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Journal of Agricultural Sciences

Journal homepage:
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The Impact of Soil Conditioners on Some Chemical Properties of Soil and Grain Yield of Corn (*Zea Mays* L.)

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ARTICLE INFO

Research Article DOI: 10.15832/ankutbd.399164

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Received: 27 February 2018, Received in Revised Form: 04 April 2018, Accepted: 17 April 2018

ABSTRACT

The goal of this study was to explore the effects of various soil conditioners on selected properties (pH; organic matter, OM; electrical conductivity, EC; cation exchange capacity, CEC) of a *Xerofluvent* soil and corn yield. During the experiment, four amendments were applied in an experimental set of plots: tobacco waste compost (TWC), poultry manure (PM), bio-humus (BH), and chemical fertilizer (NPK). Soils were treated with TWC at the rate 50 t ha⁻¹, PM at the rate 4 t ha⁻¹, BH at the rate 10 t ha⁻¹ and NPK at the rate 300 kg ha⁻¹, respectively. All organic conditioners were increased soil pH, OM, CEC, EC and corn yield when compared with the control soil and these parameters have been changed from 5.7% to 333%. The most effective soil conditioners were determined as tobacco waste compost, bio-humus, and poultry manure. The findings of current study suggest that 50 t ha⁻¹ TWC should be added to soil as a priority for improving properties of a *Typic Xerofluvent* soil and crop yield.

Keywords: Bio-humus; Poultry manure; Soil chemical properties; Tobacco waste; Yield

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1. Introduction

Nowadays, the use of organic treatments for soil nutrient improvement is getting important for sustainable productivity and soil nutrient management. The decline of organic matter in soil, as a consequence of intensive soil cultivation practices, has been identified as one of the most important threats to soil quality (Lal 2007; Batlle-Bayer et al 2010). Use of organic manures alongside chemical fertilizers often lead to increased soil organic matter, soil structure, water holding capacity and improved nutrient cycling and helps to maintain soil nutrient composition,

cation exchange capacity and biological activities (Saha et al 2008). While chemical fertilizers are important input to enhance crop productivity, over reliance on chemical fertilizers is associated with decline in some soil properties and crop yields over time (Hepperly et al 2009). Hence, integrated use of chemical fertilizers with organic manures is a sustainable approach for efficient nutrient usage which enhances efficiency of the chemical fertilizers while reducing nutrient losses (Schoebitz & Vidal 2016). Compost amendments could contribute significantly to the improvement of the soil organic carbon content in the long term (Barral et al 2009) and hence to the chemical (nutrients),

physical (structure and moisture retention) and biological (soil life) quality of the soil (Herencia et al 2011; Odlare et al 2011; Ozores-Hampton et al 2011). Plant residuals can be used as a nutrient supplement in the agricultural fields. The kinetics of plant residual decomposition in soil and their carbon and nitrogen mineralization are largely influenced by the quality of the plant materials, i.e. by their origin and composition (Heal et al 1997). Animal manures may contribute to improving the physical and biological properties of soil (Li & Han 2016) and are important source of Ca, Mg, S, and micronutrients; they contain only low and highly amounts of N, P, and K (Odedina et al 2011). Among the different sources of organic manure which have been used in plant production, poultry manure is found to be the most concentrated in terms of nutritional status (Obire & Akinde 2006). The efficiency of compost usage in agriculture mostly depends on the quality of the compost which is closely related to its stability and maturity. Some physico-chemical properties (pH, temperature, C:N ratio, cation exchange capacity, total organic C, NH_4^+ , phenols, humic-like substances) have been used to control compost quality. Nevertheless, it is difficult to add these parameters across a wide range of composts prepared from different organic wastes (Kayıkçioğlu & Okur 2011). Tobacco is an important agricultural plant in the Aegean region of Turkey and 60.5% of Turkey's total tobacco production is grown in this region according to 2016 data (TUIK 2017). Tobacco plant residues from the primary production and cigarette manufacture are classified as an agro-industrial waste. This waste contains high amounts of organic matter and nicotine and is known to be a toxic and hazardous compound if the nicotine content exceeds 500 mg kg^{-1} dry weight (Wang et al 2004; Piotrowska-Cyplik et al 2009). In this investigation, tobacco waste compost (TWC), poultry manure (PM), bio-humus (BH), and chemical fertilizer (NPK) at different ratios was applied to soil and the influences of these conditioners on selected chemical properties of a sandy loam soil and corn yield were compared.

2. Material and Methods

2.1. Site features and properties of conditioners

The experiment was laid out at the Agricultural Research Farm of Ege University in Menemen, Izmir, Turkey (38°58'35.51"-38°58'36.03"N; 27°03'84.56"-27°03'89.81"E). The aim of this study to compare the role of different materials on soil chemical properties and corn yield. The soil at the study site is characterized by sandy loam texture with slightly alkaline reaction and classified as a *Typic Xerofluvent* (Soil Survey Staff 2006). The general properties of the soil are shown in Table 1. Experimental treatments were as follows: (1) Control soil, C (No treatment); (2) Poultry manure, PM at 4 t ha^{-1} plus NPK fertilizer at 300 kg ha^{-1} ; (3) Bio-humus, BH at 10 t ha^{-1} plus NPK fertilizer at 300 kg ha^{-1} ; (4) NPK fertilizer at 300 kg ha^{-1} ; (5) Tobacco waste compost, TWC at 50 t ha^{-1} . Since tobacco waste compost had very rich organic matter and nutrient content, it was applied to the soil (at a higher dose than other materials) without NPK. Moreover, some researchers reported that tobacco waste compost had positive responses to soil properties and yield without any mineral fertilizer (Okur et al 2008; Cercioğlu et al 2012). The plot sizes were 5 m x 3 m and replicated four times according to a randomized block design. The test plant grown on the study field was corn (*Zea Mays* L.), planted during April-May-June and harvested in October of each growing season. The organic treatments [tobacco waste compost (TWC), poultry manure (PM) and bio-humus (BH)] were applied to the soil only once at the beginning of the experiment (first year). Some properties of these materials are given in Table 2 and Table 3. Tobacco wastes obtained from Izmir Kemalpaşa Socotab Factory were added to soil after composting process. Composting of tobacco waste was performed outdoor under a roof. The moisture content of the compost was analyzed approximately 55% by weighing the material regularly and adding water when necessary. Aeration was made by manual turning during the composting. After 3 months, when the temperature of the compost decreased

to the ambient level, composting was completed. Both of bio-humus (composted plant residues) and poultry manure were gathered from organic manure industry. All rates of treatments were determined according to initial soil analysis results, uptake of nutrients by plant, and recommendations from producers of organic manure. Moreover, some additional chemical fertilizers (ammonium sulfate, triple superphosphate, and ammonium nitrate) were applied, and drip irrigation method was used in the study.

2.2. Soil sampling and analytical determinations

Two soil samples (0-20 cm) were collected (planting and harvest period) each growing season from the center of each plot. To determine the initial physical and chemical properties of the soil, soil samples were air-dried and passed through a 2-mm sieve prior to analysis. Particle-size distribution was determined according to Bouyoucos (1962) and porosity was determined according to Danielson & Sutherland

(1986). Organic matter concentration (Nelson & Sommers 1982), pH (Jackson 1967), electrical conductivity (Rhoades 1996) and cation exchange capacity (Rhoades 1982a) were determined. Calcium carbonate was measured by the Scheibler method (Tüzüner 1990). Total N was analyzed by the Kjeldahl method and available K, Ca, Mg and Na were determined by the 1 N NH₄OAc (pH: 7) method. Ca, K and Na were determined by flame emission spectrometry and Mg was determined by flame atomic absorption spectrometry (AAS) (Kacar 1995). Available P was determined by the Mo blue method in a NaHCO₃ extract (Olsen & Sommers 1982). Available Fe, Cu, Zn and Mn were obtained with 40 mL DTPA+CaCl₂+TEA extract method and were found by atomic absorption spectrometry (Lindsay & Norvell 1978). Grain yield measurements were performed by 10 crops from each plots and the values were calculated by measuring total weight, corncob weight, and grain weight in t ha⁻¹.

Table 1- Some soil properties for the Ege University Menemen Agricultural Research Farm study site (sandy loam)

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	pH	EC (dS m ⁻¹)	OM (%)	CaCO ₃ (%)	Total N (%)
0-30 cm	55.28	36.00	8.72	7.78	0.72	1.11	4.70	0.07

Table 2- Main chemical quality characteristics of tobacco waste compost (TWC), poultry manure (PM), and bio-humus (BH)

Material	pH	EC (dS m ⁻¹)	OM (%)	C:N	CaCO ₃ (%)
TWC	9.18	49.50	33.60	22.40	7.06
PM	8.60	54.50	44.90	25.80	12.00
BH	7.88	9.20	46.50	29.30	26.00

Table 3- Nutrient status of tobacco waste compost (TWC), poultry manure (PM), and bio-humus (BH)

Material	%					ppm				
	N	P	K	Ca	Mg	Na	Fe	Cu	Mn	Zn
TWC	0.87	0.27	1.94	7.44	0.63	794.80	14500.00	119.00	442.00	124.00
PM	1.01	0.34	2.19	9.44	1.20	5663.00	2200.00	72.20	536.30	648.60
BH	0.92	0.20	0.69	11.76	0.92	993.50	12400.00	34.80	433.80	86.14

2.3. Statistical analysis

Analysis of variance (ANOVA) and Duncan's tests were performed with a $P \leq 0.05$ significance level and 95% confidence interval using the statistical package, SPSS Statistics 25.

3. Results and Discussion

3.1. Soil chemical properties

Soil pH values were significantly affected by all the treatments and varied between 7.49 and 7.92 ($P \leq 0.05$, Figure 1a). Soil under TWC treatment had significantly higher pH values than the other treatments. The highest pH (7.92) was observed with an increase of 3.6% over the control in the first growing season. There were no significant differences between the PM and BH treatments in the first and third growing season ($P \leq 0.05$). The study conducted by Mabuhay et al (2006) agreed with these results; they found that soil pH increased when organic and chemical fertilizers were applied to agricultural lands. Natri et al (2009) observed very slight soil pH response to addition of either organic or inorganic fertilizers. Giannakis et al (2014) reported that compost application increased soil pH from 7.80 to 8.10 and 8.20 in the 50 and 100 t ha⁻¹ application rates, respectively, at the 0-15 cm soil layer. Soil electrical conductivity (EC) was significantly different among all the treatments and varied between 0.45 and 1.95 dS m⁻¹ ($P \leq 0.05$, Figure 1b). PM and TWC treatments showed same significant effect on soil EC values in the second growing season; TWC and NPK treatments also showed same significant effect in the third growing season ($P \leq 0.05$). Release or solubilization of ions during compost incorporation may have resulted in the increased values of EC observed at the beginning of the study. Applying composted tobacco waste and poultry manure to soil raised the EC due to high level EC values of these materials (TWC: 49.50 dSm⁻¹; PM: 54.50 dSm⁻¹). Several researchers reported that addition of organic manure and compost to the soils significantly increased electrical conductivity (Candemir & Gulser 2011; Morugan-Coronado et al 2011; Cercioglu et al 2012). Addition of TWC, BH

and PM were increased significantly soil organic matter (OM) at each growing season (Figure 2a). According to the results, OM values were significantly ($P \leq 0.05$) greater (124%) in the TWC treatment when compared with the control treatment in 2009. Third growing season showed the greatest OM values (2.51 and 2.45%) by the PM and TWC treatments among all the growing seasons. The soil OM content was increased because of high OM content of organic materials (see Table 2). The increase in the levels of soil OM was expected, since, organic sources have the ability of increasing soil OM content (Ojeniyi 2000). Cercioglu et al (2012) reported that addition of composted tobacco waste on a loamy soil also increased soil organic matter content. Nevertheless, some studies showed that OM increases were temporary, since the organic material is rapidly mineralized by soil microorganisms (Mechri et al 2007; Di Serio et al 2008). Cation exchange capacity (CEC) is defined as the measure of the total capacity of a soil to hold exchangeable cations and indicates the negative charge present per unit mass of soil (Peverill et al 1999). With application of all the treatments, CEC values varied between 114.1 and 196.6 cmol (+) kg⁻¹ (Figure 2b). The greatest CEC value was obtained as 196.6 cmol (+) kg⁻¹ in the second growing season by increasing the rate 31% in the BH treatment. The TWC treatment also showed greater CEC values (124 and 145.6 cmol (+) kg⁻¹) in the first and third growing seasons. The increase in CEC of soil, as the result of organic material addition, has been reported by several researchers (Qian et al 2004; Jien & Wang 2013).

3.2. Corn yield

Grain yield values significantly varied between 6.62 and 24.36 t ha⁻¹ by all the treatments ($P \leq 0.05$, Figure 3). Poultry manure treatment had the greatest yield (24.36 t ha⁻¹) value in the first harvest with an increase of 42.3% over the control. Since the second and third growing season had an extreme dryness, yield results decreased during this time of the study. The addition of PM and TWC to soils significantly increased grain yield ($P \leq 0.05$). Positive

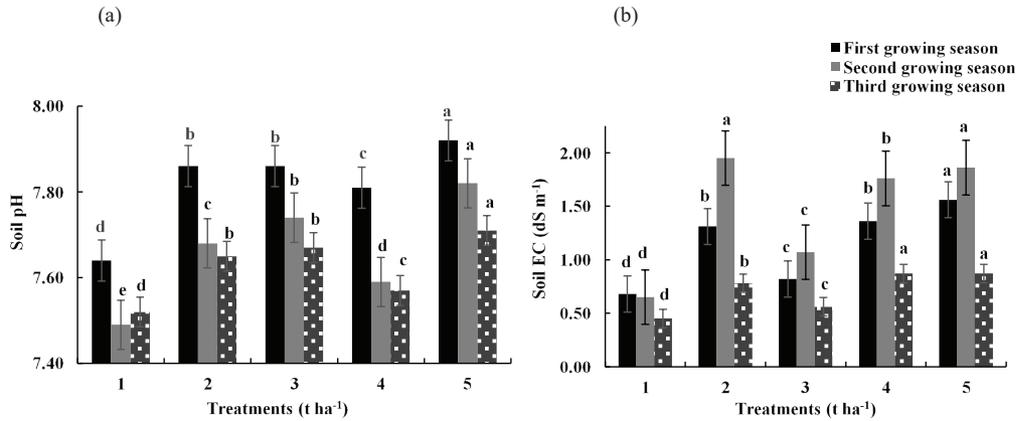


Figure 1- Changes in (a), soil pH; (b), soil EC (dS m⁻¹). Treatments 1, control soil; 2, poultry manure (4 t ha⁻¹) +NPK (300 kg ha⁻¹); 3, bio-humus (10 t ha⁻¹)+NPK (300 kg ha⁻¹); 4, NPK (300 kg ha⁻¹); 5, tobacco waste compost (50 t ha⁻¹). The error bars represent the mean ± SE of four replicates (n= 4). The letters presents significance levels among treatments for each growing season according to Duncan's test (P ≤ 0.05)

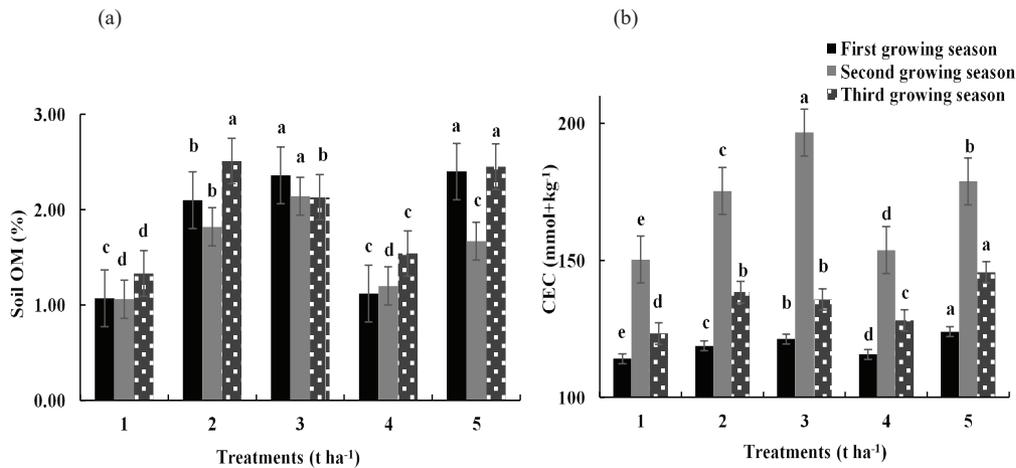


Figure 2- Changes in (a), soil OM (%); (b), soil CEC (cmol+kg⁻¹). Treatments 1, Control soil; 2, Poultry manure (4 t ha⁻¹)+NPK (300 kg ha⁻¹); 3, Bio-humus (10 t ha⁻¹)+NPK (300 kg ha⁻¹); 4, NPK (300 kg ha⁻¹); 5, tobacco waste compost (50 t ha⁻¹). The error bars represent the mean ± SE of four replicates (n= 4). The letters presents significance levels among treatments for each growing season according to Duncan's test (P ≤ 0.05)

yield responses in various plants to the addition of composted tobacco waste have been mentioned in several studies (Jakubus & Czekala 2002; Cercioglu et al 2012; Cercioglu 2017). Ojeniyi & Adeniyani (1999) reported that poultry manure can effectively improve soil fertility, yield and nutrient composition

of plant. Similarly, Garg & Bahla (2008) found that higher grain yield with increased poultry manure could be because of balanced nutrients supply throughout the growth and development stages of plant. Studies conducted by Ayoola & Makinde (2009), obtained greater grain yield in poultry

manure treatments and lower in chemical fertilizer and control treatments. Poultry manure and chemical fertilizer combinations can improve the efficiency of nutrients uptake and availability to plant (Warren et al 2006). Similar yield results found in the current study has also occurred in other studies.

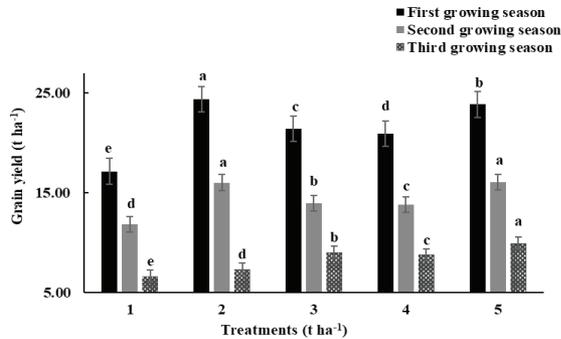


Figure 3- Changes in grain yield (t ha⁻¹). Treatments 1, Control soil; 2, Poultry manure (4 t ha⁻¹)+NPK (300 kg ha⁻¹); 3, Bio-humus (10 t ha⁻¹)+NPK (300 kg ha⁻¹); 4, NPK (300 kg ha⁻¹); 5, tobacco waste compost (50 t ha⁻¹). The error bars represent the mean±SE of four replicates (n= 4). The letters presents significance levels among treatments for each growing season according to Duncan’s test (P≤0.05)

4. Conclusions

Generally, organic materials added to the soil significantly (P≤0.05) enhanced soil pH, electrical conductivity, organic matter content, and cation exchange capacity compared to the control soil. Improvement of the soil chemical properties is important for plant yield especially for Izmir where its plant and fruit production are prominent among agricultural industries of Turkey. The benefited methods and results from this study have demonstrated that soil chemical properties are changed significantly by addition of different organic treatments. Similarly, grain yield of corn was changed by applying these amendments. However, occasionally using these materials may cause some problems. For instance, high salinity of poultry manure is the most important factor limiting the use of it. It is therefore recommended to apply

to the soil after analyzing the salt content of poultry manure. Additionally, due to the fact that experiment soil has high sand content, provides permeable structure and the applications do not cause a soil pollution problem. Nevertheless, they might cause pollution of groundwater. Hence, these materials should be added to the soil (tobacco waste compost, poultry manure and bio-humus) for improving soil properties of a *Typic Xerofluvent* soil.

Acknowledgements

I would like to express my thanks to Ege University for their financial support of this study as a scientific research project (09-ZRF-031)

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