Research Article

Role of Organic Amendments to Enhance Soil Fertility Status and Wheat Growth in Salt Affected Soil

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Abstract | Ameliorative role of organic amendments in improvement of fertility status of salt affected soil was studied in a pot experiment conducted at research area of University of Sargodha in year 2017-18. A saline sodic-soil with desirable characteristics (SP = 40.35, EC_e = 5.17 dS m^{-1}, pH_s = 8.71, SAR = 18.80 (mmol $L^{-1})^{1/2}$, bulk density = 1.49 g cm^{-3}) was selected for present study. After chemical analysis, different organic amendments were used in the study. Following treatments were applied in three replicates i.e. T1- control (recommended NPK), T2- ½ of recommended NPK, T3- full dose of FYM, T4- full dose of press mud, T5- full dose of compost, T6- full dose of poultry manure, T7- full dose of sesbania green manure, T8- T2 + ½ FYM, T9- T2 + ½ press mud, T10- T2 + ½ compost, T11- T2 + ½ poultry manure, T12- T2 + ½ sesbania green manure. After sufficient time for decomposition incorporation of organic amendments were done. Wheat (Punjab-2011) was used as a test crop. Harvesting was done at maturity stage of crop. Soil samples collection was done from each pot and fertility parameters were studied. The results suggested that soil fertility status and biomass of wheat significantly increased by incorporation of full dose of press mud, poultry manure and compost.

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Keywords | Saline-sodic soil, Organic amendments, Organic matter, Nitrogen, Phosphorus, Potassium

Introduction

Pakistan is situated in arid to semi-arid climatic zones. Due to calcareous and alkaline nature of soils, most of the nutrients are deficient in soils and unavailable to the plants. To combat this situation, artificial addition of nutrients in the form of fertilizers is performed in order to get higher yields. Resource limited farmers are reluctant to apply fertilizers at right rate, right dose, right source and right time due to inflating high prices of fertilizers and their unavailability in markets at the time when they are required (Ahmad, 2000; Zahir et al., 2007).

Under such scenario, farmers may be motivated to switch towards economical and inexpensive sources of nutrients such as organic materials to supplement the costly synthetic inorganic sources of nutrients. Organic materials augment soil organic matter status and in turn enhance nutrient availability to plants, improve soil health and increase subsequent crop yield. Although, organic materials such as FYM, poultry manures etc. are sufficiently available in bulk quantity, however, due to some reasons (e.g. straw use as animal feed and crop residues burning etc.) use of these organic materials in somewhat limited to be used for farming (Korboulewsky et al., 2002).

Role of organic amendments is evident in terms of nutrient recycling (Hemalatha et al., 2000). In order to achieve sustainability in agriculture, organic nutritional sources application is globally adopted as a necessary component of farming (Kumar et al., 1999). Organic and mineral sources of nutrients, when used in combination are more beneficial than their sole use. Organic materials increased the soil organic carbon, organic matter percentage and nutrients availability in soil. Use of chemical nutrient sources enhances soil carbon input indirectly by increasing crop biomass and yield. Collective application of organic and mineral nutritional sources supplements mineral fertilizer rates and enhance fertilizer use efficiency (Gorttappech et al., 2000; Sabah et al., 2012; Sabah et al., 2014; Leogrande and Vitti, 2018).

In order to achieve agricultural sustainability, integration of nutrient sources (organic and mineral) is a dire need of the time. It has been validated by many scientists that collective applications of organic and mineral sources of nutrients contribute towards alleviation of nutrient deficiency. Efficacies of collective application of organic and mineral fertilizers were studied by Chand et al., 2006. It was reported that combined use of FYM along with inorganic fertilizers and Sesbania substantially improved the fertility status of soil. Similarly, Agbede et al., 2008 reported that significant enhancement in soil organic matter status, N, P and K levels by the addition of poultry manure in integration with chemical fertilizers. Mahmoud et al., 2009 also confirmed the beneficial results of collective use of various nutritional sources. It was found that such integration significantly increased the levels of soil fertility parameters (organic matter, N and P). They suggested that composting of organic materials can supplement about 25% of the mineral fertilizer uses. Keeping in view the overall scenario, a pot study was conducted to evaluate the role of collective use of various sources of nutrients to increase nutrient providing ability of salt- affected soil and growth wheat crop.

Materials and Methods

A study was designed to depict the role of collective use of various sources of nutrients to increase nutrient providing ability of soil affected by toxic sodium metal ion under wheat crop in pot culture. Selection of salt-affected soil with desired traits was done (EC_e = 5.17 dS m^{-1}, pH_s = 8.71, SAR = 18.80 (mmol L^{-1})$^{1/2}$, bulk density = 1.49 g cm^{-3}, SP = 40.35). After selection of soil with desired characteristics, it was filled in the pots after grinding and sieving @ 10 kg per pot. There were 12 treatments in total which were replicated three times; T1-control (recommended NPK), T2-½ of recommended NPK, T3-FYM @ 1.5 % by soil weight, T4-full dose of press mud, T5-full dose of compost, T6-full dose of poultry manure, T7-full dose of sesbania green manure, T8-T2 + ½ FYM, T9-T2 + ½ press mud, T10-T2 + ½ compost, T11-T2 + ½ poultry manure, T12- T2 + ½ sesbania green manure. After suitable time (15-20 days) given for decomposition, organic amendments were incorporated in the pots. Physico-chemical properties of various treatments are given in Table 1. Wheat Punjab-2011 was used as test crop. Soil sampling was done from each pot and samples were brought to laboratory and prepared after harvesting. Handbook 60 (U.S. Salinity Laboratory Staff, 1954) was followed for various determinations (organic matter, Olsen phosphorus and water soluble potassium). After collection of data statistical analysis were performed.

Results and Discussion

Effect of organic amendment on wheat growth

The shoot biomass production is the main criteria to judge effect of exogenous soil amendments on the growth of crop. It is the total biomass of crop on which ultimate yield relies upon. It was evident from the data that integrated use of organic and mineral nutritional sources performed better than their sole use (Figure 1). All the treatments performed well when compared to control (T1). The data for total biomass were found significant when adjudged statistically. It was found that treatment having half dose of mineral fertilizer and half dose of compost (T10) resulted in maximum biomass of wheat with numerical value of 46.78 g. On the other hand, application of FYM (T3) resulted in minimum biomass with a value of 26.8 g.

Farmers have great interest in yield due to economic benefit. The application of FYM, press mud, compost, poultry manure and sesbania green manure alone and in combination with chemical fertilizer increased the yield of wheat significantly. A chain process was responsible for the improvement in grain yield of wheat. The percentage of soil organic matter was increased due to the application of different organic materials like FYM, press mud, compost, poultry manure and sesbania green manure. This addition of

Table 1: *Analysis of various organic nutritional sources used in experiment.*

Sr. No.	Determinations	Unit	FYM	Pressmud	Compost	Poultry manure	Sesbania green manure
1	pH (1:1)	-	8.10	7.66	7.76	8.20	7.21
2	Organic matter	%	35.56	31.19	40.79	38.90	24.94
3	Organic carbon	%	20.67	18.15	23.71	22.61	14.50
4	Total nitrogen	%	1.66	1.64	2.33	1.80	1.07
5	C/N ratio	-	12.38	10.99	10.14	12.50	13.4
6	Available phosphorus	%	0.66	1.27	1.36	0.80	0.70
7	Potassium	%	1.12	0.44	1.04	0.94	3.54

soil organic matter content caused an improvement in the physical properties of soil. Due to the up gradation of physical properties various acid or acid forming compounds were released from the application of various organic materials which lowered soil pH (Figure 5). As a result of low pH, the availability and uptake of soil nutrients by plants was enhanced. Consequently, all the above factors contributed to the improvement of yield. In case of saline sodic soil, the reclamation occurred and as a result of reclamation process, Na^+ salt present on the exchange site leached down and H^+ occupied its place thus, lowering soil pH. Hence, better physical conditions for plant growth were created. Moreover, addition of different organic materials improved the physical properties of soil permitting more leaching of excessive salts. It is found that all organic materials performed well when used in combination with mineral sources. However, compost proved superior in this regard. Findings of many researchers support these results e.g. Khan et al. (2006), Sarwar et al. (2008), Sabah et al. (2012) and Sabah et al. (2014).

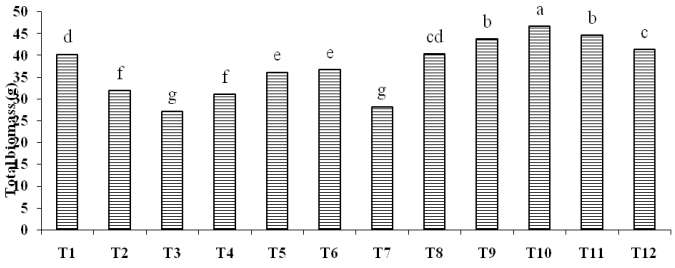

Figure 1: *Effect of organic matter amendment on biomass growth of wheat. Where; T1-control (recommended NPK); T2- ½ of recommended NPK; T3-FYM @ 1.5 % by soil weight; T4-full dose of press mud; T5-full dose of compost; T6-full dose of poultry manure; T7-full dose of sesbania green manure; T8-T2 + ½ FYM; T9-T2 + ½ press mud; T10-T2 + ½ compost; T11-T2 + ½ poultry manure; T12- T2 + ½ sesbania green manure.*

Effect of organic amendments on organic matter and nitrogen content

Organic matter status of soil is the key parameter of depicting soil fertility status. Incorporation of organic materials either single or combined with mineral nutritional sources significantly upgraded the soil organic matter status. Quantity of organic matter in soil is directly related to nitrogen content of soil. Initially soil contains 0.71 % organic matter. This value reached to the maximum level of 1.33 % in treatment T4 where full dose of press mud was used as organic material (Figure 2). Minimum level of organic matter percentage (0.71 %) was noted in T1 (control) receiving only mineral source of nutrients. However, among all organic amendments press mud proved superior in enhancing soil organic matter percentage.

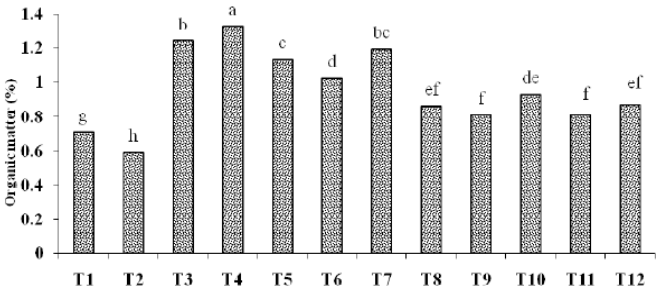

Figure 2: *Effect of organic matter amendment on soil organic matter content; Where; T1-control (recommended NPK); T2- ½ of recommended NPK; T3-FYM @ 1.5 % by soil weight; T4-full dose of press mud; T5-full dose of compost; T6-full dose of poultry manure; T7-full dose of sesbania green manure; T8-T2 + ½ FYM; T9-T2 + ½ press mud; T10-T2 + ½ compost; T11-T2 + ½ poultry manure; T12- T2 + ½ sesbania green manure.*

Organic matter serves as elixir of life in soil. It is served as major pool of all the essential plant nutrients. It is known as soil conditioner as it improves the impaired properties of soils. It provides energy source to soil microbes which are responsible for soil nutrients cycling and in maintenance of soil health. In present study, organic materials were applied at 2 levels (full dose and half dose). It was found that application of organic materials at either rate significantly increased the soil organic matter percentage. However, press

mud proved superior in this regard (Figure 2). Many researchers reported similar results e.g. Sarwar, 2005; Sarir et al. (2005), Fageria (2007), Agbede et al. (2008), Ayoola and Makinde (2009).

Effect of organic amendments on available phosphorus content

Efficacy of organic amendments on available phosphorus content was depicted in Figure 3. It was found that incorporation of sole use of organic amendments or in integration with mineral nutritional sources enhanced the soil available P content significantly. Minimum available P content (9.4 mg kg^{-1}) was recorded in treatment T2 receiving ½ rate of chemical fertilizer. That was reached to the maximum level of 20.5 mg kg^{-1} in treatment T6 receiving poultry manure as organic amendment.

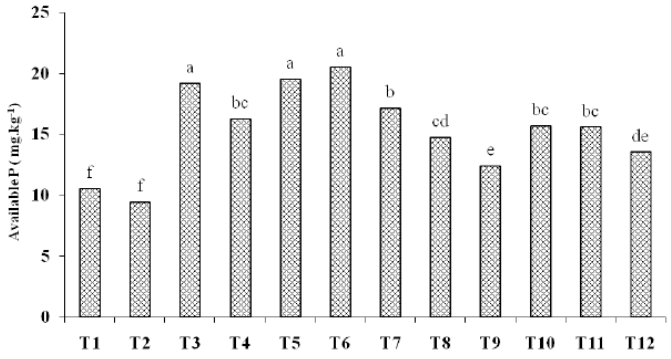

Figure 3: *Effect of organic matter amendment on soil available phosphorus content; Where; T1-control (recommended NPK); T2- ½ of recommended NPK; T3-FYM @ 1.5 % by soil weight; T4-full dose of press mud; T5-full dose of compost; T6-full dose of poultry manure; T7-full dose of sesbania green manure; T8-T2 + ½ FYM; T9-T2 + ½ press mud; T10-T2 + ½ compost; T11-T2 + ½ poultry manure; T12- T2 + ½ sesbania green manure.*

Phosphorus is one of the major essential nutrients known as cell energy currency being part of ATPs. Like many other factors, soil reaction is mainly responsible for availability of P. At pH values between 6.5-7.5, there is maximum availability of P to plants. Effect of soil pH on availability of P can be demonstrated by the following reaction given by Brady and Weil (2005):

$$H_2PO_4^- \underset{H^+}{\rightleftharpoons} H_2O + HPO_4^{2-} \underset{H^+}{\rightleftharpoons} H_2O + PO_4^{3-}$$

(Very acid solutions) (Very alkaline solutions)

The initial pH of growth media was recorded as 8.7 that were lowered to significant levels in all treatments due to acidic effects of organic materials. Data suggested that all the treatments significantly enhanced the available P content when compared with control (Figure 3). Following reaction takes place when phosphatic fertilizers are added to alkaline soil:

$$Ca(H_2PO_4)_2.H_2O + H_2O \longrightarrow CaHPO_4.H_2O + H_3PO_4$$

(Brady and Weil, 2005) Organic amendments incorporation resulted in breaking the apatite bonds of phosphorus compounds with calcium carbonate and thereby increasing the availability of P. The results of present study were in line with earlier researchers (Selvakumari et al., 2000; Pattanayak et al., 2001; Mahmoud et al., 2009; Ayeni and Adetunji, 2010; Adeleye et al., 2010)

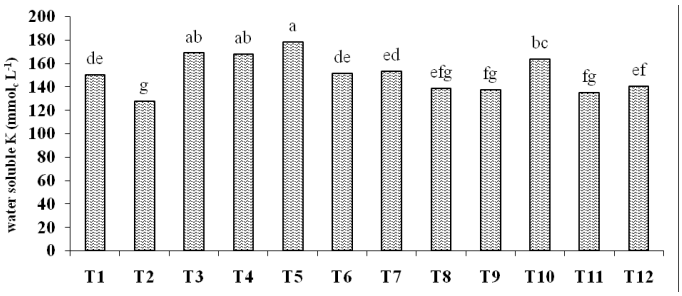

Figure 4: *Effect of organic matter amendment on soil water soluble K content; Where; T1-control (recommended NPK); T2- ½ of recommended NPK; T3-FYM @ 1.5 % by soil weight; T4-full dose of press mud; T5-full dose of compost; T6-full dose of poultry manure; T7-full dose of sesbania green manure; T8-T2 + ½ FYM; T9-T2 + ½ press mud; T10-T2 + ½ compost; T11-T2 + ½ poultry manure; T12- T2 + ½ sesbania green manure.*

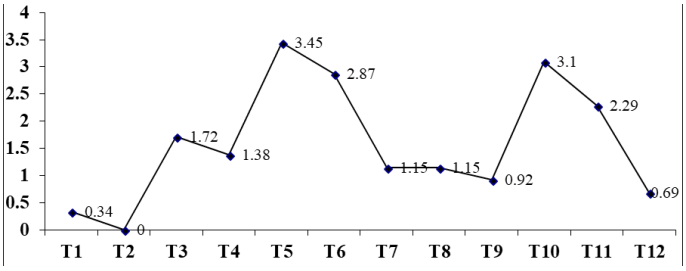

Figure 5: *Percent decrease in soil pH over original value; Where; T1-control (recommended NPK); T2- ½ of recommended NPK; T3-FYM @ 1.5 % by soil weight; T4-full dose of press mud; T5-full dose of compost; T6-full dose of poultry manure; T7-full dose of sesbania green manure; T8-T2 + ½ FYM; T9-T2 + ½ press mud; T10-T2 + ½ compost; T11-T2 + ½ poultry manure; T12- T2 + ½ sesbania green manure.*

Effect of organic amendments on water soluble potassium content

It was found that incorporation of organic amendments either alone or in integration with mineral nutritional sources enhanced the soil soluble K content substantially (Figure 4). Minimum soluble K content (124 $mmol_c$ L^{-1}) was recorded in treatment T2 where half recommended rate of chemical fertilizer was applied. That was reached to the maximum level

of 158 mmol$_c$ L^{-1} in treatment T5 where full dose of compost was applied as organic amendment. Poultry manure is enriched source of K due to high potassium feed. Therefore, high numerical value was found in those treatments where application of poultry manure was done.

Potassium is one of the major essential plant nutrients. It performs many functions in plant body. It occurs in four major pools in soil; reserve K contained in minerals lattice, reverted K, exchangeable K and solution K. Availability of potassium is influenced positively by the addition of acidic or acid forming compounds e.g. organic material incorporation. Findings of many researchers support this hypothesis e.g. Ayeni and Adetunji, 2010; Adeleye et al., 2010; Ayoola and Makinde, 2009. They reported that application of organic amendments enhanced the availability of water soluble K content.

Conclusions and Recommendations

It was found that all the organic amendments significantly enhanced the soil organic matter status either applied alone or combined with mineral fertilizers. Application of press mud proved superior in terms of enhancing organic matter content while poultry manure proved best treatment for increasing soil available P content and water soluble K content of growth media. Organic amendments performed better when used in integration with mineral sources of nutrients.

Author's Contributions

Noor-us-Sabah: Conception and design of the work, conduction of experiment and write up.
Mukkram Ali Tahir: Co-supervision, Interpretation of data and proof reading.
Ghulam Sarwar: Supervision, Drafting and technical assistance.
Sher Muhammad: Technical assistance at every step.

Conflict of interest

There is no conflict of interest regarding publication of this article.

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