DOI: 10.22620/agrisci.2022.33.001

EFFECTS OF AGRICULTURAL WASTES ON SOME PHYSICAL PROPERTIES OF CLAY LOAM SOIL

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Abstract

The recycling of agricultural wastes in the soil ecological systems has been applied to sustain physical, chemical and biological soil quality. In this study, the effects of hazelnut husk (HH) and tobacco waste (TW) on the properties of clay loam soil (bulk density (BD), total porosity (F), soil moisture constants, aggregate stability (AS) and saturated hydraulic conductivity (Ks)) were investigated. After incorporating 5% application rate of HH and TW into clay loam soil, the soil samples were incubated at field capacity moisture level about 5 months under greenhouse conditions. Both HH and TW treatments significantly increased soil organic matter (OM) content, F, AS and Ks of soil while they decreased BD over the control. The HH having the higher C: N ratio than TW had the highest increment in soil OM content. On the other hand, the application of TW having the lowest C: N ratio had the highest increase in EC, AS and Ks in clay loam soil. It was found that hazelnut husk and tobacco waste can be recycled into farmlands as soil conditioner material to improve soil physical properties and to prevent soil physical degradation.

Keywords: Hazelnut husk, tobacco, structure, soil moisture, permeability.

INTRODUCTION

The loss of soil organic matter due to intensive agricultural practices causes soil degradation and a decline of soil structure (Dexter, 2004; Usowics and Lipiec, 2009). Organic waste application into soils has the greatest effect on the organic matter content and nutrient values, and also it improves the structure, water and air balance, and microbiological activities of soils (Chenu et al, 2000; Candemir and Gülser, 2011). Soil aggregates are the main units of soil structure, and the addition of organic residues to soils improves soil structure by increasing aggregate stability (Gülser, 2006; Gülser and Candemir, 2015). Organic residues contribute to the development of soil structure with a binding agent in the formation of aggregates. The soil organic carbon has greater effect on aggregation, especially in coarse textured soils (Bronick and Lal, 2005). Organic matter and compost application into soils improve the soil physical and chemical quality. The addition of organic wastes to soils reduces bulk density, increases total pore space, permeability, microbial activity, mineralization, available nutrient elements and electrical conductivity of soils (Gülser et al., 2015). Hydraulic conductivity is an important soil physical property for determining soil hydrological processes and may change as water permeates and flows in soil due to various chemical, physical and biological processes (Hillel, 1982).

Hazelnut and tobacco are important agricultural products in the Black Sea Region of Turkey. A large quantity of hazelnut husk and tobacco waste as agricultural waste materials is available in the region. Therefore, these waste materials might be reused as an organic conditioner source in sustainable soil management systems. The objective of this study was to investigate the effects of hazelnut husk (HH) and tobacco wastes (TW) on the physical properties of clay loam soil.

MATERIALS AND METHODS

Hazelnut husk and tobacco waste used in this study were obtained from the hazelnut orchards and the tobacco processing factory in Samsun, respectively. Some properties of the organic wastes were determined according to the standard methods (Kacar and Inal, 2008). A greenhouse study was carried out in a randomized plot design with three different treatments (control, HH and TW) and four replications for 5 months. After sieving the air dried clay loam soil sample from 4 mm sieve, pots were filled with 1 kg of soil sample. According to oven dry weight basis, 5% of HH and TW were incorporated into pots homogenously. Soil samples were irrigated with distilled water to hold moisture level of soils around field capacity during the experiment.

Soil particle size distribution was determined according to the hydrometer method (Day, 1965), soil reaction (pH) and electrical conductivity (EC) values in 1:1 soil: water suspension (Kacar, 1994), soil organic matter (OM) by 'Walkley-Black' method and exchangeable cations by the ammonia acetate extraction method (Kacar, 1994). Aggregate stability (AS) using a wet sieving method according to Kemper and Rosenau (1986), saturated hydraulic conductivity (Ks) by constant head method (US Salinity Lab. Sta., 1954) were determined. After saturating the soil samples for 24 hours, the moisture content at the field capacity (FC) was measured at 33 kPa, and the permanent wilting point (PWP) was measured at 1500 kPa on a pressure plate apparatus (Demiralay, 1993). The plant available water content (AWC) was calculated with subtracting PWP values from FC values. The soil cores were sampled from the pots, and the bulk density (BD) of each soil core was determined according to Blake (1965). Total porosity (F) was calculated using the following equation; F= (BD-2.65)*100/2.65.

The correlation among the data and the variance analyses of data were run using SPSS program, the pairs of mean values compared by Duncan test.

RESULTS

The analyses results of HH and TW are given in Table 1. While organic C content and C/N ratio in HH are higher than that in TW, the total N, electrical conductivity (EC) and pH in HH are lower than that in TW.

Table 1 Some properties of the agricultural wastes used in this study.

	OC, %	N, %	C:N	EC, dS m^{-1}	pH
Tobacco waste (TW)	39.20	1.89	20.74	11.25	5.34
Hazelnut husk (HH)	47.89	0.91	52.62	7.11	4.95

The properties of soil used in this study are given in Table 2. The soil is non-saline, moderately alkaline, clay loam in texture, low in organic matter content (Soil Survey Staff., 1993).

Table 2 Some physical and chemical properties of the soil

Sand, %	42.56	EC $_{25°C}$, dS m^{-1}	0.34
Silt, %	20.71	Organic matter, %	0.64
Clay, %	36.73	Exch. K, cmol kg^{-1}	0.45
Texture	Clay loam	Exch. Ca, cmol kg^{-1}	26.17
pH (1:1)	7.91	Exch. Mg, cmol kg^{-1}	6.15

Hazelnut husk and tobacco waste applications significantly increased soil OM content and electrical conductivity (EC) over the control ($P<0.01$) (Figure 1). While the highest OM content (3.12%) was determined in HH treatment, the highest EC (3.35 dS/m) was determined in TW application. The percentage increments in OM content by the HH and TW applications over the control were found as 368% and 267%, respectively. Also, soil EC values in HH and TW treatments increased 33% and 695% over the control, respectively.

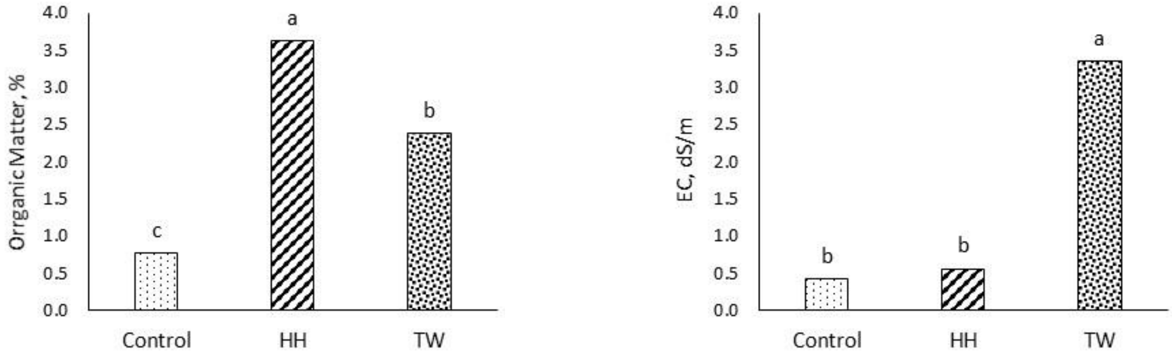

Figure 1 Changes in soil organic matter contents and EC values with hazelnut husk (HH) and tobacco waste (TW) applications.

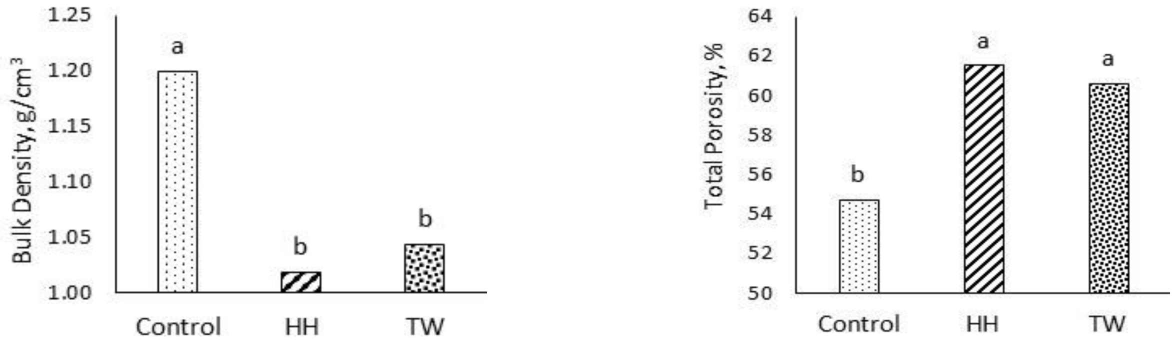

Figure 2 Changes in bulk densities and total porosity values with hazelnut husk (HH) and tobacco waste (TW) applications.

Agricultural waste applications significantly decreased soil BD and increased total porosity (P<0.05) (Figure 2). The lowest bulk density (1.02 g/cm^3) and the highest porosity (61.51%) were determined with HH treatment. According to the control treatment, percentage decreases in bulk density by the applications of HH and TW were 15% and 13%, respectively. The relationships among the soil properties are given in Table 3. The OM content gave a significant negative relation (-0.844**) with BD and a significant positive relation (0.843**) with F values.

While HH and TW applications increased FC and PWP values over the control significantly (P<0.05), increases in AWC values were not significant (Figure 3). While the lowest moisture constants were determined in the control treatment, the highest FC (36.17%), PWP (23.45%) and AWC (12.72%) were determined in HH treatment. The soil OM content had significant positive relationships with FC (0.913**), PWP (0.835**) and AWC (0.546*) (Table 3).

The aggregate stability of clay loam soil was significantly increased by the HH and TW applications (P<0.01) (Figure 4). While the lowest AS (15.66%) was found in the control, the highest AS (31.23%) was determined in TW application According to the control treatment, percentage increases in AS by the applications of HH and TW were determined as 63% and 99%, respectively. The AS values gave significant positive correlations with OM, EC, F, soil moisture constants and a significant negative correlation with BD (Table 3).

The saturated hydraulic conductivity of clay loam soil was also significantly increased by the HH and TW application (P<0.05) (Figure 4). The highest Ks value (5.32 cm/h) was determined in TW treatment while the lowest Ks value (2.36 cm/h) was found in the control treatment. The percentage increments in Ks by the HH and TW treatments over the control were estimated as 92% and 125%, respectively. The Ks values had significant correlations with all the soil parameters measured in this study (Table 3).

Table 3 Relationships among the soil properties (n=12).

	EC	BD	F	FC	PWP	AWC	AS	Ks
OM	0.116	-0.844**	0.843**	0.913**	0.835**	0.546*	0.648*	0.636*
EC		-0.360	0.370	0.293	0.278	0.149	0.762**	0.622*
BD			-1.000**	-0.797**	-0.622*	-0.763**	-0.870**	-0.800**
F				0.794**	0.620*	0.757**	0.874**	0.801**
FC					0.946**	0.513	0.722**	0.833**
PWP						0.208	0.582*	0.737**
AWC							0.640*	0.563*
AS								0.893**

**Correlation is significant at 0.01 level, *Correlation is significant at 0.05 level

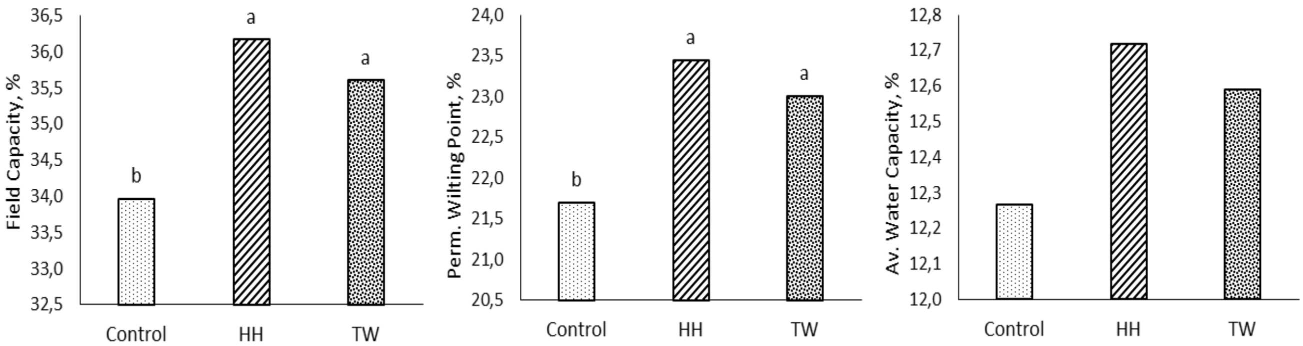

Figure 3 Changes in field capacity, permanent wilting point and available water capacity moisture levels with hazelnut husk (HH) and tobacco waste (TW) applications.

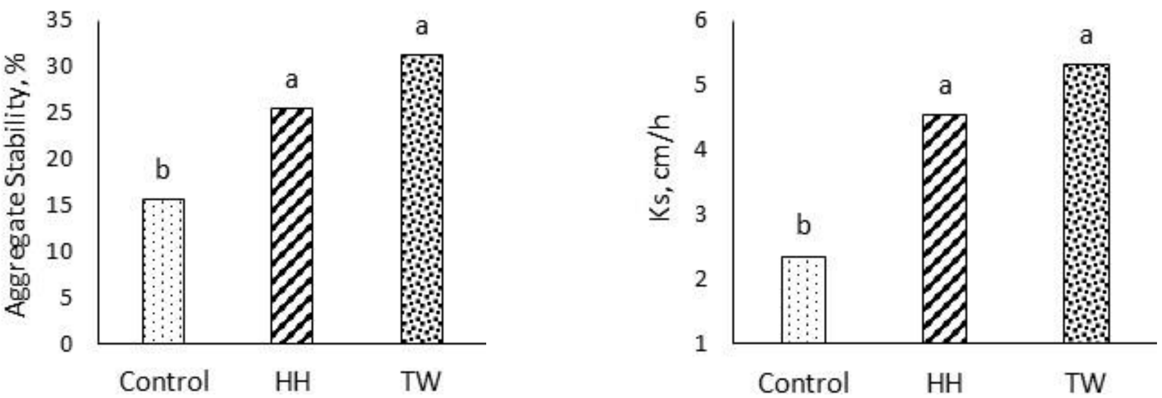

Figure 4 Changes in aggregate stability and saturated hydraulic conductivity (Ks) values with hazelnut husk (HH) and tobacco waste (TW) applications.

DISCUSSION

The significant increase in soil OM content was higher in HH application than in TW application. The organic waste having higher C: N ratio has generally a slow mineralization rate in soil (Alexander, 1977, Clement et al., 1995). In this study, mineralization rate of HH having higher C.N ratio (52.62) in soil was slower than TW (Table 1). Therefore the highest OM content in soil was obtained with HH application. Tea waste having lower C: N ratio (20.74) had a higher mineralization rate and cause less OM content in soil when compared with HH application.

Both HH and TW applications increased the EC values over the control. The EC value in soil was the highest in TW application (Figure 1). The EC is an important indicator of anion and cation forms in soils (Smith and Doran, 1996), and helps monitoring organic matter mineralization in soils (De Neve et al., 2000). Candemir and Gülser (2011) found that application of agricultural wastes increased EC values in soil. They also reported that the highest increment in soil EC value was obtained with tobacco waste application compared with the other treatments. The mineralization rate of TW in soil was faster than HH due to its lower C: N ratio, and showed the highest increase in EC in soil over the all treatments.

While increasing OM content in soil by the HH and TW applications decreased the bulk density, it increased the total porosity (Figure 2). Most studies have indicated that there is a negative relationship between OM and BD, and the addition of organic matter to soil decreases BD and increases porosity (Candemir and Gülser, 2011; Gülser et al. 2017; Demir and Gülser 2021). In this study, soil OM content had also a negative relation with BD and a positive relation with F values. The HH application having the highest soil OM content had the lowest BD and the highest F value in soil.

All soil moisture constants in clay loam soil increased with the application of the agricultural wastes (Figure 3). The researchers reported that the addition of organic matter to soil increases water holding capacity (Gupta et al., 1977; Mamedov et al., 2016). In this study, FC, PWP and AWC had significant positive correlations with soil OM content. The HH application having the highest OM content in soil had the highest FC, PWP and AWC in soil.

The improved aggregate stability by adding organic residue to soils is a result of released plant phenolic acid interactions during the decomposition of residues structural components and increasing microbial activity due to carbonhydrates metabolisms (Martens, 2000). There was a significant positive correlation between AS and soil OM content (Table 3). Gülser (2006) reported that the increments in soil organic C content significantly reduced the bulk density and increased the total porosity and the proportion of larger aggregates, and also there was a significant positive correlation between OM and AS.

The soil permeability significantly increased by the organic waste addition. The application of TW having the lower C: N ratio and faster mineralization rate showed the highest EC, AS and Ks values in soil. Candemir and Gülser (2007) reported that during the decomposition period of organic waste in soil, it reduced soil bulk density and increased soil permeability due to increases in total porosity and aggregate stability. In this study, it was similarly found that increasing OM in soil due to agricultural waste applications helps to increase soil Ks with increasing AS, F and reducing BD.

CONCLUSION

The additions of HH and TW into soil increased soil OM content, FC, PWP, AWC and EC. Increments in EC conductivity in soil solution indicated that soluble nutrient contents in the clay loam soil increased by the mineralization of HH and TW. The OM content had significant positive correlations with AS, F, Ks, and a significant negative correlation with BD. The total porosity of soil increased with reducing BD significantly by the HH and TW applications. When comparing with the TW application, the HH having the highest C: N ratio showed more significant improvements in soil physical properties due to a lower mineralization rate. On the other hand, TW having lower C: N ratio had the faster mineralization and caused the highest increment in EC, AS and Ks values. Therefore soil OM content was higher in HH application than in TW application. The recycling of agricultural wastes is a useful application with respect to environmental protection and can also benefit farmers who protect soil against physical degradation in sustainable agricultural practices.

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