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Effects of organic and inorganic amendments on soil erodibility

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Abstract

The objective of the present investigation is to find out the effect of incorporating of various organic and inorganic matter sources such as lime (L), zeolit (Z), polyacrylamide (PAM) and biosolid (BS) on the instability index. A bulk surface (0–20 cm depth) soil sample was taken from Samsun, in northern part of Turkey. Some soil properties were determined as follows; fine in texture, modarete in organic matter content, low in pH and free of alkaline problem. The soil samples were treated with the inorganic and organic materials at four different levels including the control treatments in a randomized factorial block design. The soil samples were incubated for ten weeks. After the incubation period, corn was grown in all pots. The results can be summarized as organic and inorganic matter treatments increased structure stability and decreased soil erodibility. Effectiveness of the treatments varied depending on the types and levels of organic and inorganic materials.

Keywords: structural stability, productivity, polyacrylamide, zeolit, biosolid, lime

Introduction

Soil physical properties are important for favorable conditions for crop growth and maintaining soil quality. Many practices are known to influence soil physical properties. These include crop type (Alberts and Wendt, 1985), cultivation (Gantzer and Blake, 1978) and application of organic residues (Anderson et al., 1990; Gantzer et al., 1987; Ekwue, 1990; Gajic et al., 2006; Gülser and Candemir, 2012; Cercioğlu et al., 2014). Soil degradation involves destruction of soil structure due to loss of organic matter by intensive agriculture practices (Gülser and Candemir, 2006). Most studies showed that amelioration of soil physical properties largely based on increases of organic carbon in the soils with using organic wastes. Effects of application of organic residues on soil physical properties are often related to increases in soil organic matter (Özdemir, 1993; Haynes, 2000). Soil organic matter is an essential but transient component of the soil that controls many physical, chemical and biological properties of the soil (Carter, 1996). The stability of soil aggregates often decreases for soil under annual crops, such as wheat or corn (Angers et al., 1999). Gantzer et al. (1987), reported that residue quantity had a larger effect on splash detachment, shear strength and aggregate stability than residue type. MacRay and Mehuys (1985), concluded that long-term pastures were ideal for improving soil aggregation.

Many studies have showed a clear relationship between total soil C and soil aggregation, bulk density, productivity, water retention and hydraulic conductivity (Khaleel et al., 1981). Benbi et al. (1998),

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demonstrated that amending coarse-textured soils with manure increased organic carbon content and improved saturated hydraulic conductivity, water stable aggregation and water retention.

Recent interest in sustainable cropping systems has focused renewed attention on the use of organic materials as fertilizers. Livestock manure and bio-solids (BS) are a restorative option (Dormaar et al., 1988; Larney and Janzen, 1996) but only where they are available on-farm or within a short hauling distance. However, there is a scarcity of information on the rates of manure necessary to restore productivity of eroded soils, especially in arid and semi-arid areas (Parr et al., 1989). Traditionally, all areas of a field receive the same application rate of fertilizer irrespective of inherent soil quality (e.g. soil type, nutrient status, organic matter content, level of erosion).

Use of soil amendments to increase agreggate stability of soils susceptible to erosion has been examined in the recent studies (Agassi and Ben-Hur, 1992; Flanagan et al., 1997; Shainberg et al., 1990; Shainberg and Levy, 1994). One such practice is the incorporation of lime ($CaCO_3$) into the acid soil. Lime application improves soil structure in heavy-textured soil, so that water infiltration and the ability of roots to penetrate the soil are enhanced. Sugarcane germination can also be promoted by increasing of soil calcium content (Sürücü, 1995).

Polyacrylamide (PAM) dissolved in irrigation water (10 mg kg^{-1}) has been extensively used to prevent erosion and increase infiltration in furrow irrigation (Lentz et al., 1992; Lentz and Sojka, 2000). Polyacrylamide with high molecular weight and moderate anionic charge density (18-20 % hydrolysis) was found to be most effective in preventing runoff and increasing aggregate stability (Lentz et al., 1992; Green et al., 2000). Similarly, PAM in concentrations of 5, 10, and 20 mg L^{-1} were found to be effective in controlling runoff and erosion from loamy loess and a grumusol during sprinkler irrigation (Levy et al., 1992; Flanagan et al., 1997). Soil losses in all the PAM treatments were significantly lower than those in the control treatment (Levy et al., 1992).

The objective of this investigation is to determine the effects of incorporating various organic and inorganic amendments such as lime (L), zeolit (Z), polyacrylamide (PAM), and biosolid (BS) into acidic soil on the structure stability and corn pruduct.

Material and Methods

The soil samples (0–20 cm depth) used in the experiment were taken from Samsun, northern part of Turkey. The lime (L), biosolid (BS), polyacrylamid (PAM) and zeolit (Z) were obtained from different institutions.

The soil samples, after the lime requirements done in 0, 50 and 100 % levels were treated with the inorganic and organic residues at four different levels (BS 0.0, 2.0, 4.0 and 8.0 %; Zeolit 0.0, 0.5, 1.0 and 2.0 %; PAM; 0.0, 15, 30, 60 ppm) including the control treatments, and each treatment was replicated two times in a randomized factorial block design [(3x3x4)x2]. All pots were incubated for ten weeks. After incubation period, corn was grown in all pots. After reaping of the corn, treated soil samples were rubbed by hand and sieved from 2 mm openings sieve. Some physical and chemical properties of soils were determined as fallows; soil organic matter content by a modified Walkley-Black method (Nelson and Sommers, 1982); soil texture by hydrometer methods (Demiralay, 1993) lime requirement by SMP method (Kacar, 1995); pH in 1:2.5 (v:w) soil:water suspension by pH meter (Black, 1965); exchangeable Na by ammonia acetate extraction and cation exchange capacity according to Bower method (U.S. Salinity Laboratory Staff, 1954). Instability index value was determined according to Combeau and Monnier method (Morgan, 2005). Statistical analyses of results were done by SPSS computer program.

Results and Discussion

Soil Properties

Some physical and chemical soil properties are given in Table 1. Soil properties can be summarized as; fine in texture, moderate in organic matter content, low in lime content, low in pH and free of alkaline problem (ESP <15 %), 21.2 meq $100g^{-1}$ of CEC (Soil Survey Staff, 1993).

Table 1. Some physical and chemical properties of the soil

Sand (S), g g^{-1}	0.233
Silt (Si), g g^{-1}	0.365
Clay (C) , g g^{-1}	0.402
Textural class	Clay
pH (1:2.5)	5.4
Organic matter content (OM), %	2.93
Cation exchange capacity (CEC), meq $100g^{-1}$ oven-dried soil	21.2
Exchangeable sodium percentage (ESP), %	6.40

Instability Index

After harvesting of the corn, instability index values of soil samples were determined according to Combeau and Monnier method. The effects of amendments on the instability index values depend on the type and level of amendment materials. These situations were given in Figure 1. It was observed that the instability index values of all soils decreased significantly depending on lime and amendment materials. It was suggested that, the increasing dose application of amendment materials into acidic soil decreaased erodibility**.** It was found that without lime application had the lowest effect on the instability index when compared with the other applications (Figure 1).

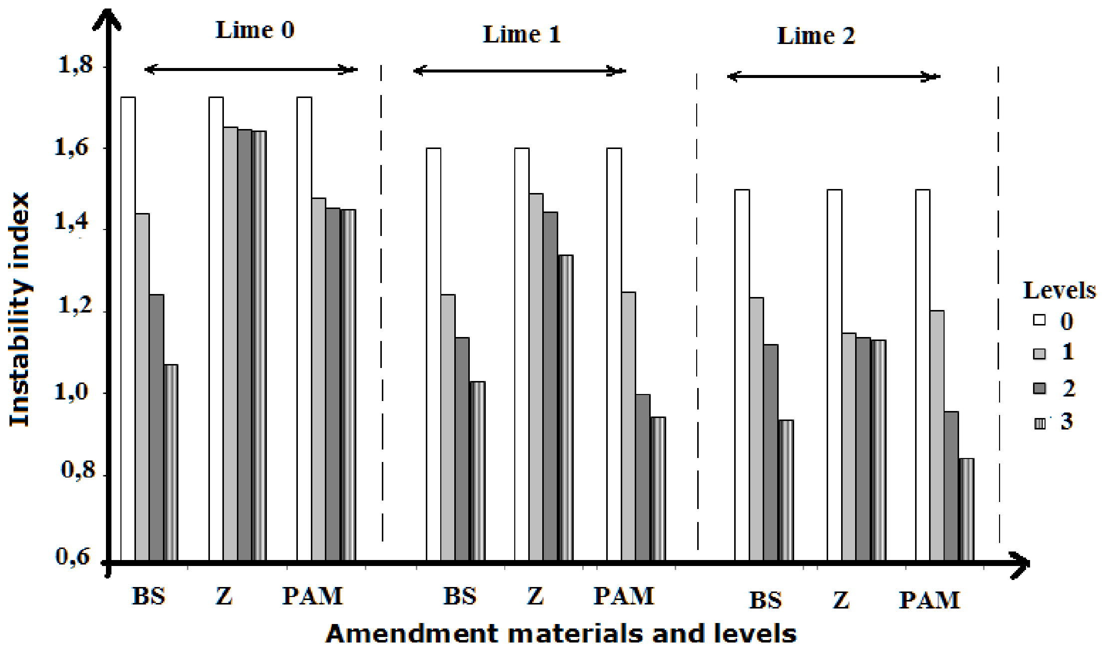

Figure 1. The comparison of instability index values as a function of lime addings

Also, decreases in the instability index (as a mean value) according to the lime addition levels were presented in Figure 2. The instability index values were different in each treatment. It is clearly seen that, zeolit application decreased the instability index lower than the other amendments.

Variance analysis results on the instability index values are given in Table 2. As shown in this table, instability index values depending on the lime levels were significantly different at p <0.01.

The effect of amendment materials (BS, Z and PAM) on the instability index and their levels were statistically significant. On the other hand, instability index values according to soils were different at the end of the corn grown period. Mean of square values of the amendment materials (p <0.01) and their levels (p <0.01) were statistically significant. As shown in Table 2, also interactions between lime-amendment, lime-level, amendments-level, and lime-amendment-level were significant (p <0.01). The comparison of mean values statistically are given in Table 3. The differences among the instability index values were significant at p <0.01.

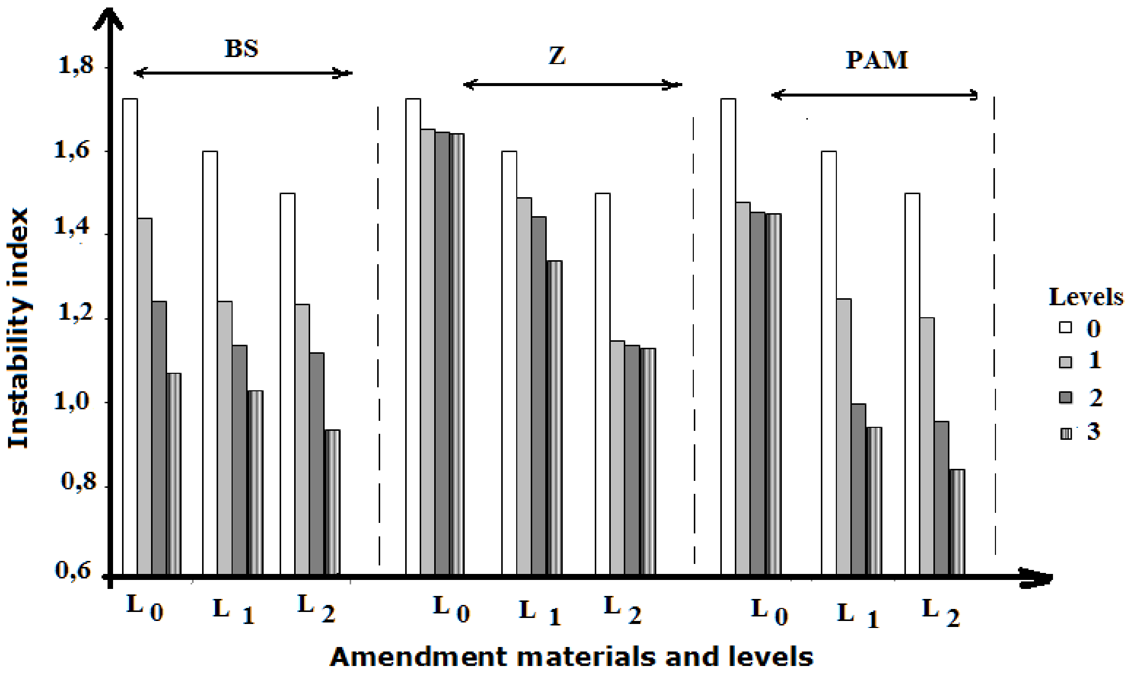

Figure 2. Decreasing of instability index as a function of liming

Table 2. Variance analysis of the instability index data

Sources	DF	SS	SM	SM
Lime (A)	2	2.113	1.057	314.922***
Amendments (B)	2	0.637	0.319	94.964***
A*B	4	0.299	0.075	22.260***
Amend. Levels (C)	3	2.833	0.944	281.501***
A*C	6	0.098	0.016	4.867***
B*C	6	0.565	0.094	28.054***
A*B*C	12	0.326	0.027	8.098***
Error	70	0.235	0.003	
General	107	7.147	0.067	

*, p < 0.05; ** : p < 0.01; ***, p < 0.001

Table 3. Mean values of amendments and levels of lime and amendments for the instability index

Applications	0	1	2	3
Lime Levels	4.752a	4.268b	3.390c	
Amendments		4.44b (BS)	4.99a (Z)	3.57c (PAM)
Amendment Levels	6.944a	4.208b	3.507c	2.688d

As shown in Table 3, the effects of amendment materials and amendment levels on instability index were different statistically. The results can be summarized as; amendment material treatments decreased the instability index values of acidic soil. Effectiveness of the amendment materials varied depending on the type of the amendment material and the soil reaction. In conclusion, the effectiveness of the zeolit had considerably lower than the other amendment materials. The highest effect on the instability index was obtained with the highest dose of PAM application in lime requirements done in 100 % level.

Conclusion

Using different organic and inorganic amendments as being in present study on acidic and erosion susceptible soils is an effective method to reduce soil erodibility and amend soil properties. Effects of amendments vary depending on conditioners type and application doses. By this way, soil losses decrease, degraded soil properties improve and thus soil quality increases.

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