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Changes in some soil properties at different incubation periods after tobacco waste application

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Abstract: *In this study, changes in organic carbon (OC), basal soil respiration (BSR), nitrate nitrogen (NO_3-N), electrical conductivity (EC) and aggregate stability (AS) of a clay loam soil due to tobacco waste (TOW) application were monitored for 240 days. After incorporating 5% TOW into soil according to oven dry weight basis, soil samples were incubated at field capacity for 20, 40, 80, 140 and 240 days under a greenhouse condition. TOW application significantly increased all soil properties over the control treatment. Soil OC and AS values had significant positive correlations each other and with the other soil properties. Soil OC, BSR and AS values significantly increased from 0.12%, 0.03 μg CO_2-C g^{-1} dry soil 24 hr and 20.7% in control treatment to 1.13%, 3.7 μg CO_2-C g^{-1} dry soil 24 hr and 54.4% in TOW treatment, respectively, in 20 days. While the highest NO_3-N (1780 ppm) was found in 40 days, the highest EC (3.35 dS m^{-1}) was in 240 days after TOW application. Disaggregation occurred in all treatments after 20 days of incubation due to probably the more substrate demands of microorganisms in soil.*

Key words: *Tobacco waste, Aggregate stability, Basal soil respiration, Nitrate, Electrical conductivity*
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Introduction

The addition of organic wastes to soils is a current environmental and agricultural practice for maintaining soil quality and has a greatest effect on organic matter content and nutrient values, and also improves structure, water and air balance and microbiological activities of soils (Aggelides and Londra, 2000; Chenu *et al.*, 2000; Candemir and Gulser, 2007; Chaturvedi *et al.*, 2008). Generally addition of organic matter and plant residues to soils having lower organic matter content, supplies C as an energy source for microorganisms and increases the microbial activity (Smith *et al.*, 1993). CO_2 production by microorganisms in soils such as earthworms, nematodes and insects, plant roots is described as soil respiration (Parkin *et al.*, 1996). Soil aggregates are the main units of soil structure (Lynch and Brag, 1985), and addition of organic residues to soils improves soil structure by increasing of aggregate stability (Aggelides and Londra, 2000; Gulser, 2006). Martens (2000) reported that accumulation of carbon content in soil increased soil aggregate stability. Stabilization of soil aggregates is a function of the physical forming forces present in soils to form aggregates and the release of aggregating agents by soil microorganisms upon organic residue decomposition (Allison, 1968). Organic matter and compost application into soils increase nutrient values and also electrical conductivities of soils (Eignberg *et al.*, 2002; Wang and Yang, 2003). Manivannan *et al.* (2009) found that vermicompost application to a clay loam soil and a sandy loam soil increased organic C, micro and macro nutrients, and microbial activity in both soil types, particularly more in clay loam soil.

Tobacco plants are grown in the Black Sea Region of Turkey. Therefore, there is much tobacco production waste in this region. This waste material might be reused as an organic matter source in agriculture to improve soil quality. The measurable minimum data set needed to evaluate soil quality includes physical, chemical and biological properties such as texture, structural stability, organic matter, soil nitrate, biological activity and electrical conductivity (Doran and Parkin, 1996). This study was conducted to investigate the temporal changes in some physical, chemical and biological quality parameters of a clay loam soil due to tobacco waste application.

Materials and Methods

A clay loam soil was taken from Kurupelit district of Samsun–Turkey. After sieving the air dried soil samples from 4 mm sieve, 30 pots were filled with 1 kg of soil sample. According to oven dry weight basis, 5% tobacco waste (TOW) was incorporated into 15 pots homogenously. A greenhouse study was carried out in a factorial experimental design as two different treatments (control and TOW) with three replications in five different incubation periods (20, 40, 80, 140 and 240 day). Soil samples were irrigated with distilled water by weighing 4 days interval to hold moisture level of soils around field capacity during the study. At the end of the each incubation period, three pots from each treatment were disturbed and sampled for analysis.

Soil particle size distribution was determined according to hydrometer method (Demiralay, 1993), soil reaction (pH) and electrical conductivity ($EC_{25°C}$) values in 1:1 soil:water suspension (Kacar, 1994), soil organic matter (OM) by 'Walkley-Black' method, total N by kjeldahl method and exchangeable cations by ammonia

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acetate extraction method (Kacar, 1994). According to soil properties, the soil is a non-saline, moderately alkaline, clay loam, low in organic matter (Soil Survey Staff, 1993). Nitrate nitrogen (NO_3-N) in soil samples was measured potentiometrically by consort P900 compatible NO_3 electrode (EPA, 1996). Aggregate stability (AS) was determined for soil samples using a wet sieving method (Kemper and Rosenau, 1986). The equivalent of 40 g of oven dried 1.00-2.00 mm soil aggregates was placed on a sieve with 0.25 mm opening. The sieve was lowered to the water surface and the soil sample allowed to wet by capillarity for 5 min. The Yoder apparatus had a vertical stroke of 45 mm, and was operated for 5 min at a speed of 37 cycles min^{-1}. The fractions left on the sieve at the end of sieving were oven dried at 105ºC to constant mass. Aggregate stability was expressed as a percentage of the total sieved samples. Basal soil respiration rate (BSR) was determined according to Isermayer (1952) by measuring CO_2 produced without adding glucose at 22°C. CO_2 production was explained as mg CO_2 100 g^{-1} oven dry soil at the end of the 24 hr incubation period after each soil sampling.

Variance analyses of the data was accomplished in a factorial experimental design with two factors by standard analysis of variance (Yurtsever, 1984) and pairs of mean values compared by least significant difference (LSD) using the MSTAT (1988) software program.

Results and Discussion

Tobacco waste significantly increased soil OC content according to the control in all incubation periods (Fig. 1). While soil OC content in the control treatment varied between 0.12 and 0.05%, OC contents in TOW treatment were between 1.13 and 0.95% during the incubation. The highest OC content (1.13%) determined in 20 day after TOW application. OC contents were decreased until 80 day and then remained almost constant during the incubation for the treatments. In numerous studies, it has been found that addition of organic residues and organic fertilizers increased the soil organic C level, soil microbial biomass and activities (Goyal *et al.*, 1999; Manivannan *et al.*, 2009).

Increases in BSR over the control at different incubation periods were observed after TOW application (Fig. 2). While basal soil respiration rates in TOW treatment were between 3.7 and 1.3 μg CO_2-C g^{-1} dry soil 24 hr, BSR in the control varied between 0.3 and 0.6 μg CO_2-C g^{-1} dry soil 24 hr. The highest BSR (3.7 μg CO_2-C g^{-1} dry soil 24 hr) was determined with TOW application in 20 day. Although BSR in TOW treatment were generally higher than BSR in the control treatment, there was not a significant difference between two treatments after 20 days. Soil respiration is the production of carbon dioxide (CO_2) as a result of biological activity in the soil by micro and macro organisms (Parkin *et al.*, 1996). Albiach et al. (2000) found that organic residues increased the size, biodiversity and activity of the microbial population in soil. A significant correlation (0.528 at 0.01 level) was found between OC and BSR. A significant decrease in soil OC in TOW treatment between 20 and 40 days may be explained with mineralization of organic matter by an increase in microbial activity until 20 days significantly. The higher soil respiration indicates a higher soil microbial activity due to addition of organic matter to the soil and the consequent stimulation of heterotrophic microorganisms (Saffigna *et al.*, 1989).

Tobacco waste application significantly increased soil NO_3-N content according to the control in 40 days after TOW application, and the following incubation periods (Fig. 3). The highest NO_3-N content (1780.2 ppm) was determined in 40 day with TOW application. NO_3-N contents of the control increased from 12.8 to 44.1 ppm during the incubation. While NO_3-N content in TOW treatment significantly increased from 136.0 to 1780.2 ppm between 20 and 40 days, it was decreased from 1780.2 to 557.8 ppm after the following incubation periods. Addition of organic matter into soil increases soil microbial activity, provides nutrients and also increases NO_3-N content of soils due to the mineralization of organic matter (Tejada and Gonzalez, 2003; Lee *et al.*, 2004).

Electrical conductivity (EC) values were significantly influenced by tobacco waste application according to the control during the incubation (Fig. 4). EC value in TOW treatment increased from 2.15 to 3.35 dS m^{-1} between 20 and 240 days. EC values in control were almost constant and varied between 0.35 and 0.42 dS m^{-1} during the incubation. Smith and Doran (1996) reported that electrical conductivity can serve as a measure of soluble nutrients for both cations and anions. EC is also useful in monitoring the mineralization of organic matter in soil (De Neve *et al.*, 2000). Patriquin *et al.* (1993) determined that NO_3-N content after organic fertilizer addition to soil showed a significant positive correlation with EC of soil. Eigenberg *et al.* (2002) also reported that there was a significant positive relation between NO_3-N values and EC values in a manure addition study, and that seasonal changes in N content of soils may be monitored using EC measurements. In this study, the EC values showed significant positive correlations with NO_3-N (0.634 at 0.01 level) and soil OC (0.921 at 0.01 level) contents.

Table-1: Some properties of the soil and tobacco waste

	Soil		Soil	Tobacco waste
Sand, %	41.44	pH	8.40	5.26
Silt, %	24.57	EC $_{25°C}$, dS m^{-1}	0.40	12.98
Clay, %	33.99	OM, %	0.19	73.50
Exc. K, cmol kg^{-1}	0.51	Total N, %	0.02	2.25
Exc. Ca, cmol kg^{-1}	29.70	C:N	6.00	18.94
Exc. Mg, cmol kg^{-1}	7.90			

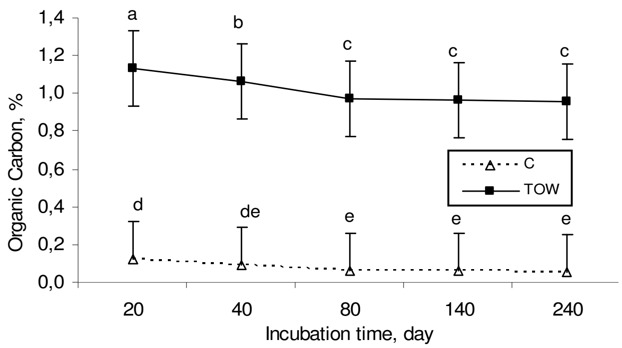

Fig. 1: Changes in soil organic carbon (OC) with tobacco waste (TOW) and Control (C) significant at p<0.05

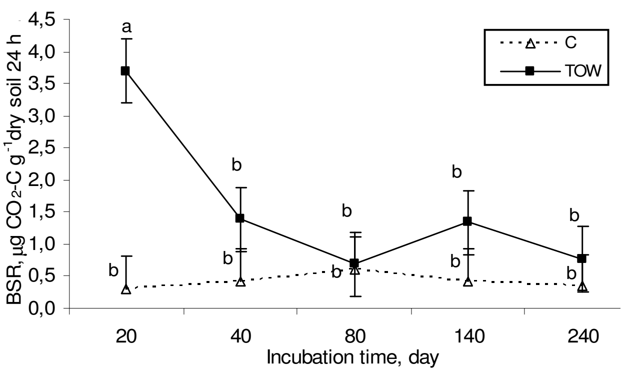

Fig. 2: Changes in basal soil respiration (BSR) with tobacco waste (TOW) and Carbon (C) significant at p<0.05

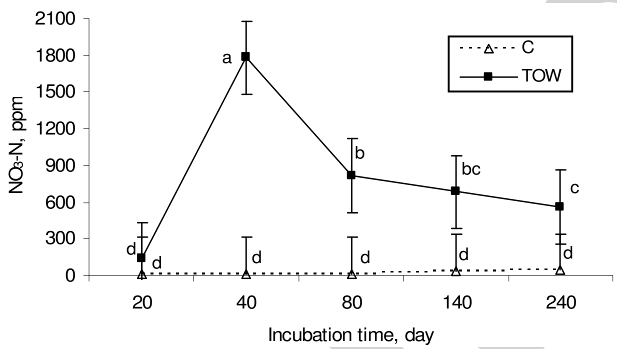

Fig. 3: Changes in soil nitrate (NO_3-N) with tobacco waste (TOW) and Control (C) significant at p<0.01

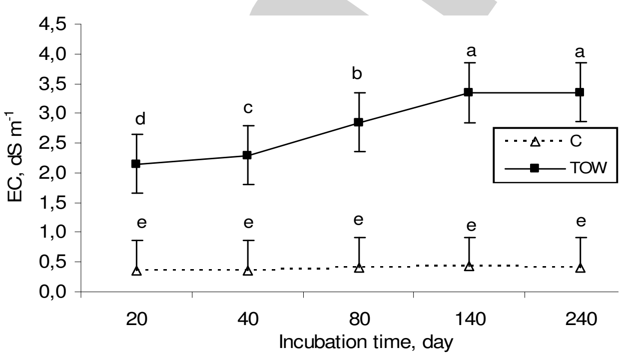

Fig. 4: Changes in electrical conductivity (EC) with tobacco waste (TOW) and Control (C) significant at p<0.01

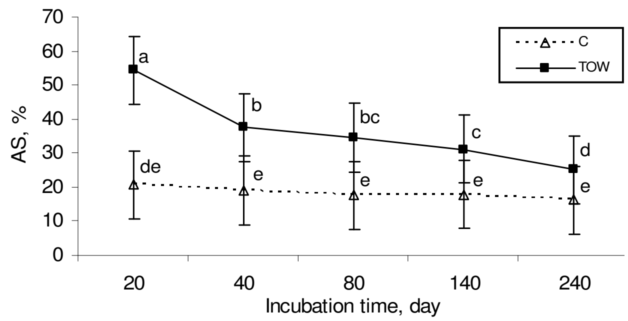

Fig. 5: Changes in aggregate stability (AS) with tobacco waste (TOW) and Control (C) significant at p<0.01

Tobacco waste treatment significantly increased aggregate stability of soil according to the control in all incubation periods (Fig. 5). While AS in control treatment varied between 16.3 and 20.7%, AS in TOW treatment varied between 25.1 and 54.4% during the incubation. In both treatments, the highest AS value was determined in 20 day and AS values decreased between 20 and 240 days. The observed positive relationship between OC and AS has been found in numerous studies (Aggelides and Londra, 2000; Gulser, 2006). Soil structural stability is influenced by microorganisms in two major ways: by the mechanical binding of soil particles together, and by the production of effective binding agents either by synthesis or through the decomposition of organic materials (Oades, 1984; Zaller, 2007). Improved aggregate stability by addition 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). In this study, AS values showed positive correlations with OC (0.837 at 0.01 level) and BSR (0.740 at 0.01 level). These relations represent that increasing aeration due to aggregation caused increases in microbial activity in soil. The greatest increases in BSR and AS values in soils were generally produced in 20 days after TOW application. BSR and AS values between 20 and 240 days decreased probably due to increasing substrate demands of bacteria in soils and bacterial attack on products which bind soil particles together reduces stability. The magnitude and longevity of the increased aggregation is a function of the added substrate, in particular, the availability of added organic C to microorganisms and the magnitude of stabilization increases with increased biological activity, but the duration over which the increased aggregation is maintained decreases (Baldock, 2002). Many of the soil aggregating substances and microbial products are able to be destroyed by other microorganisms (Waksman, 1952).

Incorporating TOW into a clay loam soil increased soil soluble nutrient contents by mineralization of organic matter and improved soil aggregate stability. Soil OC content and AS values had significant positive correlations each other and with BSR, EC and NO_3-N content. Significant increases in OC and BSR in soil due to TOW application caused rapid increases in AS and NO_3-N content. The magnitude of the aggregation increased with increasing microbial activity. Increased aggregation was maintained decreases in late incubation periods due to probably more substrate demands of microorganisms in soil. Soil OC and EC values mostly influenced properties by the TOW application according to the control treatment. EC values in soil continuously increased with TOW application during the all incubation period due to mineralization of organic matter. It indicates that TOW application has a positive effect on longevity of soluble nutrients in soil. As a result, TOW application to the clay loam soil improved soil physical, chemical and biological quality parameters.

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References

Aggelides, S.M. and P.A. Londra: Effects of compost produced from town wastes and sewage sludge on the physical properties of a loamy and a clay soil. *Biores. Technol.*, **71**, 253-259 (2000).

Albiach, R., R. Canet, F. Pomares and F. Ingelmo: Microbial biomass content and enzymatic activities after the application of organic amendments to a horticultural soil. *Biores. Technol.*, **75**, 43-48 (2000).

Allison, F.E.: Soil aggregation - Some facts and fallacies as seen by a microbiologist. *Soil Sci.*, **106**, 136-143 (1968).

Baldock, J.A.: Interactions of organic materials and microorganisms with minerals in the stabilization of structure. *In:* Interactions between soil particles and microorganisms. Impact on the terrestrial system (*Eds.*: P.M. Huang, J.M. Bollag and N. Senesi). IUPAC Series on Analytical and Physical Chemistry of Environmental Systems. Vol:8. John Wiley and Sons Ltd., NY. p. 101 (2002).

Candemir, F. and C. Gulser: Changes in some chemical and physical properties of a sandy clay loam soil during the decomposition of hazelnut husk. *Asian J. Chem.,* **3**, 2452-2460 (2007).

Chaturvedi, S., D.K. Upreti, D.K. Tandon, A. Sharma and A. Dixit: Bio-waste from tobacco industry as tailored organic fertilizer for improving yields and nutritional values of tomato crop. *J. Environ. Biol.,* **29**, 759-763 (2008).

Chenu, C., Y. Le Bissonnais and D. Arrouays: Organic matter influence on clay wettability and soil aggregate stability. *Soil Sci. Soc. Am. J.*, **64**, 1479-1486 (2000).

Demiralay, I.: Soil physical analysis. *Ataturk Univ. Agric. Fac. Pub.* No: 143, Erzurum (1993).

DeNeve, S., J. Van De Steene, R. Hartman and G. Hofman: Using time domain reflectometry for monitoring mineralization of nitrogen from soil organic matter. *Eu. J. Soil Sci.*, **51**, 295-304 (2000).

Doran, J.W. and T.B. Parkin: Quantitative indicators of soil quality: A minimum data set. *In*: Methods for assessing soil quality (*Eds.*: J.W. Doran and A.J. Jones). *Soc. Sci. Soc. Am. Spe. Publication*, **49**, 25-37 (1996).

Eigenberg, R.A., J.W. Doran, J.A. Nienaber, R.B. Ferguson and B.L. Woodbury: Electrical conductivity monitoring of soil condition and available N with animal manure and cover crop. *Agric. Ecosys. Environ.*, **88**, 183-193 (2002).

EPA: Method 9210. Potentiometric determination of nitrate in aqueous samples with ion-selective electrode. Environmental Protection. Agency. USA (1996).

Goyal, S., K. Inubushi, S. Kato, H.L. Xu and H. Umemura: Effect of anaerobically fermented manure on the soil organic matter, microbial properties and growth of spinach under greenhouse conditions. *Ind. J. Microbiol.*, **39**, 211-216 (1999).

Gulser, C.: Effect of forage cropping treatments on soil structure and relationships with fractal dimensions. *Geoderma*, **131**, 33-44 (2006).

Isermayer, H.: Eine einfache Methode Zur Bestimmung Der Bodenatmung Und der Karbonate imBoden. Z. Pflanzenaehr. *Bodenkd*, **5**, 56-60 (1952).

Kacar, B.: Chemical analysis of plant and soil analysis. Ankara Univ. Faculty of Agriculture Publication No. 3 Ankara (1994).

Kemper, W.D. and R.C. Rosenau: Aggregate stability and size distribution *In*: Methods of Soil Analysis, 2nd Edn. Part I. (*Ed.*: A. Klute) ASA, Madison, WI. pp. 425-442 (1986).

Lee, J.J., R.D. Park, Y.W. Kim, J.H. Shim, D.H. Chae, Y.S. Rim, B.K. Sohn, T.H. Kim and K.Y. Kim: Effect of food waste compost on microbial population, soil enzyme activity and lettuce growth. *Biores. Technol.*, **93**, 21-28 (2004).

Lynch, J.M. and E. Bragg: Microorganisms and soil aggregate stability. *Adv. Soil Sci.*, **2**, 133-171 (1985).

Manivannan, S., M. Balamurugan, K. Parthasarathi, G. Gunasekaran and L.S. Ranganathan: Effect of vermicompost on soil fertility and crop productivity-beans (Phaseolus vulgaris). *J. Environ. Biol.*, **30**, 275-281 (2009).

Martens, D.A.: Plant residue biochemistry regulates soil carbon cycling and carbon sequestration. *Soil Biol. Biochem.*, **32**, 361-369 (2000).

MSTAT: MSTAT microcomputer statistical program. Michigan State University, East Lansing, MI. (1988).

Oades, J.M.: Soil organic matter and structural stability: Mechanisms and implications for management. *Plant and Soil*, **76**, 319-337 (1984).

Parkin, T.B, J.W. Doran and E. Franco-Vizcaino: Field and laboratory tests of soil respiration. *In*: Methods for Assessing Soil Quality (*Eds.*: Doran, J.W. and A.J. Jones). *Soil Sci. Soc. Am. Spe. Publ.*, **49**, SSSA, Madison, WI. pp. 231-246 (1996).

Patriquin, D.G., H. Blaikie, M.J. Patriquin and C. Yang: Farm measurements of pH, electrical conductivity and nitrate in soil extracts for monitoring coupling and decoupling of nutrient cycles. *Bio. Agric. Horticul.*, **9**, 231-272 (1993).

Saffigna, P.G., D.S. Powlson, P.C. Brookes and G.A. Thomas: Influence of sorghum residues and tillage on soil organic matter and soil microbial biomass in an Australian vertissol. *Soil Biol. Biochem.*, **21**, 759-765 (1989).

Smith, J.L. and J.W. Doran: Measurement and use of pH and electrical conductivity for soil quality analysis. *In*: Methods for assessing soil quality (*Eds.*: J.W. Doran and A.J. Jones). *Soil Sci. Soc. Am. Spe. Publ.*, 49. SSSA, Madison, WI. (1996).

Smith, J.L., R.I. Papendick, D.F. Bezdicek and J.M. Lynch: Soil microbial ecology (*Ed.*: B.F. Metting). Soil organic matter dynamics and crop residue management. Marcel Dekker Inc. New York. pp. 65-95 (1993).

Soil Survey Staff: Soil survey manuel. *USDA Handbook*. No:18, Washington D.C. (1993).

Tejada, M. and J.L. Gonzales: Effects of the application of a compost originating from crushed cotton residues on wheat yield under dry land conditions. *Europ. J. Agron.*, **19**, 357-368 (2003).

Waksman, S.A.: Soil microbiology. John Willey and Sons. Inc. New York (1952).

Wang, M.C. and C.H. Yang: Type of fertilizer applied to a Paddy-upland rotation affects selected soil quality attiributes. *Geoderma*, **114**, 93-108 (2003).

Yurtsever, N.: Experimental statistical methods. T.C. Ministry of Agric. and Forestry, Pub. No: 121 (1984).

Zaller, G.J.: Vermicompost as a substitute for peat in potting media: Effects on germination, biomass allocation, yields and fruit quality of three tomato varieties. *Scientia Horticul.*, **112**, 191-199 (2007).