African Journal of Biotechnology Vol. 11(6), pp. 1425-1432, 19 January, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.2800
ISSN 1684–5315 © 2012 Academic Journals

Full Length Research Paper

Effect of elemental sulphur and compost on pH, electrical conductivity and phosphorus availability of one clay soil

Kazem Hashemimajd[1], Tayebeh Mohamadi farani[1] and Shahzad Jamaati-e-Somarin[2]*

[1]Department of soil sciences, University of Mohaghegh Ardabili, Ardabil, Iran.
[2]Young Researchers Club, Ardabil Branch, Islamic Azad University, Ardabil, Iran.

Accepted 14 November, 2011

Suitable plant nutrition is one of the most important factors in the quantity and quality of crops' yield. In plant nutrition, each nutrient should be in adequate level. The most important role of pH is the control of nutrients solubility in soil. Nutrient availability usually decreases with increasing pH. Experimental soil sample was collected from 0 to 30 cm depth from Niar village around the Ardabil city. The soil samples were mixed with solid acidifying material including elemental sulphur (S) in three levels (0.25, 0.5 and 1.0 g/kg soil), farm yard compost manure in three levels (2.5, 5 and 10 g/kg soil) and elemental S + organic matter in three levels (the same amounts of S with 5 g/kg cattle manure), and filled in 4 L pots. Soil water content was held close to field capacity and green house temperature was kept to 25 ± 5°C. Before the experiment, the physicochemical properties of soil and chemical properties of the compost were measured. At eight, 16 and 32 weeks of incubation, compound soil samples were collected from pots, and their pH, electrical conductivity (EC) and phosphorus (P) were measured. The results show that the effect of elemental S were obtained in the early period of incubation (28 days), but after that, only the 3rd level of S had a significant effect on pH reduction. Compost *S treatment had minor effect on pH reduction in the early stages of incubation, but markedly decreased the pH after 56 days. The effect of compost *S treatment on the pH of soil was shorter than that of S treatment and after 16 weeks, the pH of soil was increased. The effect of different compost levels on pH reduction was not significant at eight and 16 weeks when compared to the control; however, these treatments increased the pH of soil at 32 weeks. All rates of compost *S treatments caused significant increase of soil pH at 32 weeks, but S treatment had no significant difference on the control. S and S* compost treatments significantly increased the EC of soil during the experimental period, but the effect of compost on the elevation of EC was observed after 32 weeks. Available P of soil was improved in all treatments and it reached maximum level at eight weeks, and then decreased.

Key words: Sulphur, compost, soil, pH, electrical conductivity, phosphorus.

INTRODUCTION

Soil pH has direct impact on ion balance, nutrient availability, and the activities of microscopic organisms in soil and plant growth. Calcareous soils have a wide range of pH due to the type and nature of their constituent, calcium carbonate content and rainfall, and they vary from 7.8 to 8.2.

One of the important roles of pH is controlling nutrient solubility in soil. Solubility of most nutrients usually decreases with increasing pH (Malakouti, 1993). The presence of calcium carbonates directly or indirectly affects the chemistry and availability of nitrogen (N), phosphorus (P), magnesium (Mg), potassium (K), manganese (Mn), copper (Cu), zinc (Zn) and iron (Fe) in the soil.

P is an essential element for plant growth. Availability

*Corresponding author. E-mail: jamaati_1361@yahoo.com. Tel: +989141594490. Fax: +984517714126.

Table 1. Initial characteristics of the soil sample.

Parameter	Value
Soil texture	clayey
pH	8.01
EC (ds/m)	1.05
OC %	1.58
Sand %	28/23
Silt %	29/32
Clay %	42/34
T.N.V	4.5
P (mg kg^{-1})	9.49

OC, Organic carbon; EC, electrical conductivity; P, phosphorus. TNV;Total Neutral materials Variation

Table 2. Characteristics of cow manure compost.

Parameter	Value
Material	Compost
pH	8.36
EC (ds/m)	8.51
OC **(%)**	22.25
Total N **(%)**	1.85
P (mg kg^{-1})	1650
K (mg kg^{-1})	5000
(C/N)	12

OC, Organic carbon; EC, electrical conductivity; P, phosphorus; K, potassium; N, nitrogen. (C/N): Carbon/Nitrogen

of P is limited in calcareous soils for plants. Different forms of P in combination with calcium exist in calcareous soils. The highest amount of available P is in the pH range of six to seven for the plant. This range of pH is a desirable level for all nutrients (Havlin et al., 2005).

Frequent use of large amounts of phosphorous fertilizers in calcareous soils causes accumulation of P in soils but requires a long time for the release of P to soil solution. Applied P in the soil is available for plants only for a short period because it is converted to the insoluble form (Lee, 2001).

Acidifying materials can improve availability of nutrients in calcareous soil by decreasing pH. The amount of acidifying materials application for creating plant response depends on calcium carbonate in the soil (Obreza et al., 1993).

Sulphur (S) is often used to reduce the pH of calcareous soils (Lee, 2001), whereas elemental S is widely used in the fields because of its low price. It is an insoluble solid crystal that is used as the most effective source for acidification of calcareous soils (Slaton, 1998). Elemental S must be oxidized to sulphate ($SO4^{2-}$) biologically. Autotroph Tiobacillus is the most important microorganisms in this process (Kariminia and Shabanpour, 2002). However, a major problem after the consumption of S is its oxidation. Considering the small amount of organic matter in Iran soils, the number and activity of these bacteria in soils is limited. These bacteria have proper growth and population in favorable conditions and high humidity; thus, the biological oxidation of S is suitable in these conditions (Malakouti, 1993).

On the other hand, composts are widely used to improve soil physical properties and valuable source of organic matter. Many of the composts have relatively high pH ranging from seven to eight. High pH of the composts is one problem that limits its usage in alkaline soils. The aim of this study was to study the effect of the acidifying material on soil pH and P availability, and also to compare the combined use of compost and S in the soil as well as in their consumption alone.

MATERIALS AND METHODS

A soil sample was collected from a farm (0 to 30 cm depth) in Niar village around Ardebil city. The soil sample, after air drying and passing from 2 mm screen mixed with elemental S powder at three levels (equivalent to 0.25, 0.5 and 1 g/kg soil), compost (cow manure compost) at three levels (equivalent to 2.5, 5 and 10 g/kg soil) and elemental S * organic matter at three levels (the same amounts of sulfur with 5 g/kg cow manure), was filled in 4 kg pots. The soil water content was held close to field capacity and the green house temperature was kept at 25 ± 5°C. Soil characteristics, including pH (in the saturation paste using a pH meter) and electrical conductivity [EC (in 1:2 soil water extract with conductivity meter)] were measured (Rhoades, 1996).

Organic carbon (OC), calcium carbonate equivalent and texture were determined with Walkly and Black (Nelson and Summers, 1996), acid titration and hydrometer methods (Gee and Bauder, 1996), respectively. The plant available P that was used was measured in 0.5 M sodium bicarbonate ($NaHCO_3$) with a spectrophotometer (Table 1), and the chemical characteristics of cow manure compost, including pH and EC (in 1:5 v/v extract of manure and distilled water) and total P concentration (dried, ashed and extracted with 2.0 M HCl) were measured with similar methods (Table 2). At four, eight, 16 and 32 weeks, compound samples were taken from pots and the amount of pH, EC and P concentrations was measured. The analysis of variance (ANOVA) and comparison of mean (Duncan) were used to determine the effect of the material on soil characteristics using statistical software SAS ver. 9.

RESULTS AND DISCUSSION

The results of analysis of variance are shown in Table 3. The effect of treatments (additives), time and time *treatment interaction on pH, EC and P concentration were significant at 1% level.

Effect of time on soil pH shows that at four, eight and 16 weeks, the pH of soil was decreased as compared to the pH seen at the beginning of the experiment. Among these three times, the highest decrease of soil pH was observed at four weeks. At 32 weeks, soil pH significantly increased as compared to the start time (Figure 1). EC of soil at the time of four weeks has no significant difference

Table 3. Summary of variance analysis of soil characteristics.

Variation source	df	Min of Square		
		pH	EC(mS cm^{-1})	P (mg kg^{-1})
Replication	2	0.029	0.55	5.97
Time	4	1.68**	4.70**	2151.74**
Treatment	10	0.055**	2.40**	402.49**
Time*treatment	26	0.039**	0.127**	83.49**
Error	79	0.006	0.044	10.81
CV (%)	-	0.99	13.93	7.76

** Significant at one percent level. EC, Electrical conductivity; P, phosphorus. CV (%); Coefficient Variation

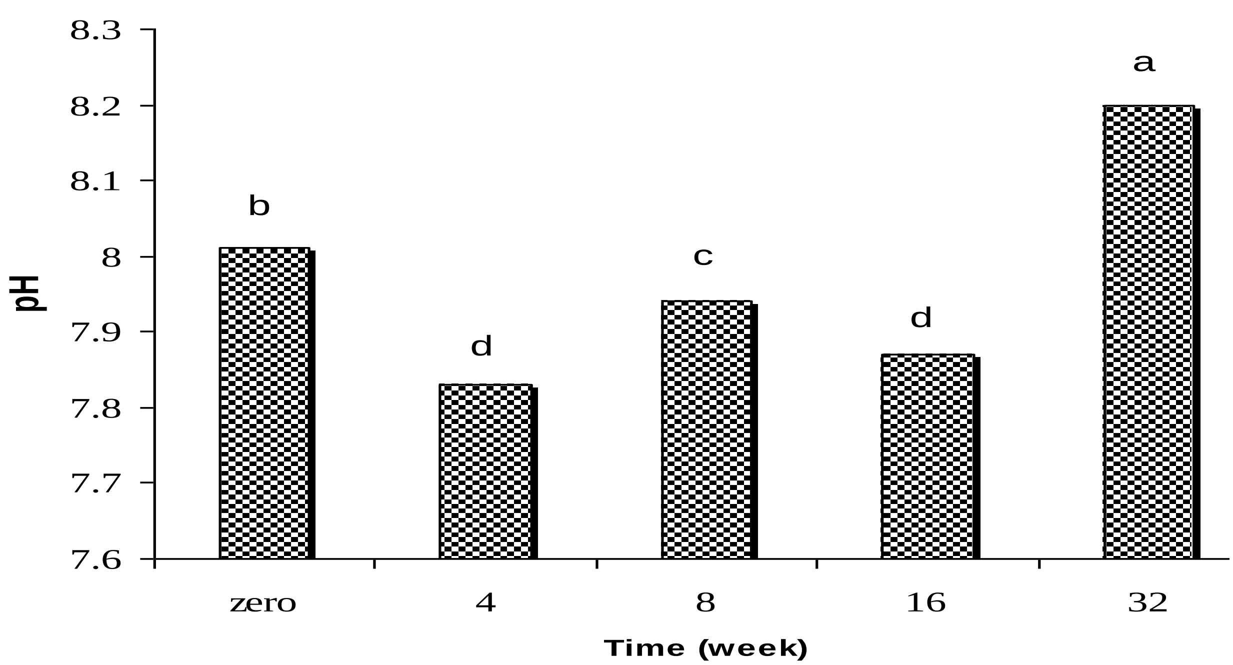

Figure 1. Effect of incubation time on soil pH and electrical conductivity.

with zero time, but significantly increased in the other times (Figure 2). Figure 3 shows that P concentration of soil at four, eight and 16 weeks was increased significantly and it reached its maximum level at eight weeks. At 32 weeks, significant decrease was observed in P concentration in soil (Figure 3).

The effect of the types and levels of acidifying materials on soil pH, EC and P content is shown in Table 3. At four weeks, the second and third levels of elemental S caused the reduction of soil pH significantly, but their difference was not significant. At eight weeks, this effect was significant only in the third level of treatment. These results also show significant decrease of soil pH at 16 weeks. Slaton (1998) noted that oxidation of each mole of S in soil produce two moles of hydrogen ions that can react with carbonate in calcareous soil and neutralize it. Neilson et al. (1993) mentioned that the highest pH decrease with consumption of elemental S was observed at four to eight weeks. Deubel et al. (2007) also reported that soil pH was reduced with an increase of elemental S after 16 weeks. However, none of the compost levels significantly decreased soil pH as compared to the control at incubation times lesser than 32 weeks, instead they increased at this time. Parham et al. (2002) reported soil pH increase with compost consumption. At four and 16 weeks, only the third level of S- compost treatment reduced soil pH significantly, but at eight weeks, all levels of this treatment had this effect and then soil pH increased gradually. At all levels of compost and S-compost treatments, soil pH increased at 32 weeks significantly, but S treatment had no significant difference with the control (Figure 4).

At four weeks, the third level of elemental S increased soil EC as compared to the control, but at eight weeks, the second and third levels of elemental S had such effect. At 16 and 32 weeks, all levels of this treatment

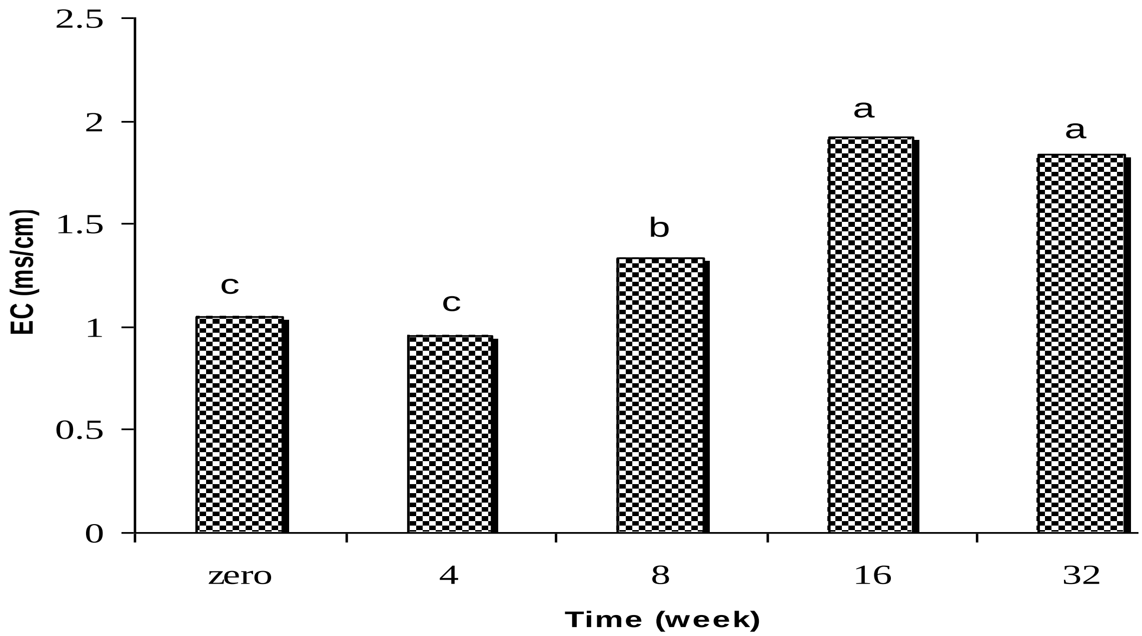

Figure 2. Effect of incubation time on soil pH and electrical conductivity.

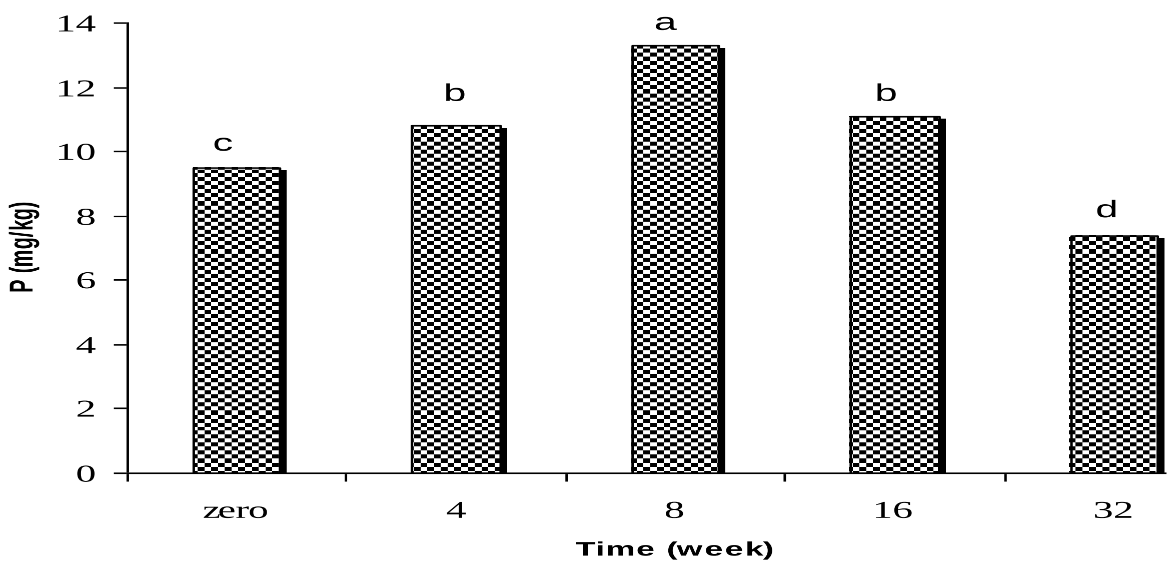

Figure 3. Effect of incubation time on soil phosphorus concentration.

also increased the EC of soil significantly. However, the levels of compost treatment have no significant effect on soil EC in none of the times. Ouedraogo et al. (2001) mentioned that soil salinity increased with the constant use of the compost that was not observed at the duration of this experiment. All levels of S-compost treatment significantly increased soil EC at eight, 16 and 32 weeks. At four and eight weeks, the first level of S-compost treatment showed significant increase in the EC of soil as compared to this level of S treatment, whereas difference in other levels at four and eight weeks and in the other time periods was not significant (Figure 5). During S oxidation in soil, the sulphuric acid formed reacted with the calcium carbonate of calcareous soil and produced gypsum. However, it was more soluble than calcium carbonate, in that it increased soil EC (Slaton, 1998). Kaplan and Orman (1998) have also reported an increase in the EC of soil with application of elemental S.

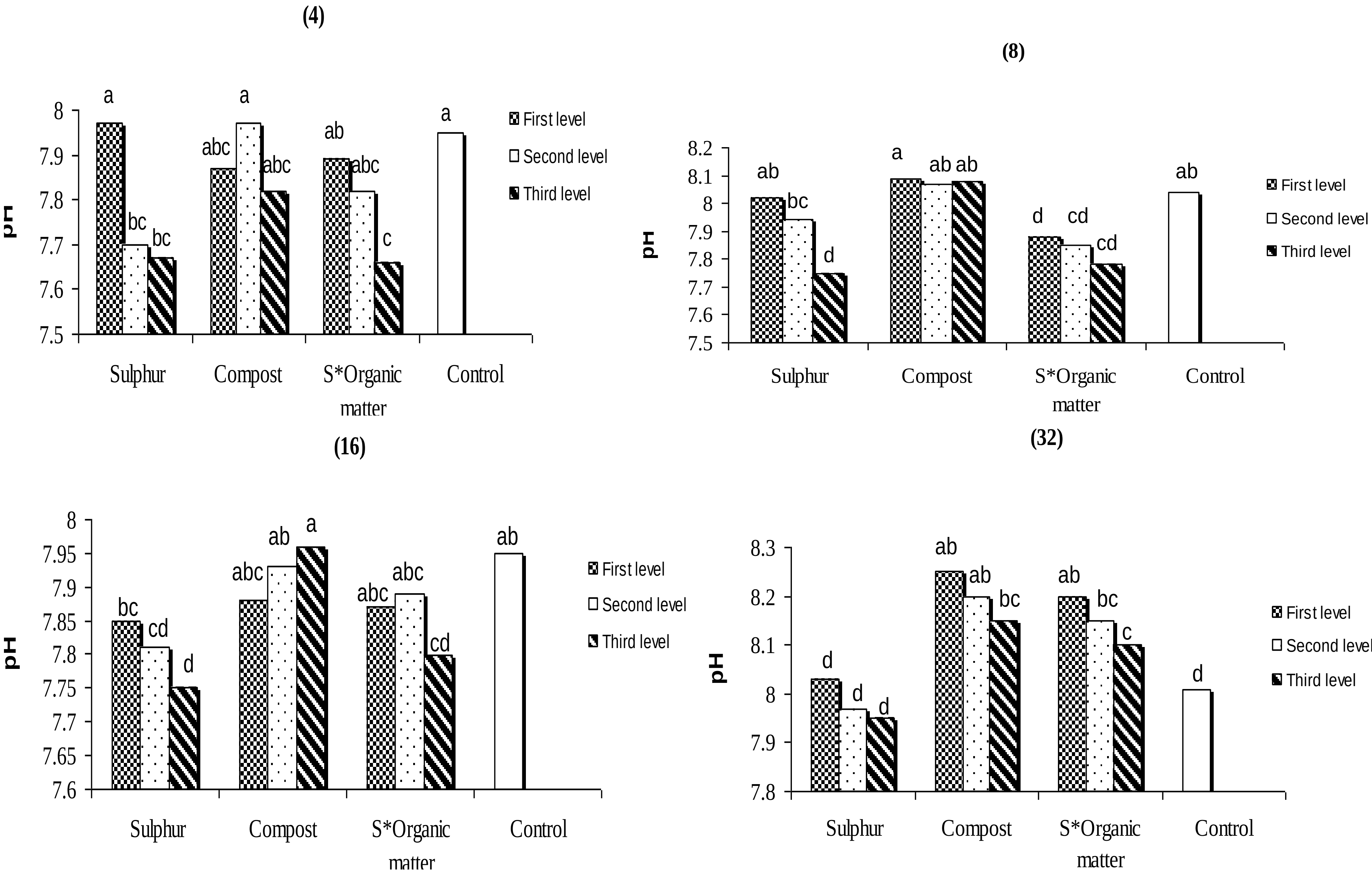

Figure 4. Changes in soil pH at four, eight, 16 and 32 weeks after applying different levels of treatments.

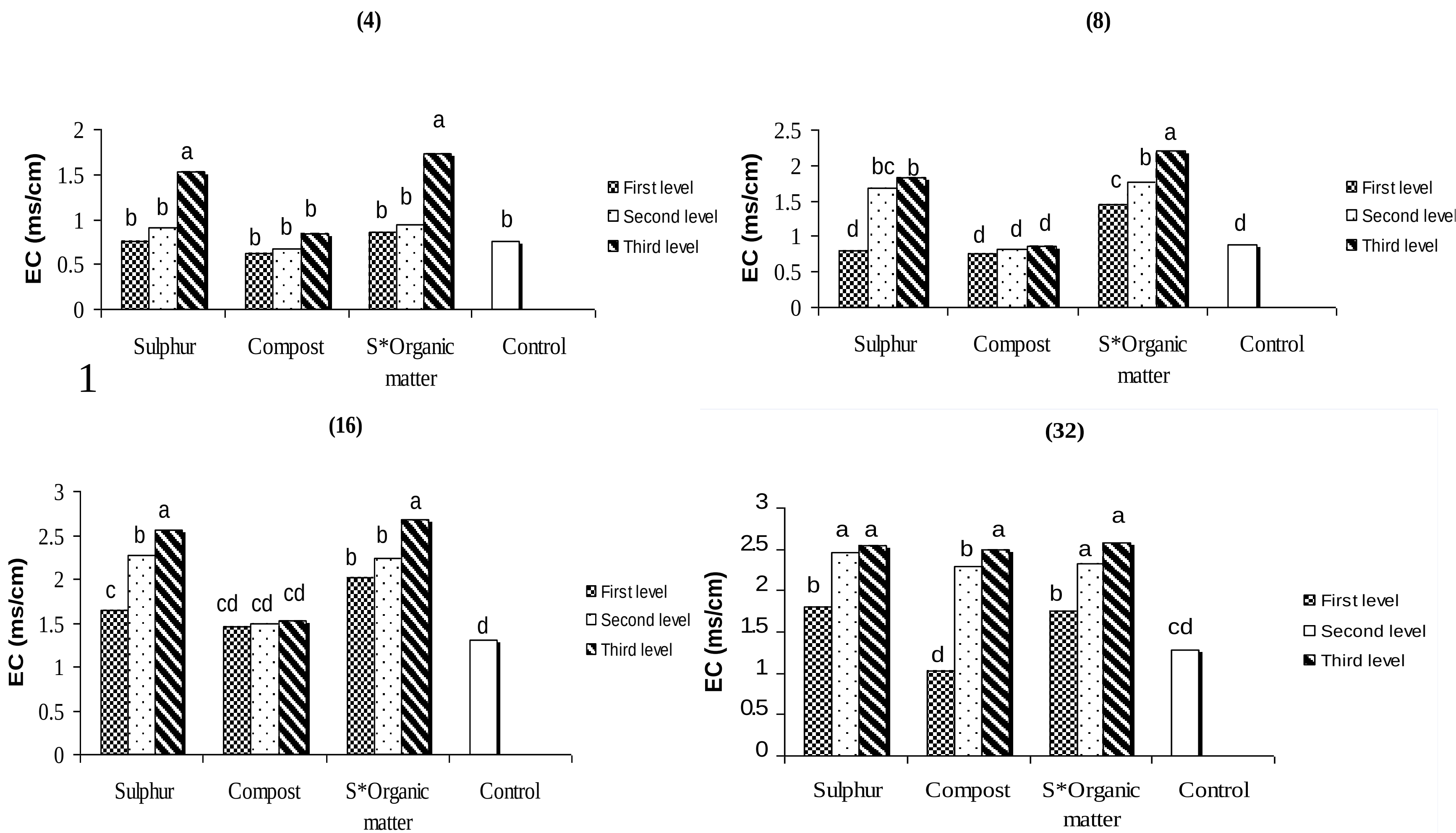

Figure 5. Changes in electrical conductivity of soil at four, eight, 16 and 32 weeks after applying different levels of treatments.

At four and eight weeks, all levels of elemental S treatment caused increase in P concentration of soil, but the difference among them was not significant. At 16 weeks, none of the treatments had significant difference as compared to the control. At 32 weeks, the first and second levels of S significantly decreased the P content of soil as compared to the control (Figure 6). Kaplan and Orman (1998) reported the increase of available soil P with consumption of elemental S to be as a result of the reducing soil pH and release of P from insoluble compounds. All levels of compost and S-compost treatment at four, eight and 16 weeks have increased soil P significantly. However, Zhang et al. (2006) confirmed the

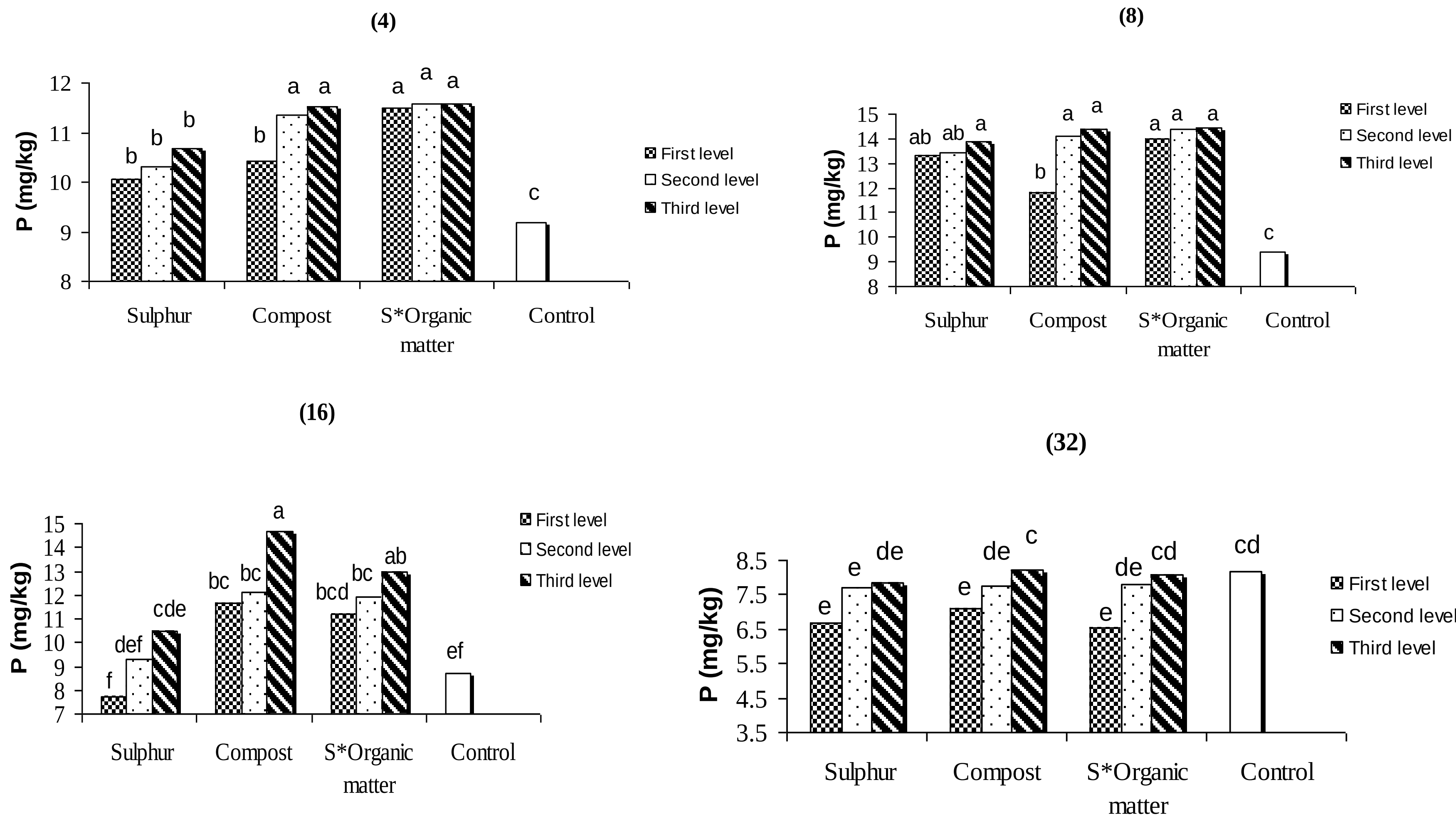

Figure 6. Mean changes in soil phosphorus at time of four, eight, 16 and 32 weeks of applying different levels of treatments.

increasing soil P by using compost. At four and 16 weeks, the P of S-compost treatment increased higher than that of S treatment, but this difference was not significant at eight weeks. At 32 weeks, the second and third levels of these two treatments had no significant difference with the control, but in the first level of these treatments, the P of soil was significantly decreased. At four and 16 weeks, all levels of S-compost treatment increased soil P significantly as compared to S treatment, but this difference was not significant at eight weeks (Figure 6). However, between soil pH and P levels, high correlation was seen in the experimental data (r = -0.63), which indicated the effect of pH on the availability of P in alkaline soils

(Havlin et al., 2005).

Conclusion

The results show that the effect of elemental S in reducing pH was observed in a short time (28 days) after application, but in a long time, only the third level of this treatment had a significant effect on reducing soil pH; whereas, at S-compost treatment, pH decrease was lower at first, but after 56 days, a significant reduction in pH was observed. The effect of S-compost treatment in comparison with S treatment was shorter, and after 16 weeks, the soil pH was increased. More so, the effect of compost levels in reducing pH was not significant as compared to the control. At 32 weeks, all levels of S and S-compost treatments increased soil pH significantly. In this study, it was observed that the levels of S and S-compost treatments significantly increased soil EC during the experiment compost. Nonetheless, all levels of treatments increased the soil P, reached the highest level at eight weeks, and then decreased afterwards.

REFERENCES

Deubel A, Braune H, Tanneberg H, Merbach W (2007). Conversion and acidifying effects of elemental sulphur in an alkaline loess soil. Arch. Agro. Soil Sci. 53(2): 161-171.

Gee GW, Bauder JW (1996). Particle size analysis, In: Klute A (Ed): Methods of soil analysis, Part1: Physical and mineralogical methods, 2nd ed. Am. Soc. Agron. Madison, WI: pp. 383-412.

Havlin JL, Beaton JD, Tisdale SL, Werner LN (2005). Soil fertility and fertilizers. 7th ed. Upper Saddle River, New Jersey.

Kaplan M, Orman S (1998). Effect of elemental sulphur and sulphur containing waste in a calcareous soil in Turkey. J. Plant Nutr. 21(8): 1655-1665.

Kariminia A, Shabanpour M (2002). Evaluation of oxidation ability of heterotroph microorganisms in calcareous soils. Soil Water Sci. J. 17(1): 69-80.

Lee Y (2001). Calcareous soils in Miami- Dade country. University of Florida. Extension Service SL. p. 183.

Malakouti MJ (1993). Soil fertility of dry region problems and solving.Tarbiat Modarres Univ. Press, p. 21.

Neilson D, Hogue EJ, Hoyt PB, Drought BG (1993). Oxidation of elemental sulphur and acidulation of calcareous orchard soils in Southern British Columbia. Can. J. Soil Sci. 73: 103-114.

Nelson DW, Sommers LE (1996). Total carbon, organic carbon and organic matter. In: Sparks DL (ed.): Methods of soil analysis, Part3: Chemical methods. SSSA Book series Number 5, Soil Sci. Soc. Am, Madison, WI: pp. 153-182.

Obreza TA, Alva AK, Calvert DV (1993). Citruse fertilizer management on calcareous soils. University of Florida Ifase Extension. CRI: p. 1127.

Ouedraogo E, Mando N, Zombre P (2001). Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa. Agric. Ecosyst. Environ. 84: 259-266.

Parham JA, Deng SP, Raun WR, Johnson GV (2002). Long- term cattle manure application in soil. Biol. Fertil. Soils, 35: 328- 337.

Rhoades JD (1996). Salinity electrical conductivity and total dissolved solids. In: Sparks DL (ed.): Methods of soil analysis, Part3: Chemical methods. SSSA Book series Number 5, Soil Sci. Soc. Am, Madison, WI: pp. 417-435.

Slaton NA (1998). The influence of elemental sulfur amendments on soil chemical properties and Rice growth. University of Arkansas. A dissertation of Doctor of Philosophy.

Zhang M, Heaney D, Henriqez B, Solberg E, Bittner E (2006). A four year study on influence of biosolids/ MSW compost application in less productive soils in Alberta: Nutrient dynamics. Compost Sci. Util.14: 68-80.