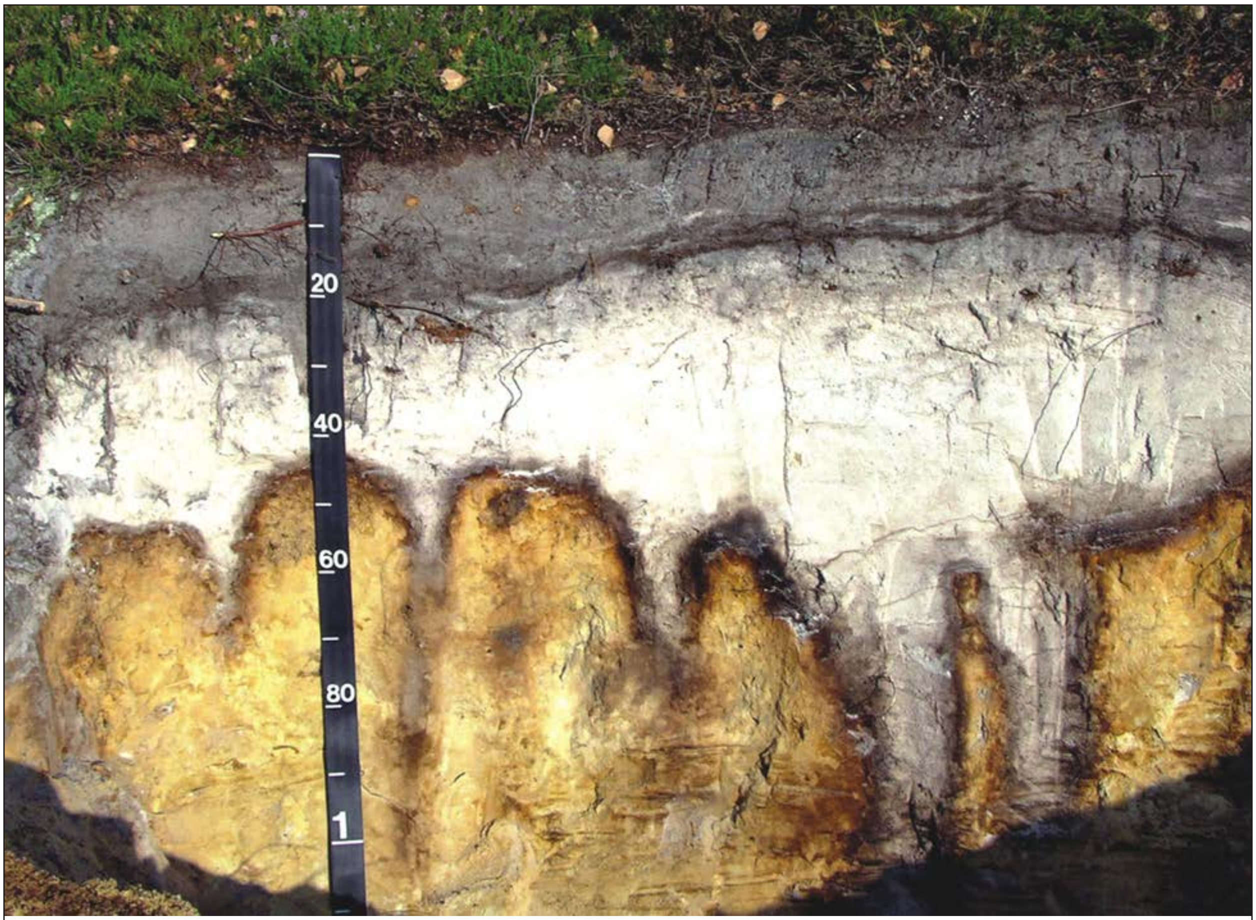

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Effect of Wheat Stubble Burning and Tobacco Waste Application on Mineral Nitrogen Content of Soil at Different Depth

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Abstract: A two year field experiment was carried out to determine the fluctuation on mineral nitrogen contents of soil with respect to wheat stubble burning. In soybean plant vegetation, tobacco waste amounting 0 (TA), 5000 (TB) and 10000 (TC) kg ha^{-1} was applied on burned (BD) or not burned (NB) plots. Results showed that treatments considerably affected nitrate and ammonium contents of top layer soil. Most proportion of soil inorganic nitrogen content consisted as nitrate. In the first year of the study the highest nitrate value of 48.13 kg NO^{-}_{3}-N ha^{-1} was observed at 13th day in BD-TC treatment, whereas in second year it was observed at 20th day in NB-TC treatment as 130.87 kg NO^{-}_{3}-N ha^{-1}. In general, higher values were observed at top layer soil (0-20 cm depth) whereas the lowest values were determined at depth of 40-60 cm. First year applications considerably affected the second year's outcome, thus, residual effects of first year increased the second year's values in terms of nitrate and ammonium.

Key words: Stubble burning, tobacco waste, soybean, nitrogen turnover, nitrate, ammonium

INTRODUCTION

Nitrogen is one of the key components of plant production and the nitrogen demand of the plant is supplied by mineral nitrogen applications. Most part of soil nitrogen contents consist as complex organic molecules that higher plants cannot use. Readily usable forms of nitrogen are nitrate (NO^{-}_{3}) or ammonium (NH_4^+) whereas the organic forms are converted to ammonium and nitrate by soil microorganisms, a process called mineralization. Therefore the amount of nitrogen available to roots depends on the rate of mineralization and it in turn depends on environmental and soil factors that affect the activity of the microorganisms (Alexander, 1991; Hackl *et al*., 2004). Excess N, which cannot be held within the system, may adversely affect the environment by leaching of nitrate into the groundwater or emission of N_2O into the atmosphere (Gok, 1988; Ottow and Benckiser, 1994).

Under semiarid Mediterranean climatic conditions, soils typically have low organic matter content and weak structure resulting in low infiltration rates (Hernanz *et al*., 2002). The soil organic matter contents of the widely arable lands of Turkey are varying between 1 to 2% even less than 1% (Ozbek *et al*., 1974). Therefore, burning of wheat harvest remains is a widely performed practice in Turkey. Different organic substrate and green manure applications have significant importance in increasing soil's organic matter and quality. Several factors such as monoculture production, burning stubble, the gathering and removing the harvest remains, rare use of organic fertilizer and the climatic conditions (especially semi-arid) may play a special role on the insufficient organic matter contents of the soil (Diercks, 1983; Gok *et al*., 1998). State Institute of Statistics in Turkey reported that

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14 million ha of agricultural land were used for cereal production in 1999 and wheat, rye, barley and oats were the major crops constituting 95.6% of cereal-planted areas. It is reported that in Turkey each year 6 to 8 million tons of cereal straw are burned (Anonymous, 2000).

Incorporation of harvest residues and agricultural industrial wastes to soil gained great importance to improve soil organic matter content especially in semi-arid ecological zones, in Turkey. However, stubble burning is a common practice used by farmers for pest and weed control as well as for expending less energy on tillage. Similarly, organic residues of tobacco factories are burned to prevent misuse; moreover when it is incorporated into soil it has great potential on sustaining soil organic matter and partially organic nitrogen content.

The average amount of processed tobacco between 1991 and 1995 was 81,992 tones and the residue of processing was around 6,306 tones. This residue is generally burned to prevent misuse, however, it contains 1-3% N, 2-4.5% K, 0.14-0.27% P, 2.5-6% Ca and 0.15-0.79% Mg and using of this amount in agricultural land would increase soil organic matter thus having positive effect on soils' biological and physical productivity (Ozguven *et al*., 1999).

Soybean is the most widely grown protein/oilseed crop in the world. Countries in North and South America are leading producers of soybean in the world. In terms of soybean production Turkey is ranked as 22nd and this production dramatically decreased in last decades due to the marketing difficulties. Subsidies given by Turkish government to soybean producers to increase soybean cultivation would significantly reduce monoculture production system thus would also sustain both soil quality and human protein demand.

The objective of this study was to investigate the effect of wheat stubble burning and tobacco waste application as organic fertilizer, on nitrogen turnover in soil.

MATERIALS AND METHODS

Field Experiment

The experiment was carried out at the Research Station of Cukurova University in Adana/Turkey during 2000-2001 cropping season. The plots (2.8×6 m) were arranged in randomized complete block design in three replications. Treatments were 0 (control; TA), 5000 (TB) and 10000 (TC) kg ha^{-1} tobacco waste applications on burned (BD) or non-burned (NB) wheat straw. The content of carbon, nitrogen and C:N ratios of organic substrates applied to soil were 41.6, 0.55 and 75.6% for wheat straw and 41.95, 2.55 and 16.5% for tobacco waste respectively. Some properties of soil at 0-20 cm in the experimental site are given in Table 1. Annual precipitation was 670 mm and the temperature ranged 25-35°C in summer and 10-20°C in winter at the research station.

Following the incorporation of organic residues, *Bradyrhizobium japonicum* (1809) inoculated on soybean seeds (*Glycine Max*. L, SA88) were sown on July 4, 2000 and July 2, 2001 for the first and second year of experiment, respectively. Before the soybean sowing, 30 kg N ha^{-1} [$(NH_4)_2SO_4$] and 200 kg ha^{-1} Triple Super Phosphate (= 87.4 kg ha^{-1} P_2O_5) were applied to each plot.

Chemical and Biological Analysis

Soil samples collected from 0-20, 20-40 and 40-60 cm depth were analyzed for their nitrate (Fabig *et al*., 1978), nitrite (Nicholas and Nason, 1957) and ammonium (Deutsche Einheitsverfahren, 1983) contents at regular intervals. Some chemical and physical properties of soil determined were as follow: total carbon, total nitrogen, calcium carbonate ($CaCO_3$), texture, total salt and cation exchange capacity (CEC) by using the methods Lichterfelder (Schlichting and Blume, 1966), Kjeldahl (Bremner, 1965), Scheibler calcimeter (Schlichting and Blume, 1966), Hydrometer (Bouyoucos, 1951), Wheatstone (U.S. Salinity Laboratory Staff, 1954) and ammonium acetate extraction (U.S. Salinity Laboratory Staff, 1954), respectively. pH was analyzed with pH-meter (Schlichting and Blume, 1966) in 1:1 soil:water ratio.

Table 1: Some physical and chemical properties of the soil of experimental farm

Sand	Silt (%)	Clay	Texture class	Organic matter (%)	Total nitrogen (%)	CEC (me 100 g^{-1})	$CaCO_3$ (%)	pH (1:1)
30.8	35.3	33.9	CL	1.27	0.072	22.18	24.2	7.5

RESULTS AND DISCUSSION

The effects of wheat stubble burning and different rate of tobacco waste applications on soil nitrate and ammonium contents at different soil depths are presented in Fig. 1 and 2 for 2000 and 2001, respectively. Moreover, the average values of this data are presented in Table 2 and 3 for both years in terms of nitrate and ammonium, respectively. Since level of nitrite was low enough to neglect (near zero) it was not reported. Experiment was conducted at the same plot for repetitive two years thus it was thought that residual effects of first year would increase the values of second year. In guidance of this, second year data were analyzed separately from first year data.

Results showed that at 0-20, 20-40 and 40-60 cm soil depth tobacco waste application increased soil nitrate concentration in first year ($p<0.05$; Table 2). Stubble burning (BD) or not burning (NB) did not affect soil nitrate concentration at various depths ($p>0.05$), except where there was a decrease in soil nitrate concentration in NB receiving TC treatment compared to NB receiving TC treatment ($p<0.05$). In second year at 0-20 cm depth, NB receiving TC treatment had higher nitrate concentration than BD receiving TC treatment ($p<0.05$; Table 3). However at 20-40 and 40-60 cm depths, NB receiving TC treatment had lower nitrate concentration than BD receiving TC treatment ($p<0.05$). On the other hand at 20-40 cm depth BD receiving TA treatment had lower nitrate concentration than NB receiving TA treatment ($p<0.05$).

Wheat stubble has wide C/N ratio as 75.6 and may cause nitrogen immobilization in biomass, thus this might be the reason for first year values to be lower. However in second year considerably higher nitrate concentrations were found especially in NB-TC treatment. This indicates that immobilized nitrogen may easily mineralize as soon as optimum C/N ratio is reached (Tisdale and Nelson, 1985; Gok, 1987; Gok and Ottow, 1988) This shows that in order to decrease nitrogen loss and ground water contamination, C/N ratio should be taken into consideration when applying organic substrates into soil.

When Limon-Ortega *et al*. (2002) compared effect of stubble burning and leaving stubble intact it was found that in second and third year there were no differences in yield however after third year yield in intact stubble was higher than that of burned stubble. Because first year values are misleading in terms of yield this effect should be well explained to farmers by extension services that stubble incorporation would increase the yield in longer run. Our study showed that second year values seemed to be more reliable than the first year data. However, first year data has great importance due to representing nitrogen status of the soil

In first year at top layer BD had higher ammonium concentration than NB regardless of tobacco applications ($p<0.05$; Table 4). However at 20-40 and 40-60 cm depths, tobacco application tended to increase NH4 concentration in BD compared to NB ($p>0.05$). When first year and second year is compared in terms of NH4 concentration it is observed that second year had higher values. In second year at top layer BD receiving TB treatment had higher NH4 concentration than NB receiving TB treatment ($p<0.05$).

In first year higher values of nitrate concentration was recorded at second sampling, which corresponded to 13th and 20th days in 2000 and 2001, respectively. In these days nitrate levels were found as 48.13 and 130.47 kg NO^{-}_{3}-N in BD and NB receiving TC treatment, respectively. In first year, high levels of NH4 were observed at 42nd day in BD receiving TB and TC treatment. However this concentration levels were not maintained in following sampling days. Treatments had limited effects on NH4 at deeper soil layers compared to top layer.

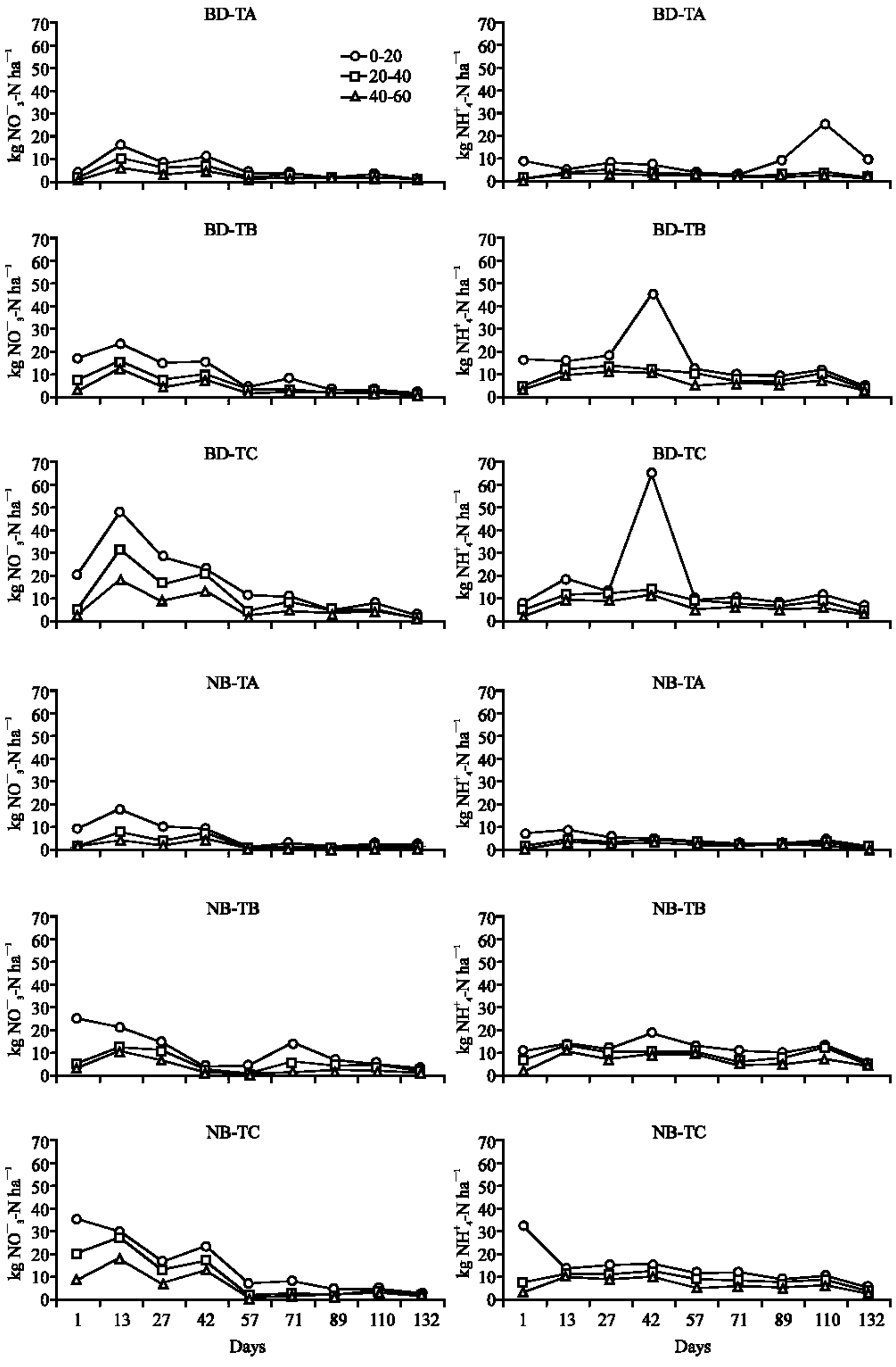

Fig. 1: Effects of wheat stubble burning and tobacco waste applications on nitrate (left) and ammonium (right) contents of soil at different depth during 2000

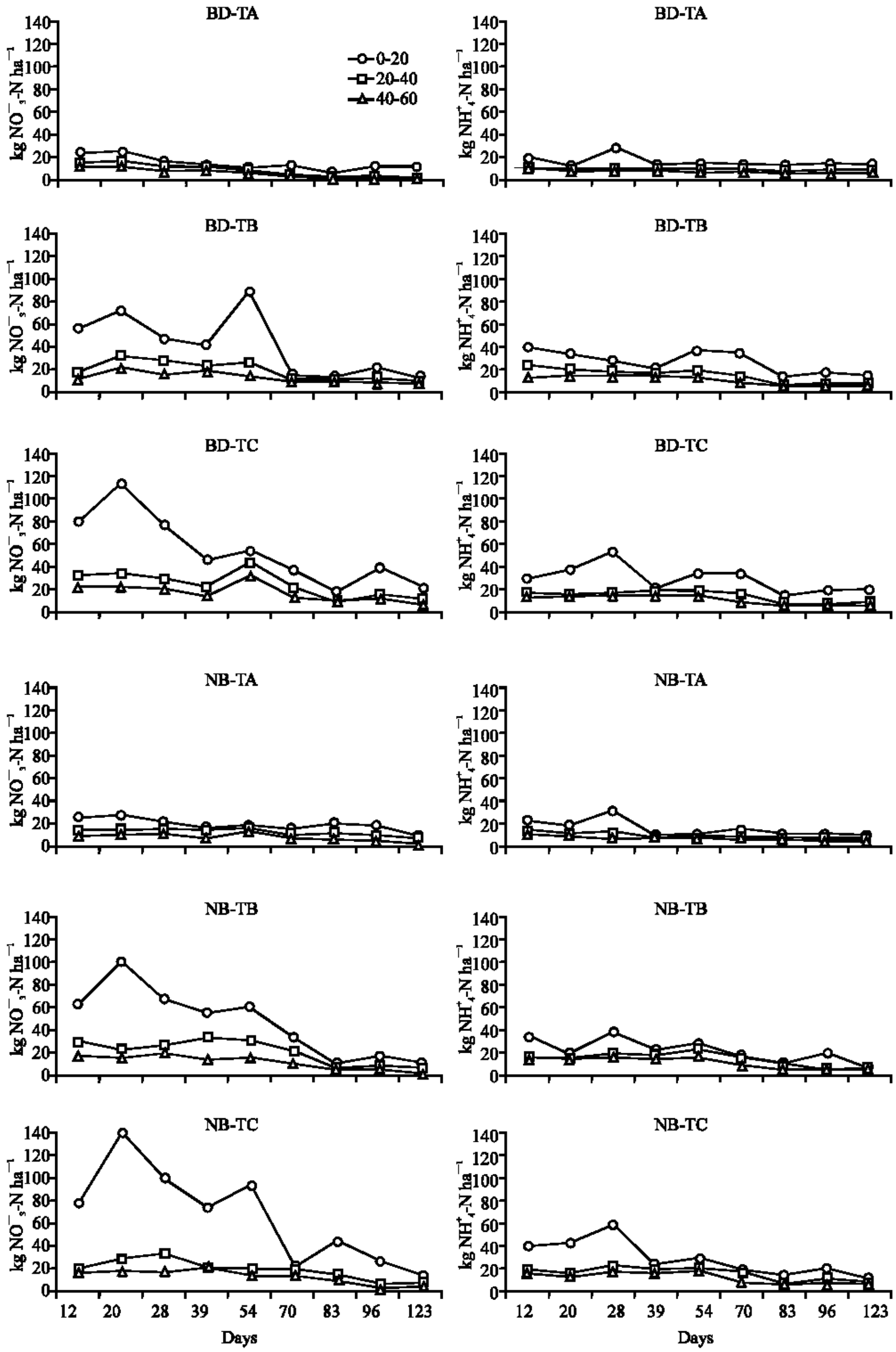

Fig. 2: Effects of wheat stubble burning and tobacco waste applications on nitrate (left) and ammonium (right) contents of soil at different depth during 2001

Table 2: Effects of stubble burning and tobacco waste applications on the average nitrate values for vegetation period in the year of 2000 (left) and 2001 (right)

	kg NO^-_3-N ha^{-1}			kg NO^-_3-N ha^{-1}		
Depth (cm)	0-20	20-40	40-60	0-20	20-40	40-60
BD-TA	5.7^{d1}	3.6^{cd2}	2.2^{de2}	14.6^{d1}	8.1^{d2}	5.8^{c3}
BD-TB	10.5^{c1}	6.3^{b2}	4.5^{bc2}	38.7^{c1}	17.6^{b2}	12.0^{b2}
BD-TC	17.3^{a1}	10.9^{a2}	6.5^{a2}	49.8^{b1}	22.5^{a2}	15.1^{a2}
NB-TA	6.3^{d1}	2.7^{d2}	1.8^{e2}	17.7^{d1}	11.6^{c2}	7.3^{c3}
NB-TB	10.4^{c1}	5.1^{bc2}	3.3^{cd2}	42.8^{bc1}	18.7^{b2}	10.8^{b2}
NB-TC	13.7^{b1}	9.3^{a2}	5.7^{ab2}	60.9^{a1}	17.6^{b2}	12.2^{b2}

[a,b,c,d]Means with different superscript in the same column are different for that respective year ($p<0.05$), [1,2,3]Means with different superscript in the same row are different for that respective year ($p<0.05$)

Table 3: Effects of stubble burning and tobacco waste applications on the average ammonium values for vegetation period in the year of 2000 (left) and 2001 (right)

	kg NH_4^+-N ha^{-1}			kg NH_4^+-N ha^{-1}		
Depth (cm)	0-20	20-40	40-60	0-20	20-40	40-60
BD-TA	9.0^{c1}	3.1^{b2}	2.3^{b2}	14.2^{c1}	7.7^{b2}	6.3^{c2}
BD-TB	15.8^{a1}	8.7^{a2}	6.5^{a2}	24.4^{a1}	13.0^{a2}	9.2^{b2}
BD-TC	16.4^{a1}	8.6^{a12}	6.3^{a2}	27.2^{a1}	12.5^{a2}	9.7^{ab2}
NB-TA	4.6^{d1}	2.8^{b2}	2.2^{b2}	14.4^{c1}	8.6^{b2}	6.7^{c2}
NB-TB	11.7^{b1}	8.7^{a2}	6.6^{a3}	19.4^{b1}	12.4^{a2}	9.8^{ab2}
NB-TC	13.2^{b1}	8.3^{a2}	6.1^{a2}	25.9^{a1}	13.7^{a2}	10.6^{a2}

[a,b,c,d]Means with different superscript in the same column are different for that respective year ($p<0.05$), [1,2,3]Means with different superscript in the same row are different for that respective year ($p<0.05$)

Since results reveal that treatments affected soil nitrate concentration in two months following the application this suggests that in order to decrease nitrogen loss and environmental impact this duration should be considered.

In both years nitrate level was higher at surface soil ($p<0.05$; Table 2). Even though nitrate level at 20-40 cm in both years was higher than that of 40-60 cm this was not significant ($p>0.05$) except BD and NB receiving TA treatment ($p<0.05$). This infer that application did not have much influence on nitrogen level at deeper layers.

Similarly to the trend observed in nitrate levels, ammonium levels were higher at top layer soil ($p<0.05$; Table 3) and concentration at 20-40 cm did not differ that of 40-60 cm ($p>0.05$).

CONCLUSION

High clay contents caused insufficient aeration of soil. This probably limited the nitrification and thus considerable ammonium peaks observed even 42nd day of second year experiment. Determined nitrate concentration at 40-60 cm soil depth revealed that wheat stubble burning and tobacco waste applications had quite limited effect on nitrogen enrichment at sub-soil layers. When stubble is burned nutritional elements other than nitrogen become available to the plant, however stubble burning destroys organic matter that is a source of energy for microorganisms as well as an important amendment for soil properties.

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