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EVALUATION OF DEWAXED FILTER CAKE PRESS MUD FOR P-RELEASE FROM INDIGENOUS ROCK PHOSPHATE AND ITS UTILIZATION BY MAIZE

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Rock phosphate is the cheapest source of phosphorus nutrition. But its water soluble P is low. To enhance plant available P from rock phosphate afield experiment was performed to determine the impact of de-waxed filter cake press mud (organic amendment) for the release of available P from insoluble P source (local Hazara rock phosphate) in normal soil (pH_s= 8.15, EC_e= 1.28 dS m^{-1}, SAR = 4.77 mmol L^{-1}, saturation percentage = 29%, Available P = 7.1 mg kg^{-1} and sandy clay loam texture). The research was carried out using randomized complete block design (RCBD) with five treatments replicated thrice namely T1, recommended basal NPK; T2, NP0K (control); T3, NK + Rock Phosphate Red (RPR); T_4, NK + Filter Cake Press mud (FCP) and T_5, NK + Rock Phosphate Red (RPR) + Filter Cake Press mud (FCP). Results suggested application of recommended doses of NPK proved superior in terms of enhancing plant height, total biomass, biological yield, leaf area index and soil available P. However, soil organic matter and P content remained highest in treatments receiving organic amendments. Based on this study, application of organic nutrition i.e. dewaxed filter cake press mud (FCP) proved beneficial for the release of P from local red rock phosphate and also enhanced soil organic carbon fraction in similar growth environment.
Keywords: Rock phosphate, organic manure, maize, carbon fraction, P release.

INTRODUCTION

Phosphorus is an essential element for plant health. It is one of major nutrient that predict the plant growth as there are limited plant available sources of phosphorus (Ezawa *et al*., 2002). Phosphorus performs multiple functions in plants. Most of the soils contain about 0.05% P while the plant available contents are only 0.1% of the total P (Achal *et al*., 2007).
Globally, there is a problem of phosphorus deficiency and likewise in Pakistan (Grant *et al*., 2001; NFDC, 2001). Therefore, in order to overcome this problem application of P through phosphatic fertilizers is done. But low efficiency (10-25%) of most of the phosphatic fertilizers used worldwide contributes to about 1.0 mg kg^{-1} soil bio-available P contents (Goldstein, 1994). Phosphorus availability to the plants is highly pH dependent. Pakistani soils are alkaline in nature so HPO_4^{-2} is most available form of P in most of our soils (Aziz *et al*., 2006).
A substantial amount of chemical phosphatic fertilizers moves to inert pools after application through interaction with calcium ions in case of alkaline soils and become precipitated (Gyaneshwar *et al*., 2002). In spite of high total P content, the plant available portion is limited. Thus, it is essential to mobilize insoluble and reverted forms of P for the sake of enhancing accessibility of P in soil (Aseri *et al*., 2009). Heavy prices of phosphatic fertilizers make it mandatory to explore some cost effective substitutes like rock phosphate (Halder *et al*., 1990). Low solubility of RP under Pakistani soils conditions due to alkalinity also demands some solution (Aziz *et al*., 2006).
There is considerable quantity of rock phosphate deposits located in Pakistan especially in Hazara division of KPK province. Rock phosphate is used as basic material for formulation of different water soluble phosphorus fertilizers. These are approximately 6.9 million tons of which 4.58 million tons are recoverable (Naseer and Muhammad, 2014). Application of raw rock phosphate as such is troublesome under alkaline soil conditions like Pakistan. Therefore, several means are needed to be employed to increase solubility of P from RP such as composting of RP with FYM, poultry manure, green manure, use of RP with phosphorus solubilizing microorganisms (PSMs), partial acidulation of RP and use of RP in conjunction with some chemicals etc. (Kumari and Phagat, 2008).
Based on these findings the present study was designed to check phosphate mobilization from local rock phosphate along with integrated use of dewaxed filter cake press mud (FCP) in maize under field conditions. The major objective of the study was to evaluate the soil organic matter change by addition of filter cake press mud.

MATERIALS AND METHODS

***Experiment location and treatments*:** A field experiment was performed in order to evaluate the effect of organic amendment for phosphorous-solubilization from rock phosphate by maize at University College of Agriculture (UCA), University of Sargodha. Chemical fertilizer were applied @ 120, 90 and 60 kg ha^{-1} for basal dose of N, P and K respectively by using urea as source of N, super and rock phosphates as a source of P and sulfate of potash as a source of K with integration of organic amendment (FCP) on the basis of their analysis in respective plots. Indigenous rock phosphate termed as red rock phosphate taken from the region of Hazara, KPK, and Pakistan containing total 28% P_2O_5, was used. The experiment was carried out under Randomized Complete Block Design (RCBD) replicated thrice. The experiment was comprised of 5 treatments with a plot size of 3 x 5 m^2. The distance between rows was 75 cm and distance between plants was 50 cm with a seed rate of 25 kg ha^{-1}. Hybrid maize was used as test crop. The experiment was conducted in normal P deficient field conditions. The crop was harvested at maturity. The artificial irrigation was applied using tube well water. Recommended dose of N and K along with suitable combination of P source was also applied. De-waxed filter cake press mud (18.14% organic carbon, 10.99 C/N ratio, 1.28% available P) was used as selected organic amendment with various treatments include T_1 = Recommended NPK; T_2 = Recommended NK + (Indigenous P) P^0; T_3 = Rock phosphate + NK; T_4 = filter cake press mud (FCP) + NK; T_5 = Rock phosphate + FCP + NK.

***Sample preparation and analysis*:** Plants samples were dried in an oven (Binder, ED 115, Germany) at 65°C till constant weight. After oven-drying size reduction was made by using grinding mill (Polymix, CH-6014, Kinematica AG, Switzerland) having 2mm sieve. Blue color method was followed for the estimation (Olsen, 1954). In a conical flask 1 g of dried plant sample was taken. 10 ml of digestion mixture (Per-chloric acid and Nitric acid @ 1:2) was used for digestion of sample. This mixture was then left for overnight. Next day the mixture was then digested at hot plate till colorless solution. The color developing reagent solution was used to estimate P concentration in shoot and soil sample by using spectrophotometer at 880 nm wavelength (Shimadzu, UV-1201, Kyoto, Japan). The organic carbon from soil sample was estimated by loss on ignition (L.O.I) method by using electric muffle furnace (Daihan lab Tech, LEF- 130 S, Seoul, Korea). Relative growth rate (RGR) was calculated and proposed as g kg^{-1}day^{-1} by Beadle (1987).

$$RGR = (W2–W1) / (T2–T1)$$

Where W1 and W2 are the total dry weights harvested at time interval T1 and T2, respectively.

***Statistical analysis*:** Analysis of variance (ANOVA) was used as statistical tool and ranking of treatments were done by using LSD test (Steel *et al.*, 1997) using R-software for windows.

RESULTS

***Plant height* (*cm*):** Data pertaining to the effect of local rock phosphate on plant height (cm) of maize was depicted in Figure 1. It was observed that all the treatments had improved the plant height significantly when compared to T_2. Maximum plant height was observed in T_1, in which growth of maize crop was recorded 215 cm with application of recommended dose of NPK followed by T_5 (200 cm), where local or Rock phosphate red (RPR) was applied in combination with filter cake press mud (FCP) and recommended NK. While, minimum plant height (170 cm) was recorded in T_2 (170 cm) that received only NK in the growth medium.

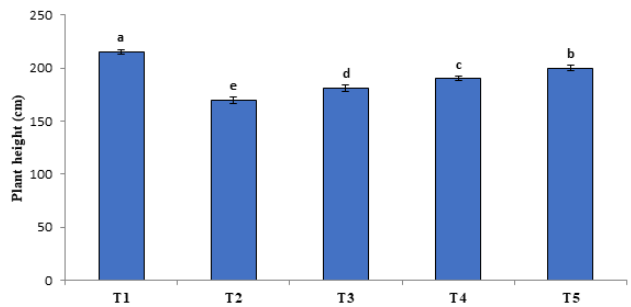

Figure 1. Impact of different P sources on plant height (cm) of maize under field condition.

***Biological yield* (*t ha^{-1}*):** Data regarding the difference in biological yield of maize for different P sources in combination with organic amendments (OA) was depicted in Figure 2. The highest biological yield was obtained in T_1, in which3300 kg ha^{-1} growth of maize crop was recorded with application of recommended dose of NPK followed by T_5 with values of 3200 kg ha^{-1}, where integrated application of RPR with FCP and recommended NK was made. On the other hand, the lowest biological yield (2200 kg ha^{-1}) was observed in T_2 that received NK without any exotic source of P in the growth medium.

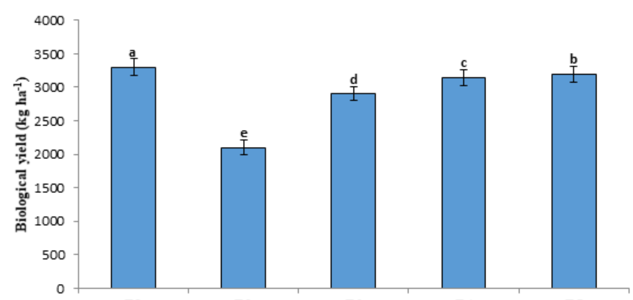

Figure 2. Impact of different P sources on biological yield (kg ha^{-1}) of maize under field condition.

***Leaf area index*:** Data presented in Figure 3 showed the impact of various sources of P on leaf area index of maize. It was depicted from data that differences among various treatment means were found significant statistically when compared with each other. Maximum leaf area index (8) was observed in T_1, in which growth of maize crop was recorded with application of recommended dose of NPK followed by $T_5$with numerical value of 7.88, where RPR was applied in combination with organic amendment (FCP) and recommended NK. On the other hand, minimum leaf area index (7.1) was recorded in T_2 that received only NK in the growth medium.

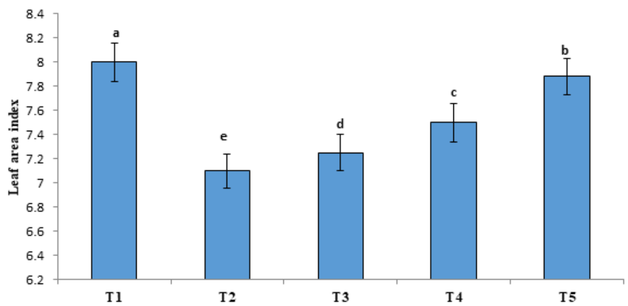

Figure 3. Impact of different P sources on leaf area index of maize under field condition.

***Relative growth rate* (*g kg^{-1}day^{-1}*):** It was depicted from Figure 4 that the lowest value (0.09 g kg^{-1}day^{-1}) of relative growth rate was recorded in T_2 (recommended NK+ P^0) which was reached to the highest value of 0.12 g kg^{-1}day^{-1}in T_1 where chemical fertilizer was applied at recommended doses. This was followed by T_5, where selected organic manure (press mud) was integrated with local rock phosphate (RPR) along with recommended dose of N + K with respective value of 0.11 g kg^{-1}day^{-1}.

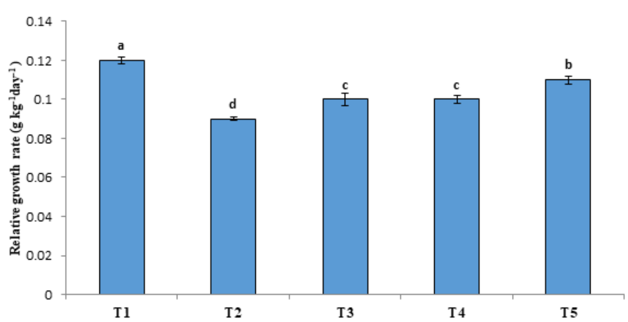

Figure 4. Impact of different P sources on relative growth rate (g kg^{-1} day^{-1}) of maize under field condition.

***Total biomass* (*kg ha^{-1}*):** Data presented in Figure 5 shows the impact of various sources of P on total biomass of maize. Minimum total biomass (1931 kg ha^{-1}) was recorded in T_2 where recommended doses of NK were applied without any external source of P. This was reached to the maximum value of 2350 kg ha^{-1} in treatment T_1 receiving recommended rates of NPK, followed by T_5 (OA + RPR + NK) with numerical value of 2210 kg ha^{-1}. Furthermore, the integrated use of RRP in combination with selected organic amendment and recommended dose of NK had significant impact on total biomass.

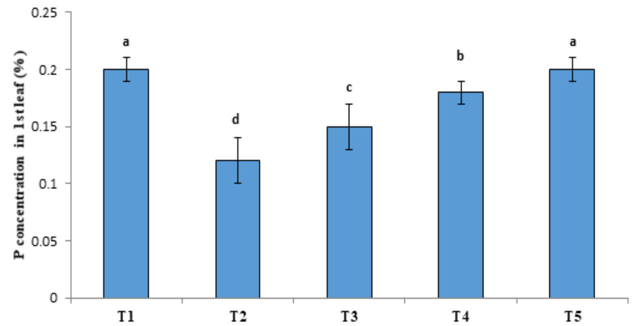

Figure 5. Impact of different P sources on total biomass (kg ha^{-1}) of maize under field condition.

***P concentration in first leaf* (*%*):** Data regarding efficiency of various sources of P on phosphorus concentration of 1st leaf of maize is presented in Figure 6. It was found that all the sources of P whether natural or inorganic significantly enhanced the P content in leaf of maize. Minimum P concentration (0.12%) was observed in treatment T_2, where only recommended doses of NK were applied without any extraneous source of P. This value was reached to the highest value of 0.2% in treatments T_1 (recommended NPK) and T_5 (OA + RPR + NK). Data indicated that use of any source of P (organic or inorganic) substantially increased the P concentration of leaf.

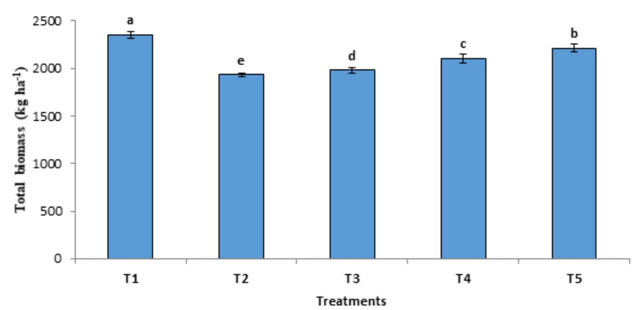

Figure 6. Impact of different P sources on P concentration in 1st leaf (%) of maize under field condition.

***Soil available P* (*mg kg^{-1}*):** Effect of integrated use of organic (FCP) and inorganic (Red rock phosphate; chemical fertilizer) sources of P on available P content of soil is shown in Figure 7. Available phosphorus content of soil ranged between 8 to 12 mg kg^{-1}. The data reveals that addition of either source of phosphate substantially increased the P content of soil compared to treatmentT_2. Minimum available P content (8 mg kg^{-1}) was observed in soil of those plots receiving no source of P (T_2). This value was reached to the maximum level of 12 mg kg^{-1} in T_1 where recommended doses of NPK were applied to the soil. It was found that addition of rock phosphate red (local) in integration with organic manure (FCP) and recommended NK significantly enhanced the soil available P content when compared to T_2.

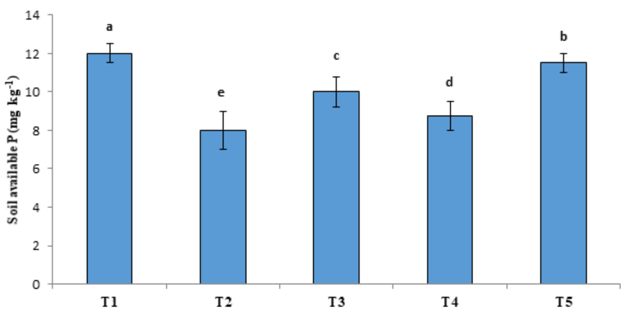

Figure 7. Impact of different P sources on soil available P (mg kg^{-1}) under field condition.

***Soil organic matter (%)*: ** Efficiency of various natural and inorganic sources of P on soil organic matter content maize was displayed in Figure 8. There was significant effect of synergistic use of organic manures (filter cake press mud) with local rock phosphate along with recommended doses of NK on soil organic matter content and proved superior to all other treatments in this regard. Minimum level of soil organic matter (0.72%) was recorded in T_1 (recommended NPK) which approached to the maximum level of 1.09% in T_5 where selected organic manures (filter cake press mud) was applied in combination with local rock phosphate and recommended dose of N + K. It was proved from the findings that all treatments receiving the addition of organic manure resulted in buildup of soil organic matter status.

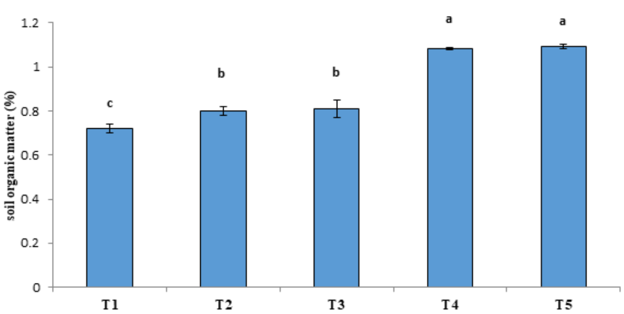

Figure 8. Impact of different P sources on soil organic matter (%) under field condition.

DISCUSSION

Contribution of different organic and inorganic nutritional sources of phosphorus (super phosphates, and organic phosphorus) on growth of maize plant, various yield contributing parameters (plant height, leaf area index, and relative growth rate etc.) and soil features (available P and organic matter) were evaluated in this field study. Effect of organic manure selected from previous studies on P solubilization from rock phosphate was also verified under field conditions. The effects of various sources of P were found significant in terms of enhancing growth and yield contributing parameters of maize as well as soil compared to control. Use of mineral fertilizer NPK as a source of P and organic amendment (FCP) proved statistically significant and superior to control. The high growth rate and large biomass production by maize necessitates the use of high amount of phosphorus (Mengel and Kirkby, 2001). According to Mani (2002), plant height as well as yield of maize significantly improved with application of every bit of NPK.

Chemical fertilizers are quick and readily available source of NPK and it can provide nutrient to the plants immediately. On the other hand organic manures required some time to decompose therefore; much longer time is required for the nutrient to become available to the plants. Therefore, use of chemical fertilizer is essential for promoting maize growth and for getting better yields. While, application of organic manure (FCP) is highly suggested to farmers in quest of enhancing maize yield (Wisdom *et al*., 2012).

The organic source amendments proved a successful way for the release of available P from water insoluble P source. The organic amendment selected from previous laboratory as well as pot studies was proved more bio-active source. The advantage of using organic amendment for such processes is the addition of organic matter in growth medium. Soil organic matter also affects nutrients availability. The buildup of organic matter to the soil due to added organic material contributed to the betterment of soil properties (Brady and Weil, 2005).

As the plant height increases, the higher will be the nutritional requirement of plant and higher will be the yield of plant. The results of impact of different P sources in combination with organic manure on plant height of maize proved that use of RPR along with selected organic manure and recommended NK resulted in significant increase in plant height compared with sole use of NK or combination of NK with RPR or NK with organic manure.

Boateng *et al*. (2006) suggested the use of organic amendments being high amount of NPK and other nutrients. In addition to provide nutrients, organic amendments also buildup soil organic matter status and ultimately improved various soil properties (Sabah *et al*., 2011; Dekissa *et al*., 2008). Organic amendments are responsible for continuous supply of essential nutrients to the plants on sustained basis which could be the reason behind enhanced yield. Many researchers reported the enhancement in yield of maize crop by the addition of organic manure (Akande *et al*., 1998; Ali *et* *al*., 2014; Sharif *et al*., 2011, Aziz *et al*., 2010;Adamu and Leye, 2012).

During this study organic amendment was used in various combinations in order to check its impact on organic matter percentage of growth medium. It was observed that addition of organic amendment either in combination with recommended NK or along with RPR and recommended NK proved superior in terms of enhancing organic matter content of growth medium. This increase in organic matter percentage was attributed to the addition of organic amendment since treatments without organic amendment had lower organic matter content than treatments receiving organic amendment. Findings of this study were in line with results of earlier workers like (Ali *et al*., 2014; Sharif *et al*., 2011; Sharif *et al*., 2013; Ibrahim *et al*., 2008; Akande *et al*., 2005; Hellal *et al*., 2013). Similarly, Sarwar *et al*. (2009), Sarwar *et al*. (2010), Wang *et al*. (2000) and Sarwar (2005) also reported the role of organic amendments on enhancing soil organic matter status.

***Conclusion*:** Application of organic amendments is responsible for continuous supply of essential nutrients to plants. Soil health features are also improved which contribute to enhanced growth and yield of maize. Addition of selected organic amendment (FCP) improves the growth of maize by enhancing organic C fraction in growth media. Selected organic manure addition substantially enhances the P availability in growth media by lowering the pH of growth media. Integrated use of RP-OA proved an effective tool to fulfill P nutrition demand of maize crop in comparison to chemical P fertilizers.

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