ORIGINAL SCIENTIFIC PAPER

Effects of PVA, PAM and HA on Mean Weight Diameter and Wet Aggregate Stability of Soils

Ekrem Lütfi Aksakal, Taşkın Öztaş

Ataturk University Faculty of Agriculture Department of Soil Science, Erzurum –Türkiye. (toztas@atauni.edu.tr).

Abstract

Different organic polymers and substances are getting commonly used for soil structural improvements. The objective of this study was to determine and compare effects of PVA, PAM and HA on mean weight diameters and wet aggregate stability of soil aggregates in different size groups. Soil stabilizers were applied to soil samples passed through a 2 mm sieve with six different doses including the controls (0); 0.001, 0.005, 0.01, 0.05 and 0,1% *w/w* for PVA and HA, and 0.00025, 0.0005, 0.001, 0.0025 and 0,005% *w/w* for PAM. Soil samples were separated into 4 different aggregate size groups (<0.42; 0.42-0.84; 0.84-2.0; 1.0-2.0 mm) at control (untreated) samples and 7 different aggregate size groups (<0.42; 0.42-0.84; 0.84-2.0; 1.0-2.0; 2.0-6.4; 6.4-12.7 and >12.7 mm) at the treated samples. Results indicated that mean weight diameter of soils and wet aggregate stability of different aggregate size groups increased with increases in application doses of PVA and PAM. It was also determined that PVA produced new aggregates at higher doses.

Key words: Mean weight diameter (MWD), aggregate stability, polyvinylalcohol (PVA), polyacriylamide (PAM), humic acid (HA).

Introduction

As well as aggregate formation in soil, the stability of soil aggregates against disruptive effects of mechanical forces and water are also important for soil protection. Resistance of soil aggregates to detachability and stability and continuity of soil pores throughout soil profile have great importance in soil erosion and water movement within the soil.

Adding soil organic material into top soil layer is a common practice for improving soil aggregation and stability in soils with weak structure. Since the amount of organic material needed for soil structural development is too much and the time for incubation is too long, the researches on alternative soil amendments are getting importance. For this purpose, different organic-sourced soil stabilizers including polyvinyl-alcohol (PVA), polyacriylamide (PAM) and humic acid (HA) are being intensively studied in recent years. Most of these studies indicated that application of synthetic organic polymers on to soil surface even with very low concentrations have positive effects on aggregate stability and soil structural characteristics (De Boodt, 1993; Sojka and Lentz, 1994; Zhao and Xu, 1995; Nadler et al., 1996; Imbufe et al., 2005).

Anionic polyacrylamide (PAM) and polyvinylalcohol (PVA) are effective on improving soil aggregation in all textural groups (Sojka and Lentz, 1997). Painuli and Pagliali (1990) reported that PVA application on clay and loam textured soils significantly decreased the amount of dispersed silt+clay in water. Barry et al. (1991) stated that soil detachability significantly declined by PVA application. Dodd et al. (2004) applied different concentrations (0,2%, 0,001% and 0,00005% *w/w*) of PAM on alkaline and non-alkaline soils and found that polymer application increased the percentage of water stable aggregate, infiltration rate and hydraulic conductivity of soil. Piccolo et al. (1997) reported

that humic acid (HA) application on soil with a rate of 0.05 g kg^{-1} decreased soil losses with a rate of 36 %, and increased aggregate stability and water holding capacity.
The objective of this study was to determine and compare effects of polyvinylalcohol (PVA), polyacriylamide (PAM) and humic acid (HA) on mean weight diameters (MWD) and wet aggregate stabilities (WAS) of soil aggregates in different size groups of clay and sandy loam textured soils.

Materials and methods

Two disturbed soil samples taken from 20 cm depth of Calciorthid (39°54'N / 41°14'E) and Typic Ustert (39°59'N / 40°55'E) soil great groups commonly distributed in Erzurum (39°10'N - 40°57'N / 40°15'E - 42°30'E) were used in this study. General properties of the soils were determined using the Bouyoucos hydrometer for texture (Gee and Bauder, 1986), pH-meter for soil reaction (McLean, 1982), Scheibler calcimeter for $CaCO_3$ (Nelson, 1982), Smith-Weldon for organic matter (Nelson and Sommers, 1982), Yoder type wet sieving analysis for aggregate stability (Kemper and Rosenau, 1986), using a rotary sieve (<0.42; 0.42-0.84; 0.84-2.0; 2.0-6.4; 6.4-12.7 and >12.7 mm) for mean weight diameters and dry aggregate size distribution (Kemper and Rosenau, 1986).
Soil samples passed through 2 mm sieve were treated with PVA, HA (0, 0.001, 0.005, 0.01, 0.05 and 0.1% *w/w*) and PAM (0, 0.00025, 0.0005, 0.001, 0.0025, 0.005% *w/w*) at field capacity, incubated for 48 hours and then dried. Aggregate stability of soil samples were determined by wet sieving analysis for different aggregate size groups; <0.42; 0.42-0.84; 0.84-2.0 and 1.0-2.0 mm for the control and <0.42; 0.42-0.84; 0.84-2.0; 1.0-2.0; 2.0-6.4; 6.4-12.7 and 12.7 mm for treated samples.

Results and discussion

General properties of soils used in this study are given in Table 1. Soils are sandy-loam (SL) and clay (C) textured, low in organic matter and lime contents.

Table 1. Some general characteristics of the soils studied.

Property	Soil # 1 (Calciorthid)	Soil # 2 (Typic Ustert)
Sand, %	55.7	22.0
Silt, %	31.3	21.8
Clay, %	13.0	56.2
Textural class	SL	C
pH (1:2.5)	7.81	6,97
Organic matter, %	1.50	1,27
$CaCO_3$, %	2.02	1,81
Aggregate stability, %		
<0.42 mm	1.4	5.4
0.42-0.84 mm	4.5	9.6
0.84-2 mm	8.2	14.5
1-2 mm	11.1	20.2

The ANOVA and the multiple comparison test results indicated that there were significant differences among the soils, treatments, doses and aggregate size groups in respect to mean weight diameter and aggregate stability (Table 2, 3 and 4).

Table 2. ANOVA for the mean weight diameter and aggregate stability.

Mean weight diameter			Aggregate stability		
Variation sources	**df**	**F**	**Variation sources**	**df**	**F**
Soils (S)	1	2751,3**	**Soils (S)**	1	3,24*
Treatments (T)	2	4791,1**	**Treatments (T)**	6	231,33**
Doses (D)	5	17937,4**	**Aggregate size (AgS)**	2	6,52**
SxT	2	2240,0**	**SxT**	6	9,08**
SxD	5	351,4**	**SxAgS**	2	1,64 ns
TxD	10	1175,2**	**TxAgS**	12	1,61 ns
SxTxD	10	594,5**	**SxTxAgS**	12	0,98 ns

***: p<0.05, ** : p<0.01, ns: non-significant.**

Table 3. Duncan's multiple comparison test results for the mean weight diameter.

Soils	Treatments	Doses						
		Control	1	2	3	4	5	Mean
SL	PAM	0,61f	4,13Be	4,28Bd	4,75Bb	4,77Ab	4,84Aa	3,89A
	HA	0,61f	4,45Ac	5,13Ab	5,73Aa	3,15Ce	3,87Cd	3,82A
	PVA	0,61e	1,72Cd	1,73Cd	3,03Cc	3,77Bb	4,26Ba	2,52B
Mean		**0,61f**	**3,43e**	**3,72d**	**4,50a**	**3,89c**	**4,32b**	**3,41 A**
C	PAM	0,78f	3,11Be	3,31Bd	3,39Bc	3,60Bb	3,72Aa	2,99B
	HA	0,78e	3,35Ad	3,58Ac	4,13Aa	3,76Ab	3,61Bc	3,20A
	PVA	0,78f	2,49Ce	3,13Cd	3,34Bc	3,47Cb	3,74Aa	2,83C
Mean		**0,78e**	**2,98d**	**3,34c**	**3,62b**	**3,61b**	**3,69a**	**3,00 B**

Capital letters show mean differences in vertical and small letter in horizontal directions.

Table 3 indicates that the mean weight diameter increased with application doses of PAM, PVA and HA in both soils. On the average there were no significant differences in MWD between PAM and HA treated samples, but PVA was the least effective in SL soil. On the other hand, all three substances produced different MWD in clay-textured soil, HA being the most effective.

Table 4 shows that all three soil stabilizer agents produced new soil aggregates, improved aggregate stability and had effectiveness in both sandy-loam and clay textured soils for different aggregate size groups. For instance, aggregate stability of 1-2 mm aggregate size group was 11.1 and 20.2 % for the untreated samples of SL and C textured soils. But, it was on the average 26.8 and 33.9 % for the same size group of the PVA, PAM and HA treated samples. For the specific aggregate size group, treatments were more effective in SL-textured soil than C-textured soil, since the increasing rate of aggregate stability was almost two times higher in SL-texture soil (141%) than that of in C-textured soil (68%). Among the treatments, PVA was more effective than PAM and HA in both soils.

Table 4. Duncan's multiple comparison test results for the aggregate stability.

Soils	Treatments	Aggregate size, mm							Mean
		<0,42	0,42-0,84	0,84-2	1-2	2-6,4	6,4-12,7	>12,7	
SL	PAM	12,71Bc	15,15Cb	18,59Ba	15,94Bb	13,39Bc	10,33Bd	9,63Bd	13,68**B**
	HA	13,79Bc	22,06Ba	15,44Bb	13,33Bc	11,51Bd	13,13Bc	11,95Bd	14,46**B**
	PVA	28,37Ad	58,46Aab	57,99Ab	51,09Ac	55,64Ab	58,94Aab	60,27Aa	52,96**A**
Mean		**18,29c**	**31,89a**	**30,67a**	**26,79b**	**26,84b**	**27,47b**	**27,28b**	27,03
C	PAM	17,07Bc	30,40Ba	31,78Ba	26,45Bb	16,49Bc	13,56Be	14,35Bd	21,45**B**
	HA	15,02Bc	29,46Ba	26,05Cb	27,82Bab	17,32Bc	11,70Bd	15,03Bc	20,34**B**
	PVA	41,15Ad	51,79Aa	52,92Aa	47,48Ab	49,30Ab	44,66Ac	41,81Ad	47,01**A**
Mean		**24,40d**	**37,21a**	**36,92a**	**33,92b**	**27,70c**	**23,31d**	**23,73d**	29,60

Capital letters show mean differences in vertical and small letter in horizontal directions.

Although there was significant differences among the application doses of PAM, PVA and HA on aggregate stability (*ANOVA was not given because of page limitation*) there was no clear trend except for PVA (Figure 1). Increase the PVA application dose, increased the aggregate stability in soil. But there was no statistically significant differences between the higher two doses.

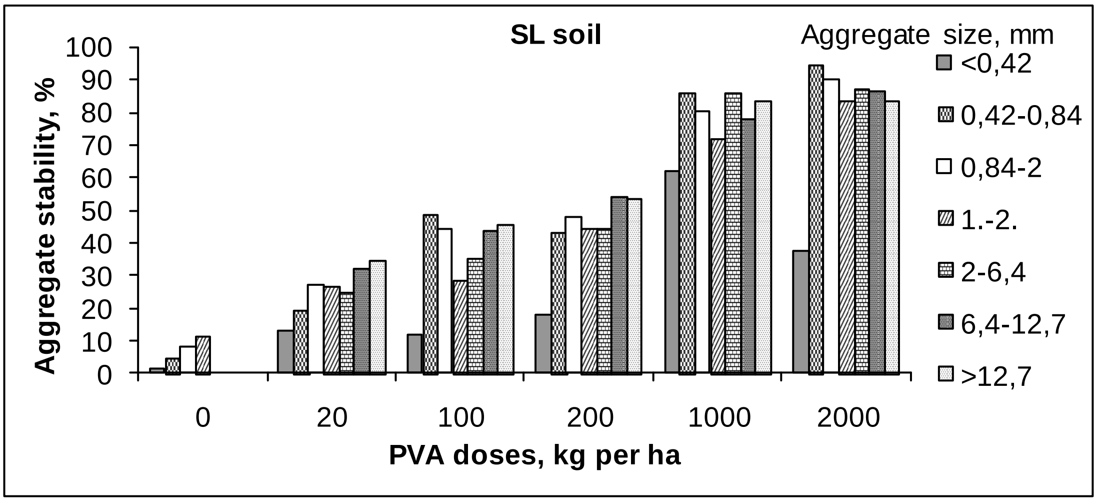

Figure 1. Effect of PVA doses on aggregate stability of sand-loam texture soil.

Conclusion

The results of this study clearly indicated that PVA, PAM and HA application significantly affected on aggregate stability and mean weight diameter of Calciorthid and Typic Ustert soils commonly distributed soil types of the study area, Erzurum (Turkey). All three treatments were more effective in sandy-loam textured soil than clay-loam textured soil. The most effective soil stabilizer agent on mean weight diameter was HA and PVA on aggregate stability.

References

Barry, P.V., Stott, D.E., Turco, R.F., and Bradford, J.M., (1991). Organic polymers' effect on soil shear strength and detachment by single raindrops. Soil Sci. Soc. Am. J. 55(3), 799-804.

De Boodt, M.F., (1993). Soil conditioning, a modern procedure for restoring physical soil degradation. Pedologie, 43: 157-195.

Dodd, K., Guppy, C.N., Lockwood, P., and Rochester, I., (2004). Comparison of applications of sand and polyacrylamide for separating the impact of the physical and chemical properties of sodic soils on the growth and nutrition of cotton (Gossypium hirsutum L.). Supersoil 2004: Proceedings of the 3rd Australian New Zealand Soils Conference, University of Sydney, Australia, 5–9 December.

Gee, G.W., and Bauder, J.W., (1986). Particle-Size Analysis. Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. 2nd Edition. Agronomy No: 9. 383-411, 1188 p, Madison, Wisconsin USA.

Imbufe, A.U., Patti, A.F., Burrow, D., Surapaneni, A., Jackson, W.R., and Milner, A.D., (2005). Effects of potassium humate on aggregate stability of two soils from Victoria, Australia. Geoderma, 125(3-4): 321-330.

Kemper, W.D., and Rosenau, R.C., (1986). Aggregate Stability and Size Distribution. Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. 2nd Edition. Agronomy No: 9. 425-442, 1188 p, Madison, Wisconsin USA.

McLean, E.O., (1982). Soil pH and Lime Requirement. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. 2nd Edition. Agronomy No: 9. 199-224, 1159 p, Madison, Wisconsin USA.

Nadler, A., Perfect, E., and Kay, B.D., (1996). Effect of polyacrylamide application on the stability of dry and wet aggregates. Soil Sci. Soc. Am. J., 60(2): 555-561.

Nelson, D.W., and Sommers, L.E., (1982). Total Carbon, Organic Carbon, and Organic Matter. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. 2nd Edition. Agronomy No: 9. 539-579, 1159 p, Madison, Wisconsin USA.

Nelson, R.E., (1982). Carbonate and Gypsum. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. 2nd Edition. Agronomy No: 9. 181-197, 1159 p, Madison, Wisconsin USA.

Painuli, D.K., and Pagliali, M., (1990). Effect of Polyvinyl Alcohol, Dextran and Humic Acid on Some Physical Properties of a Clay and Loam Soil. I. Cracking and Aggregate Stability, Agrochimica, 34(1-2): 117-130.

Piccolo, A., Pietramellara, G., and Mbagwu, J.S.C., (1997). Reduction in soil loss from erosion-susceptible soils amended with humic substances from oxidized coal. Soil Technology 10: 235-245.

Sojka, R.E., and Lentz, R.D., (1994). Time for yet another look at soil conditioners. Soil Sci., 158: 233-234.

Sojka, R.E., and Lentz, R.D., (1997). Reducing furrow irrigation erosion with polyacrylamide (PAM). Journal of Production Agriculture, 10(1): 47-52.

Zhao, B.Z., and Xu, F.A., (1995). Improvement of soil physical properties with soil conditioners. Pedosphere, 5(4): 363-370.