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RESIDUAL EFFECT OF COMPOSTED OLIVE OIL MILL SLUDGE ON PLANT GROWTH

P. Martín-Olmedo, F. Cabrera, R. López, and J.M. Murillo.
Instituto de Recursos Naturales y Agrobiología de Sevillla. (CSIC). Apartado 1052. 41080 Sevilla. Spain

Summary: Residual effect of a composted olive oil mill sludge on growth and mineral composition of tall fescue (*Festuca arundinacea*) was studied. Results were compared with those obtained for a mineral fertilizer treatment and a control. Compost and inorganic fertilizer had been previously applied to two different soils at two rates for five years. The compost did not display the phytotoxicity of olive oil mill wastewater, and produced, at high doses, the highest yield and concentrations of P and K in tissue, while decreasing Na, Mn, and Zn assimilability.

Key words: Compost, olive oil effluents, plant nutrition, micronutrients assimilability.

INTRODUCTION

The disposal of olive oil mill wastewater (A, "alpechín") is a critical and still increasing problem in the Mediterranean Area. The possible agronomic use of "alpechín", based on its high organic matter [1], has been widely studied in recent years [1, 2, 3]. Nevertheless, its putrescible nature, high content of mineral salt (E.C. 8-22 dS/m), presence of organic phytotoxic compounds[4] and highly diluted liquid form[3] make necessary a conditioning treatment which gives a more stable and better agricultural manageable end-product.

Composting is considered as an environmentally suitable method of treatment for rapidly reducing large amounts of organic waste, and for recycling essential nutrients for plant growth.[3,5]

A compost (AC) made up of dried sludge from evaporation ponds of "alpechín", and other agricultural by-products (grapeseed residues, cotton wastes, branches and twigs pruned from olive trees, and other olive residues) shows no phytotoxicity as well as having beneficial effects on the general soil fertility and crop yield.[6, 7, 8]

This study is conducted to determine the residual effect of the alpechín compost (AC) over a long period of time on growth and mineral composition of tall fescue.

MATERIALS and METHODS.

From 1989 to 1993, a composted olive oil mill sludge ("alpechín" compost) (Table 1) was applied to greenhouse containers (ca. 0.42 m^2, 50 cm depth) filled with two topsoils (Table 2): a Xerorthent (loam-clay-sandy soil, **S1**) and a Xeropsamment (sandy soil, **S2**).

During this period, five fertilization treatments in a completely randomized design with five replicates per treatment, were assayed: two rates of compost (**AC1** and **AC2**); two rates of a mineral fertilizer (**MF1** and **MF2** supplying the same amounts of N and P as the compost treatments); and a control (**C**), without fertilization. A summary of fertilization during the period 1989-1993 is shown in Table 3. Ryegrass (*Lolium multiflorum*) was cropped annually and the yield and nutritional content of tissue plants determined.

Table 1: *Analysis of the "Alpechín" Compost.**

Moisture	*18*	**pH**	*7.6*	**E.C**	*3.2*
O.M.(%)	*21*	**C/N**	*15.6*	**Ca (%)**	*8.7*
N (%)	*0.8*	**P (%)**	*0.2*	**K (%)**	*1.8*
Na (%)	*0.3*	**Mg(%)**	*0.8*	**Fe (%)**	*0.7*

*Mean values of five years.

In 1994, (study reported here), the residual effect was evaluated and, thus, no organic or mineral fertilizer was applied. Tall fescue (*Festuca arundinacea* cv. Manade) was grown in the same containers. At 76, 129 and 172 days after sowing, tall fescue was clipped to 3-cm height, weighed and analysed. Plant samples were washed with tap and deionized water, oven dried at 70°C for 48 h, and ground to pass through a 40 mesh screen. Nitrogen was determined after Kjeldahl digestion. Mineral elements were determined according to Jones et al.[9] following dry ashing and ash dissolution with conc. HCl on a hot plate. Sodium and K were determined by flame emission; Ca, Mg, Fe, Cu, Mn and Zn by atomic absorption spectrometry and P by colorimetric determination using the phosphovanadomolybdic complex.

Table 2: *Soil Characteristics.*

SOIL	Trt.	N	P	K	O.M.	PH	E.C.
		mg kg^{-1}			(%)		(1:5)
Initial conditions							
S1	----	*536*	*2.5*	*170*	*0.53*	*7.90*	---
S2	----	*347*	*3.0*	*47*	*0.14*	*8.45*	---
After five years of treatment.							
S1	**C**	*689*	*3*	*91*	*1.29*	*7.29*	*0.80*
	AC1	*990*	*8*	*216*	*2.03*	*7.57*	*0.55*
	AC2	*1521*	*15*	*349*	*3.98*	*7.61*	*0.60*
	MF1	*746*	*9*	*108*	*1.52*	*7.68*	*0.64*
	MF2	*746*	*14*	*91*	*1.47*	*7.78*	*0.43*
S2	**C**	*646*	*5*	*75*	*0.81*	*8.04*	*0.14*
	AC1	*699*	*6*	*125*	*0.84*	*7.86*	*0.32*
	AC2	*1077*	*19*	*282*	*0.86*	*8.02*	*0.25*
	MF1	*495*	*7*	*50*	*0.53*	*8.07*	*0.20*
	MF2	*480*	*11*	*42*	*0.84*	*7.91*	*0.23*

From dried weight and nutritional mineral content of tissue plants, nutrient extraction at each clipping and the total nutrient extraction were determined.

Table 3: ***Annual fertilization of greenhouse containers from 1989 to 1993.***

Treatment	Fertilizer	kg ha-1	Fert. Equivalent Units kg ha-1 N	P	K
Control	nill		*0*	*0*	*0*
AC1	Alp. Compost	*20 000*	**128*	**33*	**288*
AC2	Alp. Compost	*50 000*	**320*	**83*	**721*
MF1	15-15-15	*487*	*73*	31	61
	Urea **	*102*	*47*	*0*	*0*
MF2	15-15-15	*1200*	*180*	79	149
	Urea **	*260*	*120*	*0*	*0*

*Mean values of the five years of treatment.
**Applied as sidedress

The data were subjected to analysis of variance and the mean separation performed by the Tuckey test. A significance level of $P<0.05$ was considered throughout the study.
Multivariant Discriminant Analysis was carried out for total nutrient extraction data by the Statgraphics computer program[10].

RESULTS and DISCUSSION.

Yield

Yield of tall fescue was higher in soil S1 (loam-clay-sandy soil) than in soil S2 (sandy): mean grass weight averaged (across all treatments and clippings) was 1341 kg ha^{-1} for S1 and 773 kg ha^{-1} for S2. Earlier laboratory incubation studies had showed a much higher N release from the mineralization of the residual organic N in soil S1 than soil S2 after three years of treatment with AC, MF and C[8]. Furthermore, increases in tall fescue growth as the soil clay content increased were also observed by other authors[11, 12].

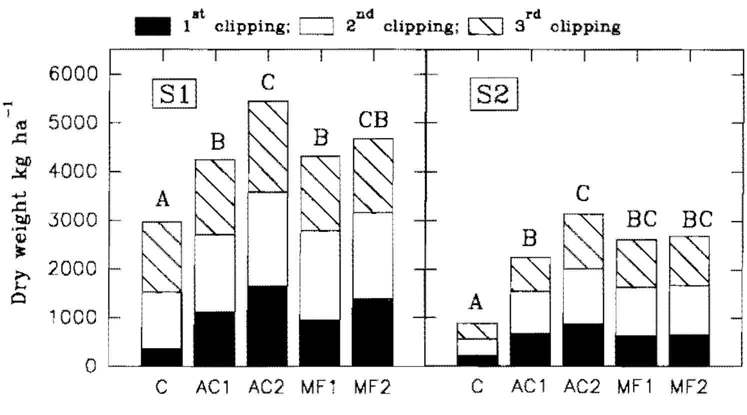

Figure 1: Dry weight of tall fescue biomass for each treatment in soil S1 and soil S2.

The mineralization process, slower in soil S1 than soil S2 due to a higher protection of the organic matter and soil biomass[8, 13], might be responsible for greater differences in soil S2 between organic (AC1 and AC2) and mineral (MF1 and MF2) fertilizer treatments.

Maximum yields at each harvest clipping in both soils (Figure 1) corresponded to the high compost treatment (AC2), in agreement with anterior studies[8] in which potentially mineralizable nitrogen, total-N and organic matter were higher in soils treated with compost than those treated with mineral fertilizer or control. AC1 and MF1 produced almost equal yields, being both statistically higher than control.

No phytotoxicity was observed after long-term compost application, ratifying previous studies[7].

Nutritional stage.

The intrinsic fertility, greater in soil S1 than S2, is responsible for greater levels of macro and micronutrients in plants grown in soil S1 (Table 4).

Table 4: ***Effects of different treatments and soil type on elemental composition of tall fescue at selected clippings.***

Clip.	Treat.	N	P	K	Na	Mn	Zn
		%				mg kg⁻¹	
		SOIL S1					
	C	*2.93* ***b***	*0.18* ***a***	*2.10* ***b***	*0.57* ***ab***	*98* ***b***	*42* ***b***
	AC1	*2.33* ***a***	*0.21* ***ab***	*2.11* ***b***	*0.56* ***ab***	*82* ***ab***	*34* ***ab***
2	**AC2**	*2.06* ***a***	*0.26* ***b***	*2.23* ***b***	*0.52* ***a***	*70* ***a***	*23* ***a***
	MF1	*2.43* ***ab***	*0.24* ***ab***	*1.76* ***a***	*0.73* ***b***	*93* ***ab***	*29* ***ab***
	MF2	*2.13* ***a***	*0.25* ***b***	*1.69* ***a***	*0.66* ***ab***	*100* ***b***	*22* ***a***
		SOIL S2					
	C	*3.30* ***c***	*0.11* ***a***	*2.06* ***ab***	*0.37* ***ab***	*111* ***c***	*61* ***c***
	AC1	*2.59* ***b***	*0.13* ***ab***	*2.22* ***bc***	*0.40* ***ab***	*52* ***a***	*30* ***ab***
2	**AC2**	*2.17* ***a***	*0.17* ***c***	*2.47* ***c***	*0.34* ***a***	*39* ***a***	*23* ***a***
	MF1	*2.35* ***ab***	*0.16* ***bc***	*1.79* ***a***	*0.58* ***c***	*83* ***b***	*39* ***b***
	MF2	*2.28* ***ab***	*0.17* ***c***	*1.73* ***a***	*0.48* ***bc***	*77* ***b***	*30* ***ab***

Data corresponding to others clippings showed similar trends among treatments.

A decrease of the fescue nitrogen content (FNC) was observed along the growth period. In the first clipping (data not shown) FNC values for all the treatments were within the proposed critical range (2.8-3.4%)[14], while, in further clippings FNC values, excepting for the control, were below that range. In general, an inverse relationship between dry matter weight and FNC was observed: lowest FNC are registered for AC2 treatment as a dilution effect[15]. Similar results were reported by Eck et al.[16] and Lund and Doss[17]. These low values at the end of the experiment were most likely due to reduced N release from residual N of soils with time, and also due to the possible presence of dead and senescent tissues in the final harvest[11].

High compost rate (AC2) produced the highest P and K concentration in fescue, probably related to the higher previous fertilization rates (Table 3). Both sets of values were lower than the established critical range: 0.26-0.32% for P and 2.5-2.8% for K[14]. On the other hand, AC2 presented the lowest Na tissue content presumably due to replacement by K[7].

Mn and Zn contents were lower for compost treatments. This fact has been observed in previous studies[18] and could be attributed to the presence of complexing agents in the residual organic matter.

Extraction.

Multivariant Discriminant Analysis (Figure 2) shows a visual separation of the population data of the different treatments. Function 1 and 2 explain the 95.6% and 92.3% of the variance in soil S1 and soil S2, respectively.

The Standardized discriminant coefficients for all variables defining Function 1 and 2 (Table 5), allow the discernment of the most determinant variables in the separation of the treatments. AC2 treatment, which has extracted significantly the greatest amount of N, P, and K, is obviously the best differentiated from the rest of treatments in both soils.

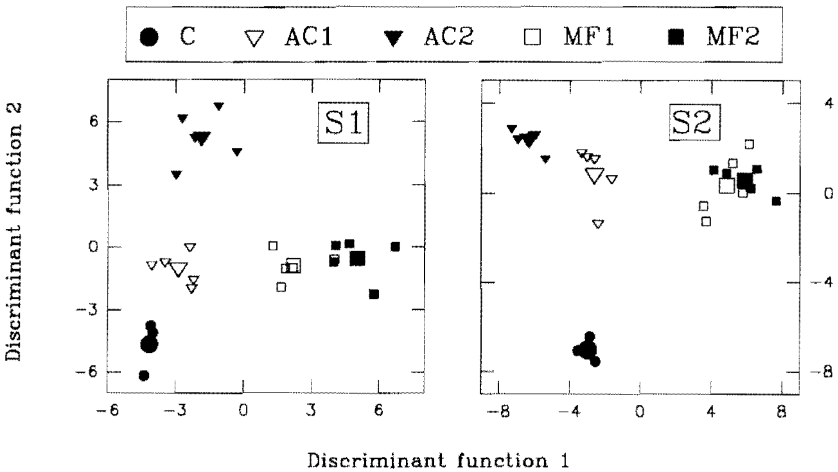

Figure 2: Discriminant analysis of total nutrient extraction data.
(Big symbols correspond to group centroids)

Table 5: *Standardized discriminant coefficients*

	SOIL S1		SOIL S2	
Variables	**Function 1**	**Function 2**	**Function 1**	**Function 2**
N	-0.0322	-0.7004	-0.4011	0.8170
P	0.3272	0.7660	-0.3551	-2.5649
K	-0.6760	1.2583	-2.1514	0.4207
Na	0.7316	0.0395	0.9734	0.4464
Ca	0.2299	1.4760	0.5756	0.4738
Mg	0.8286	-1.5099	2.7434	1.3688
Fe	-0.4831	-0.5153	-0.8782	0.3444
Cu	-0.4494	0.0959	-0.7412	1.0411
Mn	0.6230	0.0348	-0.3798	-1.3235
Zn	-0.7246	0.6509	-0.5419	0.1247

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