APPLICATION OF ORGANIC AND INORGANIC AMENDMENTS ON SOIL PHYSICAL PROPERTIES OF A XEROFLUVENT SOIL

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Abstract
The aim of this study was to investigate the impacts of application of different amendments as composted tobacco waste (CTW), poultry manure (PM), bio-humus (BH), zeolite (Z) and lime (L) on soil physical properties. This research was performed in the experimental fields of the Agriculture Faculty's research farm at Ege University in Menemen, Izmir, Turkey from 2009 to 2011. In this study, tobacco wastes gathered from the cigarette industry were composted and bio-humus (composted plant residuals), poultry manure were obtained from organic manure industry for this study. It has been analyzed that application of organic amendments (CTW, BH, PM) increased porosity, field capacity, available water content, wilting point, sturucture stability index between the rates of 14% and 26.4%; decreased bulk density, particle density of soil samples between 3.4% and 15.8% rates when compared with the variation of the control. The results show that these organic wastes were determined as the most effective amendments on soil physical properties.

Key words: bio-humus, lime, physical properties of soil, poultry manure, tobacco waste, zeolite.

INTRODUCTION

The addition of agricultural wastes with high OM content to soil is a current environmental and agricultural practice for maintaining soil OM, reclaiming degraded soils and supplying plant nutrients (AGGELIDES AND LONDRA, 2000). Tobacco waste material might be reused as an OM source in agriculture to improve soil quality. The measurable minimum data set needed to evaluate soil quality includes physical, chemical and biological properties such as texture, structural stability, organic matter (DORAN AND PARKIN, 1994). Direct use of tobacco waste could create an unfavorable soil environment; however, composting tobacco waste could accelerate the breakdown of nicotine and result in the production of a less toxic and more useful organic amendment (ADEDIRAN ET AL., 2004). A considerable increase in crop yields can also be achieved with lime application (HAYNES AND NAIDU, 1998). Zeolite is used as a soil conditioner in organic farming. It has been estimated that zeolite provides using fertilizers economically on soils which are sandy or have less organic matter content (ERTIFTIK, 1998).

In the present study, composted tobacco waste (CTW), bio-humus (BH), poultry manure (PM), lime (L) and zeolite (Z) combined with mineral fertilizer at different ratios were applied to soil and the influences of these amendments on some physical properties of a Xerofluvent soil were compared.

MATERIALS AND METHODS

Site and organic waste description

This research was performed in the experimental fields of the Agriculture Faculty's research farm at Ege University in Menemen region (Western Anatolia) of Izmir, Turkey between the years of 2009-2011. The experiment was arranged in a randomized block design with four replicates. The soil was a sandy loam, classified as a Xerofluvent with pH of 7.62. Organic matter (OM), total N and total soluble salt contents of soil were analyzed that 1.11 g kg^{-1}, 0.07 g kg^{-1} and 0.046 g kg^{-1}, respectively. In this study, tobacco wastes gathered from the cigarette industry were composted and bio-humus (composted plant residuals), chicken manure were obtained from organic manure industry for this study. Treatments were as follows: (1) 1 t ha^{-1} Z+NPK, (2) 4 t ha^{-1} PM+NPK, (3) 1 t ha^{-1} L+NPK, (4) 300 kg ha^{-1} NPK, (5) 50 t ha^{-1} CTW, (6) 10 t ha^{-1} BH+NPK and (7) control. During the research, soil samples were taken six times in three years. (I, 3 June 2009; II, 23 October 2009; III, 1 June 2010; IV, 5 November 2010; V, 13 July 2011; VI, 21 October 2011). Tab. 1 and Tab. 2 show that the composition of different soil amendments in the study.

Tab. 1. – The composition of composted tobacco waste (CTW); poultry manure (PM); bio-humus from composted plant residues (BH); zeolite (Z)

Material	OM (%)	C:N	pH	EC (ds m^{-1})
CTW	33.6	22.41	9.18	49.5
PM	44.9	25.84	8.60	54.5
Z	-	-	7.33	0.065
BH	46.5	29.35	7.88	9.20

Tab. 2. – Macro and micro element status of the amendments

Material	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)
CTW	0.87	2770	19486	74440	635	794.8	14500	119	442	124
PM	1.01	3470	21985	94424	12000	5663	2200	72.2	536.3	648.6
Z	0.01	0.378	11205	3454	80.86	3185	0.928	0.298	2.422	0.690
BH	0.92	2050	6995	117656	9200	993.5	12400	34.8	433.8	86.14

Soil sampling and analysis

During the research, soil samples were taken as disturbed and undisturbed (0-20 cm) from the center of each plot in planting and harvest periods. The samples were air-dried and sieved through 2 and 8 mm sieves. Particle-size distribution was determined according to BOUYOUCOS (1951). Bulk density was determined from undisturbed soil samples that were taken by using a steel cylinder of 100 cm^3 volume (BLACK, 1965). Porosity was determined according to DANİELSON ET AL., (1986). Field capacity, wilting point, and available water content were determined using disturbed soil samples sieved through a 2 mm-mesh utensil (U.S. SALINITY LABORATORY STAFF., 1954). Total salt, OM concentration, calcium carbonate and pH were all determined according to PAGE ET AL., (1982). Some characteristics of the soil are given in Tab. 3.

Statistical analysis

ANOVA and Duncan tests were performed according to 0.05 significance level ($p \leq 0.05$) and 95% confidence interval by using the statistical package, SPSS Statistics 19 (SPSS 19, 2010). The experimental design was performed three factors and mixed-level factorial randomized block as shown in Tab. 4.

Tab. 3. – Initial soil characteristics

Clay (%)	8.72
Silt (%)	36
Sand (%)	55.28
$CaCO_3$ (%)	4.70
BD (g cm^{-3})	1.46
PD (g cm^{-3})	2.65
PO (%)	50.66
FC (%)	17.77
WP (%)	10.26
AWC (%)	7.51

(BD: Bulk density PD: Particle density PO: Porosity FC: Field capacity WP: Wilting Point AWC: Available water content).

Tab. 4. – Mixed-level experimental design

Factor	Parameter	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
A	Year	2009	2010	2011	-	-	-	-
B	Sampling	I	II	-	-	-	-	-
C	Treatment	1	2	3	4	5	6	7

(1) Zeolite at 1 t ha^{-1} + NPK, (2) poultry manure at 4 t ha^{-1} + NPK, (3) lime at 1 t ha^{-1} + NPK, (4) NPK at 300 kg ha^{-1}, (5) composted tobacco waste at 50 t ha^{-1}, (6) bio-humus at 10 t ha^{-1} + NPK and (7) control (Duncan test, $p \leq 0.05$).

RESULTS AND DISCUSSION

Changes in physical properties of soil samples

By the addition of amendments, physical properties of soil samples were analyzed statistically significant when compared with the control (Tab. 5, 6, 7). All the applications were ensured a significant ($p \leq 0.05$) decrease on bulk density compared to the control plots. The lowest bulk density was analyzed last year of the experiment by the treatment of PM as 1.05 g cm^{-3}. Maximum porosity values were found last year of the study by application of PM compared to the control plots. MBAGWU (1989), noted that organic wastes incorporated into the soil at the rate of 10% increased the total porosity by 23%. MARİNARİ ET AL. (2000), also found that total soil porosity increased with organic fertilizers and compost, depending on the amount of materials applied. The water holding capacity of soils at field capacity (FC), wilting point (WP) and available water content (AWC) were significantly ($p \leq 0.05$) effected by additions of organic wastes. Plots amended with bio-humus resulted in the highest values in FC each year of experiment. FC values varied as 21.89%, 21.65% and 20.29% in BH treated soil samples according to years respectively. The highest wilting point (WP) results of each year were analyzed in PM plots. By addition of PM, wilting point (WP) was determined as high as 11.50% in 2010 (Tab. 6). AWC values varied between 7.36% and 10.83%. Second year of experiment, the maximum AWC was determined in L treated soil samples (Tab. 6). AGGELIDES AND LONDRA (2000) determined that porosity and water-retention capacity of loamy and clay soils increased with application of compost. However, HAYNES AND NAIDU (1998) concluded that water content at both field capacity and wilting point was generally increased by additions of manure applications but available water content was not significantly changed.

All the treatments were determined statistically significant ($p \leq 0.05$) on structure stability of soil. The highest structure stability values of all years were analyzed that by PM treatment compared with the variation of the control (Tab. 5, 6, 7). Since there is a strong correlation between SSI and amounts of high organic matter (OM) in PM, BH and CTW, the application of these materials increased soil aggregation and SSI. Additionally, our findings were in agreement with findings of CHENU ET AL. (2000), PUGET ET AL. (2000), and TEJADA AND GONZALEZ (2003, 2004), who found that soil structure depended on the content and nature of the OM added.

Tab. 5. – Changes in physical properties of soil by application of amendments in 2009

Treatments (t ha^{-1})	BD (g cm^{-3})	PO (%)	FC (%)	WP (%)	AWC (%)	SSI (%)
1	1.24	50.38	21.22	10.09	11.13	17.55
2	1.23	50.41	21.67	11.21	10.46	22.37
3	1.27	49.46	19.87	9.76	10.10	18.64
4	1.29	49.29	18.72	9.45	9.28	17.49
5	1.20	51.08	21.76	11.04	10.73	21.66
6	1.19	51.38	21.89	11.19	10.71	17.78
7	1.39	45.64	18.86	9.16	9.69	15.54

(1)Zeolite at 1 t ha^{-1} + NPK, (2) poultry manure at 4 t ha^{-1} + NPK, (3) lime at 1 t ha^{-1} + NPK, (4) NPK at 300 kg ha^{-1}, (5) composted tobacco waste at 50 t ha^{-1}, (6) bio-humus at 10 t ha^{-1} + NPK and (7) control. (Duncan test, $p \leq 0.05$)

Tab. 6. – Changes in physical properties of soil by application of amendments in 2010

Treatments (t ha^{-1})	BD (g cm^{-3})	PO (%)	FC (%)	WP (%)	AWC (%)	SSI (%)
1	1.31	49.42	20.46	10.57	9.89	20.06
2	1.26	51.11	21.20	11.50	9.69	22.47
3	1.34	48.51	21.14	10.31	10.83	19.87
4	1.37	47.85	18.50	9.95	8.54	19.68
5	1.23	52.46	20.99	11.18	9.81	21.44
6	1.24	51.08	21.65	11.27	10.38	20.83
7	1.43	45.88	17.97	9.73	8.23	18.68

(1)Zeolite at 1 t ha^{-1} + NPK, (2) poultry manure at 4 t ha^{-1} + NPK, (3) lime at 1 t ha^{-1} + NPK, (4) NPK at 300 kg ha^{-1}, (5) composted tobacco waste at 50 t ha^{-1}, (6) bio-humus at 10 t ha^{-1} + NPK and (7) control. (Duncan test, $p \leq 0.05$)

Tab. 7. – Changes in physical properties of soil by application of amendments in 2011

Treatments (t ha^{-1})	BD (g cm^{-3})	PO (%)	FC (%)	WP (%)	AWC (%)	SSI (%)
1	1.15	55.94	19.25	9.99	9.25	16.17
2	1.05	59.55	20.00	11.26	8.74	18.37
3	1.19	54.55	19.25	10.45	8.79	16.64
4	1.28	51.19	17.15	9.45	7.70	17.18
5	1.07	57.66	20.02	10.66	9.36	18.14
6	1.10	57.28	20.29	10.67	9.62	17.19
7	1.33	49.85	16.62	9.26	7.36	15.79

(1)Zeolite at 1 t ha^{-1} + NPK, (2) poultry manure at 4 t ha^{-1} + NPK, (3) lime at 1 t ha^{-1} + NPK, (4) NPK at 300 kg ha^{-1}, (5) composted tobacco waste at 50 t ha^{-1}, (6) bio-humus at 10 t ha^{-1} + NPK and (7) control. (Duncan test, $p \leq 0.05$)

CONCLUSIONS

It was observed that the use of organic wastes had a positive impact on physical characteristics of a Xerofluvent soil because of their high organic matter content which promotes flocculation of particles, the essential condition for the aggregation of soil particles. In the present study, application of 50 t ha^{-1} CTW, 4 t ha^{-1} PM and 10 t ha^{-1} BH with chemical fertilizers increase soil organic matter content and this results in decreased bulk density the rate of 16.5%; and increased porosity, field capacity, wilting point, available water content and structure stability index as 15.4%, 19.5%, 20.6%, 22.6% and 26.8% as compared to the average of the years and control plots. They can therefore be used at those rates for improving soil physical properties. Occasionally applying the organic and inorganic materials may cause some problems. For instance, high salinity of PM is the most important factor limiting the usage of it. It is therefore recommended to apply to the soil after analyzing the salt content of PM. In addition, due to the fact that experimental soil has high sand content, provides permeable structure and the applications do not cause any soil pollution problem. Nevertheless, they might cause pollution of groundwater. It is highly recommended that 50 t ha^{-1} CTW, 4 t ha^{-1} PM with NPK fertilizer and 10 t ha^{-1} BH with NPK fertilizer should be added to soils for improving soil physical properties.

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