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Effects of tobacco waste and Farmyard manure on macro element status of soil and yield of grown lettuce (*Lactuca sativa L.var. capitata*)

Tütün atığı ve ahır gübresinin baş salata (*Lactuca sativa L.var. capitata*) yetiştiriciliğinde toprağın makro besin element içeriği ve verime olan etkileri

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Anahtar Sözcükler:

Tütün atığı, ahır gübresi, baş salata (*Lactuca sativa L. var. capitata*), toprağın makro besin element içeriği

ÖZET

Bu çalışmanın amacı, kompostlaştırılmış tütün atığı ve ahır gübresinin toprağın makro besin elementi içeriği ve verime olan etkilerini karşılaştırmaktır. Bu araştırma 2005-2006 yıllarında, E.Ü. Ziraat Fakültesi Menemen Araştırma Uygulama ve Üretim Çiftliği'nin deneme alanında yürütülmüştür. Sigara fabrikasından alınan tütün atıklarının olgunlaştırılmasıyla elde edilen kompost ve ahır gübresi kullanılarak baş salata (*Lactuca sativa* L. *var. capitata*) yetiştirilmiştir. Çalışmada ticari gübre ve bitki koruma amaçlı pestisid vb. kullanılmamıştır.
Denemeye ait uygulamalar şu şekildedir: (1) kontrol, (2) 12.5 t ha^{-1} ahır gübresi + 37.5 t ha^{-1} tütün atığı kompostu, (3) 25 t ha^{-1} ahır gübresi + 25 t ha^{-1} tütün atığı kompostu, (4) 50 t ha^{-1} ahır gübresi, (5) 50 t ha^{-1} tütün atığı kompostu, (6) 37.5 t ha^{-1} ahır gübresi + 12.5 t ha^{-1} tütün atığı kompostu. Denemede iki farklı dönemde toplam üç kere (7 Eylül 2005, 11 Kasım 2005 ve 14 Nisan 2006 olmak üzere) toprak örneklemesi yapılmıştır. Araştırmada, tütün atığı kompostunun ve ahır gübresinin, toprağın makro besin element içeriklerine ve bitki verimine olan etkileri incelenmiştir. Tütün atığı ve ahır gübresi uygulamalarının dozları ile toprağın makro besin element içerikleri ve verimde kontrole göre olumlu yönde artışlar saptanmıştır. Topraklara ait verimlilik parametrelerinden olan N-P-K gibi makro besin element içeriklerinde gerçekleşen artışlar marul bitkisinin veriminde de gözlenmiştir. Maksimum verim, özellikle 50 t ha^{-1} tütün atığı kompostunun uygulandığı parsellerde 102.7 t ha^{-1} olarak hesaplanmıştır. Araştırmadan elde edilen sonuçlar, tütün atığı kompostunun toprağın bitki besin maddesi düzeyini iyileştirmek için kullanılabileceğini göstermiştir.

Key Words:

Tobacco waste, farmyard manure, *Lactuca sativa L. var. capitata*, soil macro elements

ABSTRACT

The aim of this study is to compare effects of composted tobacco waste (CTW) with farmyard manure (FYM) on macro element status of soil and yield of lettuce. This research was held in the experimental fields of Agriculture Faculty's Research Farm of Ege University in Menemen-Izmir-Turkey in the years of 2005 and 2006. Tobacco wastes gathered from cigarette industry were composted and applied to lettuce (*Lactuca sativa L. var. capitata*) with manure. No mineral fertilizers or pesticides were applied. The treatments were; (1) control, (2) 12.5 t ha^{-1} FYM + 37.5 t ha^{-1} CTW, (3) 25 t ha^{-1} FYM + 25 t ha^{-1} CTW, (4) 50 t ha^{-1} FYM, (5) 50 t ha^{-1} CTW, (6) 37.5 t ha^{-1} FYM + 12.5 t ha^{-1} CTW. During the experiment, soil samples were taken three times in two different periods (1st, September 7, 2005; 2nd, November 11, 2005; and 3rd, April 14, 2006). The effects of CTW and FYM on soil nutrients and the yield were investigated. All application rates provided increasing effects on soil when compared with control. Increasing N, P, K contents provided a rise in yield. Maximum lettuce yield was 102.7 t ha^{-1} at the plots where 50 t ha^{-1} CTW was applied. The results show that CTW can be used as a plant nutrients resource.

INTRODUCTION

Soil needs nutrients as every ecosystem. It has been known that organic matter which is a nutrient for soil organisms has got positive effects on soil physical, chemical and biological properties. Protection of soil natural efficiency is related to its content of organic matter. Therefore, soil needs to organic matter. Soil organic matter and various physical properties have been proposed as indicators of soil quality (Doran and Parkin, 1994). The influence of organic matter on soil biological and physical fertility is well known. It affects crop growth and yield either directly by supplying nutrients or indirectly by modifying soil physical properties such as stability of aggregates and porosity that can improve the root environment and stimulate plant growth (Darwish et al. 1995). Increasing problems concerning the environmental quality in arable landscapes and the long-term productivity of agro-ecosystems have emphasized a need to develop and improve management strategies that maintain and protect soil function and resources. Changes in management may lead to changes in soil organic matter quantity and quality depending on site characteristics such as soil texture (Janssen, 1984; Campbell et al. 1999).

Farmyard manure which is the most useful manure as an organic matter source is provided from various animal wastes. Due to the fact that farmyard manure is not found enough amounts in farms and it is an expensive material, other organic materials can be used instead of manure to improve soil properties.

Agro-industrial waste presents an alternative to inorganic fertilizer. It is possible to use tobacco waste as a soil amendment due to its high organic matter and low toxic element content. Tobacco waste has no immediate use and cigarette companies have to pay for its disposal. The majority of this waste is destroyed by burning. Tobacco solid waste is classified as agro-industrial waste. Because of the high organic matter and low toxic element content, it has potential use as a soil amendment. Direct use of tobacco waste could create an unfavorable soil environment; however, composting tobacco waste could accelerate the breakdown of nicotine and result in the production of a less toxic and more useful organic amendment (Adediran et al. 2004). Benefits of composts amendments to soil have been reported by many authors (Roig et al.1987; Drinkwater et al. 1995; Stamatiadis et al. 1999). They include higher plant available water holding capacity and cation exchange capacity, lower bulk density, pH stabilization and better aggregation. Bulluck et al.(2002) found that the addition of recycled organic wastes decreased the number of plant pathogenic microorganisms. In this way, two problems can be simultaneously solved: disposal of waste and enrichment of soil with organic matter. Positive effects of organic waste application on soil properties have been documented for soil structure, bulk density, water retention characteristics, CEC, and soil biological activities (Levi-Minzi et al. 1985; Dar, 1997; Elsgaard et al. 2001). The nutrient value of organic wastes is considered to be moderate (Petersen, 2001), although the variation in waste quality is large dependent on waste type and processing method (Smith et al. 1998). Delibacak et al. (2009), found that addition of increasing treated sewage sludge application to Typic Xerofluvent soil was significantly increased total salt, OM, total porosity, micro porosity, macro porosity, field capacity, wilting point, available water content, structure stability index and aggregation percentage values of soil when compared with control.

In the present study CTW combined with FYM at different ratios were applied to soil and compared effects of these amendments on physical, chemical properties of soil and lettuce yield was studied.

MATERIALS AND METHODS

The study was carried out in Agriculture Faculty's Research Farm of Ege University in Menemen-Izmir-Turkey, during 2005–2006. Study area is in the Western Anatolia region of Turkey. The experiment was conducted on loamy and low alkaline soil with 7.52 pH. Some properties of soil are shown in Table 1.

The experiment was conducted in 18 plots in a randomized-block design with three replications. The plot size was 3x2 m. The organic materials applied were composted tobacco waste (CTW) and farmyard manure (FYM). The general properties of the organic materials used are shown in Table 2. The treatments were (1) control, (2) 12.5 t ha^{-1} FYM + 37.5 t ha^{-1} CTW, (3) 25 t ha^{-1} FYM + 25 t ha^{-1} CTW, (4) 50 t ha^{-1} FYM, (5) 50 t ha^{-1} CTW, (6) 37.5 t ha^{-1} FYM + 12.5 t ha^{-1} CTW. Tobacco waste was taken from Izmir Kemalpaşa Socotab Factory and farmyard manure was obtained from Agriculture Faculty's Research Farm of Ege University, Menemen. Both materials were applied to the soil after composting.

Table 1. Some physical and chemical properties of the experimental soil.

Soil Texture	Loam
Sand (%)	44.26
Silt (%)	44.13
Clay (%)	11.61
pH	7.52
Total Soluble Salt (%)	0.085
$CaCO_3$ (%)	5.38
Organic Matter (%)	2.53
Bulk density (g cm^{-3})	1.28
Particle density (g cm^{-3})	2.58
CEC (me 100 g^{-1})	17.3
Agregation (%)	29.11
Structure stability ind. (%)	10.88
Available water (%)	9.7
Total porosity (%)	50.44
Total-N (%)	0.129
Available P (mg kg^{-1})	8.88
Available K (mg kg^{-1})	447.2
Available Ca (mg kg^{-1})	2752
Available Mg (mg kg^{-1})	529.4
Available Na (mg kg^{-1})	217.9

At the beginning of the experiment (1st of September, 2005), 50 t ha^{-1} materials were applied to the soil because lettuce plant needs 50-100 kg N ha^{-1} (IFA, 1991). No mineral fertilizers were applied. 540 lettuce seedlings were planted in first vegetation period, on 1st of September, 2005 by furrow irrigation. After that, irrigation method was changed as drip irrigation. First harvest was made on the 11th of November, 2005. Similarly, during the second vegatation period, 540 lettuce seedlings were planted on 25th of November, 2005 by irrigation and they were not irrigated until the end of harvest. Second period harvest was performed on the 14 th of April, 2006.

Table 2. Some properties of CTW and FYM.

	CTW[1]	FYM[2]
pH	9.17	8.70
EC(dSm^{-1})	40	38.5
Org.C (%)	37.87	39
OM (%)	65.3	67.2
C:N	17.37	16.5
$CaCO_3$ (%)	2.43	2.09
60 ^{0}C water content (%)	7.19	5.50
105^{0}C water content (%)	29.79	25.13
Total N (%)	2.18	2.35
Total P (mg kg^{-1})	4900	5800
Total K(mg kg^{-1})	26880	3072
Total Na (mg kg^{-1})	2552	2816
Total Ca (mg kg^{-1})	12870	15210
Total Mg (mg kg^{-1})	6552	6152

[1]: Composted tobacco waste,
[2]: Farmyard manure

The Head Lettuce (*Lactuca sativa L. var. capitata*) is a main group of lettuce. Production of lettuces are 21 000 000 ton in 1 000 000 ha area in the world. In Turkey, there are 18 700 ha production area and approximetly 360 000 ton lettuce production and 60 000 tons of these productions are head lettuce (Anonymous, 2002).

During the experiment, undisturbed and disturbed soil samples (0-20 cm) were taken from the center of each plot after one week of planting and before 1st and 2nd harvest. The samples were air-dried and sieved through 2 and 8 mm sieves. Undisturbed soil samples were taken by using a steel cylinder of 100 cm^3 volume (5 cm in diameter, and 5 cm in height). Bulk density and field capacity were determined from these soil samples. Wilting point was determined using disturbed soil samples sieved through a 2 mm sieve. Dry bulk density was measured by the core method (Blake and Hartge, 1986), particle density was determined by pycnometer method (Soil Survey Staff, 1951), particle size distribution was determined by the Bouyoucos hydrometer method (Bouyoucos, 1962), nonaggregated silt+clay and total silt+clay were determined by using A.S.T.M. Soil testing cylinder (Soil Survey Staff, 1972), structure stability index and aggregation percentage were calculated by formula (Soil Survey Staff, 1951). Total salt, OM concentration, calcium carbonate and pH were all determined according to Page et al., (1982). Available P was determined by the Mo blue method in a $NaHCO_3$ extract (Olsen et al., 1954). Available Ca, Mg, K and Na were analyzed with 1 N NH_4OAc extract method. Ca, K and Na were determined by flame emission spectrometry and Mg was determined by flame atomic absorption spectrometry (AAS) (Kacar, 1994). Some properties (total salt, OM concentration, calcium carbonate, pH, total N, P, K, Ca and Mg) of the experimental soil, CTW and FYM were also determined according to Page et al. (1982). Total porosity was calculated using bulk density and particle density values. Water retention capacity at -33kPa (field capacity) was determined in undisturbed soil samples and at -1500 kPa (permanent wilting point) in disturbed samples using a ceramic plate apparatus. Available Water Content (AWC) was calculated as the difference between water retained at -33kPa and at -1500 kPa (Klute, 1986).

Analysis of variance was performed using the Statistical Package for the Social Sciences (SPSS) version 9 (SPSS, 1999). Treatment differences between mean values of parameters were evaluated by one-way analysis of variance followed by Duncan test of significant at $p \leq 0.05$.

RESULTS and DISCUSSION

Soil macro nutrients (N, P, K, Ca, Mg, Na) were increased by CTW and FYM applications. They are given in Table 3, 4, 5.

Total N was determined as 0.129 % in the first soil samples in control. Maximum total N was determined as 0.159 % with 12.5 t ha^{-1} FYM + 37.5 t ha^{-1} CTW in first soil samples taken after one week from planting. The increasing rate was 23.2 % compared to the control. It was closely related to the high nitrogen content of CTW applied to the soil. Similar results were reported by Wang et al. (2004) in plots treated with composted dairy and swine manures. According to Ayuso et al. (1996), the increase may be attributed to a direct effect of organic N derived from the compost, which is slowly mineralized in soil after the composting process (Castellanos and Pratt, 1981).

Available P was found as 8.88 mg kg^{-1} in the first soil samples in control. After the addition of CTW and FYM, available P contents of soil were changed between 8.88 and 12.38 mg kg^{-1}. The highest available P content was analyzed as 12.38 mg kg^{-1} with 12.5 t ha^{-1} FYM + 37.5 t ha^{-1} CTW level in the first soil samples taken after one week from planting. The increasing rate was 39.4 % compared to the control. Also, similar results was found as 12.34 mg kg^{-1} by the treatment of 50 t ha^{-1} CTW in first harvest soil samples. Chhabra et al. (1981) reported that alkaline soils contain high amounts of available phosphorus because phosphorus constitute easily soluble compounds in soils with high pH and alkalinity. Available K amount was determined as 447.29 mg kg-1 in the first soil sampling in control. The highest value was found as 573.80 mg kg^{-1} with application of 100 % CTW in the first soils taken one week after planting. The increasing rate was 28.3 % compared to the control. Available K content of CTW and FYM materials which were used in the study 2.68 % and 3.07 %, respectively. Saltalı et al. (2000) found that increasing rate of tobacco waste increased total N and available P, K contents. Obtained data showed that application of tobacco waste to alkaline soils improved both soil conditions and nutrient concentration of soil increased for a sufficient crop production. Some authors have also shown an increase in K and Mg after organic amendment (Bulluck et al., 2002; Edmeades, 2003). They attributed the result to the high nutrients content of the compost and the increase of exchange sites due to organic matter added. Available Na content of soil was increased by the amendments of CTW and FYM when compared with control (217.92 mg kg^{-1}). The highest available Na values were found as 235.18 mg kg^{-1} in the first soil samples taken one week after planting with the treatments of 100 % FYM. The increasing rate was 7.92 % compared to the control. The lowest available Na values were analyzed as 73 mg kg^{-1} in second harvest soil samples with application of 50 % CTW+ 50 % FYM.

Saltalı et al.(2000), were found that available Na amount was decreased in alkali soil by increasing CTW doses.

Available Ca contents was analyzed as 2752.5 mg kg^{-1} in control soil. Addition of different organic materials did not affect available Ca content of soils. CTW and FYM materials which were used in the study contained low amounts $CaCO_3$ as 2.43 % and 2.09 % respectively, less than $CaCO_3$ content of study soil (5.38 %). Because of that, after application of these organic materials, it was not found any statistical differences between the treatments.

Available Mg content was analyzed as 529.46 mg kg^{-1} in the first soil samples in control. Available Mg contents of soil were changed around 529.46-610.83 mg kg^{-1}. The highest available Mg value was determined as 610.83 mg kg^{-1} by application of 100 % CTW in the first soil samples taken after one week from planting. Agbede et al. (2009), determined that application of poultry manure to any tillage treatment improved soil total N, available P, exchangeable K, Ca and Mg concentrations and grain yield of sorghum.

Table 3. Effects of CTW and FYM rates on macro element content of soil samples taken after one week from planting (7 September 2005) (Duncan; P ≤ 0.05).

Treatments		N (%)	P	K	Na	Ca	Mg
			mg kg^{-1}				
Control	1	0.129 D	8.88 B	447.29 D	217.92 B	2752.5 A	529.46 B
25 % FYM + 75 % CTW	2	0.159 A	12.38 A	557 AB	227.67 A	2792.6 A	609.26 A
50 % FYM + 50 % CTW	3	0.143 C	12.12 A	536.01 ABC	229.04 A	2725.8 A	590.06 A
100 % FYM	4	0.146 BC	11.95 A	486.6 CD	235.18 A	2725.8 A	589.1 A
100 % CTW	5	0.157 AB	12.23 A	573.80 A	228.27 A	2722.6 A	610.83 A
75 % FYM + 25 % CTW	6	0.146 BC	12.02 A	508.19 BC	232.58 A	2732.5 A	594.06 A

Table 4. Effects of CTW and FYM rates on macro element content of first harvest soils (11 November 2005) (Duncan; P ≤ 0.05).

Treatments		N (%)	P	K	Na	Ca	Mg
			mg kg^{-1}				
Control	1	0.117 B	9.03 B	406.23 B	153.33 B	2662.67 A	512 B
25 % FYM + 75 % CTW	2	0.140 A	11.67 A	485.33 A	176.63 A	2589.33 AB	579.43 AB
50 % FYM + 50 % CTW	3	0.136 A	11.90 A	492.46 A	171.43 A	2513.33 B	583.06 A
100 % FYM	4	0.141 A	12.28 A	492.43 A	179.73 A	2569.33 AB	582.36 A
100 % CTW	5	0.141 A	12.34 A	493.6 A	173.56 A	2556.22 AB	582.63 A
75 % FYM + 25 % CTW	6	0.138 A	12.18 A	495.06 A	176.63 A	2550.44 AB	584.53 A

Table 5. Effects of CTW and FYM rates on macro element content of second harvest soils (14 April 2006) (Duncan; P ≤ 0.05).

		mg kg-1					
Treatments		N (%)	P	K	Na	Ca	Mg
Control	1	0.115 B	8.30 B	349.06 C	65.73 C	3126.4 A	554.65 B
25 % FYM + 75 % CTW	2	0.133 A	11.42 A	385.23 AB	74.13 B	3076 A	592.5 AB
50 % FYM + 50 % CTW	3	0.130 A	10.62 A	380.7 AB	73 B	3067.7 A	585 AB
100 % FYM	4	0.128 A	10.89 A	375 AB	80 A	3063.4 A	591.3 AB
100 % CTW	5	0.132 A	11.41 A	396.83 A	74.4 AB	3084.2 A	606.5 A
75 % FYM + 25 % CTW	6	0.128 A	11.15 A	382.46 AB	77.06 AB	3052 A	AB

After the treatments, it was found statistical differences in lettuce yield values. Yield of lettuce was significantly affected by adding CTW. The highest yield was 62.7 t ha^{-1} in the first vegetation (1 September–11 November, 2005) plants by the application of 50 t ha^{-1} CTW (Fig. 6). Since the second vegetation period (25 November 2005-14 April 2006) was realized in winter season (especially in December, January and February have been very cold), lettuce yield decreased. Total lettuce yield (first + second vegetation) was determined as 102.7 t ha^{-1} by the amendment of 50 t ha^{-1} CTW (Fig. 1). This amount of organic matter source was needed to provide a suitable balance in soil nutrition and increase lettuce yield. Okur et al. (2008) reported the application of CTW and FYM resulted in a significant increase in lettuce yield when compared to the control. Polat et al. (2004) also found that 20 and 40 t ha^{-1} spent mushroom compost applications gave the best result in terms of total lettuce yield.

CONCLUSIONS

Soil organic matter content changes very slowly, and therefore, many years are required to measure significant changes (Pascual et al., 1999). Thus, effects of management practices on soil fertility criteria are best evaluated using long-term field experiments. Furthermore, the total content of soil organic matter cannot be used as a simple criterion for soil quality (Sparling, 1992). Comparing the two organic amendments the most significant differences will be observed after long-term application of FYM and CTW.

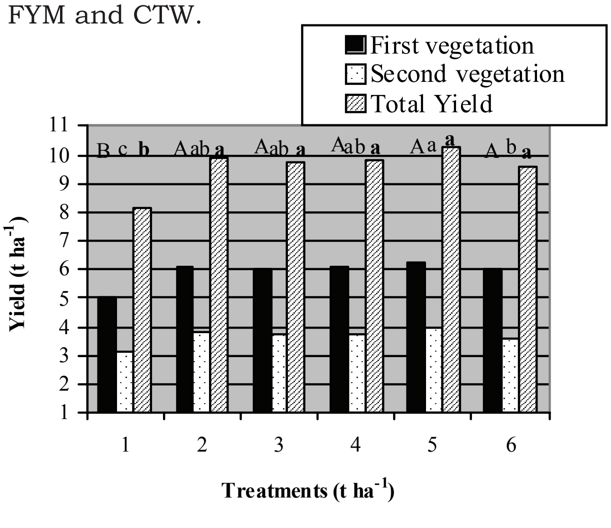

Fig. 1. Effects of CTW and FYM rates on yield. Treatment 1: non-fertilized control, treatment 2: fertilized with 12.5 t ha^{-1} FYM + 37.5 t ha^{-1} CTW, treatment 3: 25 t ha 1FYM + 25 t ha^{-1} CTW, treatment 4: 50 t ha^{-1} FYM, treatment 5: 50 t ha^{-1} CTW, treatment 6: 37.5 t ha^{-1} FYM + 12.5 t ha^{-1} CTW (Means of letters above bars indicate that A, B, AB, C: differences between the treatments in first sampling; a, b, ab, c: differences between the treatments in second sampling; **a, b**, **ab**, **c**: differences between the treatments in third sampling). (Duncan test of significant at p ≤0.05).

Consequently, application of CTW to soils significantly affected soil nutrients and yield of lettuce. Since CTW is also a nutrient and OM source, it increases the yield. These results demonstrated the importance of the incorporation of CTW to soil as an alternative organic amendment for improving plant nutrients in dryland and especially in Mediterranean soils, which are characterized by low organic matter content. It is recommended that 50 t ha^{-1} CTW can be added for improving plant nutrients in Typic Xerofluvent soil. For lettuce this amount of organic matter source was needed to provide a suitable balance in soil nutrition and increase lettuce yield. Maximum lettuce yield was found 102.7 t ha^{-1} at the plots where 50 t ha^{-1} composted tobacco wastes were applied. In order to maintain and improve soil quality, further studies must be performed to confirm the positive long-term effects of CTW. Incorporation of these wastes to the soil is important to evaluate them as organic matter and plant nutrients resource and also to prevent enviromental pollution.

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