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# Changes in Organic Carbon, $NO_3$-N, Electrical Conductivity Values and Soil Respiration Along a Soil Depth Due to Surface Application of Organic Wastes

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Changes in some chemical properties along a clay loam soil depth due to application of hazelnut husk, tea and tobacco wastes to soil surface were investigated under greenhouse conditions. At the end of 20, 40 and 80 d of incubation, changes in organic carbon, total nitrogen, soil respiration ($CO_2$ production), $NO_3$-N, pH, EC were determined in 10, 20, 30, 40 and 50 cm depth of the clay loam soil. While organic carbon in 0 to 20 cm soil depth decreased after 20 d, organic carbon in 30 to 50 cm soil depth increased between 40 and 80 d for all organic waste treatments. Except control treatment, organic carbon leached from soil surface (0-20 cm) to deeper soil layers (30-50 cm) of organic waste treatments between 40 and 80 days. Soil respiration significantly increased near the surface soil layers of organic waste treatments compared with the control. Organic carbon contents along soil depth generally increased with control (C) < tobacco wastes < hazelnut husk < tea applications. $NO_3$-N values in all soil depths generally increased after 20 d and decreased between 40 and 80 d. Electrical conductivity values gave the significant positive correlations with organic carbon, total N and $NO_3$-N and a negative correlation with soil pH. The most increases in $NO_3$-N and electrical conductivity values of all soil depths were obtained with tobacco wastes application. Leaching of decomposed materials along soil depth was greater with tobacco wastes application due to its fast mineralization.

**Key Words: Hazelnut husk, Decomposition, Tea, Tobacco waste, Soil depth.**

## INTRODUCTION

Organic matter addition to soils has a greatest effect on organic matter contents of soils[1]. Natural wastes are important to increase soil productivity and nutrition values as organic fertilizers. Organic wastes also improve soil structure, water and air balance and microbiological activity[2]. Decomposition of organic wastes into soil depend on composition of organic waste and some other environmental factors such as soil moisture, temperature, aeration and quantity of nutrients in soil[3]. Application of organic wastes to soil increase carbon, nitrogen content, microbial respiration, N mineralization and available nutrient elements of soil[4,5]. Composition of organic wastes, especially its N content and C:N ratio, is significant for decomposition of organic material into soil. Slow decomposition rate of organic matter in soil is generally related with high C:N ratio of organic matter[6]. High C:N ratio and high lignin content reduce to mineralization rate of organic matter. Low N content in organic wastes causes immobilization of nitrogen in soil[7,8]. Soil respiration explains energy use of soil microflora and sufficiency of microorganisms for decomposition of organic matter[9]. Crop residues in soil increase carbon content which is energy source for the living microorganisms and cause biological N transformations[10,11].

Direction and magnitude of change in soil pH by addition of organic matter depend on initial pH value of soil, anionic organic matter concentration of waste and decomposition rate of waste[12]. Addition of organic matter and compost to soil increase electrical conductivity value of soil[13,14]. Due to its net negative charge, dissolved organic matter is generally very mobile through the soil system in neutral pH ranges[15].

In this study, effects of surface application of hazelnut husk, tea and tobacco wastes on changes in organic carbon, total N, $NO_3$-N, soil respiration rate, electrical conductivity and pH values were investigated along a clay loam soil depths in different incubation periods.

## EXPERIMENTAL

Soil sample was taken from Kurupelit district of Samsun, Turkey. After sieving the air dried soil samples from 4 mm sieve, same amount of soil sample was packed into each PVC column in 10 cm diameter and 50 cm height over the sieve shaker at equal time. According to oven dry weight basis, 5 % of hazelnut husk, tea and tobacco wastes were incorporated into first 10 cm of soil columns homogenously. The greenhouse study was carried out 36 piece columns in factorial experiment design as four different treatments (control, hazelnut husk, tea and tobacco wastes), three different incubation periods (20, 40 and 80 d) with three replications. During the experiment, soils were irrigated with distilled water by weighing 4 d interval to hold moisture level of soil columns around field capacity. At the end of the each incubation period, three soil columns were disturbed for each treatment and sampled in every 10 cm interval of each soil column.

Particle size distribution was determined according to hydrometer method[16], soil reaction (pH) and electrical conductivity ($EC_{25°C}$) values in 1:1 soil:water suspension[17], total lime ($CaCO_3$) by Schebler Calcimeter method, soil organic matter (OM) by 'Walkley-Black' method and total N by Kjeldahl method[18]. According to some soil properties given in Table-1, the soil is a non-saline, moderately alkaline, clay loam, low in organic matter[19]. Nitrate nitrogen ($NO_3$-N) in soil samples was measured potentiometrically by consort P900 compatible $NO_3$ electrode[20]. Soil respiration rate was determined according to Isermayer[21] 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 h incubation period after each soil sampling.

TABLE-1
SOME PHYSICAL AND CHEMICAL PROPERTIES OF SOIL

| Soil properties | | Soil properties | |
|---|---|---|---|
| Sand (%) | 41.44 | Exch. Na (cmol $kg^{-1}$) | 0.84 |
| Silt (%) | 24.57 | Exch. K (cmol $kg^{-1}$) | 0.51 |
| Clay (%) | 33.99 | Exch. Ca (cmol $kg^{-1}$) | 29.70 |
| pH (1:1) | 8.40 | Exch. Mg (cmol $kg^{-1}$) | 7.90 |
| $EC_{25\,°C}$ (dS $m^{-1}$) | 0.40 | $CaCO_3$ (%) | 12.99 |
| OM (%) | 0.19 | Total N (%) | 0.07 |

Some chemical properties of the organic wastes were determined as follows: organic carbon (OC) and organic matter (OM) content were determined according to Kacar[18]; pH and salt content in saturation extract by using pH and EC meter, respectively[22], total nitrogen content by a Kjeldahl method[18].

TABLE-2
SOME PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC WASTES

| Organic wastes | OC (%) | OM (%) | N (%) | C:N | $EC_{25\,°C}$ (dS $m^{-1}$) | pH (sat. ext.) |
|---|---|---|---|---|---|---|
| Tobacco | 42.76 | 73.71 | 3.10 | 13.79 | 12.98 | 5.26 |
| Hazelnut husk | 52.42 | 90.37 | 0.95 | 55.47 | 6.05 | 4.90 |
| Tea | 52.50 | 90.51 | 2.89 | 18.17 | 5.17 | 4.76 |

Statistical analysis of experimental data was accomplished by standard analysis of variance using the TARIS software program and pairs of mean values compared by least significant difference (LSD)[23].

## RESULTS AND DISCUSSION

Organic waste treatments significantly increased organic carbon, total N values and soil respiration rate ($CO_2$) in 0-20 cm depth of soil according to the control treatment in all incubation periods (Table-3). Organic carbon, total N and $CO_2$ values in soil columns generally decreased as soil depth increased. Organic carbon contents along soil depth for control treatment decreased after 20 d incubation. Organic carbon contents in 0 to 20 cm soil depth for all organic waste treatments decreased after 20 d. However, organic carbon contents in 30 to 50 cm soil depth increased for all organic waste treatments between 40 and 80 d. Mean, organic carbon content and mean total N values through soil depth increased in the following order; control < tobacco wastes < hazelnut husk < tea (Fig. 1), control < hazelnut husk < tobacco wastes < tea (Fig. 2), respectively.

TABLE-3
ORGANIC CARBON, TOTAL N AND $CO_2$ PRODUCTION VALUES ALONG SOIL DEPTH FOR INCUBATION PERIODS

| Soil depth (cm) | Organic carbon (%) | | | Total N (%) | | | $CO_2$ (mg $CO_2$ 100 $g^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 20 d | 40 d | 80 d | 20 d | 40 d | 80 d | 20 d | 40 d | 80 d |
| C 10 | 0.121 | 0.094 | 0.063 | 0.028 | 0.027 | 0.027 | 3.02 | 4.18 | 1.41 |
| C 20 | 0.153 | 0.088 | 0.077 | 0.027 | 0.028 | 0.026 | 3.43 | 3.80 | 1.77 |
| C 30 | 0.208 | 0.160 | 0.070 | 0.024 | 0.029 | 0.029 | 3.49 | 4.04 | 2.08 |
| C 40 | 0.200 | 0.120 | 0.070 | 0.024 | 0.029 | 0.029 | 3.72 | 4.17 | 1.76 |
| C 50 | 0.190 | 0.081 | 0.070 | 0.024 | 0.028 | 0.028 | 3.86 | 3.11 | 1.02 |
| HH 10 | 1.462 | 1.427 | 1.399 | 0.065 | 0.071 | 0.071 | 32.19 | 14.94 | 9.99 |
| HH 20 | 0.632 | 0.310 | 0.281 | 0.042 | 0.039 | 0.032 | 15.18 | 6.29 | 7.34 |
| HH 30 | 0.271 | 0.140 | 0.168 | 0.028 | 0.028 | 0.029 | 13.06 | 4.60 | 2.89 |
| HH 40 | 0.250 | 0.120 | 0.155 | 0.026 | 0.027 | 0.028 | 9.42 | 2.80 | 2.05 |
| HH 50 | 0.210 | 0.100 | 0.150 | 0.026 | 0.026 | 0.028 | 8.07 | 4.66 | 1.71 |
| TEW 10 | 1.666 | 1.622 | 1.483 | 0.152 | 0.161 | 0.157 | 64.77 | 24.88 | 24.27 |
| TEW 20 | 1.017 | 0.438 | 0.309 | 0.080 | 0.057 | 0.034 | 20.48 | 6.06 | 4.26 |
| TEW 30 | 0.240 | 0.202 | 0.260 | 0.029 | 0.033 | 0.029 | 16.47 | 5.17 | 2.85 |
| TEW 40 | 0.230 | 0.182 | 0.253 | 0.028 | 0.030 | 0.029 | 11.56 | 3.09 | 2.68 |
| TEW 50 | 0.229 | 0.192 | 0.253 | 0.028 | 0.028 | 0.029 | 8.84 | 2.32 | 1.94 |
| TOW 10 | 1.130 | 1.063 | 0.969 | 0.119 | 0.122 | 0.115 | 37.00 | 13.82 | 6.94 |
| TOW 20 | 0.692 | 0.357 | 0.288 | 0.073 | 0.038 | 0.041 | 17.73 | 7.23 | 6.22 |
| TOW 30 | 0.288 | 0.181 | 0.273 | 0.030 | 0.031 | 0.036 | 15.01 | 4.24 | 3.13 |
| TOW 40 | 0.271 | 0.168 | 0.260 | 0.029 | 0.029 | 0.034 | 9.11 | 3.73 | 2.01 |
| TOW 50 | 0.252 | 0.168 | 0.231 | 0.028 | 0.028 | 0.033 | 6.38 | 1.88 | 2.53 |
| LSD | 0.20 (P = 1 %) | | | 0.01 (P = 1 %) | | | 6.50 (P = 1 %) | | |

C = control; HH = hazelnut husk; TEW = tea waste; TOW = tobacco waste treatments.

Higher soil respiration rates along soil depth were obtained with organic waste treatments after 20 d. $CO_2$ values along the soil column, except control treatment, generally decreased between 20 and 80 d. Organic waste treatments gave the higher mean $CO_2$ production values in depths than the control treatment (Fig. 3). The highest $CO_2$ values

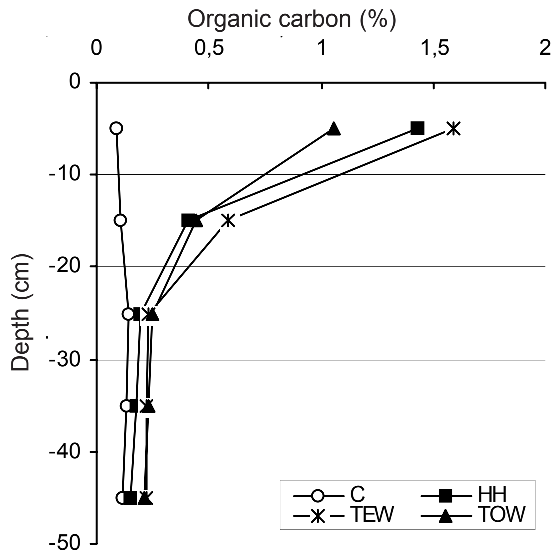



Fig. 1. Changes in mean organic carbon along soil depth with organic waste treatment (C = Control, HH = Hazelnut husk, TEW = Tea waste, TOW = Tobacco waste) LSD = 0.09 (P = 1 %)

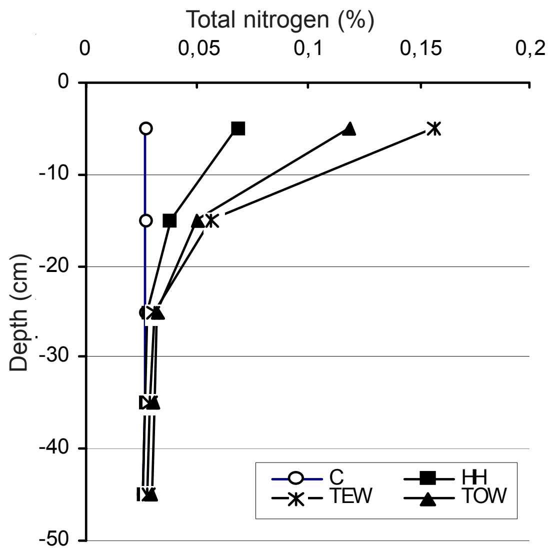



Fig. 2. Changes in mean total N along soil depth with organic waste treatment (C = Control, HH = Hazelnut husk, TEW = Tea waste, TOW = Tobacco waste) LSD = 0.005 (P = 1 %)

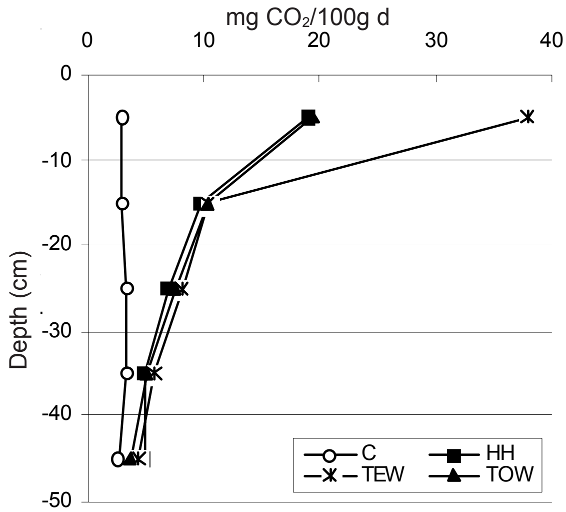



Fig. 3. Changes in mean $CO_2$ along soil depth with organic waste treatment (C = Control, HH = Hazelnut husk, TEW = Tea waste, TOW = Tobacco waste) LSD = 15.20 (P = 1 %)

along all soil depths were found with tea treatment in 20 d. $CO_2$ values in near the organic waste applied soil surfaces (0-20 cm) were higher than $CO_2$ values in deeper soil depths (30-50 cm). It is known that the rate of $CO_2$ production decreases as soil depth increases and less changes in $CO_2$ production occurs more than 50 cm soil depths. This decrease in $CO_2$ production parallels the drop in organic carbon level in soils[6].

Slow mineralization rate of organic matter in soil is generally related to high C:N ratio[6,24]. Additions of organic materials having high C:N ratio can cause N immobilization. Inorganic N can be produced by mineralization of organic matter or it can be immobilized by microbial biomass in the soil. Organic carbon in the structure of organic matter can be lost from soil in the form of $CO_2$ due to mineralization[10]. The lowest organic carbon, except control treatment, obtained with the application of tobacco waste, which had the lowest C:N ratio among the organic wastes, demonstrated that tobacco waste mineralized faster than the other wastes. The lowest total N values through soil profile, except control treatment, obtained with the application of hazelnut husk treatment. Lower mineralization rate in hazelnut husk among the other wastes can be expected due to its higher C:N ratio. Organic residues with low C:N ratios show more N mineralization than that with large C:N ratios[25].

According to the control treatment, increases in $NO_3$-N and electrical conductivity values were significant with TOW application and were not significant with tea and hazelnut husk applications statistically (Table-4).

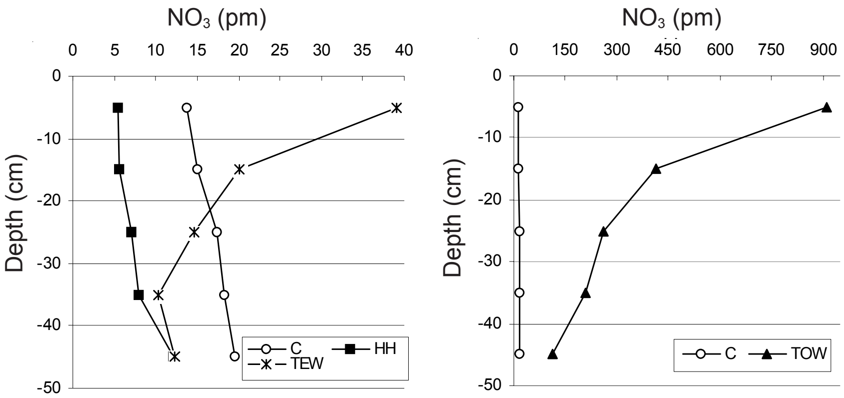
TABLE-4
$NO_3$-N, EC AND pH VALUES ALONG SOIL DEPTH
FOR INCUBATION PERIODS

| Soil depth (cm) | $NO_3$ (ppm) | | | EC (dS/m) | | | pH (1:1) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 20 d | 40 d | 80 d | 20 d | 40 d | 80 d | 20 d | 40 d | 80 d |
| C 10 | 12.8 | 13.6 | 14.8 | 0.356 | 0.363 | 0.407 | 8.55 | 7.82 | 7.77 |
| C 20 | 14.6 | 15.4 | 14.9 | 0.390 | 0.361 | 0.405 | 8.50 | 7.92 | 7.83 |
| C 30 | 13.3 | 20.7 | 18.1 | 0.408 | 0.376 | 0.423 | 8.45 | 7.97 | 7.35 |
| C 40 | 14.3 | 22.7 | 17.9 | 0.457 | 0.410 | 0.452 | 8.25 | 7.92 | 7.83 |
| C 50 | 18.1 | 22.8 | 17.9 | 0.502 | 0.430 | 0.487 | 8.35 | 7.93 | 7.63 |
| HH 10 | 3.8 | 5.3 | 7.1 | 0.522 | 0.493 | 0.597 | 8.27 | 8.07 | 7.83 |
| HH 20 | 1.0 | 7.6 | 9.5 | 0.465 | 0.394 | 0.452 | 8.57 | 8.27 | 7.58 |
| HH 30 | 4.0 | 5.5 | 11.6 | 0.408 | 0.394 | 0.467 | 8.47 | 8.33 | 7.70 |
| HH 40 | 1.0 | 10.4 | 13.3 | 0.453 | 0.451 | 0.487 | 8.50 | 8.27 | 7.37 |
| HH 50 | 4.2 | 13.3 | 19.1 | 0.503 | 0.455 | 0.498 | 7.87 | 8.30 | 7.30 |
| TEW 10 | 21.4 | 79.9 | 16.1 | 0.660 | 0.696 | 0.733 | 8.20 | 7.57 | 7.73 |
| TEW 20 | 20.1 | 24.8 | 15.2 | 0.522 | 0.451 | 0.494 | 8.47 | 7.88 | 7.60 |
| TEW 30 | 15.7 | 15.9 | 12.4 | 0.443 | 0.438 | 0.508 | 8.40 | 8.02 | 7.88 |
| TEW 40 | 1.0 | 19.0 | 11.8 | 0.499 | 0.497 | 0.535 | 8.07 | 7.97 | 7.17 |
| TEW 50 | 4.1 | 23.9 | 9.1 | 0.528 | 0.493 | 0.492 | 8.27 | 8.02 | 7.42 |
| TOW 10 | 136.0 | 1780.2 | 817.5 | 2.152 | 2.294 | 2.849 | 7.23 | 7.47 | 7.07 |
| TOW 20 | 242.1 | 636.6 | 358.7 | 1.583 | 1.127 | 1.206 | 7.67 | 7.82 | 7.23 |
| TOW 30 | 256.7 | 331.8 | 195.6 | 0.863 | 0.777 | 0.892 | 7.70 | 7.98 | 7.78 |
| TOW 40 | 222.3 | 256.0 | 145.7 | 1.045 | 0.802 | 0.806 | 7.83 | 8.02 | 7.10 |
| TOW 50 | 83.3 | 178.3 | 78.9 | 0.804 | 0.684 | 0.667 | 7.73 | 8.03 | 7.47 |
| LSD | 103.1 (P=1%) | | | 0.136 (P=1%) | | | Not significant | | |

C= control; HH = hazelnut husk; TEW = tea waste;
TOW = tobacco waste treatments.

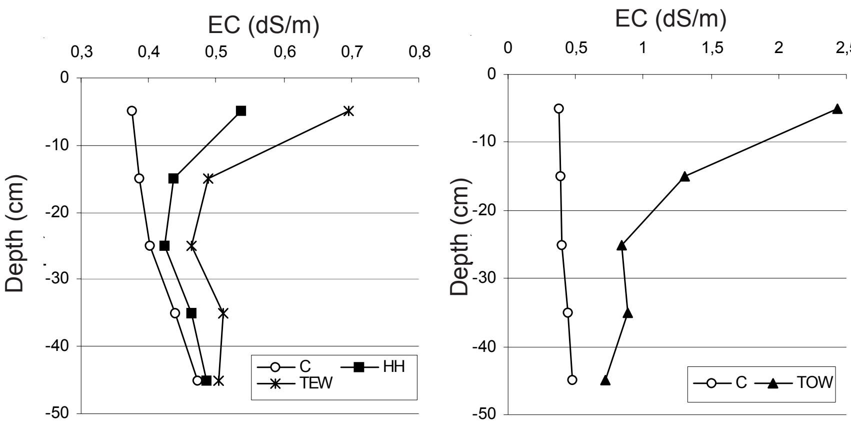
$NO_3$-N in all soil depths generally increased after 20 d and decreased between 40 and 80 d. Hazelnut husk treatment decreased mean $NO_3$-N in whole soil depths compared with the control treatment (Fig. 4a). The highest mean $NO_3$-N values in whole soil depth were obtained with tobacco waste treatment (Fig. 4b). Organic waste treatments increased the electrical conductivity values in all soil depths between 20 and 80 d. The lowest increases in mean electrical conductivity values along soil depths compared with the other treatments was obtained with HH treatment (Fig. 5a). Fast mineralization rate of tobacco waste due to the lowest C:N ratio among the other wastes caused the highest and significant increases in mean electrical conductivity values along soil depth (Fig. 5b).

It is known that addition of organic matter and compost into soilsignificantly increases electrical conductivity value of soil[13,14]. Although




(a) (b)

Fig. 4. Changes in mean $NO_3$-N contents through soil depth with (a) Control (C), Hazelnut husk (HH) and Tea waste (TEW), (b) Control (C) and Tobacco waste (TOW) treatments, LSD: 46.11 (P = 1 %)




(a) (b)

Fig. 5. Changes in mean electrical conductivity values through soil depth with (a) Control (C), Hazelnut husk (HH) and Tea waste (TEW), (b) Control (C) and Tobacco waste (TOW) treatments, LSD: 60.96 (P = 1 %)

the electrical conductivity value is generally related with salinity, it is an important parameter for reflecting dissolved nutrient elements in anion and cation forms in soil[26] and monitoring organic matter mineralization in soil[27]. In this study, electrical conductivity values as an indicator of organic matter decomposition along the soil profile increased as follow: tobacco waste > tea > hazelnut husk. It indicated that leaching of decomposed materials through soil profile was greater with application of tobacco waste due to its lower C:N ratio and fast mineralization rate among the other wastes.

While tea and tobacco waste treatments decreased pH values of the soil, hazelnut waste generally increased pH values of the soil according to the control treatment between 20 and 80 d (Table-4). The most decrease in mean pH value of the soil was obtained in soil 0 to 20 cm soil surface with tobacco waste application (Fig. 6).

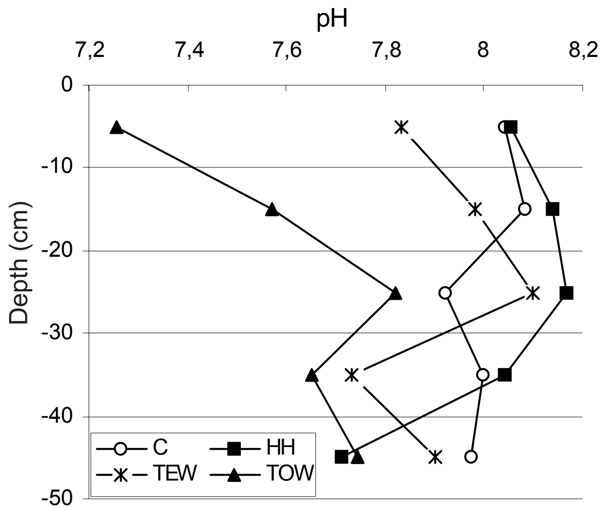



Fig. 6. Changes in mean pH along soil depth with organic waste treatment (C = Control, HH = Hazelnut husk, TEW = Tea waste, TOW = Tobacco waste) LSD = 0.241 (P = 1 %)

Carbonic acid in soil occurs after organic matter decomposition product of $CO_2$ reacting with water[10]. Xua *et al.*[28] showed that soil pH decreased with the applications of different rates of plant residues. Tang and Yu[12] reported that the magnitude in pH changes depend on the organic anion concentration in the residues, initial soil pH and the decomposition degree of residue.

Relationships among some chemical and biological properties were given in Table-5. Soil pH values had significant negative correlations with organic carbon, $CO_2$, electrical conductivity, $NO_3$ values. The highest significant correlations among the properties were obtained between OC × total N (0.934**), OC × $CO_2$ (0.944**), total N × $CO_2$ (0.953**), EC × $NO_3$ (0.989**). In a study by Patriquin *et al.*[29], $NO_3$-N content gave a significant positive correlation with electrical conductivity of soil and a

TABLE-5
RELATIONSHIPS AMONG THE PROPERTIES

| | N | $CO_2$ | pH | EC | $NO_3$ |
|---|---|---|---|---|---|
| OC | 0.934** | 0.944** | -0.305 | 0.467* | 0.367 |
| N | | 0.953** | -0.414 | 0.548* | 0.457* |
| $CO_2$ | | | -0.235 | 0.368 | 0.269 |
| pH | | | | -0.850** | -0.825** |
| EC | | | | | 0.989** |

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

significant negative correlation with soil pH after organic fertilizer addition to soil. Decreases in soil pH with addition of organic matter into soil depend on $H^+$ ions occurred after transformation of $NH_4^+$ to $NO_3^-$ in nitrification process[10]. Therefore, there was a significant negative relation between pH and $NO_3$-N content of soils in this study. Tejeda *et al.*[30] reported that addition of organic matter into soil increased soil microbial activity and also increased $NO_3$-N contents of soils due to mineralization of organic matter. Eigenberg *et al.*[13] also reported that there was a significant positive relation between $NO_3$-N values and electrical conductivity values in a manure study and seasonal changes in N content of soils may be monitored using electrical conductivity measurements in the regression equations.

## Conclusion

After incorporating of organic waste into 10 cm of soil surface, organic carbon, total N, $NO_3$-N, electrical conductivity values and soil respiration significantly increased and soil pH decreased within 0 to 20 cm soil surface compared with the control treatment. The effects of surface applied organic wastes on the soil properties were generally decreased between 30 and 50 cm soil depths. While $CO_2$ production increased, organic carbon content decreased in 0 to 20 cm soil depth. Except control treatment, organic carbon content for all organic waste treatment increased in 30 to 50 cm soil depth between 40 and 80 d. It shows that organic carbon leached from soil surface (0-20 cm) to deeper soil layers of organic waste treatments compared with the control. Increases in $NO_3$-N and electrical conductivity values along soil depths indicated that mineral matter contents in all soil depths increased due to decomposition of organic wastes compared with the control treatment. Significant increases in $NO_3$-N and electrical conductivity values along soil profile were generally observed in tobacco waste treatment due to its fast mineralization rate among the other wastes.

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