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Araştırma

EFFECTS OF DIFFERENT PASTURE AMELIORATION METHODS ON SOME SOIL PROPERTIES IN MINOZ CREEK BASIN

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Abstract: In this study, effects of five different pasture amelioration methods and polyacrylamide (PAM) as a synthetic soil conditioner on bulk density (BD), aggregate stability (AS) and organic matter (OM) content of pasture soil in Minöz Creek Basin were monitored between 2006 and 2009. Experiment in a natural pasture soil was conducted with seven treatments; control under uncontrolled grazing (C), control under controlled grazing (CG) and the treatments of fertilizing (F), PAM, spread seeding (SS), cultivation or aeration (A), and spread seeding + fertilizing + aeration (SSFA) under controlled grazing in seven plots. Soil samples were taken two times a year in spring (May) and fall (October) seasons. According to the C and CG treatments, the other treatments generally increased aggregate stabilities, organic matter contents and decreased bulk densities of the plots. These changes in the soil properties varied among the sampling seasons. The lower bulk densities generally determined in A and SSFA treatment plots. The highest decrease in bulk density was obtained as 1.14 g cm^{-3} with SSFA treatment in October 2009. Aggregate stabilities of the treatments were usually higher in spring (May) sampling than in fall (October) sampling. The highest increases in AS and OM contents were determined as 79.15% and 6.31% with PAM treatment in May 2009, respectively. SS, PAM and SSFA treatments usually increased AS and OM contents of the pasture soil during the study.
Key Words: Pasture soil, Controlled grazing, Spread seeding, Fertilizing, PAM, Aeration

1. INTRODUCTION

Maintenance of soil structure associated with aggregate stability is a key indicator of sustainable agroecosystems because of its role in many biological and physical soil processes. Soil structure controls or modulates the flow and retention of water, solutes, gases and biota in agricultural and natural ecosystems (Lal, 1991, Young et al., 1998).

Soil structural degradation tends to accelerate the high soil strength, poor infiltration, increased runoff and soil erosion problems. The effectiveness of pasture species like ryegrass in improving soil structure has been well reported (Tisdal and Oades, 1979; Haynes and Beare, 1997). Grass and legume cover crops have been maintained successfully in many regions for soil reclamation (Lal et al., 1979). Cover crops reduce sediment production from cropland by reducing the amount and the velocity of runoff and also increase soil quality by improving soil physical, chemical and biological properties (Dabney et al., 2001).

Application of synthetic organic polymers, such as polyacrylamides (PAM) to soils prevents degradation in soil hydraulic and physical properties due to improving aggregate stability and soil structure, reducing the tendency of soils to from seals (Sivapalan, 2002). PAM reduces erosion in agricultural soils with stabilizing soil aggregates, preventing surface seal formation and increasing infiltration of both irrigation and rainfall (Fox and Bryan, 1992; Norton, 1992; Lentz and Sojka, 1994; Levy and Agassi, 1995).

The effects of one or more factors including soil properties, climatic conditions, biological characteristics of the grass species, pasture and cattle management can results in declining pasture quantity or quality (Martinez and Zinck, 2004). The objective of this study was to determine effects of fertilizing (F), spread seeding (SS), cultivation or aeration (A), and polyacrylamide (PAM) treatments under controlled razing on physical properties and organic matter content of pasture soil in Minöz Creek Basin.

2. MATERIAL AND METHODS

A field experiment in a natural pasture was conducted on Lithic Ustorthent in Minöz Creek Basin in a randomized block design with seven treatments; controls, uncontrolled (C) and controlled grazing (CG), and the treatments of fertilizing (F), PAM, spread seeding (SS), cultivation or aeration (A), and spread seeding+fertilizing+aeration (SSFA) under controlled grazing plots (10.0x1.5 m^2). Sheep grazing in controlled grazing treatments was allowed between April 20 and October 30 in each year. Spread seeding of natural cover plants and aeration plots were established in the first year. Aeration in A and SSFA treatments was done cultivating the plot at 30cm row spacing. The rates of spread seeding for the natural cover plant species were 20% for sainfoin (*Onobrychis viciifolia*), 15% for salad burnet (*Poterium sanguisorba)*, 40% for crested wheatgrass (*Agropyron cristatum*) and 25% for smooth brome (*Bromus inermis*). Applications of 20 kg/ha PAM, and fertilization of N, P and K were done in each year.

Soil samples were taken two times a year in spring (May) and fall (October) seasons between 2006 and 2009. Monthly precipitation values from 2006 to 2009 are given in Figure 1. According to soil sampling intervals, total annual precipitation was divided into two groups as spring and fall precipitations. Spring precipitations between November and May, and fall precipitations between June and October are given with total annual precipitation of each year in Figure 2. Total and spring precipitations in 2006 and 2009 were higher than that in 2007 and 2008.

After the soil samples were air dried and passed through a sieve with 2 mm size opening, some soil characteristics were determined as follows; particle size distribution, bulk density, organic matter (OM) contents, soil reaction (pH) and electrical conductivity ($EC_{25°C}$) in saturated soil paste measured using laboratory tests as described by the Soil Survey Staff (1996). Bulk density (BD) of surface soil (0-15 cm depth) in each plot was measured as three replicates using cylindrical soil cores (5.2 cm inner diameter; 5 cm depth) by weighing undisturbed soil and oven-drying at 105 ºC for 24 h (Blake, 1965). Aggregate stability (AS) was determined on soil samples using a wet sieving method (Kemper and Rosenau, 1986). Selected soil properties of the experimental field on Lithic Ustorthent are given in Table 1. According to soil analyses, the textural class is sandy loam; neutral in pH and non-saline (Soil Survey Staff., 1993). Correlation analyses of the experimental data were performed using the SPSS software package program.

3. RESULTS AND DISCUSSION

The treatments, CG, F, PAM, SS, A and SSFA under controlled grazing, generally increased soil organic matter content compared with the control treatment (C) in uncontrolled grazing (Figure 3). While PAM treatment in October 2006 had the lowest soil OM content (1.85%), the highest OM content (6.31%) was also determined with PAM treatment in May 2009. There were temporal fluctuations in soil OM content with the sampling season. Mean OM contents of the treatments in May, except C and SSFA treatments, were higher than that in October (Figure 4A). Soil OM content had a significant positive correlation (r = 0.536 at 0.01 level) with cumulative spring and fall precipitation values. During the study, increases in mean OM contents of the treatments under controlled grazing according to C treatment were ordered as follows; CG < A < SS < F < PAM < SSFA (Figure 4B). It has been known that there is a positive effect of cover crops on the soil organic matter content (Obi, 1999). Gülser (2006) found that forage cropping treatments increased soil organic C content significantly compared with the bare soil treatment. Rubio et al. (1992) determined that emergence of grasses was increased with PAM in filed condition. PAM application can increase OM content more permanently with increasing aggregation because aggregates can protect OM from decomposition (Goebel et al., 2005; John et al., 2005, Busscher et al., 2006). Zhong et al. (2010) found that soil organic C, total N and available N were significantly increased by the application of mineral NPK fertilizer. In this study, soil OM content was also clearly increased with SSFA, PAM and F treatments compared with the control.

Table 1. Some soil properties of the experimental field

Sand %	Silt %	Clay %	Soil texture	pH (1:1)	EC dS/m	Organic Matter, %	CEC cmol kg^{-1}	$CaCO_3$ %
67.68	22.46	9.86	SL	6.89	0.200	1.68	7.39	3.98

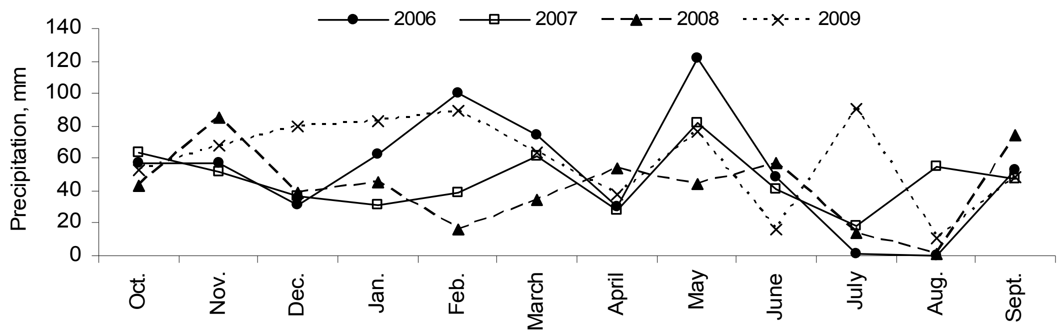

Figure 1. Monthly Precipitation between 2006 and 2009

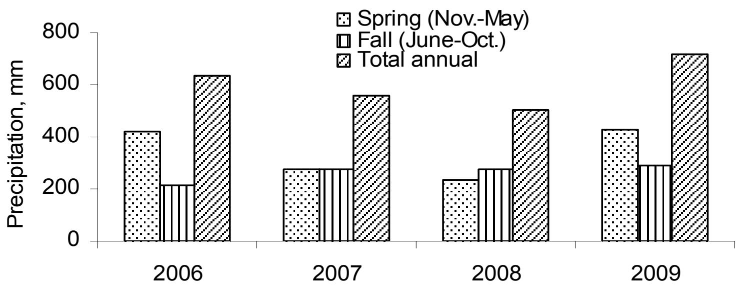

Figure 2. Cumulative spring and fall precipitations between soil sampling intervals

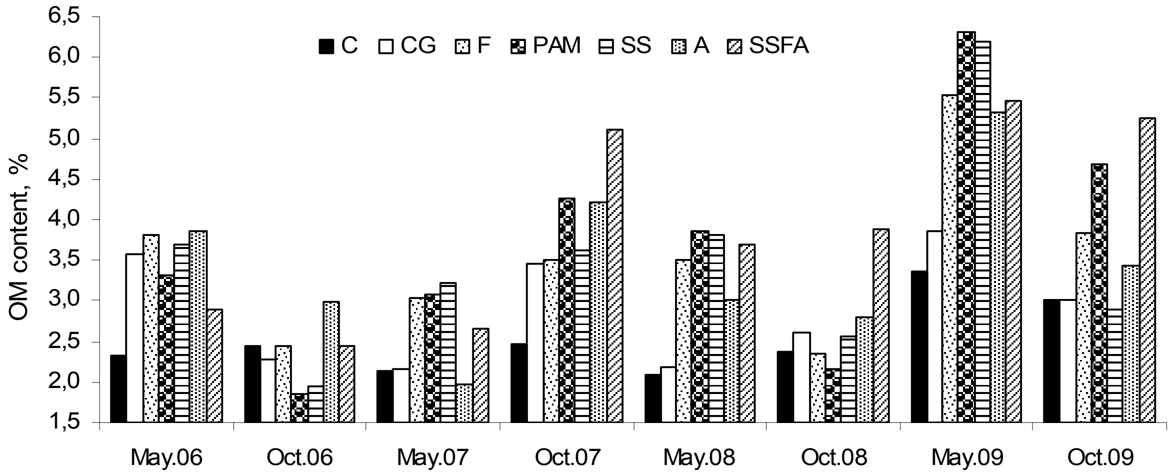

Figure 3. Changes in soil organic matter (OM) contents under different treatments from 2006 to 2009. (C: control in uncontrolled grazing, Treatments in controlled grazing are CG: controlled grazing, F: fertilizing, PAM: polyacrylamide, SS: spread seeding, A: cultivation, SSFA: spread seeding+fertilizing+cultivation)

The treatments under controlled grazing generally increased soil aggregate stability compared with the C treatment (Figure 5). While fertilizing treatment in October 2006 had the lowest AS (44.89%), the highest AS (79.15%) was determined with PAM treatment in May 2009. Aggregate stabilities in soil also showed a temporal fluctuation with the sampling season. Mean AS values of the treatments in May were always higher than that in October (Figure 6A). Aggregate stability had significant positive correlations with soil OM (r = 0.626 at 0.01 level) and cumulative spring and fall precipitation values (r = 0.362 at 0.01 level). During the study, increases in mean AS values of treatments under controlled grazing according to C treatment were ordered as follows; A < CG < F < PAM < SSFA < SS (Figure 6B). It is known that aggregate stability shows large inter-annual and seasonal variability, and it is usually lowest during winter and increases in spring. These variations occur regardless of residue treatments and are often larger than the differences between soils or cropping systems (Perfect et al., 1990; Angers et al., 1999). Perfect et al. (1990) reported that two factors mainly control these fluctuations: i) climate that can directly affect aggregate stability through its action on soil moisture and indirectly through seasonal stimulation of microbial activity, and ii) organic matter incorporations. Gülser (2006) found that increments in organic C content due to forage cropping significantly increased the proportion of larger aggregates, and there was a significant positive correlation between organic C and aggregate stability. Busscher et al. (2007) found that aggregate stability and water holding capacity of loamy sand soils increased with increasing amounts of PAM application.

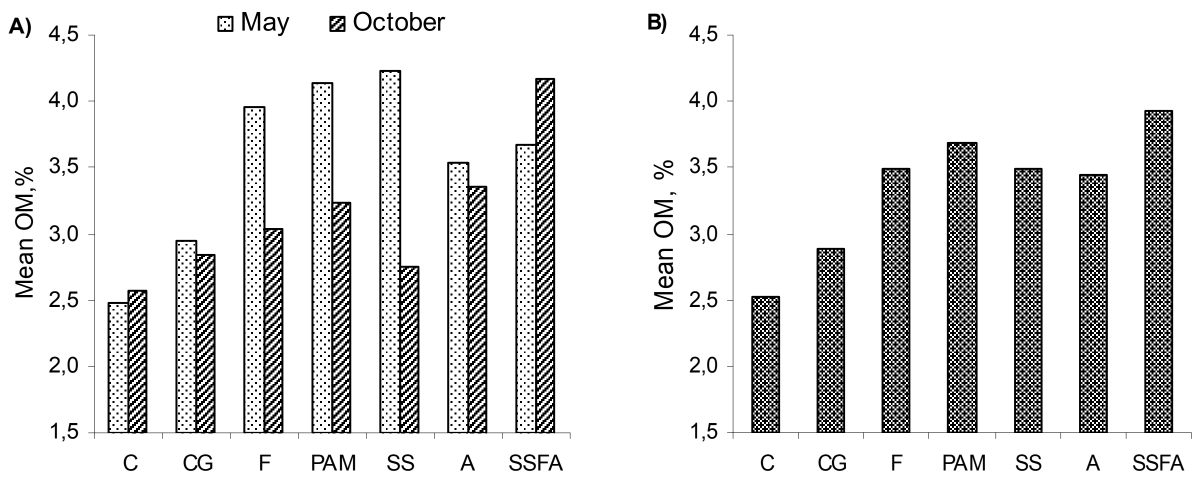

Figure 4. A) Seasonal changes in mean organic matter (OM) contents under different treatments. B) Effects of the treatments on mean OM contents. (C: control in uncontrolled grazing, Treatments in controlled grazing are CG: controlled grazing, F: fertilizing, PAM: polyacrylamide, SS: spread seeding, A: cultivation, SSFA: spread seeding+fertilizing+cultivation)

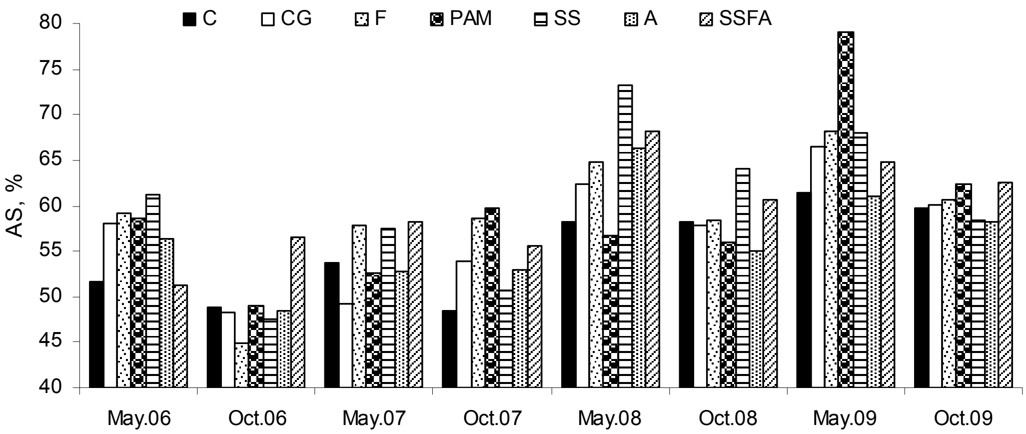

Figure 5. Changes in aggregate stability (AS) under different treatments from 2006 to 2009. (C: control in uncontrolled grazing, Treatments in controlled grazing are CG: controlled grazing, F: fertilizing, PAM: polyacrylamide, SS: spread seeding, A: cultivation, SSFA: spread seeding+fertilizing+cultivation)

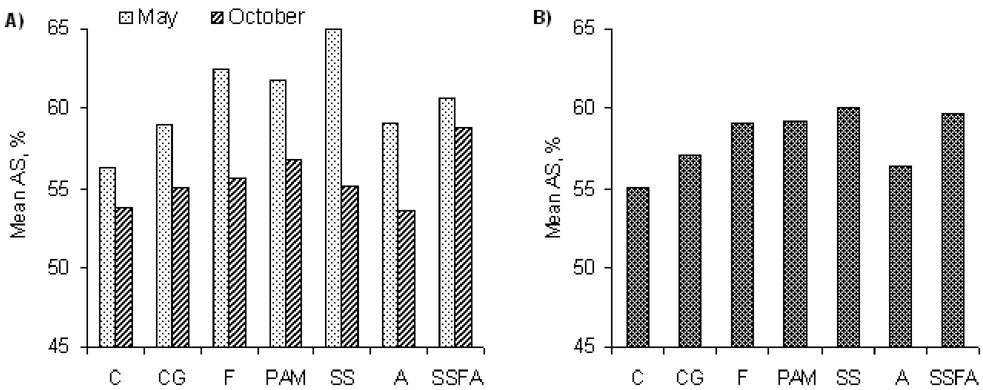

Figure 6. A) Seasonal changes in mean aggregate stability (AS) under different treatments. B) Effects of the treatments on mean AS. (C: control in uncontrolled grazing, Treatments in controlled grazing are CG: controlled grazing, F: fertilizing, PAM: polyacrylamide, SS: spread seeding, A: cultivation, SSFA: spread seeding+fertilizing+cultivation)

The treatments under controlled grazing generally decreased bulk density compared with the control treatments (Figure 7). While SSFA treatment in October 2009 had the lowest bulk density (1.14 g cm^{-3}), the highest bulk density (1.76 g cm^{-3}) was determined with C treatment in October 2006. Bulk density values showed a temporal fluctuation with the sampling season. Mean BD values of the treatments in May, except SS and SSFA treatments, were higher than that in October (Figure 8A). Drewry et al. (2004) reported that soil compaction and recovery may occur in a cycle under grazing systems. While deterioration in soil physical condition can occur during wet spring periods under dairy cattle grazing, natural recovery of soil physical condition occurred over summer and autumn for many soil properties. Bulk density values had significant negative correlations with soil OM ($r=-0.584$ at 0.01 level) and AS ($r=-0.417$ at 0.01 level).

Cultivation treatments of A and SSFA showed lower bulk densities compared with the others (Figure 8B). During the study, decreases in mean BD values of treatments under controlled grazing according to C treatment were ordered as follows; SSFA < A < F < PAM < SS < CG. The highest bulk densities in pasture soil were always determined in C and CG treatments. Grazing or trampling in pasture lands causes changes in physical soil properties with reducing infiltration and increasing runoff, erosion and bulk density. The magnitude of the trampling effect depends on the number of cattle per area, the grazing system, soil texture and soil moisture content (Van Haveren, 1983). Lal et al. (1979) reported that the vegetation with deep tap roots and the ability to provide quick cover caused high improvements in soil structure. Gülser (2004) found that forage cropping significantly decreased bulk density and increased porosity and infiltration due to loosening effects of roots and increasing soil fauna over the bare soil.

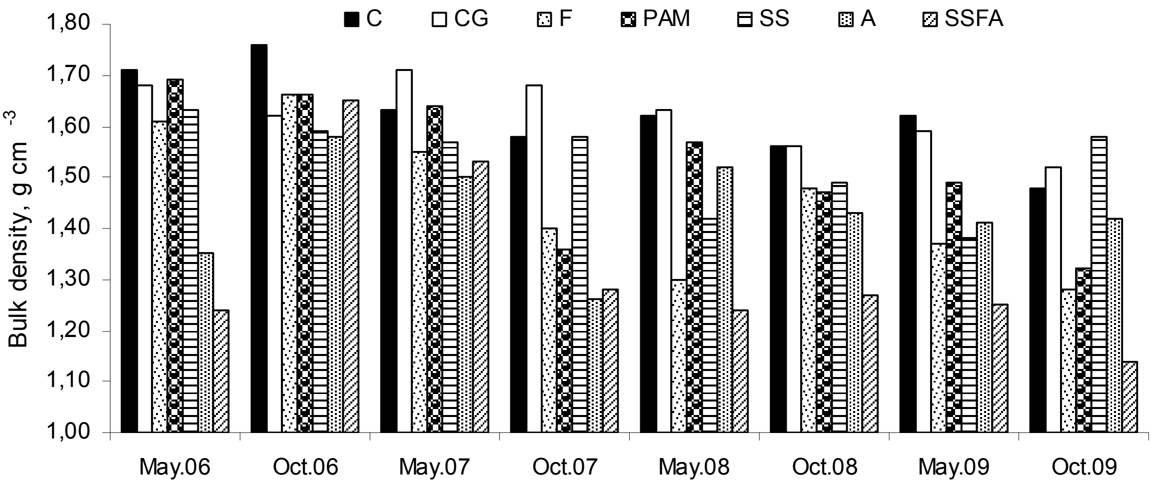

Figure 7. Changes in bulk density under different treatments from 2006 to 2009. (C: control in uncontrolled grazing, Treatments in controlled grazing are CG: controlled grazing, F: fertilizing, PAM: polyacrylamide, SS: spread seeding, A: cultivation, SSFA: spread seeding+fertilizing+cultivation)

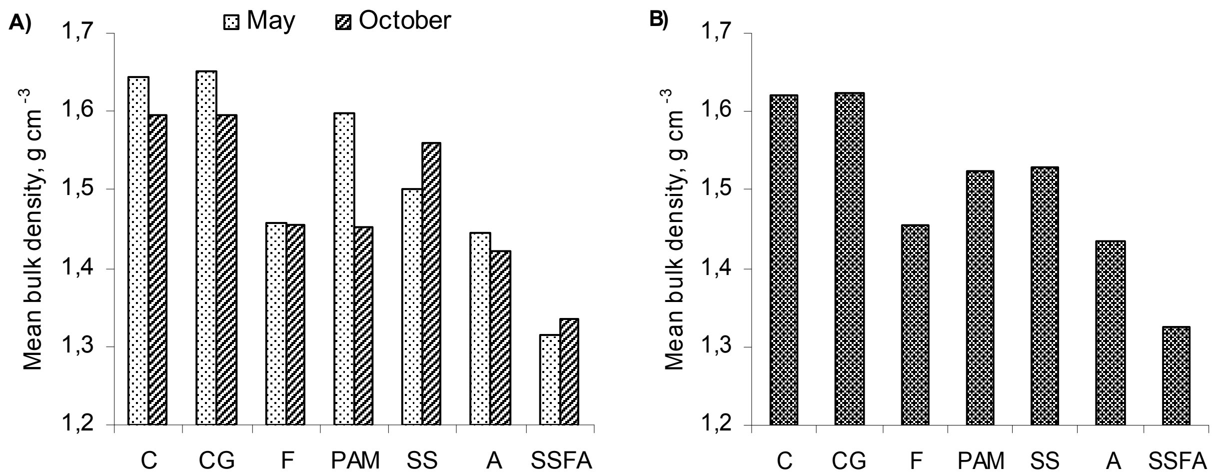

Figure 8. A) Seasonal changes in mean bulk density under different treatments. B) Effects of the treatments on mean bulk density (C: control in uncontrolled grazing, Treatments in controlled grazing are CG: controlled grazing, F: fertilizing, PAM: polyacrylamide, SS: spread seeding, A: cultivation, SSFA: spread seeding+fertilizing+cultivation)

4. CONCLUSION

Treatments of SS, F, A, SSFA and PAM under controlled grazing clearly affected soil organic matter content, aggregate stability and bulk density of sandy loam pasture soil compared with the control treatments. Changes in soil physical properties and OM content showed temporal fluctuations with soil sampling period. Generally, AS and OM contents of the treatments in May were higher than that in October. The treatment of SSFA under controlled grazing was the most effective one improving pasture soil properties with decreasing bulk density, and increasing OM and AS. PAM application also improved soil structural stability with increasing AS and OM content of the soil.

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