Research Article

Residual Effect of Rock Phosphate, Farmyard Manure and Effective Microorganisms on Nutrient Uptake and Yield of Wheat

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Abstract | Deficiency of Phosphorus (P) is a serious concern for agricultural productivity in more than 90% of Pakistan's soils. In addition to P deficiency, high pH level and soil carbonate contents further limit the utilization of P by plants. This research was conducted during wheat cropping season of year 2010 and 2011 and it consisted of determination of the residual effect of six treatments (T_0 = control without rock phosphate & farmyard manure, T_1= rock phosphate @150 kg P_2O_5 per hectare, T_2 = FYM @5 tons per hectare, T_3 = RP @100 kg P_2O_5 per hectare+ FYM @5 tons per hectare, E_0 = without effective microbes and E_1= EM-Biozote @ 50 l ha^{-1}) on yield parametrs of wheat crop planted after the harvest of rice. All yield parameters significantly increased by the treatments consisting of RP (100 kg) with FYM (5 t ha^{-1}) and EM @ 50 l ha^{-1}, which also enhanced the nutrient uptake of the crop. It can be concluded that accurate use of cheaper rock phosphate, farm yard manure and effective microbes proved as an alternative of costly fertilizers and sustaining the agricultural productivity. Residual effect of rock phosphate with additional use of farmyard manure with effective microorganisms would be a promising strategy for enhancing P use efficiency and productivity of wheat crop in eco friendly way.

Received | April 20, 2017; **Accepted** | May 22, 2017; **Published** | June 19, 2017
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Citation | Jalil, S., A. Hayat, A. Majeed, S.H. Abbas, M. Noman, M.I. Kasana and M.M. Hussain. 2017. Residual effect of rock phosphate, farmyard manure and effective microorganisms on nutrient uptake and yield of wheat. *Sarhad Journal of Agriculture,* 33(2): 282-287.
DOI | http://dx.doi.org/10.17582/journal.sja/2017/33.2.282.287
Keywords | Wheat, Rock phosphate, Nutrient uptake, Farmyard manure, Effective microbes

Introduction

Wheat (*Triticum aestivum L.*) is a chief source of food for a greater population of Pakistan. As the population increases with time, the requirement of wheat also increases progressively every year. About 9.04 million hectares of land is cultivated under this crop annually with total production of 25.29 million tons giving average yield of 2.797 tha^{-1} (PBS, 2014). The food security can be tackled with enhancing yield per hectare of wheat crop. The major hurdle to get high yield is not just the availability of balance nutrients to crop. Tranaviciene et al. (2007) stated that quantity of fertilizer applied to plants must be warily managed to make it certain that nutrients are available throughout the growing season. Saleem et al. (2008) observed that suitable nutrition can enhance crop yield by producing strong growth as reflected by increases in plant stature, biomass and economic output. However, if soil has sufficient quantities of essential nutrients, there may be no need to apply chemical fertilizers. Nitrogen & Phosphorus have considerable role in various metabolic activities of crop (Muhammad et al., 2013). Jalil et al. (2014) reported that composting manures enriched with RPs increased dissolution of rocks. Phospahte play key role in establishment of good root system and winter survival of wheat crop (Franzen, 2015). Singh and Amberger (1991) revealed that all organic materials (Farm Yard Manures and Humic Acid etc.) with

rock phosphate (RP) enhance the solubility of phosphorus from RP. The physical and chemical condition of soil improved through usage of organic fertilizers. It put significant impact regarding nutrient uptake of the crop which resulting in enhanced yield of crop. The naturally occurring beneficial microorganisms (Effective Microbes) increased the crop growth and yield by increasing microbial diversity in the field. These EM improve the physical properties of soil (Muhammad et al., 2014). The price hike in inorganic phosphorus fertilizers and their timely unavailability in market have worsened the situation. Therefore, to find out alternative phosphorus sources is dire need of the day to sustain crop productivity. Keeping this in view, the objective of this experiment was to find the effect of RP, FYM and EM on the yield and yield relating components of wheat.

Materials and Methods

The wheat crop was sown after harvesting of rice crop at research area of National Agricultural Research Centre, Islamabad during rabi season of year 2010 and 2011. The samples of soil were collected from depth of 0-30cm before sowing of wheat and analyzed Table 1 (Ryan et al., 2001). The experimental plots had pH 7.2 with low in organic matter, available nitrogen and phosphorus. The experiment was laid out in RCBD with three replications. The wheat cultivar NARC-2009 was used as test variety. Net plot size of 2.5m x 5m was maintained with row to row distance of 23 cm. Six treatments (T_0 = control without RP & FYM, T_1 = RP @150 kg P_2O_5 per hectare, T_2 = FYM @5 tons per hectare, T_3 = RP @100 kg P_2O_5 per hectare+ FYM @5 tons per hectare, E_0 = without EM and E_1 = EM-Biozote @50 l ha^{-1}) were detrmined for wheat yield.

Table 1: *Physico-Chemical Analysis of the Soil*

Parameters	Unit	Value
pH		7.2
ECe (1:1)	dSm^{-1}	0.25
OM	%	1.22
NO_3-N	mg kg^{-1}	3.45
P	mg kg^{-1}	6.28
K	mg kg^{-1}	108
Sand	%	15.3
Silt	%	55.2
Clay	%	29.5
Texture Class		Silty Clay Loam

Effective Microbes (EM) culture Biozote™ was obtained from Land Resources Research Institute, NARC, Islamabad, Pakistan. EM culture contained plant growth promoting rhizobacteria (PGPR), nitrogen fixers (NF) and phosphorus solubilizers (PS). Tap water was added for preparation of 0.2% solution of culture. This solution was utilized just after prepration. The respective plot of EM treatment was irrigated along with 0.2% dilute solution. This application was repeated with fortnightly intervals throughout the experiment period (Javaid, 2006).

Different parameters like plant height (cm), tillers per $meter^{-2}$, grains per spike, 1000-grains weight (g) and grain yield (tons per hectare) were recorded. Two year's average data was analyzed statistically and values were compared by LSD at 5% (Steel et al., 1997).

At harvest, grain samples were analyzed for NPK uptake. The plant N concentration was calculated by Kjeldahl Method (Jackson, 1958), P and K by Method 54a and 58a, respectively (US Salinity Lab. Staff, 1954). Total uptake of N/P/K was calculated separately by the following formula (Sharma et al., 2012):

$$\text{Uptake of N/P/K (kg/ha)} = \frac{\text{N\%P\%K\%} \times \text{dry matter } (\frac{kg}{ha})}{100}$$

Results and Discussion

Climatic conditions during the reported period (2010)

Figure 1 showed that total amount of rainfall received during the reported period was 951.2 mm. Maximum rainfall was received in the month of July, 2010 (418mm). The maximum temperature was observed in the month of June (37.5°C) while minimum temperature was reported in the month of November (8°C). Moreover, the highest average temperature was recorded in the month of July, 2010 (29.5°C).

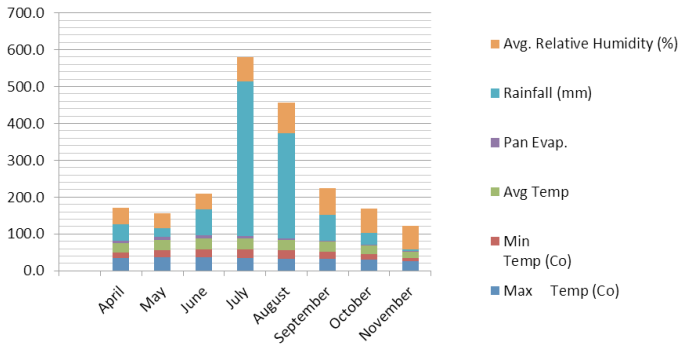

Figure 1: *Climatic conditions during 2010*

Table 2: *Residual effect of Rock Phosphate with FYM and EM on Wheat Crop*

Treatments	Number of tillers/m^2	Plant height (cm)	Grains Spike^{-1}	1000-grain weight (grams)	Biological yield (t/ha)	Yield (t/ha)
EM						
E_0 (Without EM)	244.04 b	84.46 b	42.55 b	37.49 b	9.29 b	3.45 b
E_1 (With EM)	269.50 a	90.04 a	45.95 a	40.03 a	12.50 a	4.30 a
LSD(5%)	8.3859	2.0204	0.7028	1.1162	0.0200	0.5622
Rock Phosphate						
T_0 (Control)	206.00 d	82.58 d	41.26 d	35.35 d	7.69 c	2.72 c
T_1 (P_2O_5 @ 150 kg/ha)	264.33 b	85.50 c	44.34 b	39.34 b	10.83 b	3.81 b
T_2(FYM@5t/ha)	240.42 c	87.83 b	42.91 c	37.98 c	11.16 b	3.99 b
T_3 (P_2O_5 @ 100 kg/ha+ FYM @ 5 t/ha)	316.33 a	93.08 a	48.51 a	42.35 a	13.91 a	4.98 a
LSD (5%)	10.410	1.8457	0.5687	0.7306	0.5114	0.3981
Interaction	NS	NS	NS	NS	NS	NS

Climatic conditions during the reported period (2011)

Figure 2 showed that total amount of rainfall received during the reported period was 850.8 mm. Maximum rainfall was received in the month of July 2011(308.8mm). when the maximum temperature was observed it was noted in the month of May (38.1 °C) while minimum temperature was reported during the month of November (9.7°C). Moreover, the highest average temperature was recorded in the month of June, 2011 (30.6°C).

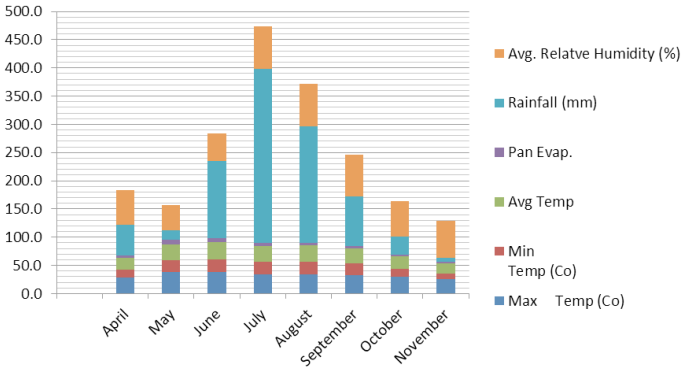

Figure 2: *Climatic conditions during 2011*

Plant height

Environmental changes affect the plant height of crop as well as plant height is also affected genetically. The residual effect of rock phosphate along with soil incorporated FYM and EM was showed significant variation in plant height (Table 2). The treatment of EM_1 produced tallest plants of (90.04 cm) height. The lowest value of Plant height (84.46 cm) was recorded in control treatment. Present results of the study coincided with the findings of Kumar et al. (1999), who observed that plant height of sorghum enhanced due to different microorganisms. Integrated nutrient management was significantly affected plant height. The maximum plant height (93.08 cm) observed in T_3 (RP @100 kg ha^{-1} + FYM @ 5 t ha^{-1}). The minimum plant height (82.58 cm) recorded in F_0 (control). The interaction between EM and RP showed non-significant differences. The findings of Mandal and Sinha (2004) were also in lined with these results, those recorded the maximum plant height of Brassica juncea crop in the treatments of receiving FYM in conjunction with inorganic fertilizers.

Number of tillers per m^2

The data indicated that tillers per m^{-2} were affected significantly by the residual effect of RP alone and along with FYM & EM on wheat crop. These results (Table 2) showed that use of effective microbes expressed significant impact for more number of tillers per m^{-2} (269.50) as compared with control treatment (244.04). Integrated nutrient management was significantly increased the number of tillers per m^2. The maximum no. of tillers per m^2 (316.33) recorded in F_3 (RP @100 kg ha^{-1} + FYM @ 5 tons per hectare). The min no. of tillers per m^2 (206) recorded in F_0 (control treatment). The interaction of EM and integrated plant nutrition levels was found statistically non-significant. These investigations agreed with the findings of Hussain et al. (1998), who reported that different organic materials with mineral fertilizers significantly increased the yield parameters.

Number of grains per spike (NGS)

The data (Table 2) expressed that nnumber of grains per spike had significant values due to the residual

effects of soil incorporated rock phosphate in combination with FYM and EM on wheat crop. The maximum number of grains per spike (48.51) was observed in T_3 (RP @100 kg ha^{-1} + FYM @ 5 t ha^{-1}). The minimum number of grains $spike^{-1}$ (41.26) was recorded in T_0 (control). The interaction between EM and integrated RP nutrient management was found statistically highly significant. These results corroborate thefindings of 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 wheat.

1000-Grains weight

The data indicated that effective microbes along integrated rock phosphate were significantly affected the 1000-grains weight. The integrated RP treatment T_3 (RP @100kg per hectare +FYM @ 5 tons per hectare) showed highest 1000-grains weight (42.35 g) while minimum 1000-grains weight (35.35 g) was recorded in control treatment. The interactive effect of EM and RP was found statistically non-significant. These results were completely in lined with results of Soniet al. (2004), who observed the cumulative effects of different organic sources i.e., FYM, biogas slurry (BGS) and phosphorus solubilizing bacteria (PSB) with rock phosphate on wheat.

Biological yield

Biological yield was significantly varied by residual rock phosphate in combination with FYM and EM. Significantly more biological yield was obtained from EM treated plot (12.50 tons per hectare), as compared to control which was recorded (9.29 tons per hectare). Khaliq et al. (2006) reported similar kind of findings, who recorded that application of organic matter and effective microorganisms along with NPK was resulted in the highest cotton yield, which was economically more viable than fertilizer application alone.

Integrated RP nutrient management was significantly enhanced the biological yield of wheat. Highest biological yield (13.91tons per hectare) was produced in T_3 plot where RP @ 100 kg P_2O_5 per hectare+ FYM @ 5 tons per hectare were applied. Minimum biomass (7.69 t ha^{-1}) was yielded in control (T_0). These findings were agreed with those of Swarup and Yaduvanshi (2000) who reported that different yield parameters including total biomass was significantly increased with the use of organic and inorganic fertilizers. The rate of organic matter for crop accumulation to the rate of photosynthesis and conservation of light energy into chemical energy by plants us called crop productivity (Reddy, 2004).

Grains yield

Grain yield showed significant results due to applying EM and RP along with FYM. The treated plot with EM resulted in more grain yield (4.30 tons per hectare) than that of control (3.45 tons per hectare). These results are concided with findings of Javaid (2006) who observed the crop yield enhanced by the application of effective microorganisms.

Among the integrated nutrient management treatments, T_3 (RP @100kg per hectare + FYM @ 5 tons per hectare) had significant impact on grain yield and produced 4.98 (tons per hectare) while minimum yield 2.72 (tons per hectare) was found in control treatment. The findings of Roy et al. (1997) are in lined with the results and found that rice yield was improved by usage of legume straw and Phospho-bacteria (*Bacillus polymyxa* and *Pseudomonas striata*) in slightly alkaline soils. Akande et al. (2003) also reported that yield of okra enhanced significantly by usage of rock phosphate, urea and poultry manure.

Table 3: *Residual effect of Rock Phosphate with FYM and EM on uptake of N, P and K*

Treatments	N- Grain Uptake	P- Grain Uptake	K- Grain Uptake
EM			
E_0 (Without EM)	95.89 b	6.10 b	13.09 b
E_1 (With EM)	125.93 a	8.67 a	17.37 a
LSD	19.41	1.73	2.85
Rock Phosphate			
T_0 (Control)	58.86 c	4.11 d	8.96 c
T_1 (P_2O_5 @ 150 kg/ha)	106.21 b	7.86 b	14.68 b
T_2(FYM@5t/ha)	115.99 b	6.73 c	15.51 b
T_3 (P_2O_5 @ 100 kg/ha+ FYM @ 5 t/ha)	162.57 a	10.85 a	21.76 a
LSD (5%)	12.85	0.81	1.66

Residual effect of Rock phosphate, FYM and EM on nutrient (N,P& K) uptake of Wheat

Data on the residual effect of rock phosphate application with FYM and EM showed significant variations on Nitrogen, Phosphorus and Potash uptake by wheat. The highest value of 125.93 kg, 8.67 kg and 17.37 kg per hectare Nitrogen (N), Phosphorus (P)

and Potassium (K) uptake respectively were recorded in the plots consisted EM as compared with control treatment (Table 3). Similar findings were reported by Manjaiah et al. (1996) who recorded that combination of MRP, organic amendments and P solubilizing microorganisms made N, P, K and S available as fertilizer. While, the application of rock phosphate in conjunction with FYM showed that the highest values of N, P and K uptake were recorded in the treatment which consisted RP @100 kg per hectare + FYM @ 5 tons per hectare. The lowest P uptake was obtained where RP and FYM were not applied. Results reported by Bagavathiammal and Mahimairaja (1999) showed that the rock phosphate along with organic manures helped in dissolution of rock phosphate and enhanced the availability of Phosphorus for plant.

Conclusion

Results of the trial depicted that rock phosphate in combination with farmyard manures and effective microbes applied to soil, significantly improved the wheat yield and yield attributes. Effective microbes showed better results to solubilize higher amounts of Phosphorus from Rock Phosphate and would be more beneficial for phosphate solubilizing activity. Moreover, the accurate use of cheaper RP and FYM with EM proved an alternative of costly fertilizer and also sustaining the agriculture productivity. Residual effect of rock phosphate with additional use of farmyard manure with effective microorganisms would be a promising strategy for enhancing Phosphorus use efficiency and productivity of wheat crop.

Authors Contribution

SJ planned the study and wrote the manuscript. AM wrote abstract and conclusion. SHA collected and described meteorological data and correct the manuscript grammatically. AH did physiochemical analysis of soil. MN and MIK assisted in field for data collection. MMH analysed the data.

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