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Response of Rock Phosphate Tailing and Phosphate Solubilizing Bacteria on Nutrient Content and Productivity of Wheat (*Triticum aestivum* L.)

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ABSTRACT: The present experiment on wheat (*Triticum aestivum* L.) was conducted during two consecutive *Rabi* season 2021-22 and 2022-23 at MPUAT, Udaipur, Rajasthan. The field research consisted of 9 treatments which are replicated thrice in a Randomized Block Design (RBD). Nowadays, farmers are trying to get maximum yield with better food quality, at the same time trying to minimize cost of production and to use ecofriendly technologies. There are many factors which influence the concentration of nutrients and among them climatic situation, soil types, nature of crops and amount of fertilizer are important. Hence, the present research is proposed with the objective to study the content of nitrogen, phosphorus and potassium in grain and straw of wheat. The results show of two year study indicated that application of SSP, rock phosphate tailing and seed treatment with PSB significantly increased the concentration of nutrients in grain and straw of wheat by providing different combination of phosphorus sources. The study revealed that application of 50% RDP through SSP + 50% RDP through RPT + PSB statically at par with 75% RDP through SSP + 25% RDP through RPT + PSB and significantly superior over 25% RDP through SSP + 75% RDP through RPT + PSB, 100% RDP through SSP + PSB, 100% RDP through SSP, 100% RDP through RPT + PSB, 125 RDP through RPT + PSB, 100% RDP through RPT and as well as control treatment. Therefore, 50% RDP through SSP + 50% RDP through RPT + PSB treatment is best combination for getting higher nutrient content in grain and straw and grain yield.

Keywords: SSP, RDP, rock phosphate tailing, PSB, Wheat.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop and known as “King of cereals”, which plays an important role in food and nutritional security. It ranked among the top three most produced cereals crops in the world, along with corn and rice. India contributes nearly 25 per cent to the total food grain production. In India, total area under wheat is 31.4 M ha, with production of 107.6 MT and the productivity 3.4 t/ha (Anonymous, 2021). In 21st century, there will be a need of approximately more than 250 MT of food grains to meet the demand of rapidly growing population. As no additional land is vacant for wheat production has to come through amplified yield per unit of production area. Increasing grain yield of wheat is an important national goal to face the continuous increasing food demand of India. Phosphorus (P) is a major element and performs vital functions for sustenance, growth and development of plants. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next. In soil, occurs in organic as well as inorganic form which exits in different phases and in equilibrium (Ahemad *et al.*, 2009). According to Cordell *et al.*

(2013) phosphorus underpins the world's food system by ensuring soil fertility, maximizing crop yields, supporting farmer livelihoods and ultimately food security.

Phosphate rock is an important mineral resource with numerous uses and application in agriculture and the environment. Based on estimates of current PR reserves, studies indicate that a depletion of global reserves is not likely to occur within this century (Heckenmuller *et al*., 2014). PR also contains a number of essential element required for plant nutrition including macro (P, Ca and Mg) and micro (Mn, Mo, B, Fe, Cu and Zn) nutrients. It's generally must be treated to convert the mineral phosphate to water soluble or plant available forms as P fertilizer. Phosphate tailings have significant risk to the environment as point sources of basic, carbonate-rich effluents. These dolomitic tailing along with rock phosphate can be potentially useful in agriculture (Babel *et al.*, 2014). Jhamarkotra rock phosphate is the premier source of phosphate in India and a unique Precambrian stromatolite phosphate deposit that has attracted attention of the entire world. It is being mined by opencast mining that handles nearly 20 million tonns of rock annually and beneficiates ~3000 tons of ore per day. The more than 30% P_2O_5 ore ground and marketed as such to the fertilizer industry, but bulk of the low grade ore-18-20 % P_2O_5, is upgraded by forth floatation method to 32-34% P_2O_5 and marketed as beneficiated RP. A substantial amount of ~14 % P_2O_5 ore is stacked at mines as waste (Ranawat *et al*., 2010).

Such phosphate-solubilizing microorganism converts the unavailable forms of P into one that is easily assimilated by plants and promotes the growth of plants leading to more yield. Phosphate-solubilizing bacteria play a vital role in P solubilization by producing organic acids (Panhwar *et al.*, 2013). There are various factors which influence the concentration nutrients and among them climatic conditions, soil types, nature of crops and amount of fertilizers are important. Hence, the present investigation is proposed with the objective to evaluate the effect of various sources of P on nutrient content and productivity of irrigated wheat.

MATERIAL AND METHODS

Experimental Site and Soil. The field experiments were conducted for two years on a same site during *Rabi* season 2021-22 and 2022-23 under irrigated condition. The experimental field was located in Sub-humid Southern Plain and Aravalli Hills) of Rajasthan and is situated at 24°35' North latitude, 74°42' East longitude and at an altitude of 581.16 m above mean sea level (MSL). The mean monthly maximum temperatures of 40ºC and 37.5ºC were recorded in April and minimum temperatures of 3.3ºC and 3.1ºC were recorded in January, respectively during 2021-22 and 2022-23. The experimental soil was clay loam in texture and slight alkaline in reaction.

Experimental design and treatments. The experimental field was laid out in randomized block design with nine treatments replicated thrice at Instructional farm, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan. The treatments consisting of various nutrient combination *viz*., 50% RDP through SSP + 50% RDP through RPT + PSB (T_5), 75% RDP through SSP + 25% RDP through RPT + PSB (T_4), 25% RDP through SSP + 75% RDP through RPT + PSB (T_6), 100% RDP through SSP + PSB (T_3), 100% RDP through SSP (T_2), 100% RDP through RPT + PSB (T_7), 125 RDP through RPT + PSB (T_8), 100% RDP through RPT (T_9) and control (T_1). The phosphorus was applied as per treatment recommendation through single super phosphate and rock phosphate tailing and seed treatment with PSB. Other nutrients like N and K were applied in the form of urea and MOP, respectively.

Plant analysis. The plant samples were collected at harvest of the wheat crop. The plant samples were shade dried for 2 to 3 days and then oven dried at 65ºC for 12 hours followed by grinding in Willey mill. The powdered plant samples were stored in butter paper bags for the estimation of nutrients.

RESULTS AND DISCUSSION

A. Grain yield

The data in respect to grain yield presented in fig. 1 show that the application of treatment T_5 (50% RDP through SSP + 50% RDP through RPT + PSB) was significantly increased the grain yield of wheat. The treatment T_5 (50% RDP through SSP + 50% RDP through RPT + PSB) statically at par with T_4 (75% RDP through SSP + 25% RDP through RPT + PSB) and these treatment superior over T_6 (25% RDP through SSP + 75% RDP through RPT + PSB), T_3 (100% RDP through SSP + PSB), T_2 (100% RDP through SSP), T_7 (100% RDP through RPT + PSB), T_8 (125% RDP through RPT + PSB), T_9 (100% RDP through RPT) as well as T_1 (control). The percentage increased due application of 50% RDP through SSP + 50% RDP through RPT + PSB, 75% RDP through SSP + 25% RDP through RPT + PSB and 25% RDP through SSP + 75% RDP through RPT + PSB was 32.12, 28.30 and 20.70 over control, respectively. The crop production affected due to applied P from fertilizer gets fixed to plant unavailable forms. On the other hand, inoculation of PSB resulted in continuous solubilization of P from RP tailing and soil-fixed-P, simultaneously PSB also inhibited P-fixation. Thus, P availability increased to the crops compared to alone SSP. Similar results was reported by Ghosal *et al*. (2013) and Roy *et al.* (2018). The positive effect of PSB inoculation could be attributed to relatively less precipitation of the applied soluble P an due to solubilization of indigenous insoluble P fraction (Saleem *et al.* 2013; Mali *et al.* 2018; Biswas *et al*. 2022).

B. NPK content in grain

Result of two year pooled data presented in (Table 2 & 3) that the maximum nitrogen, phosphorus and potassium content in seed was recorded under treatment T_5 (50% RDP through SSP + 50% RDP through RPT + PSB) but its effect was found at par with treatment T_4 (75% RDP through SSP + 25% RDP through RPT + PSB). This was related to the increase in the availability of these nutrients in soil due to the combined application of SSP, rock phosphate tailing and seed inoculation through PSB both organic and inorganic sources of nutrients and also conversion of unavailable form of phosphorus into available forms during crop growth period. In current study, inoculation of PSB resulted in enhance the root shoot ratio because optimum supply of nutrients and P-solubilization bacteria excrete hormones that induce longer root growth, which lead to increased nutrient content in grain (Saxena *et al.* 2013 and Saxena *et al.* 2015, Sonadi *et al*., 2023). Application of phosphorus through Rock phosphate tailing + SSP and seed treatment with PSB increased the availability of nitrogen, phosphorus and potassium to plants and increase the P solubility in soil. It also enhances the production of growth promoting hormones. This also resulted in balance utilization of other nutrients like phosphorus by plants.

C. NPK content in straw

The perusal of data depicted in Table 2 & 3 revealed that application of T_5 (50% RDP through SSP + 50% RDP through RPT + PSB) was significantly increased the NPK content in straw followed by T_4 (75% RDP through SSP + 25% RDP through RPT + PSB), T_6 (25% RDP through SSP + 75% RDP through RPT + PSB), T_3 (100% RDP through SSP + PSB), T_2 (100% RDP through SSP), T_7 (100% RDP through RPT + PSB), T_8 (125% RDP through RPT + PSB), T_9 (100% RDP through RPT) as well as T_1 (control). It also observed that treatment (50% RDP through SSP + 50% RDP through RPT + PSB) significantly at with T_4. Application of phosphorus fertilizer improve the P availability to crop (Adnan *et al*. 2022).

Table 1: Effect of rock phosphate tailing and PSB on nitrogen and phosphorus content in grain and straw of wheat.

Treatments	Nitrogen content (%)						Phosphorus (%)					
	Grain			Straw			Grain			Straw		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Control (T_1)	1.220	1.224	1.222	0.496	0.502	0.499	0.249	0.250	0.250	0.122	0.124	0.123
100% RDP through SSP (T_2)	1.296	1.299	1.297	0.535	0.536	0.535	0.271	0.272	0.271	0.137	0.139	0.138
100% RDP through SSP+ PSB (T_3)	1.303	1.310	1.307	0.538	0.541	0.540	0.277	0.278	0.278	0.145	0.148	0.146
75% RDP through SSP + 25% RDP through RPT+PSB (T_4)	1.369	1.371	1.370	0.568	0.569	0.569	0.294	0.296	0.295	0.157	0.165	0.161
50% RDP through SSP + 50% RDP through RPT + PSB (T_5)	1.372	1.392	1.382	0.569	0.578	0.574	0.298	0.301	0.300	0.170	0.176	0.173
25% RDP through SSP+ 75% RDP through RPT + PSB (T_6)	1.330	1.337	1.334	0.550	0.553	0.552	0.278	0.279	0.279	0.145	0.148	0.147
100% RDP through RPT+PSB (T_7)	1.303	1.311	1.307	0.538	0.542	0.540	0.276	0.276	0.276	0.143	0.145	0.144
125% RDP through RPT + PSB (T_8)	1.291	1.307	1.299	0.533	0.540	0.536	0.275	0.277	0.276	0.142	0.143	0.142
100% RDP through RPT (T_9)	1.270	1.282	1.276	0.523	0.528	0.526	0.265	0.269	0.267	0.129	0.137	0.133
SEm ±	0.012	0.017	0.011	0.005	0.008	0.005	0.005	0.004	0.003	0.006	0.009	0.006
CD (P=0.05)	0.037	0.051	0.030	0.016	0.023	0.013	0.016	0.013	0.010	0.019	0.027	0.016

Table 2: Effect of rock phosphate tailing and PSB on potassium content in grain and straw of wheat.

Treatments	Grain			Straw		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Control (T_1)	0.424	0.425	0.424	1.214	1.228	1.221
100% RDP through SSP (T_2)	0.477	0.489	0.483	1.271	1.272	1.271
100% RDP through SSP+ PSB (T_3)	0.489	0.497	0.493	1.284	1.286	1.285
75% RDP through SSP + 25% RDP through RPT+PSB (T_4)	0.523	0.525	0.524	1.317	1.324	1.321
50% RDP through SSP + 50% RDP through RPT + PSB (T_5)	0.531	0.536	0.533	1.326	1.327	1.326
25% RDP through SSP+ 75% RDP through RPT + PSB (T_6)	0.489	0.501	0.495	1.285	1.291	1.288
100% RDP through RPT+PSB (T_7)	0.486	0.487	0.487	1.280	1.282	1.281
125% RDP through RPT + PSB (T_8)	0.483	0.488	0.485	1.274	1.283	1.279
100% RDP through RPT (T_9)	0.463	0.466	0.465	1.259	1.268	1.263
SEm ±	0.010	0.013	0.008	0.012	0.010	0.008
CD (P=0.05)	0.030	0.038	0.023	0.035	0.030	0.022

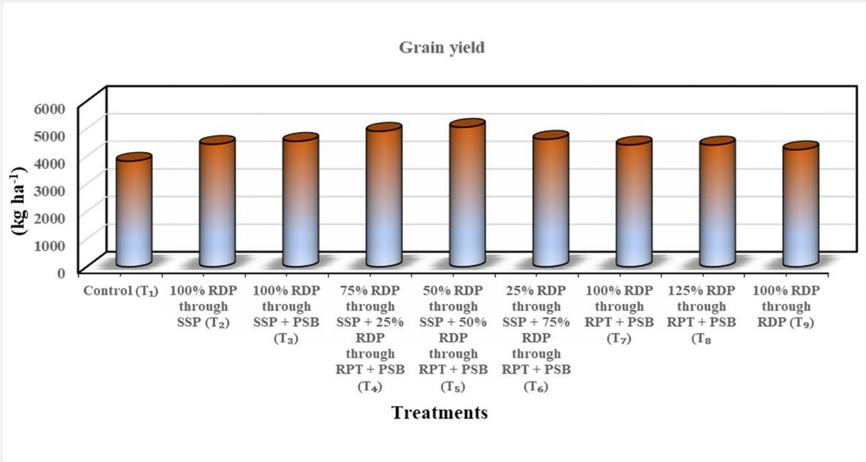

Fig. 1. Effect of rock phosphate tailing and PSB on grain yield of wheat.

CONCLUSION

Application of phosphorus fertilizer through single super phosphate, rock phosphate tailing and seed inoculation with PSB in combination of 50% RDP through SSP + 50% RDP through RPT + PSB (T_5) significantly increased the nutrient content and grain yield of wheat when compared to other treatments such as T_4 (75% RDP through SSP + 25% RDP through RPT + PSB), T_6 (25% RDP through SSP + 75% RDP through RPT + PSB), T_3 (100% RDP through SSP + PSB), T_2 (100% RDP through SSP), T_7 (100% RDP through RPT + PSB), T_8 (125% RDP through RPT + PSB), T_9 (100% RDP through RPT) and T_1 (control).

FUTURE SCOPE

On the basis of present investigation application of phosphorus through rock phosphate tailing, SSP and seed inoculation with PSB reduce the cost of fertilizer and also significant risk to environment from fertilizers. It is enhancing the soil phosphorus availability.

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