organic solid wastes (Díaz *et al.*, 1993), obtaining composts easily handy with higher P content and lower salinity. Land composts application is recognized as an important alternative disposal method both in recycling nutrients essential for plant growth and in increasing soil fertility (Gallardo-Lara and Nogales, 1987). The present paper deals with the effect of ten composts of vinasse in cotton crop. Plant N status (nitrate concentration in petiole), nutritional status of leaves, yield (weight of fibre) and fibre quality were determined.

Materials and methods

Composts of vinasse

A concentrated vinasse was mixed with each of ten solid agricultural residues. The solids used for the mixtures and the initial proportions between the solid wastes and the vinasse are shown in Table 1. The mixtures were composted in controlled conditions of moisture and temperature during 4 months and left to mature for the following 3 months. The chemical characteristics of these composts obtained after this period are shown in Table 2.

Soil and treatments

The composts of vinasse were applied in deep fertilization to a soil whose characteristics are indicated in Table 3. The doses of composts used were 4000 kg ha^{-1} for mixtures C and T (treatments TC and TT respectively), 5000 kg ha^{-1} for mixtures O, C + L, S,

Table 1. Initial composition of the mixtures

Mixture	Vinasse (%)	Solid waste
O	50	Olive-pressed cake (50%)
O+L	50	Olive-pressed cake (25%) + Leonardite (25%)
C	75	Cotton gin trash (25%)
C+L	50	Cotton gin trash (25%) + Leonardite (25%)
M	35	Municipal solid wastes (65%)
T	60	Tobacco dust (40%)
E	30	Composted olive-oil-mill effluents (70%)
S	30	Olive-oil-mill sludge (70%)
G	50	Grape marc (50%)
R	50	Rice husk (50%)

Table 2. Chemical composition of the composts

	O.M (%)	Kjel-N (%)	C/N	NO_3^--N (%)	P_2O_5 (%)	K_2O (%)	Na (%)
O	53	3.45	11.5	0.10	0.14	3.46	4.11
O+L	40	1.50	13.5	0.10	0.13	2.50	3.50
C	24	3.57	10.2	0.20	0.23	5.94	4.10
C+L	34	2.32	12.1	0.16	0.21	5.11	3.14
M	12	2.19	5.6	0.02	0.87	2.49	2.01
T	25	3.67	9.6	0.21	0.28	6.27	3.50
E	15	2.06	8.5	0.01	0.72	3.23	1.72
S	32	3.55	10.5	0.02	0.37	3.78	2.30
G	36	3.38	12	0.09	0.26	5.24	3.10
R	35	2.39	13	0.11	0.11	5.16	2.50

G (treatments TO, T(C + L), TS and TG respectively) and 10000 kg ha^{-1} for mixtures O + L, M, E and R (treatments T(O + L), TM, TE and TR respectively). A mineral treatment (TF) consisting of 400 kg ha^{-1} of 15-15-15 was used for comparison and a treatment without fertilizaation (TB) was used as control. All treatments, except TB, received two top dressings of 150 kg ha^{-1} of urea (46% N).

The experiment was carried out in 10 m^2 plots in a complete randomized block with 3 replicates per treatment. Cotton, *Gossypium hirsutum* L, c.v. Alba was the test variety used in this experiment.

Table 3. Soil characteristics

Parameter		
pH		7.6
$CaCO_3$	%	22.5
O.M	%	1.30
Kjeldahl-N	mg kg^{-1}	980
Olsen-P	mg kg^{-1}	16.3
Available-K	mg kg^{-1}	340
C/N		7.0
Sand	%	59.8
Lime	%	20.0
Clay	%	20.2

Chemical analysis of plant material

Youngest fully mature leaves on main stem were collected prior to first bloom. The leaves and petioles were collected at 1025 degree days after sowing (2 days before the first top dressing).

Plant material was dried at 70 °C after decontamination by washing with deionized water and finely milled. Nitrogen was determined in leaves after Kjeldahl digestion. Mineral elements were determined according to Jones *et al.* (1990) following dry ashing and ash dissolution by treatment with conc. HCl on a hot plate. Sodium and K were determined by flame photometry, Ca, Mg, Fe, Cu and Zn were determined by atomic absorption spectrometry and P by colorimetric determination using the phosphovanadomolybd complex. Nitrate was extracted treating petioles (0.5 g of dry sample) for one hour with 50 ml of 0.1 *M* KCl solution. Filtered solution was analysed for NO_3-N using selective electrode (Davis *et al.*, 1972).

Yield and fibre quality

Yield (weight of fibre) was determined in the field. Analysis of fibre quality was performed according to the U.S. Department of Agriculture, (RAEA, 1993). The analysis was carried out in a H.V.I. (Height Volume Instrument), using International Standards. Several parameters were studied to evaluate the fibre quality: length (LEN), uniformity (UN), maturity (MIK), elongation (EL), resistance (STL), reflectance (RD) and yellowness grade (B).

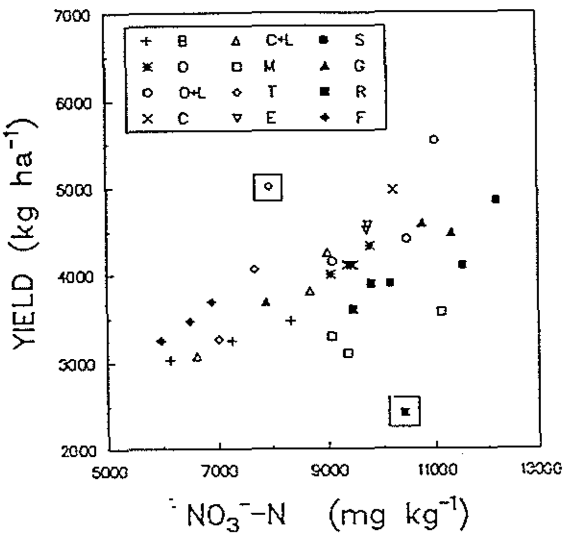

Fig. 1. Cotton fibre yield for the different treatments.

Table 4. NO_3^- N contents (mg kg^{-1}) in cotton petiole before the first top dressing

Treatments	NO_3-N (mg kg^{-1})	
TB	7243	ab
TO	9240	bcd
T(O + L)	10190	cd
TC	9677	bcd
T(C + L)	8107	abc
TM	9847	bcd
TT	7563	abc
TE	9613	bcd
TS	11300	d
TG	9990	bcd
TR	9897	bcd
TF	6470	a

*Values followed by the same letter in the same column do not differ significantly ($p < 0.05$).

Statistical analysis

The data of yield, nitrate content in petiole, parameters of fibre quality and nutrient content on leaves were analyzed by ANOVA and the differences among treatments were compared using Tukey's test. A significance level of $p < 0.05$ was considered throughout the study,

Results and discussion

Figure 1 shows yields (weight of fibre) for the different treatments. Weights of fibre for treatments TB, TM, TR and TF were lower than the mean value obtained for this variety of cotton in Andalusia (3700 kg ha^{-1}) (RAEA, 1993). However, for the remainder treatments, the weights of fibre were higher than that mean value. These high yields can be attributed to the moderate addition of Na through compost application, which appears to enhance the nitrogen uptake and yield of cotton crops (Perssarkli and Tucker, 1985)

Table 4 shows the nitrate level in petiole for all treatments. The nitrate level in petiole is suggested to be used as a criterion for plant N status (Jones *et al.*, 1990). All composts treatments, except TT, displayed the required NO_3^--N concentrations for mid-blossom stage (ca. 8000 mg kg^{-1}) reported by Jones *et al.*, (1990), while the mineral and control treatments (TF and TB) showed values below 8000 mg kg^{-1}.

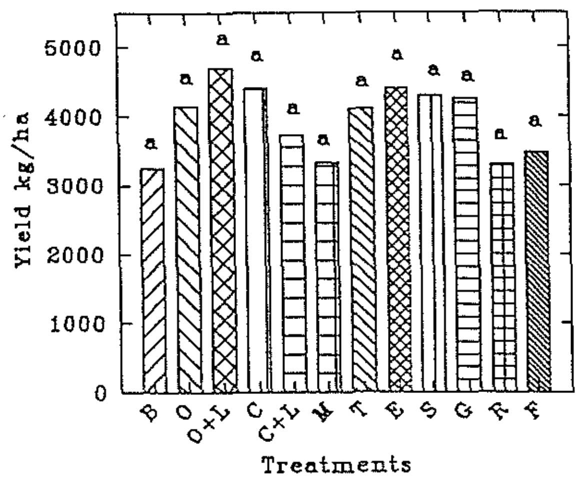

Fig. 2. Relationships between obtained yield (weight of fiber) and concentration of NO_3^--N in the petiole.

This indicates an adequate N supply through compost addition. A positive and highly significant relationship between the yield and the NO_3^--N content in petiole was found (Fig. 2.; r = 0.71, $p < 0.001$). Prediction of yield through this relationship has been suggested by Jones *et al.* (1990).

Macro and micronutrient analysis of leaves did not show any significant difference among treatments (Table 5). The nutrient concentrations of cotton top leaf were within the range reported by Jones *et al.* (1990).

Table 5. Nutritional content in cotton leaves collected prior to first bloom

Treatments	N (%)	P (%)	K (%)	Na (%)	Ca (%)	Mg (%)
TB	3.43 a	0.25 a	1.62 a	0.33 a	3.79 a	0.61 a
TO	3.75 a	0.27 a	1.74 a	0.31 a	3.78 a	0.55 a
T(O +L)	3.71 a	0.24 a	1.84 a	0.34 a	3.89 a	0.61 a
TC	3.77 a	0.24 a	1.96 a	0.32 a	4.13 a	0.65 a
T(C+L)	3.62 a	0.28 a	2.01 a	0.30 a	3.39 a	0.54 a
TM	3.75 a	0.25 a	1.58 a	0.38 a	4.15 a	0.64 a
TT	3.83 a	0.28 a	1.56 a	0.24 a	3.62 a	0.55 a
TE	3.75 a	0.25 a	1.42 a	0.20 a	3.69 a	0.58 a
TS	3.75 a	0.23 a	2.10 a	0.39 a	4.13 a	0.63 a
TG	3.60 a	0.26 a	1.96 a	0.33 a	3.65 a	0.57 a
TR	3.55 a	0.24 a	1.86 a	0.39 a	4.34 a	0.66 a
TF	3.69 a	0.23 a	1.91 a	0.37 a	3.78 a	0.59 a

Table 6. Parameters of fibre quality

Treatment	LEN	UN	STR	EL	MIK	B	RD
TB	1.12 a	84.1 a	29.1 a	6.53 a	3.97 a	7.90 a	69.3 a
TO	1.10 a	84.5 a	25.8 a	6.30 a	4.00 a	8.27 a	67.2 a
T(O + L)	1.14 a	84.1 a	25.6 a	6.43 a	4.10 a	8.17 a	68.7 a
TC	1.16 a	85.1 a	30.2 a	6.66a	4.10 a	7.97 a	70.5 a
T(C + L)	1.11 a	84.5 a	29.3 a	6.50 a	4.20 a	8.20 a	65.4 a
TM	1.30 a	84.4 a	26.3 a	6.37 a	3.80 a	8.17 a	65.6 a
TT	1.30 a	84.5 a	24.7 a	6.40 a	3.83 a	8.07	70.0 a
TE	1.19 a	83.9 a	27.4 a	6.45 a	3.95 a	8.05 a	71.13 a
TS	1.13 a	84.1 a	28.3 a	6.40 a	3.83 a	7.77 a	66.9 a
TG	1.12 a	84.0 a	27.7 a	6.27 a	3.93 a	8.33 a	67.1 a
TR	1.13 a	35.0 a	30.4 a	6.60 a	4.03 a	7.93 a	66.4 a
TF	1.09 a	84.3 a	25.7 a	6.60 a	3.90 a	8.20 a	56.6 a

* Values followed by the same letter in the same column do not differ significantly ($p < 0.05$).

Values of the parameters of fibre quality (Table 6) were within the normal values for this variety of cotton under Andalusian conditions (RAEA, 1993). No effect of fertilization on fibre quality was observed since no significant differences ($P<0.05$) among treatments were found for these parameters. These results are in agreement with those of RAEA (1993), which reported that generally, the fibre quality is more affected by crop variety and irrigation than by fertilization.

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