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Efficacy of Direct Application of Rock Phosphate Alone and in Combination with FYM and EM on Growth, Yield and Nutrient Uptake of Rice

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Abstract:

Field studies were carried out to investigate the effect of direct application of rock phosphate, FYM alone and in integration, along with EM on the growth, yield and yield related parameters of rice. The experiment was conducted at Rice research area, NARC, Islamabad for two successive years from 2010 to 2011. The experiment was laid in Randomized Complete Block Design (RCBD) with split plot arrangement. In the main plots, presence and absence of EM was compared. In sub plots, the treatments include T_0 = control without RP, FYM, T_1 = RP @ 150 kg P_2O_5 ha^{-1} alone, T_2 = FYM @ 5 t ha^{-1} alone and T_3 = RP @ 100 kg P_2O_5 ha^{-1} + FYM @ 5 t ha^{-1} (sub-plots). Results

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showed that direct application of rock phosphate @100 kg P_2O_5 along with FYM @ 5 t ha^{-1} and EM @ 50 L ha^{-1} significantly enhanced the growth and yield parameters of rice and also increased the nutrient (N, P, and K) uptake by the plants.

Key words: Rice, Rock Phosphate, FYM, EM and Paddy yield

Introduction

Rice (*Oryza sativa*) is an important cereal crop of the Pakistan due to its economic importance and food value. It is a major source of foreign exchange earnings and stands next to wheat as a staple food for millions of people in Pakistan. The rice crop is grown on 2.57 million hectares of land with a total production of 6.16 million tonnes and the average rice yield per hectare is 2396 kg ha^{-1} (GOP, 2012).

Phosphorus is the second major plant nutrient which plays a vital role in photosynthesis, respiration, energy storage and cell division/ enlargement. Further, it is significant in building up soil fertility, particularly under intensive agriculture. Rapid increase in the prices of commercial Phosphatic fertilizers has increased the cost of production. Recently, some non - conventional P fertilizers such as phosphate rocks (PR's) and partially acidulated phosphate rocks have been tested as potential alternative to conventional water – soluble P fertilizers (Pazhanivelan *et al*., 2006). Some reports indicated that the efficacy of fertilizer nutrient being increased when they are used in combination with organic manure (Deshpande *et al*., 1983) and (Sah & Mikkelsen, 1986). Manuring with FYM of Rock Phosphate enriched maintain higher levels of P in soil solution for a longer period than the fertilizer alone. It has been claimed that composting manures with PRs enhances the dissolution or rocks. Among the various factors responsible for low rice yields in the country, the use of

rock phosphate fertilizers need to be thoroughly studied to find out the best combination of P nutrients that should be both economical and adequate to enhance the productivity owing to the increase in traditional phosphatic fertilizers.

The concept of Effetive Microorganism (EM) was developed by Professor Teruo Higa, University of the Ryukyus, Okinawa, Japan (Higa & Wididana, 1991). EM contains selected species of microorganisms including predominant populations of lactic acid bacteria, yeasts, smaller numbers of photosynthetic bacteria, actinomycetes, fermentative fungi and other types of organisms. All of these are mutually compatible with one another and can coexist in liquid culture. EM may enhance the fermentation of organic materials and efficacy as a fertilizer. EM-bio-fertilizer improved soil properties such as organic matter content and total N, P, K in soil. Research has shown that the inoculation of EM cultures to the soil - plant ecosystem can improve soil health, growth and yield of crops. Karim *et al.,* 1993 concluded that EM used properly, can significantly improve the soil and crop growth and yield.

The efficiency of applied Rock Phosphate fertilizers with organic manures, can meet part of the nutrient needs of crops in a cropping system (Khalil *et al*., 2002). The organic and other bio sources of plant nutrients not only supply necessary nutrients but by positive interaction with chemical fertilizers they also increase their efficiency and thereby reduce environmental hazards (NFDC, 1988). Keeping this in view the above points, present investigation was undertaken to find the best combination of various amendments as well as EM inoculum for enhancing agronomic effectiveness of local rock phosphate.

Materials and Methods

A two year field experiment was conducted at Rice research area, NARC, Islamabad during kharif season 2010 and 2011.

Soil samples were collected from 0-30 cm depth before transplanting rice nursery and analyzed for physico-chemical characteristics (Table 1) according to the methods described by Ryan *et al*., 2001). The experiment was laid out using RCB design with Split Plot arrangements replicated thrice where EM was kept in main plots and RP/FYM in sub plots. Basmati-385 was used as test variety. The net plot size was 2.5 x 5 (12.5 m^{-2}) with 10 rows. The seed for raising seedlings was sown in 1st week of June and the seedlings were transplanted by trained manual laborers in the 2nd week of July. Row to Row and Plant to Plant distances were maintained at 20cm. A recommended doses of P_2O_5 as rock phosphate and FYM were applied at the time of final land preparation while nitrogen as Urea was applied in two equal splits. The EM (1:1:20, EM: Molasses: water) was applied @ 50 L ha^{-1} in six irrigations after each 15 days interval. All the agronomic operations except those under study were kept normal and uniform for all the treatments. The treatments included in the experiment were, T_0 = control without RP and FYM, T_1 = RP @ 150 kg P_2O_5 ha^{-1} alone, T_2 = FYM @ 5 t ha^{-1} alone and T_3 = RP @ 100 kg P_2O_5 ha^{-1} + FYM @ 5 t ha^{-1} (sub-plots) and E_0 = without EM and E_1 = With EM (main-plots).

Yield and yield related parameters i.e plant height (cm), productive tillers m^{-2}, number of grains $panicle^{-1}$, 1000-grain weight (gm), biomass (t ha^{-1}) and paddy yield (t ha^{-1}) were recorded at maturity and statistical analysis of 2 year average data was carried out using MSTATC statistical computer software. When significant F values were obtained then applying Least Significant Difference (LSD) test at 5% probability, compared the treatment means (Steel *et al*., 1997).

Table 1. Physico-Chemical Analysis of the Soil

Parameters	Unit	Value
pH		7.76
ECe (1:1)	dSm-1	0.62
OM	%	0.58
NO_3-N	mg Kg^{-1}	2.28
P	mg Kg^{-1}	3.44
K	mg Kg^{-1}	80
Sand	%	15.3
Silt	%	55.2
Clay	%	29.5
Texture Class		Silty Clay Loam

Results and Discussion

Effect of Rock phosphate and FYM alone and in combination with EM on growth attributes of rice

Application of rock phosphate and FYM alone and in combination with EM showed a significant difference amongst the treatments for growth parameters. Maximum days to 100% flowering were recorded in the plot without EM (76.54 days), while minimum days to flowering (73.75 days) where EM was applied @ 50 l ha^{-1} (Table 2). Similar results have been recorded by Muthaura *et al*., 2010 who studied that growth and yield of pigweeds may be improved by inoculating the plants with effective microorganisms and as a result reduce the use of fertilizers in production of this vegetable hence promoting sustainable agriculture. The longest duration to 100% flowering (80.50 days) was noted in the treatment where no RP and FYM was applied whereas minimum days to flowering (71.50 days) were taken by the treatment where RP @100 kg ha^{-1} + FYM @ 5 t ha^{-1} was applied. The Plant height of rice was non significantly amongst the treatments and their interaction. Number of tillers $plant^{-1}$ was significantly influenced by the application of EM. The highest number of tillers was recorded

(14.18) in plots where EM treated over those without EM treatment (11.78).

Table 2: Effect of sole Rock Phosphate, FYM and application with FYM and EM on different growth parameters of rice

Treatments	Days to 100% flowering	Plant height (cm)	Numbers of tillers Plant^{-1}	Number of tillers/m^2	Panicle length (cm)
EM (Main plot)					
E_0 (Without EM)	76.54 a	126.51	11.78 b	305.67 b	24.36 b
E_1 (With EM)	73.75 b	129.00	14.18 a	352.29 a	26.30 a
LSD	1.0905	NS	0.6749	30.713	0.7278
Rock Phosphate (Sub plot)					
T_0 (Control)	80.50 a	127.70	10.86 d	274.25 c	23.15 d
T_1 (P_2O_5 @ 150 kg/ha)	75.42 b	126.47	13.56 b	330.33 b	24.65 c
T_2(FYM@5t/ha)	73.42 c	128.77	12.44 c	336.08 b	26.00 b
T_3 (P_2O_5 @ 100 kg/ha+ FYM @ 5 t/ha)	71.50 d	128.07	15.07 a	375.25 a	27.53 a
LSD	0.8353	NS	0.6544	11.918	0.8320
Interaction	NS	NS	NS	NS	NS

Integrated nutrient management also significantly increased the number of tillers plant^{-1}. The maximum number of tillers plant^{-1} (15.07) was observed in T_3 (RP @100 kg ha^{-1} + FYM @ 5 t ha^{-1}). The minimum number of tillers plant^{-1} (10.86) was recorded in T_0 (control). These results are in accordance with the findings of Dixit and Gupta (2000) who claimed that with the use of different organic materials alone and in combination with mineral fertilizers, the number of tillers plant^{-1} of rice crop was positively affected and ultimately contributed towards increase in paddy yield. Tillers m^{-2} were also significantly affected by direct application of rock phosphate along with FYM and EM on rice. It is evident from data that the treatment with the use of EM produced significantly greater number of tillers m^{-2} (352.29) as compared to control (305.67). Kumar *et al*., 1999 were also in the same direction that phosphate-solubilizing

microorganisms had a significant effect on number of plants per meter. The rock phosphate fertilizer dose @100 kg P_2O_5 ha^{-1} + FYM @ 5 t ha^{-1} produced more tillers (375.25) as compared to other treatments. The minimum number of tillers (274.25) was produced in the control. Panicle length (cm) was affected significantly by direct application of rock phosphate along with FYM and EM of rice. Significantly longer panicles (26.30 cm) were found E_1 as compared to E_o (24.36 cm). Similarly, integrated RP nutrient management (T_3) also showed increased panicle length (27.53 cm) as compared to T_o where (23.15 cm) was recorded. The interactive effect of EM and RP remained statistically non-significant. Robin *et al.,* 2009 who concluded that the combination of organic and inorganic fertilizers could increase plant growth, yield, quality and soil fertility.

Effect of Rock phosphate and FYM alone and in combination with EM on Yield and yield components of rice

The data on effect of RP and FYM with and without EM showed significant influenced on the yield parameters of rice (Table 3). Number of grains $panicle^{-1}$ showed significant variation between soil incorporated rock phosphate in combination with FYM and EM. Maximum number of grains $panicle^{-1}$ (133.51) was produced from EM treated plot while minimum number of grains $panicle^{-1}$ (119.42) was observed in control where no EM was applied. The treatments of integrated RP nutrient management also significantly increased the number of grains $panicle^{-1}$. The maximum number of grains $panicle^{-1}$ (140.72) was recorded in T_3 (RP @100 kg ha^{-1} + FYM @ 5 t ha^{-1}). The interaction between EM and integrated RP nutrient management was found statistically highly significant ($P < 0.01$).

Table 3. Effect of direct Rock Phosphate application with FYM and EM on rice yield parameters

Treatments	Number of grains panicle^{-1}	1000-grain weight (g)	Days to maturity	Biological Yield (t ha^{-1})	Paddy yield (t ha^{-1})
EM (Main plot)					
E_0 (Without EM)	119.42 b	20.32	100.50 a	10.28 b	3.97 b
E_1 (With EM)	133.51 a	20.52	97.12 b	11.36 a	4.67 a
LSD	3.2965	NS	103535	0.4514	0.1764
Rock Phosphate (Sub plot)					
T_0 (Control)	106.55 d	18.66	103.75 a	8.94 c	3.32 c
T_1 (P_2O_5 @ 150 kg/ha)	125.15 c	20.63	100.67 b	10.72 b	4.40 b
T_2(FYM@5t/ha)	133.43 b	21.11	97.42 c	10.62 b	4.28 b
T_3 (P_2O_5 @ 100 kg/ha+ FYM @ 5 t/ha)	140.72 a	21.30	93.42 d	13.00 a	5.28 a
LSD	3.7518	NS	0.4917	1.0340	0.2934
Interaction	**	NS	NS	NS	NS

Interaction = Interaction between EM and PR along with FYM

Similar results have been found by Zhang *et al.* (1999) who reported that yield attributes (tiller numbers, grain number and 1000 grain weight) increased with the addition of P which ultimately improved the productivity of rice. 1000 grain weight was non significantly influenced by the application of EM along with RP, FYM. Biological yield of rice was significantly affected by direct application of rock phosphate in combination with FYM and EM. Significantly more biological yield was obtained from EM treated plot (11.36 t ha^{-1}), as compared to control which was recorded (10.28 t ha^{-1}). These results are in line with the findings of Chabot and Antoun (1996) who observed increase in biological yield of sorghum, maize and rice respectively. The treatment also showed significant effect on the biological yield of rice. Maximum biological yield (13.00 t ha^{-1}) was produced in T_3 plots. Minimum biomass (8.94 t ha^{-1}) was yielded in control (T_0) where no rock phosphate, FYM and EM was applied. The interaction between EM and integrated RP nutrient management was found statistically non-significant.

Our findings also agree with those of Swarup and Yaduvanshi (2000) who reported that different yield parameters including total biomass significantly increased with the use of organic and inorganic fertilizers.

Paddy yield was significantly increased by application different treatments. EM and RP application in conjunction with FYM resulted in more paddy yield (4.67 t ha^{-1}) than the control (3.97 t ha^{-1}). Similar findings have been reported in grain yield of wheat by the application of calcium superphosphate along with bacterial inoculation (Saad & Hammad, 1998). Among the integrated nutrient management treatments, T_3 (RP @100 kg ha^{-1} + FYM @ 5 t ha^{-1}) had significantly increased paddy yield and produced (5.28 t ha^{-1}) over control (3.32 t ha^{-1}). The interaction between EM and RP levels was found statistically non-significant. These results are in concurrence with Aziz *et al*., (2006) who revealed that agriculture productivity around the globe could be increased by efficient management of phosphorus because it is deficient on most of our soils due to its reaction with calcium to form insoluble compounds. Gill *et al*. (2004) also examined the similar findings that Pakistani soils, being calcareous, are generally deficient in P and this deficiency of phosphorus can reduce the yield of crops up to 10 - 15%.

The increase in yield with the direct application of rock phosphate fertilizer in combination with FYM and EM is credited to the increase in number of tillers m^{-2}, grains $panicle^{-1}$ and biological yield. These findings of Zaka *et al*. (2003) were also in the same direction that organic and inorganic fertilizers which significantly affected growth parameters and yield attributes that ultimately enhanced paddy yield.

Effect of Rock phosphate and FYM alone and in combination with EM on N, P and K uptake of rice

Significant variations were observed on the effect of rock phosphate application with FYM in the presence or absence of

EM on N, P and K uptake by paddy. The highest value of 37.58, 11.63 and 20.35 kg ha^{-1} N, P and K uptake respectively were found in the plots receiving EM over the control. While, the effect of rock phosphate with FYM showed that the highest values of N, P and K uptake were recorded when RP @100 kg ha^{-1} + FYM @ 5 t ha^{-1} was applied. The lowest P uptake was obtained where no RP and FYM was applied. The highest uptake of N, P and K with RP and FYM combination might be due to the increase in P solubility as a result of organic acids produced during organic matter decomposition.

Similar results were stated by Laskar *et al*. (1990) that the use of RP alone and in combination with organic manures significantly increases the P content in soils. Satyajit *et al*., 2003 showed that the application of phosphorus fertilizers increased the concentration and uptake of nutrients (N, P, K and S) in straw and grain of chick pea and the results also indicated that addition of FYM gave the highest concentration and uptake of these nutrients.

Table 4. Effect of direct Rock Phosphate application with FYM and EM on uptake of N, P and K (Kg ha^{-1}) in paddy

Treatments	N- Paddy Uptake	P- Paddy Uptake	K- Paddy Uptake
EM (Main plot)			
E_0 (Without EM)	30.24 b	9.32 b	16.68 b
E_1 (With EM)	37.58 a	11.63 a	20.35 a
LSD	1.6290	0.8926	0.5928
Rock Phosphate (Sub plot)			
T_0 (Control)	24.79 d	7.40 d	14.53 c
T_1 (P_2O_5 @ 150 kg/ha)	30.02 c	8.99 c	16.54 c
T_2(FYM@5t/ha)	36.70 b	11.33 b	18.99 b
T_3 (P_2O_5 @ 100 kg/ha+ FYM @ 5 t/ha)	44.13 a	14.19 a	24.01 a
LSD	4.0682	1.3492	2.2227

Conclusion

The overall results of the present investigations, lead us to the conclusion that there is a significant effect of direct application of rock phosphate fertilizer when applied in combination with soil incorporated FYM and EM on the growth, yield and yield components of rice. EM showed better results to solubilize higher amounts of P from RP and would be more beneficial for phosphate solubilizing activity and RP could be used with FYM and EM for P solubilization.

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