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Research Article

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The Effect of Sewage Sludge Applied to Vetch + Barley Mixture on Some Soil Properties*

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Abstract This study was carried out to determine the effect of sewage sludge applied to vetch + barley mixture on some soil properties. The research was conducted in a randomized complete block design in four replications in the experimental fields of Ege University, Faculty of Agriculture in Bornova for two years in 2015 and 2016. In research beside control and mineral fertilizer 10, 20 and 30 t ha^{-1} treated sludge was applied into the soil. In trial pH, EC, organic matter and calcitic lime were investigated. Although the application affected pH and salinity in both years, organic matter was affected in the first year of study. Applications had no affect on calcitic lime. As a result of study, it is seen that sewage sludge applications decreased pH and increased organic matter and soil salinity.

Keywords Calcitic lime, mineral fertilizer, organic matter, pH, salt

Introduction

Plant nutrients in the soil are of great importance in the growth of plants and for high yields. In addition to the total amount of these nutrients, it should be known how much of this amount is in the form that the plants can take. Various factors play a role in the transformation of plant nutrients into the form that plants can take. Some of these factors are under people's control, while others are not. Considering the protection and development of the structural properties of the soil, it is important to mix organic and inorganic materials into the soil in the right time and amount effectively. The organic matter ratio of the soil is an important detail in improving the physical, chemical and biological properties of the soil. Considering the deficiency of organic matter in our country's soils[1], it becomes clear how important it is to mix organic sources into the soil. The fact that organic matter amount is less than 1% in agricultural land in Turkey shows the need of country soils to the organic matter. In order to meet this need, different sources of organic matter should be sought and studies and researches should be made in this direction[2].

The fact that organic-based urban sewage sludge is easily available and low cost supports the idea of using these wastes in agricultural areas[3]. There are many studies reporting that sewage sludge contains many nutrients as well as high organic matter, and when used correctly, it balances pH and increases soil organic matter [4 – 5]. In a study [6] it was reported that a soil pH of 12 was sufficient to suppress heavy metals in sewage sludge. The researcher stated that lime is mostly used as a basic agent to raise the pH of the sewage sludge to around 12. Treatment sludges contain macronutrients, trace elements and heavy metals. These sludges can be used as cheap fertilizers for agricultural soils containing high calcitic lime and low organic matter. However, special attention should be paid to treatment sludge in terms of heavy metals[4 – 7 – 8].

Since treatment sludges contain approximately 50-70% organic matter in dry matter and a significant amount of plant nutrients, it is thought as a significant soil organic matter and organic fertilizer source in recent years. The

plant nutritional value of sewage sludge was found to be similar to barn manure and organic compost[9 – 10]. The aim of this study is to investigate the effect of treated sewage sludge (TSS) applied to vetch + barley mixture on some soil properties.

Materials and Methods

Experimental site

The experiment was carried out during 2015-16 and 2016-17 growing seasons at Bornova experimental fields (38°27.236 N, 27°13.576 E) of Agricultural Faculty of Ege University, Izmir, Turkey. The experimental site is in the Western Anatolia region of Turkey, where the Mediterranean climate prevails with a long-term mean annual temperature of 18.1 °C. Long-term mean annual precipitation is 688.9 mm, representing about most of rainfalls during the winter and spring (Table 1). Long-term mean annual potential evapotranspiration is 1,570 mm [11].

Table 1: Some meteorological parameters of experimental area at Bornova

	Long Year Average (1970-2013)		**2015**		**2016**		**2017**	
	AT (^oC)	**TP (mm)**	**AT (^oC)**	**TP (mm)**	**AT (^oC)**	**TP (mm)**	**AT (^oC)**	**TP (mm)**
January	9.0	112.2	8.9	125.1	8.5	161	6.3	237.6
February	9.2	99.7	9.5	101.9	13.6	76.5	10.4	55.6
March	11.8	82.9	11.7	75.6	13.8	103	13.3	72.2
April	16.1	46.4	15.9	46.4	18.9	12.8	16.6	15.7
May	21.0	25.4	20.8	30.9	21.2	28.2	21.7	27
June	26.0	7.5	25.6	9.8	27.7	9.2	26.5	1.8
July	28.3	2.1	28.0	1.8	29.9	1.2	29.8	1.4
Agust	27.9	1.7	27.7	2.6	29.4	3.0	29.4	0.3
September	23.9	19.9	23.7	15.0	25.1	6.4	24.6	0.9
October	19.1	43.2	18.8	45.3	19.2	1.4	18.8	45.7
November	13.8	109.7	14.0	94.8	14	101	13.3	62.1
December	10.5	137.9	10.6	141.1	6.8	15.2	11.8	73.9
Ave.-Total	**18.1**	**688.9**	**17.9**	**690.3**	**19.0**	**518.6**	**18.5**	**594.2**

AT: Average Temperature
TP: Total Precipitation

The soil of the trial area has a clay-loam structure and is slightly alkaline. Soil is poor in organic matter. It is seen that the amount of available Cu, Zn and Mn of the trial soil is sufficient and the Fe content is low. Some physical and chemical properties and plant nutrient content of the experimental soil is given in Table 2 and some selected properties and total heavy metal concentrations in TSS used in the experiment is given in Table 3.

Table 2: Some physical and chemical properties and plant nutrient contents of experimental area

Analysis	**Result**	**Evaluation**	**Method**
pH	7.51	Slightly alkaline	[12]
Electrical Conductivity (µS/cm)	920	No salinity danger	[12]
Organic Matter (%)	1.17	Low	[12]
Lime ($CaCO_3$) (%)	9.91	Calcerous	[13]
Sand (%)	40.80		[14]
Clay (%)	34.94	Clay loam	
Silt (%)	24.26		
Total N (%)	0.094	Middle	[15]

Available P (mg/kg)	21.12	Enough	[16]
Available K (mg/kg)	352	High	[17]
Available Ca (mg/kg)	6875	Very high	
Available Na (mg/kg)	30.8	Very low	
Available Mg (mg/kg)	304.2	High	
Available Fe	4.39	May show deficiency	[18]
Available Mn	7.58	Enough	
Available Zn	1.38	Enough	
Available Cu	1.66	Enough	

Table 3: Analysis results of the treated sewage sludge used in the experiment

pH (1/10)		7.18	Na	mg/kg	1390.5
EC (1/10)	µS/cm	1945	Fe	mg/kg	12754.96
Organic matter	%	51.20	Cu	mg/kg	176.5
Organic C	%	29.66	Zn	mg/kg	1376.59
Lime ($CaCO_3$)	%	5.35	Mn	mg/kg	350
N	%	2.99	Ni	mg/kg	69.73
P	%	0.2275	Pb	mg/kg	17.44
K	%	0.34	Cr	mg/kg	112.53
Ca	%	6.36	Cd	mg/kg	2.83
Mg	%	2.04	B	mg/kg	16.1

Field experiment

Five different applications including the control, mineral fertilizer and TSS (10 t ha^{-1}, 20 t ha^{-1} and 30 t ha^{-1}) as dry matter were compared in a field trial arranged in the Randomized Complete Block Design with four replications in 2015 and 2016. The plot dimensions were 2 m width and 5 m length and each parcel had 10 rows of 20 cm spacing. The TSS used in the experiment was obtained from the wastewater treatment plant of Metropolitan Region, Izmir city. TSS was added into the soil before sowing. Also 60 kg N, 60 kg P_2O_5, 60 kg K_2O ha (15.15.15. composed fertilizer) were applied to the mineral fertilizer plots at the same time and was mixed into the soil to 15 cm dept. Vetch (150 kg ha^{-1}) and barley (50 kg ha^{-1}) [19] were sown by hand on December 08, 2015 in first year and on December 12, 2016 in second year. Weeds were removed by hand as needed. Since the experiment was conducted during the winter months, there was no additional irrigation. After removing one row from each side and 50 cm from each side as an edge effect, the remaining area was harvested. After harvest three soil samples were taken from each plot.

Laboratory analysis

Three soil samples were mixed and electrical conductivity [20], pH [21], $CaCO_3$ and organic matter [22] were determined in the laboratory.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 17 [23]. LSD test was used to find if differences in the treatments were significant at $P \leq 0.05$ [24].

Results & Discussion

The applications had significant effect at the level of 0.01 on pH and electrical conductivity in both years. Organic matter was affected from applications in only first year at the significant level of 0.05. Calcitic lime was not affected from applications.

In the first year of the study, the highest pH content was taken from the control application as 7.56, while the lowest pH content (7.40) was taken from 30 t ha^{-1} sewage sludge application. In the second year, the highest pH values were obtained with control, 10 t ha^{-1} and mineral fertilizer applications as 7.58 and 7.56, respectively,

while the lowest pH values were obtained as 7.45 and 7.44 from 20 t ha^{-1} and 30 t ha^{-1} sewage sludge applications, respectively.

In terms of salinity values of the soil, in the first year of the study, the highest salinity values between 683 and 730 were obtained by the application of mineral fertilizers in addition to all applications of the treatment sludge. The control application gave the lowest salinity value with 619 EC value. In the second year, the highest salinity value was obtained as 926 EC from 3 t / ha sewage sludge application, while the lowest salinity values were 637 EC and 658 EC, respectively, for control and mineral fertilizer applications.

Organic matter content of the soil increased in the first year depending on the sewage sludge and was statistically significant at the 0.05 level, but no significant effect was observed in the second year. In the first year, the highest organic matter contents were 2.82% and 3.02, respectively, with 20 and 30 t ha of sewage sludge applications, while the lowest organic matter contents were 1.12% and 1.37, respectively, from control and mineral fertilizer applications.

Tablo 4: Effects of applications on some soil properties

Applications	pH		EC (micros/cm)		Org. Matter (%)		$CaCO_3$ (%)	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	7.56A*	7.58A	619B	637C	1.12B	2.61	21.58	21.70
10 t ha^{-1} TSS	7.49BC	7.56A	730A	753BC	1.87AB	2.74	22.05	20.13
20 t ha^{-1} TSS	7.44CD	7.44B	705A	844AB	2.82A	3.25	20.78	21.90
30 t ha^{-1} TSS	7.40D	7.45B	740A	926A	3.02A	3.49	20.23	19.00
Min. Fertilizer	7.53AB	7.56A	683A	658C	1.37B	2.69	22.03	16.65
LSD (0.05)	0.057**	0.08**	60.1**	145.8**	1.35*	ö.d	n.s	n.s

*: Denotes significant differences at $p \leq 0.05$; n.s: not significant; TSS: Treated sewage sludge

The increase in EC of soil is related to the relatively high EC of treatment sludge and it is emphasized that the pH value of the soil decreased and the EC value increased with sewage sludge applications [25 – 26]. The results confirm the results obtained from our study.

Increasing sewage sludge levels significantly increased the organic matter content of the soil [4 – 27]. In our study, although the application of sewage sludge caused an increase in the organic matter of the soil compared to the control and mineral fertilizer, the organic matter content decreased as the amount of sludge increased. It is also reported that sewage sludges can be used to solve the organic matter shortage of soils due to their high organic matter content [10]. Many researchers also agreed that sewage sludge increases the amount of organic matter in the soil [28 – 29 – 30 – 31]. Similar results were obtained in our study.

In our study, it was found that the applications did not affect the soil calcitic lime. Many research results [28 – 25] were supported our results. Researchers suggested that sewage sludge application did not change the amount of calcitic lime in the soil.

Conclusion

Studies should be carried out to increase the amount of organic matter for the sustainable use of agricultural areas. For this reason, necessary amount of organic matter should be mixed with the soil to improve the physical and chemical properties of the soil. In addition, organic matter wastes generated by urbanization and the growth of urban life should be made compatible with the environment and used as compost and / or treatment sludge in agriculture.

In this study it was determined that the sewage sludge increased soil pH and salinity. Organic matter was affected in first year, only and calcitic lime was not affected from applications. When the results are evaluated in general, it is concluded that 20 or 30 t ha-1 of sewage sludge can be easily used in vetch + barley mixtures, taking into account the results of soil analysis and the amount of heavy metals that can be applied into the soil.

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