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The Effects of Leonardite Applications on Climbing Bean (*Phaseolus vulgaris* L.) Yield and the Some Soil Properties

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Abstract: The effect of leonardite application with fertilizer-N and P doses on climbing bean yield and soil properties were studied during 2003 and 2004 years. The experiment was conducted as a randomized split-plot design with three replications. Soil EC (electrical conductivity), pH and lime did not change significantly at the application of leonardite. The differences between soil organic matter (OM) and phosphorus (P) contents at leonardite treatments compared with control treatment (no leonardite) were significant at $p<0.01$ and $p<0.05$ levels, respectively, but significant effects between leonardite treatments were not obtained. Marketable bean yield was greater in T_2 treatment (recommended fertilizer plus 10 Mg ha^{-1} leonardite) than that of T_1 treatment (control plot; recommended fertilizer doses) and this difference between T_2 and T_1 treatments was significant at $p<0.05$ levels. Marketable bean yields in the half of the recommended fertilizer dose plus 1 Mg ha^{-1} leonardite dose (T_4) and 20 Mg ha^{-1} leonardite doses (T_5) treatments were higher observed compared with T_1 treatment. The obtained results showed beneficial effect of leonardite on bean yield.

Key words: Fertilizer, field scale, nutrients, organic matter, treatments

INTRODUCTION

The benefit of organic materials in soils is well known and application of organic materials on agricultural soils positively affects physical, chemical and biological properties of soils (Flaig *et al*., 1977). The effects of organic material (leonardite) and humic acids which extracted from organic materials are more apparent in soils with low organic matter than in soils with high organic matter (Duplessis and Mackenzie, 1983). Leonardite as an organic material is soft coal-like deposits that occur at shallow depth. It was more oxidized than lignite and naturally occurred in conjunction with deposits of lignite (Burdick, 1965). Rumpel and Kögel-Knabner (2002) pointed out that lignite in soil can be mineralized as well as humified and must be considered in the soil carbon cycle. Although leonardite has low heating content as a fuel, its high content of HA (humic acids; which ranges from 30-80%) may make it useful as a soil amendment (Akinremi *et al*., 2000). Kalaitzidis *et al*. (2003) suggested that the humic acid content was essential parameter for organic sediments (leonardite) and leonardite could be evaluated as a soil improvement material for agricultural applications.

Pollution in groundwater and surface water systems caused by intensive use of commercial fertilizers are directed the public to use of alternative nutrients sources and soil conditioners. Leonardite is a very concentrated form of humic and fulvic acids which usually used in agricultural production and widely known agronomic potential. The effects of HA and FA (fulvic acid) on soil properties and plant growth have explored in several researches (Lee and Barlett, 1976; Andriesse, 1988; Schnitzer, 1992). However, there are few literatures on the effects of leonardite on soil properties and plant growth, directly. Increasing demand and elevating cost for used materials as soil conditioners in agriculture have led to investigate leonardite use on a field- scale. The aim of this study was to investigate the effects of different levels of fertilizer-P and N in combination with ground leonardite as an organic material on climbing bean and some soil properties.

MATERIALS AND METHODS

The experiment was conducted in the experimental station of Agricultural Faculty of Gaziosmanpasa University during 2003-2004 growing seasons in Tokat (40° 19' N, 36° 28' E), Turkey. The average annual precipitation is 436 mm and means annual air temperature 13°C in the region (Anonymous, 2005).

The experiment was conducted as a randomized split-plot design with three replications. The size of plot was 3 m^2 (75×40 cm) and interrow spacing was 75 cm. Plant (climbing bean sofya cv) distances within the rows were 40 cm. The factors studied were ground leonardite and

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fertilizer rates. Leonardite was ground and passed through a 2 mm mesh sieve and was applied at the rates of 10 and 20 Mg ha^{-1} (on an air dry weight basis) to the plots. Control plots were fertilized according to the results of soil testing to supply sufficient plant nutrients. The application rates were 130 N kg ha^{-1} and 100 P_2O_5 kg ha^{-1} (Control, T_1), 130 N kg ha^{-1} and 100 P_2O_5 kg ha^{-1} plus 10 Mg ha^{-1} leonardite (T_2), 130 N kg ha^{-1} and 100 P_2O_5 kg ha^{-1} plus 20 t ha^{-1} leonardite (T_3), 65 N kg ha^{-1} and 50 P_2O_5 kg ha^{-1} plus 10 Mg ha^{-1} leonardite (T_4), 6.50 N kg ha^{-1} and 50 P_2O_5 kg ha^{-1} plus 20 Mg ha^{-1} leonardite (T_5). The phosphorus and the half of Nitrogen (N) fertilizers were applied at bean seed sowing and the rest of fertilizers-N was given at growth stage. Potassium (K) fertilizers were not applied since the soils were rich in K. Pesticide was applied to control insects and diseases when growth stage possible. During the experiment, beans were irrigated by a drip irrigation system. Bean seeds were sown on the 20th of May. The pods were regularly harvested while it was young for the best crops. After each harvesting, the fresh fruits were weighed and marketable total yield, the number of pod and length of pod were observed in the each parcel.

The soil samples for analyses were taken from 0-20 cm depth at beginning and after first and second year of experiment and the soil samples were air-dried, sieved using a 2 mm mesh size stainless steel sieve and stored in polyethylene bags until analysis. Particle size distributions of the soil samples were determined by using the hydrometer method, soil pH and electrical conductivity (EC) in a 1:2.5 soil: water (w: v) extract and organic matter (OM) content using the Walkley-Black method, carbonates by calcimeter method, available P (Olsen-P) by the Olsen method using spectrophotometer (Kacar, 1994). The observed data were tested by means of Generalized Linear Model procedure of SPSS. The data distribution was analyzed for homogeneity and significance was determined by LSD test.

RESULTS AND DISCUSSION

The observed data show that the soils in experimental area were slightly basic, with low organic matter content (2.26%) medium lime contents (7.5%) and loamy texture (Table 1). The mean concentrations of nitrogen (N) phosphorus (P) and potassium (K) in the 0-20 cm soil depth were 850, 11 and 240 mg kg^{-1} at beginning, respectively.

The soil properties (pH, % lime, % organic matter content) and the mean N, P, K levels in the treatments plots compared with the same properties in the control plots after first and second years. According to the results, there was not found significant differences between years. A significant effect of leonardite on soil EC, pH and lime were not obtained in this study. Soil organic matter content significantly ($p<0.01$) increased at leonardite treatments compared with the control treatments (no leonardite). But, there was not found a significant increasing between leonardite treatments. Turgay *et al*. (2004) reported that soil organic matter content increased with the application of lignite and gyttja containing lignite in a incubation experiment. In the leonardite applied soils, P contents was greater ($p<0.05$) than the control soils, but the differences between leonardite treatments (T_2, T_3, T_4, T_5) were not significant (Table 1). This could be attributed to some of organic bound-P not extracted by Olsen method (Hedley *et al*., 1982; Araujo *et al*., 2004; Saltali *et al*., 2007).

Nitrogen contents of soils (except T_5) at leonardite application tended to increase relative to the control plots. Soil N content increased from 850 mg kg^{-1} at beginning to 872 mg kg^{-1} in the control plot. Soil N contents at the leonardite treatments (except T_5) were higher found relative to the control plot. These differences could be attributed to the N content (0.73%) of leonardite and decomposition of leonardite in soils. Duplessis and Mackenzie (1983) reported that application of leonardite increased yield and N, P concentrations in soils and uptake of corn on a loamy sand, but had no effect on yield of corn on a clay soil and the effect of leonardite was masked in soils with high clay content.

At beginning of experiment soil K content was 240 mg kg^{-1} in experiment areas and soil K levels were decreased in the all plots. The variations in the soil K levels can be attributed to the uptake of K by climbing bean during the growing season and the effect of

Table 1: Soil values at beginning and the means of first and second year and properties of leonardite

Treatments	EC (1:2.5)	pH (1:2.5)	OM (%)	Lime (%)	N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})
T_1	174	7.68	2.21a[1]	11.10	872	9.5a	178
T_2	199	7.63	2.46b	11.45	943	11.9b	190
T_3	190	7.71	2.54b	11.46	891	11.4b	193
T_4	192	7.67	2.49b	11.38	944	11.2b	205
T_5	173	7.66	2.56b	11.50	863	12.2b	197
Year1 (mean)	188.7	7.69	2.45	11.40	908	10.7	198
Year2 (mean)	182.5	7.74	2.45	11.40	897	11.7	187
Leonardite	2300	4.24	43.60	-	7300	4.2	140

EC (µS cm^{-1}); electrical conductivity (in weight/volume), OM ; soil organic matter content, N; Nitrogen; P; Phosphorus, K; Potassium, Initial values; Soil properties at beginning of experiment; [1]Averages indicated with the same letter(s) fall into statistical group

Table 2: The influence of leonardite on bean yield, pod number and pod length

	Observations		
Treatments	Marketable yield (kg m^{-2})	Pod No. (No. m^{-2})	Pod length (cm)
T_1	5.433bc[1]	662.72	18.40
T_2	6.099a	612.72	18.20
T_3	5.118c	557.89	18.12
T_4	5.630abc	624.16	17.70
T_5	5.920ab	613.10	17.60
LSD	0.611*	ns	ns

*Significant at $p<0.05$ level, ns: Not Significant; [1]Averages indicated with the same letter fall into statistical group

leonardite. It clearly shown that decreases in soil K levels were greater in the control plots relative to the leonardite-applied plots. Duval *et al*. (1998) used leonardite as a crop growth enhancer and they reported that where all nutrients (N, P and K) were applied to the soil, soil K levels increased in the other treatments compared with the control and significant differences not occurred soil N and P contents under the conditions outlined in their investigate.

The influence of leonardite on climbing bean, pod number and pod length were investigated. The effects of leonardite on the pod number and pod length were not significant between all the treatments (Table 2). The lower marketable bean yield was 5.118 and 5.433 kg m^{-2} in T_3 and T_1 treatments and the higher marketable bean yield was 6.099 kg m^{-2} in T_2 treatment (Table 2).

Marketable bean yields in the half of recommended fertilizer doses plus 10 Mg ha^{-1} leonardite doses (T_4) and 20 Mg ha^{-1} leonardite doses (T_5) treatments were higher than that of T_1 treatment. However, the benefit of leonardite on the bean yield reduced when applied recommended fertilizer dose plus 20 Mg ha^{-1} leonardite treatments (T_3). It could be related to the higher vegetative growth of bean, although biomasses of bean on each plot were not weighted.

T_2 treatment resulted in a 10.9, 16.1, 7.7 and 2.9% increases in marketable yield of bean compared with T_1, T_3, T_4 and T_5 treatments, respectively. The differences between the T_2 and T_1, T_3 at climbing bean yield were statistically significant ($p<0.05$). Akinremi *et al*. (2000) reported that where all nutrients were applied, the DMY (dry matter yield) of Canola showed a significant ($p<0.01$) linear response to leonardite application at rates 10, 20, 60 and 200 g to 3 kg of the soil, and application of leonardite to the soil facilitated the uptake of nutrient by Canola. Additionally, response of crop to the application of leonardite also depended on crop type, fertility status of soil and applications rates of leonardite. Wallace and Wallaca (1986) also stated that the applications of leonardite in the range of 5.8 -11 Mg ha^{-1} increased the yield of tomato on soils with low organic matter, but had no effect on the DMY of wheat.

CONCLUSION

Soil organic matter and P contents significantly increased at application of leonardite compare with control plot. The results of the experiment show that leonardite could be used as soil conditioner material in soils with lower organic matter content and to increase the yield of climbing bean and could be increase the yield at agricultural and horticultural applications. In addition, to maintain yield and decrease the adverse effect of commercial fertilizers on the environment, commercial fertilizers may be combined with an amount of leonardite as depending on soil and crop type. In future, further studies on application of leonardite to soils are required for more detailed views in different ecological conditions.

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