Potentiality of Some Agricultural Residues and Industrial Wastes As Manure

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Geliş Tarihi (Received) : 02.06.2011 **Kabul Tarihi (Accepted) : 02.01.2012**

ABSTRACT: Composting is one of the applied methods to organic waste disposal methods. In this study, some agricultural and industrial organic wastes of agricultural sector are composted, as different compositions, to see whether they are usable as agricultural aids. To this end, apple juice factory waste (AW), cigarette factory waste (TW), leather processing factory waste (LW), organic wastes, namely wheat stalk (WW) and corn stalk (CW) material are used as composted material. Indore method of composting process was adopted; seven different compositions prepared from the aforementioned organic wastes were prepared. Laboratory experiments were carried out in conditions according to a pattern of coincidence plot experiment that was carried out by three replications. Prepared at room temperature, the mixtures (20-25 °C) were left to decompose for six months. Compost mixtures were mixed carefully every 10 to 15 days. Finally after 6 months compost mixtures were found to be fully composted. Obtained 7 different composts, yield analysis were determined and the effects of these mixtures on soil when applied in certain proportions in previously unused pots and on oat plant (*Avena sativa* L.) which was cultivated were determined. Plants were allowed to grow for a period of 45 days and then they were harvested to determine their dry weight and N, P, K, Fe, Cu, Zn contents. Results of the statistical analysis in terms of variance analysis and Duncan test were obtained.

According to the results; N, P, K, Fe, Cu, Zn and Mn contents of seven different compost mixtures were found to be between 4.03 and 9.24 g kg^{-1};0.09 and 0.92 g kg^{-1};10.0 and 24.2 and g kg^{-1}; 5.3 and 14.2 mg kg^{-1}; 1.50 and 2.80 mg kg^{-1};6.20 and 12.3 mg kg^{-1}; 19.7 and 27.2 mg kg^{-1}, respectively. Electrical conductivity of seven different compost mixtures was measured between 1,750 and 11,100 µmhos cm^{-1}; pH was found to be between 6.85 and 8.32 and C/N was detected to be between 8.9 and 28.2. Compared to the control, all seven compost mixtures were found to increase plant yield and this increase was found to be between 6% and 45%. Based on the results, all compost mixtures, especially three compost mixtures (since they gave statistically significant difference), were found to increase soil fertility as well as plant yield being as useful in agriculture.
Key Words: Composting, agricultural wastes, industrial organic wastes, oat plant, yield

Bazı Tarımsal ve Endüstiyel Atıkların Organik Gübre Olarak Kullanılma Olanakları

ÖZET: Organik atık ve artıkların bertarafı için uygulanan yöntemlerden biri de kompostlamadır. Bu çalışmada, bazı tarımsal ve endüstriyel organik atıkların farklı kompozisyonlarda kompostlanarak tarımda kullanılma olanakları araştırılmıştır. Bu amaçla; elma suyu fabrika atıkları (AW), sigara fabrikası atıkları (TW), deri işleme fabrikası atıkları (LW), buğday sapı (WW) ve mısır sapı (CW) gibi organik atıklar kompostlama materyali olarak kullanılmıştır. Indore yönteminin kullanıldığı kompostlama işleminde, adı geçen organik atıkların farklı oranlarından 7 farklı karışım hazırlanmıştır. Altı aylık kompostlama periyodundan sonra elde edilen 7 farklı kompostun verimlilik özellikleri yapılan analizler ile belirlenmiş, verime etkisini belirlemek için tın bünyeli Regosol toprağa belli oranlarda karıştırılan kompostların olduğu saksılarda yulaf bitkisi (*Avenasativa* L.) yetiştirilmiştir. Bitkiler 45 günlük iken deneme sonlandırılmış ve kuru ağırlıkları ile N, P, K, Fe, Cu, Zn içerikleri belirlenmiştir. Sonuçları istatistiki olarak değerlendirmek için varyans analizi ve Duncan testi uygulanmıştır.

Araştırma sonucunda elde edilen kompost karışımlarının N derişiminin,4.03-9.24-g kg^{-1}; P derişiminin,0.09-0.92g kg^{-1}; K derişiminin, 10.0-24.20-g kg^{-1}; Fe derişiminin;5.30- 14.20-mg kg^{-1}, Cu derişiminin,1.50-2.80-mg kg^{-1}; Zn derişiminin,6.20-12.30-mg kg^{-1}, Mn derişiminin, 19.7-27.20-mg kg^{-1}; EC'nin1.750-11.100-µmhos cm^{-1}; pH'ın, 6.85-8.32 ve C/N oranının da, 8.90-28.20-arasında olduğu belirlenmiştir. Kompost uygulamalarının kontrole göre verimde artışa neden olduğu, artışın kompost çeşidine göre değiştiği, artış oranının ise %6-%45arasında değiştiği belirlenmiştir. Araştırma sonucuna göre, elde edilen tüm kompost varyantlarının bitki besin elementlerince zenginleştirilerek yulaf bitkisi için organik gübre olarak kullanılabileceği sonucu elde edilmiştir.
Anahtar Kelimeler: Kompostlama, tarımsal atıklar, endüstriyel organik atıklar, yulaf, verim

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INTRODUCTION

Organically rich solid wastes could easily be degraded via natural or synthetic decay to circumvent causing bad odors and also impede providing a reservoir that attracts flies and other infectious agents (Dinçer and Çolak, 1989; Dinçer and Çolak, 1990; Dinçer and Çolak, 1992; Richard, 2005; Gómez et al. 2006). Anaerobic digestion, incineration, landfilling and compost production are some principal solutions applied to the solid wastes generated by various human activities (Anonymous, 1997; Theodore et al. 1997). Composting is an uncommon process in nature due to the natural formation of piles of organic materials (Miller and Donahue, 1995). In other words, it hardly occurs under natural circumstances. Huang et al. (2005), indicated that 52% of municipal solid wastes generated from the city of Regina, Canada, consist of compostable yard wastes and organic wastes while Raven et al. (1995) noted that 75% (weight basis) of household garbage is organically suitable for composting in the event that their pesticide and heavy metal concentrations are not excessive. However, composting activities should be performed with great care since various air, water and soil contaminants could be emitted into the environmental compartments during the formation and/or application of compost mixtures (Peigné and Girardin, 2004).

Economically, Turkey largely depends on agricultural activities. The country, however, has a solid waste problem caused by agricultural and related industrial wastes. The State Statistical Institute of Turkey (Anonymous, 1994) projected an increase of composted solid waste amount from 1.1% in 1994 to 2% in 2000. Yet, this projection was not achieved and only 1.51%, 1.25% and 1.4% of solid wastes collected by municipalities were composted in 2002, 2003 and 2004, respectively (Anonymous, 2007). According to Calvin and Knutson (1983) and Ouédraogo et al. (2001), agricultural societies can beneficially use composts for the enrichment of organic matter in soil. The composting process relies on bacterial decomposition initially followed by fungi and protozoan communities both assist in the decomposition of parent materials; finally, beetles, earthworms, millipedes and centipedes complete the process (Hynes, 1990).

Danzell et al. (1987) recommended that excessive amounts of organic materials should be supplied in order to balance soil humidity and to add nutritional elements that are needed by plants into the soil, especially when agribusinesses are situated in dry and semi-dry climatic regions in the world. Positive effects of composts' on soil as raising the soil till, soil fertility and plant yield while decreasing nitrification rates in the soil were noted by various researchers (Diaz et al. 1994; Ouédraogo et al. 2001; Fortuna et al. 2003; Richard, 2005).

In this investigation, we explored the usability of different waste materials, namely, apple pulp, tobacco powder, leather processing waste, wheat straw and cornstalks, as compost raw input materials.

MATERIAL and METHODS

Material

Waste Materials

The waste materials used in this study were chosen from among easily found, easily compostable materials that were produced in large quantities in Southern Anatolia, Turkey. Tobacco powder from Adana Cigarette Factory, apple pulp from Niğde Apple Juice Factory, leather processing waste from Niğde University Leather Processing Facility, and wheat straw and cornstalks from agricultural fields nearby were obtained to perform the experiments. Regardless of the compost mixture, wheat straw was used in all mixes. All theoretical mixes, such as tobacco powder and leather processing waste, were not prepared since some theoretically constructible compost combinations cannot yield optimal C:N, which should be between 15:1 and 30:1, and cannot reach recommended N, P, K levels recommended by various researchers (Richard, 2005; Diaz et al. 1994).

Soil

Original soil, regosol, was a loam and had the following constituents: pH (7.4); total N (760 mg kg^{-1}); total P (0.10 mg kg^{-1}); total K (45.2 mg kg^{-1}); percent organic matter (0.16); percent Ca_2CO_3 (0.83); Mn (7.8 mg kg^{-1}); Zn (mg kg^{-1}); Fe (5.2 mg kg^{-1}); salt (not detected);; total N+P+K (805.3 mg kg^{-1}). This soil was used for control and also mixed with compost materials.

Method

Composting Procedure

The Indore Method (Calvin and Knutson, 1983) was applied to the compost heaps under room temperature. Prepared compost mixtures were noted as follows: Mixture 1 included a total of six materials, almost all raw materials used in this study. These are tobacco powder (TW), apple pulp (AW), leather processing waste (LW), wheat straw (WW), cornstalks (CW), and soil. Mixture 2 was composed of four materials; tobacco powder, wheat straw, cornstalks, and soil. Mixture 3 also consisted of four materials. These were: apple pulp, wheat straw, cornstalks and soil. Mixture 4 was the product of adding leather processing waste, wheat straw, cornstalks, and soil mix. Mixture 5 included a total of three materials, namely, tobacco powder, wheat straw and soil. Mixture 6 was made from leather processing waste, wheat straw, and soil mix. Finally, mixture 7 was composed of apple pulp, wheat straw, and soils. Table 1 summarizes the ingredients of the compost mixtures listed above.

Table 1. Ingredients of compost mixtures

Mixture 1	Mixture 2	Mixture 3	Mixture 4	Mixture 5	Mixture 6	Mixture 7
Wheat straw (3 kg)	Wheat straw (3 kg)	Wheat straw (3 kg)	Wheat straw (3 kg)	Wheat straw (3 kg)	Wheat straw (3 kg)	Wheat straw (3 kg)
Tobacco powder (3 kg)	Tobacco powder (3 kg)	Apple pulp (3 kg)	Leather processing waste (3 kg)	Tobacco powder (3 kg)	Leather processing waste (3 kg)	Apple pulp (3 kg)
Cornstalks (3 kg)	Cornstalks (3 kg)	Cornstalks (3 kg)	Cornstalks (3 kg)	-	-	-
Apple pulp (3 kg)	-	-	-	-	-	-
Leather processing waste (3 kg)	-	-	-	-	-	-

Physico-Chemical Analysis

The nitrogen and phosphorus contents in waste materials prepared to make the compost heaps were measured according to modified Kjeldahl method (Kacar, 1972) and based on Vanadomolibdophosphoric yellow color method, which is used with Shumadzu® UV-1208 model spectrophotometer, respectively. Potassium concentration was determined by dry digested flame photometric technique in Elvi® 655 model flame photometer (Kacar, 1972). Organic carbon was determined by the method given by Nelson and Sommers (1982). Electrical conductance and pH were measured following dilution of raw matter with deionized water 1:1 based on Richards (1954). Iron, copper, zinc, and manganese were determined, after dry digestion preparation (Kacar, 1972), with a Perkin Elmer® 700 model Atomic Absorption Spectrophotometer. Carbon to nitrogen (C:N) ratios of organic materials were computed in order for this ratio to be approximately 20:1 so that the decomposition process could easily take place.

The prepared mixtures were periodically watered, blended, and turned over every 10 to 15 days, depending on the characteristics of the composts. A darkish color as time passed was a determinant indicating that decomposition was progressing. When the darkest color was finally achieved, it was assumed that the compost process was complete, which took approximately six months.

Organic matter content was determined using the method taken from Nelson and Sommers (1982), pH and electrical conductivity were measured according to U.S. Salinity Laboratory (Richards, 1954), potassium and phosphorus (Olsen and Sommers, 1982), which was determined by spectrometric method, were measured using a method noted by Jackson (1973), total nitrogen, NH_4^+ – N, and NO_3^-– N were detected by the method suggested by Bremner (1982), and iron, copper, manganese, and zinc were determined by atomic absorption spectrometer technique (Lindsay and Norvell, 1978). Available potassium was determined by the method given by Knudsen et al. (1982).

Planting Procedure

In order to measure the effect of the compost mixtures on the oat yield, 44.4 gram samples from prepared compost heaps were distributed for each kilogram of soil. This amount equals 0.1 ton for each square meter in the field. 30 oat seeds were added to each container (Yüksel, 2006). Three replicates were taken and containers filled with the compost mixtures were randomly selected. These materials were blended with soil according to the Indore method (Calvin and Knutson 1983) to yield seven different mixtures and finally the mixtures were applied to oat plants (*Avena sativa* L.) to determine the yield response and determine which mixtures should be applied in the field.

A total of 20 oat plants were allowed to grow; the rest were removed. The plants were harvested 45 days after emergence. The dry weights of the oat plants were determined subsequent to being dried at 65 ˚C. These dry samples were used to determine the nitrogen, phosphorus, and potassium contents of the plants (Table 4).

Statistical Assessment

Variance analysis and other statistical comparisons were performed in order to see the difference between individual values obtained and a Duncan test was applied using SPSS® 10 computer program.

RESULTS and DISCUSSION

The materials used for compost production were found to contain the different nutritional elements needed by plants. Table 2 includes a number of specifications of the parent compost materials used in this study.

Table 2. Some properties of the raw materials (dry matter) *

Property	Waste material: Tobacco powder	Apple pulp	Wheat straw	Corn stalks	Leather processing waste	Statistical properties
Total N, mg kg^{-1}	4.83	2.55	2.04	1.97 ^{c}	25.10	$r^2 = 0.997$ F: 411.8**
Total K, mg kg^{-1}	125.00	184.00	28.50	160.00^{b}	19.20	$r^2 = 0.995$ F: 264.2**
Total P, mg kg^{-1}	0.15	0.32	1.08	1.69 ^{a}	0.83	$r^2 = 0.995$ F: 245.3**
Sum (N+P+K), mg kg^{-1}	130.00	187.00	32.00	164.00	45.00	
K:N:P	839:32	580:8	26:2	95:1	23:30	When P = 1
C:N	8.51	19.00	24.20	25.50^{a}	2.05	$r^2 = 0.957$ F: 25.9**
[Fe], mg kg^{-1}	3,81	986.00	191.00	161.00^{c}	47.80	$r^2 = 0.999$ F: 1,517.5**
[Cu], mg kg^{-1}	25.30	10.20	6.20	6.80 ^{bc}	7.30	$r^2 = 0.983$ F: 73.9**
[Zn], mg kg^{-1}	45.20	12.20	2.70	5.90 ^{c}	2.70	$r^2 = 0.906$ F: 319.5**
[Mn], mg kg^{-1}	197.00	38.80	5.20	28.20^{c}	0.48	$r^2 = 0.998$ F:698.2**
pH (1:10 H_2O)	5.53	6.25	6.20	5.77 ^{b}	3.57	$r^2 = 0.995$ F: 245.2**
EC, (10^6) µmhos cm^{-1}	6,40	930.00	5,60	4,45	13,80	$r^2 = 1.00$ F: 4,431.7**

* Mean value of three replicates, **p<0.01, *p<0.05

Table 3 summarizes the selected ingredients and their concentrations in the compost mixtures produced.

Tobacco powder was found to have the highest iron, copper, manganese, and zinc concentrations although it was found to have a relatively lower C:N ratio compared to other parent materials. Kara (1996) reported that application of tobacco powder containing composts (4 kg tobacco powder mixed with 2 kg soil) caused an increase in nitrogen concentrations in the soil. Leather processing waste was found to have the lowest level of phosphorus and C:N ratio; nevertheless, it has the highest electrical conductivity value and is the most acidic waste (pH of 3.57) among all raw materials examined here. Similar results for pH in composts were reported by Özü (1991). The high electrical conductance in leather processing waste is caused by the pelt preservation technique, which involves salt being applied on raw pelts. C:N ratios of apple pulp (pH=6.3), wheat straw (pH=6.2), and cornstalks (pH=5.8) were found to be optimal since the C:N in these biological organic matter was originally approximately 20 to 1 (between 30:1 and 15:1). Wheat straw was found to have low copper and zinc concentrations. The raw mixtures' N content was found to be inversely correlated with the C to N ratio (correlation coefficient= 97.87%), as similarly noted by Richard (2005).

A number of characteristics of the composts are tabulated in Table 2. Composts were found the following characteristics: total nitrogen concentration is between 9.24 and 4.03 g kg^{-1}; phosphorus concentration is between 0.92 and 0.09 g kg^{-1}; potassium concentration is between 0.92 and 0.09 g kg^{-1}; iron concentration is between 14.2 and 5.3 mg kg^{-1}; copper concentration is between 2.80 and 1.50 mg kg^{-1}; zinc concentration is between 12.3 and 6.20 mg kg^{-1}; manganese concentration is between 27.2 and 19.7 mg kg^{-1}; electrical conductivity is between 11100 and 1750 µmhos cm^{-1}; pH is between 6.85 and 8.32; carbon-to-nitrogen ratio is between 28.9 and 8.9 (Table 3). As expected, leather processing waste containing mixtures (4 and 6) were found to have lower pH levels (close to neutral pH level) than the other compost mixtures (Table 3).

Table 3. Some properties of compost mixtures (dry matter)*

Property	Mixture 1	2	3	4	5	6	7	Statistical properties
N, g kg^{-1}	5.21	6.27	4.03	6.50	7.42	6.07	9.24	$r^2 = 0.910$ F: 11.8**
P, g kg^{-1}	0.48	0.29	0.19	0.09	0.29	0.92	0.11	$r^2 = 0.967$ F: 34.6**
K, g kg^{-1}	20.40	10.00	15.20	17.20	23.70	10.20	24.20	$r^2 = 0.950$ F: 23.3**
Sum (N+P+K), g kg^{-1}	26.09	16.56	19.42	23.79	31.41	17.19	33.55	
K:N:P (weight basis)	42:11	34:22	91:21	191:72	82:26	11:70	220:84	When P = 1
C:N	18.00	14.20	28.20	14.10	10.60	12.80	8.90	$r^2 = 0.957$ F: 25.9**
[Fe], mg kg^{-1}	14.20	5.30	11.30	7.30	14.20	5.10	5.90	$r^2 = 0.981$ F: 59.5**
[Cu], mg kg^{-1}	2.60	1.60	2.00	1.50	2.30	1.60	2.80	$r^2 = 0.975$ F: 46.2**
[Zn], mg kg^{-1}	7.20	6.20	7.80	10.50	8.60	6.20	12.30	$r^2 = 0.989$ F: 108.1**
[Mn], mg kg^{-1}	25.10	20.20	27.20	26.80	19.70	24.20	24.60	$r^2 = 0.749$ F: 3.49 ns
pH (1:5 H_2O)	8.21	8.05	8.32	7.26	8.07	6.85	7.40	$r^2 = 0.930$ F: 15.2**
EC (10^6), µmhos cm^{-1}	3,98	1,88	1,75	11,10	4,50	6,25	2,10	$r^2 = 1.00$ F: 2,546.2**

* Mean value of three replicates
** $p < 0.01$, * $p < 0.05$; ns: not significant

Organic wastes that are used to make compost have the following specifications: total nitrogen is between 4.83 and 1.97 mg kg^{-1}; total phosphorus is between 1.69 and 0.149 mg kg^{-1}; total potassium is between 184 and 19.2 mg kg^{-1}; iron is between 986 and 3.8 mg kg^{-1}; copper is between 25.3 and 6.20 mg kg^{-1}; zinc is between 45.2 and 2.70 mg kg^{-1}; manganese is between 197 and 0.48 mg kg^{-1}; pH is between 6.25 and 3.57; electrical conductivity is between 13800 and 930 µmhos cm^{-1}. Carbon-to-nitrogen ratio of organic materials used to make composts is between 25.5 and 2.05 (Table 2). In order to accelerate the decomposition process, 200 grams of soil were added to each kilogram of organic matter in the mixtures. The contribution of waste material to each compost mix was 3 kg. If the original C:N ratio was high, nitrogen was added as 15 g nitrogen per kg mix in order to increase mineralization.

Moreover, their salinity levels were found to be higher than other mixtures since the leather processing waste was also detected to have higher salt content. Therefore, mixture 4 should be used with care on agricultural land and only plants that tolerate salt should be planted when this mixture is used. According to Anaç and Okur (1998) ideal compost mixtures should have the following specifications: total nitrogen concentration 1.5 to 3.5%; P_2O_5 concentration 0.5 to 1.0%; K_2O concentration 1 to 2%. Based on this research's results, compost mixtures are not within these ranges in terms of nitrogen, phosphorus and potassium. Therefore, nitrogen, phosphorus and potassium should be added to the mixtures before use. Despite the fact that mixture 1, whose copper and manganese concentrations were high and iron concentration was the highest, also included some leather processing waste, since it was composed of more parent materials (a total of six) than mixtures 6 and 4, it was found that this mixture was the most alkaline one. Based on t-test results, yield values of the mixtures 1, 6 and 7 were found to be statistically different from the mean yield value (significant at 5%). Control mixture was also found to be different in terms of yield value from the mean yield.

Table 4. Yield and some properties of oat plants produced using the prepared mixtures*

Parameter	Mixture							
	Control	1	2	3	4	5	6	7
Yield, kg m^{-2}	1.49 [c]	**2.16** [a]	**1.98** [ab]	1.76 [abc]	1.75 [bc]	**1.86** [ab]	1.58 [abc]	1.64 [bc]
N, %	0.50	2.58	0.28	2.32	3.40	2.69	2.56	2.80
P, %	0.08	0.06	0.08	0.06	0.08	0.06	0.05	0.08
K, %	4.80	5.40	3.40	3.50	5.00	5.90	2.20	5.00
Sum (K+N+P)	6.05	8.54	4.44	6.42	9.18	9.18	5.27	8.61
K:N:P	64:10	96:46	45:4	58:39	64:44	100:46	43:50	62:35
[Fe], mg kg^{-1}	942.00	866.00	1203.00	836.00	185.00	-	-	224.00
[Cu], mg kg^{-1}	232.00	250.00	304.00	223.00	38.80	-	-	38.00
[Mn], mg kg^{-1}	1344.00	722.00	841.00	1182.00	221.00	-	-	86.00
Decrease in [Mn]		-86.1%	-37.4%	-12.1%	-836%	-	-	-936%
[Zn], mg kg^{-1}	288.00	472.00	364.00	417.00	30.00	-	-	42.00

Means followed by the same letter do not differ at the 0.05 level of significance
Only mixtures 1, 2 and 5 differ from the control
** $p< 0.05$, *** not significant (α =0.05)

Compared to the control, all compost mixtures showed an increase in yield. The highest increase in yield (45%) was observed with respect to use of mixture 1. On the other hand, the lowest increase in yield (6%) was observed with respect to use of mixture 6. Based on increase in yields the following order was found: 1>2>5>3>4>7>6. Based on per cent increase in yields with respect to the control the following order was detected (based on the same order just given above): 45%, 33%, 24%, 18%, 17%, 10% and 6%. Increase in yield of mixture 1, mixture 2 and mixture 5 was found statistically significant (Table 4). These mixtures all include tobacco waste. Sönmez et al. (2002) reported that Volterranani et al. (1996) applied compost made by domestic wastes on peach and tomatoes production, but noted that commercial fertilizers should also be used in addition to composts because composts are lack of utilizable nutrient.

It should also be emphasized that the nitrogen, phosphorus, and potassium values in all mixtures prepared are lower than the nitrogen, phosphorus, and potassium content of the parent materials used to produce the composts. Potassium in compost mixture causes an increase in K in the plant as shown in Figure 1.

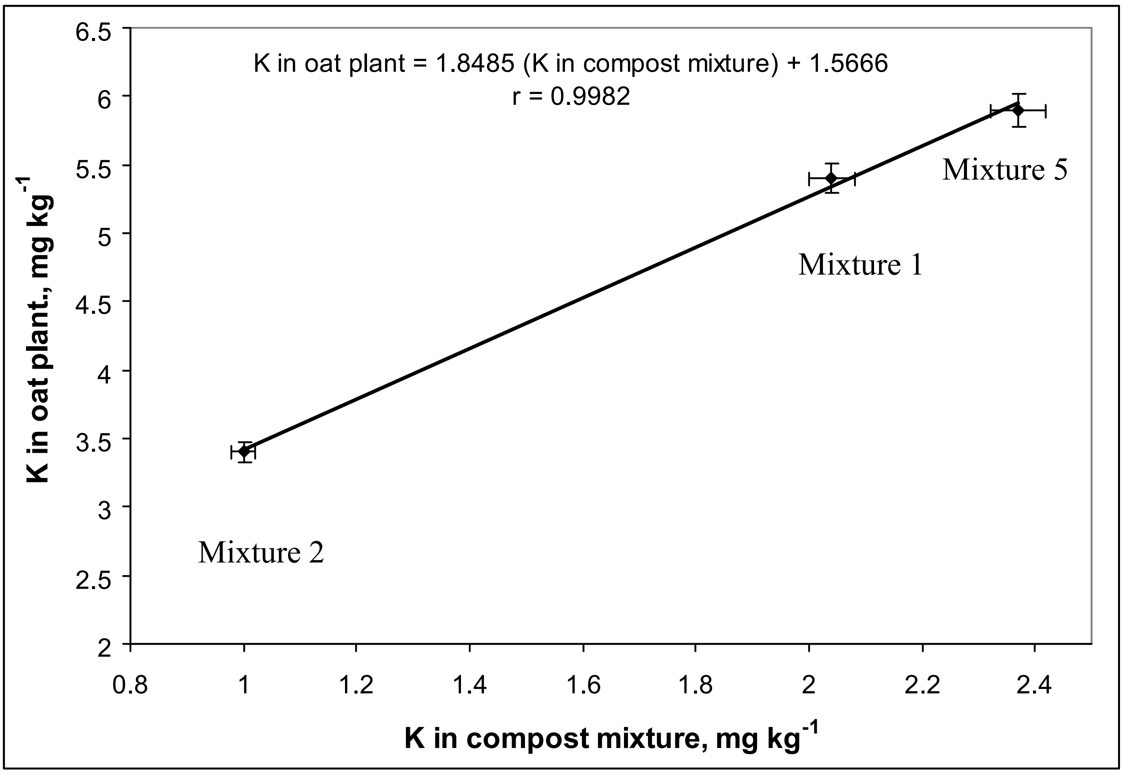

Figure 1. Relation between K in compost mixture and K in plant (these mixtures yielded statistically significant oat plant yield compared to the control)

The figure includes only mixtures that yielded significant increases (compared to the control) in yield. It is an unexpected finding that the correlation between the compost mixtures' P concentrations and the plants' phosphorus levels was computed to be -75.46%. This might mean that soil P levels are insufficient to transfer P to the plants. Eghball and Power (1999) concluded that phosphorus in soil is directly linked to phosphorus applied over a long period (4 years). This could also be attributed to the nature of compost production since different materials are mixed during compost manufacturing and this mixing process ends up with a decrease in the chemical properties of individual parent matters. Moreover, chemical reactions taking place in compost heaps could also be responsible for a decrease in the concentration of chemical properties of the parent materials. On the other hand, the correlation between compost mixtures' potassium concentrations and plant potassium concentrations was calculated to be 88.93%. There is also a high correlation (72.16%) between K:N and the total iron concentrations of the compost mixtures despite the fact that there is a relatively negative correlation between N:P and total iron (-63.40%). The relationship between K:N in the mixture and K:N in the plant is shown in Figure 2.

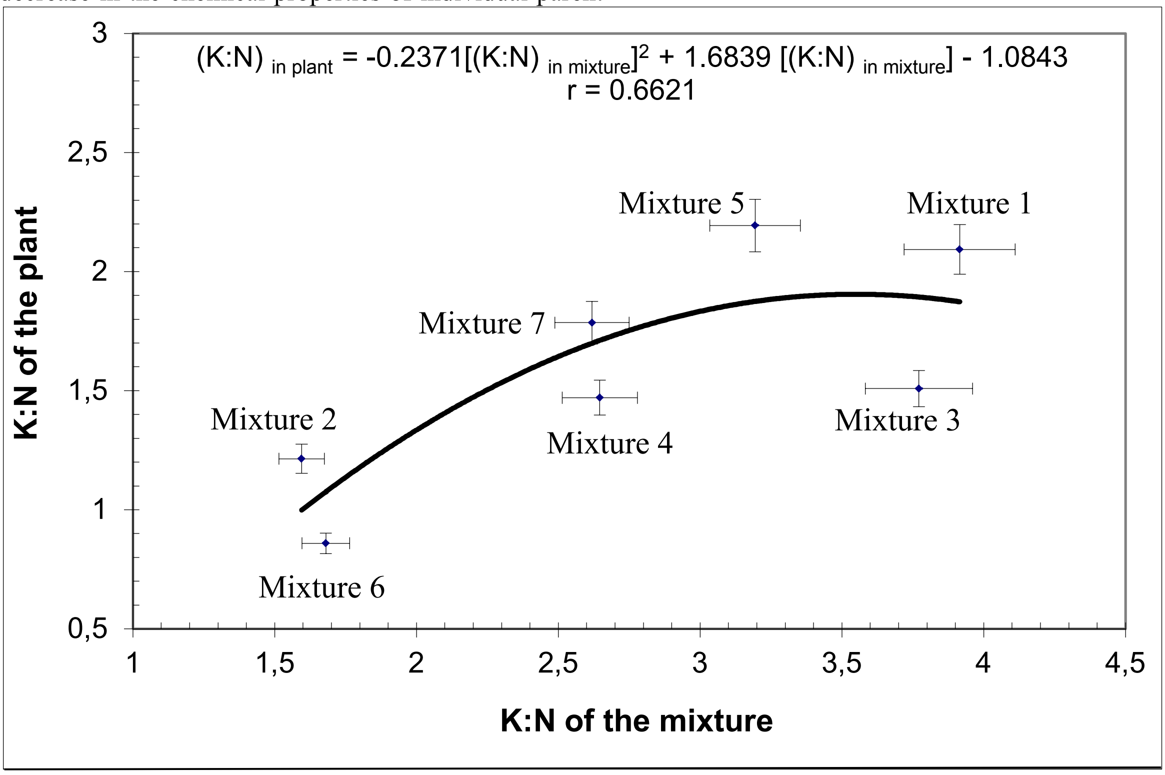

Figure 2. Relationship between K:N of the compost mixture and K:N of the plant

As shown, K:N in the mixture above 3% did not affect K:N of the plant. Similarly, the total K, N, and P of the mixture was found to be optimum at around 3%, as shown in Figure 3. Table 3 provides information about oat plants that were planted for this research in terms of their yields and a number of chemical properties. Sönmez ve ark., (2002) reported that macro and micro nutrients of composts produced by (1) raw domestic wastes, (2) material before press and (3) material after press show similar characteristics in terms of organic matter, pH, electrical conductivity, N, P, K, Ca, Mg, Na, Fe, Zn and Cu. All mixtures examined in this study were found to augment the yield from a minimum of approximately 6% (mixture 6) to a maximum of 45% (mixture 1). The yields were found to increase as 45%, 33%, 18%, 17%, 24%, 6%, and 10% respectively in relation to compost mixtures 1-7 sequentially (Table 4).

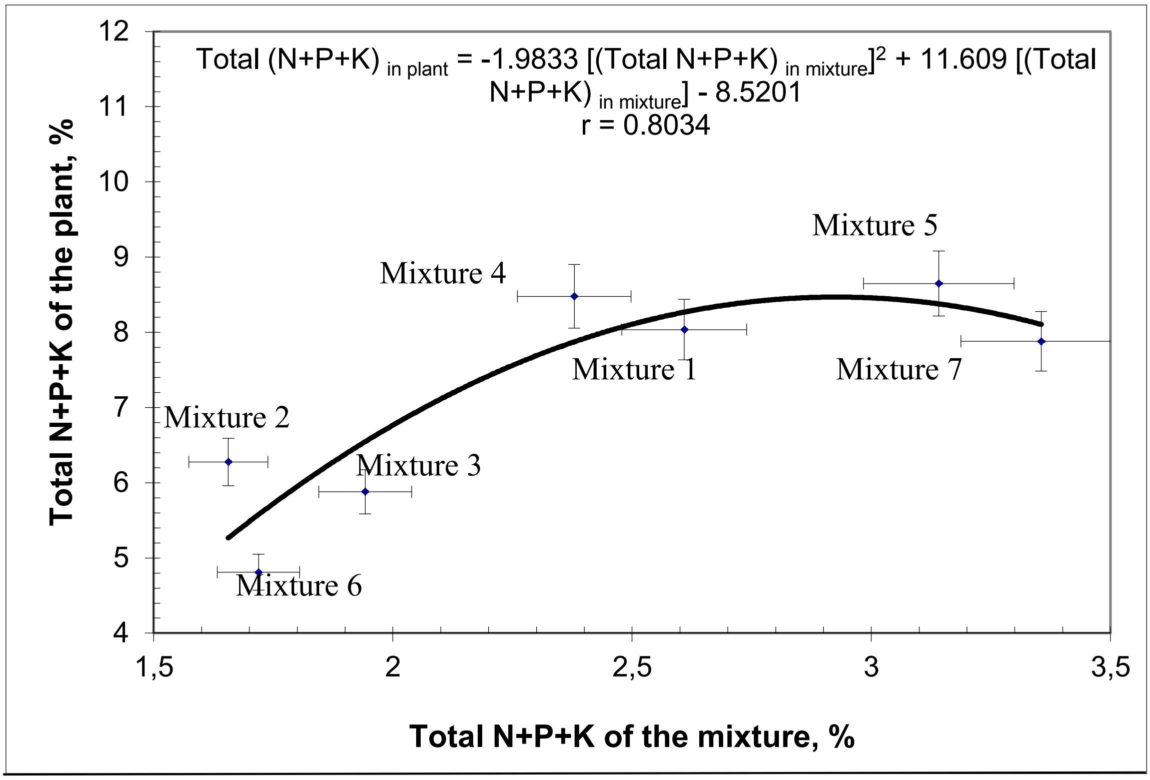

Figure 3. Relation between total N+P+K of the mixture and total N+P+K of plant ($r_{critical}$ equals 0.754 based on 5% significancy)

The mean yield value was computed to be 1.776 kg m^{-2} ($p < 0.05$). Application of Duncan test indicated compost mixtures 6 and 7 are different in terms of yield from other compost mixtures based on multiple regression and correlation analyses ($p < 0.05$), which may be due to the fact that the micronutrients (Cu, Mn and Zn) evaluated are in minute quantities compared to the micronutrients in other composts. To generalize for optimal plant yield, Mn in compost should not be less than 20 mg kg^{-1}. Although the Mn concentration in compost mixture 6 is greater than this value, its K:N is less than 1. This fact might have caused an important reduction in yield of the plant. As noted in various sources, in living organisms the living cells should contain an optimum N:P ratio of 3:1. In terms of nutritional element limitations, all compost mixtures, except mixture 2, were found to have excessive nitrogen. It should be underlined that perhaps it is the total potassium that plays an important role in yields. In Figure 4, the relationship between Mn concentration in the plant and the yield is shown. In raw soil matter Mn was detected to be 1344 mg kg^{-1}. It must be noted that this figure is the highest among all experimental mixtures. In terms of total Mn concentrations, compost mixtures 1 and 2 were found to be the most suitable mediums to get the highest yields from oat plants. Moreover, the electrical conductance of mixture 1 should be emphasized as being the most moderate among all the compost mixtures tested in spite of the fact that electrical conductivity in mixture 2 was found to be on the low side. In terms of C:N ratio, both mixture 1 and mixture 2 were found to be on the moderate side (approx. 14-18). The correlation between Mn and C:N ratio was computed to be approximately 86.2%. In the soil sample (control), K:P ratio was calculated to be approximately 64:1. Compost mixtures 1, 5 and 7 were found to have enriched potassium concentrations; while compost mixtures of 2, 3 and 6 potassium concentrations were found to be low compared to the control. Additionally, both total copper and total manganese concentrations found in oat plants grown in compost mixture 7 were found to be lower than the same values of total copper and total manganese in other mixtures. The manganese concentration in particular was found to be extremely low in mixture 7. Correlation between compost mixture phosphorus and plant phosphorus was found to be negative (correlation coefficient = -89.54%). Although Bucher and Schenk (2000) determined a maximum level of 4.5 mg $CaCl_2$ – extractable Zn L^{-1} compost peat material to avoid chlorosis in petunias, it was found in this study that zinc does not impede growth when its total concentration is below 7.5 mg kg^{-1} total zinc in compost mixtures. The lowest numerical yield was found to belong to mixture 6, whose K:P ratio was computed to be 43:1, which is remarkably different from other mixtures. However, this was not statistically different.

CONCLUSION

In summary, many compost mixtures examined in this study were determined to be suitable for agricultural use since they were found to contain a sufficient amount of the nutritional elements needed by plants, to be within recommended salinity limits, and to possess the recommended alkalinities. With the exception of mixtures 6 and 7, the compost mixtures were found to be useful soil aids in terms of organic material quality due to the fact that all compost mixtures increased yields remarkably following their application on oat plants. Being an important agricultural area, Turkey offers many advantages in composting practices. Wastes from agricultural sector should be considered as valuable input for soil improvement practices. Mixture 6, if chosen to be applied, should be carefully used with plants that are tolerable to salt since it has high salinity concentration. For the best increase in plant yield, compost mixture 1 should be applied when feasible in fields where the raw materials are easily and cheaply obtained, due to the fact that mixture 1's manganese, electrical conductance, C:N and K:P ratios are all within moderate levels. It is recommended that all parent materials (tobacco powder, apple pulp, wheat straw, cornstalks, and leather processing waste) could be used in appropriate quantities where they are available in order to convert waste materials into a more valuable form and then apply the final products in agriculture effectively. The composting process should be performed by using several raw (parent) materials where available since the nutritional elements are more greatly enriched in the final product. It has not yet been reported the importance of K to N ratio in compost materials. This study reports optimum level of K:N in compost, which is between 3.15 and 3.80, that enhance oat plant yield. Finally, organic wastes used to make compost mixtures can be efficiently used in agricultural sector and money spent for commercial fertilizers can be saved and environmental pollution can be eliminated. Most importantly, it is highly recommended that similar studies should be carried on.

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