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Response of Wheat (*Triticum aestivum)* to Phosphate and Potash Solubilizing Bacteria on Calcareous Clayey Soil

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ABSTRACT

A field experiment was conducted on calcareous clayey soil at Junagadh (Gujarat) during rabiseason of 2014-15 to study the effect of phosphate and potash solubilizing bacterial inoculationson growth and yield of wheat. The experimental results revealed that application of 45 kg P_2O_5/ha + phosphate solubilizing bacteria (PSB) seed inoculation + PSB soil application, being statistically at par with application of 45 kg P_2O_5 + PSB seed inoculation, significantly promoted dry matter per plant, effective tillers, grains/spike and 1000-seed weight, and ultimately gave higher grain yield (40.1q/ha) and straw yield (60.2q/ha) with higher net return (`45256/ha) andB:C (2.10) over the control. Significantly higher values of growth and yield attributes viz., dry matter per plant, effective tillers and test weight were registered with application of 45 kg K_2O/ha + potash solubilizing bacteria (KSB) seed inoculation + KSB soil application remained at par with application of 45 kg K_2O/ha + KSB seed inoculation, resultantly gave higher grain and straw yield of 40.8 and 60.8q/ha, respectively along with higher net return (`46946/ha) and B:C (2.15) over the control. The results clearly indicated that PSB and KSB inoculation saved 25% P and K fertilizers.

Key words: *Wheat, phosphate solubilizing bacteria (PSB), potash solubilizing bacteria (KSB), economics*

INTRODUCTION

Wheat is a crop of global significance. It is grown in diversified environments. It is a staple food of millions of people. Wheat is the second most important crop in India next to rice. The fertilizer is essential as well as expensive input in agricultural production. Fertilizer plays a leading role in increasing crop production by almost 41% of the agronomic factors known to augment wheat yield[5]. There is a correlation between fertilizer use and agricultural production, its effect being manifested quickly on the plant growth and ultimately on crop yields. Phosphorus is the second important key element after nitrogen as a mineral nutrient in terms of quantitative plant requirement.

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To fulfill crop nutritional requirements, P is usually added to soil as synthetic P fertilizer, however synthesis of chemical P fertilizer is highly energy consuming processes, and has long term impacts on the environment in terms of eutrophication, soil fertility depletion and carbon footprint. Moreover, plants can use only a small amount of this P since 75–90% of added P is precipitated by metal-cation complexes, and rapidly becomes fixed in soils. Such environmental concerns have led to the search for sustainable way of P nutrition of crops.In this regards phosphate-solubilizing micro-organisms (PSM) have been seen as best eco-friendly means for P nutrition.PSMs solubilize insoluble form of phosphates by acidification, chelation and exchange reactions and also by production of organic acids. This process not only compensates for higher cost of manufacturing fertilizers in industry, it also mobilizes the fertilizers applied to the soil reported by Sharma *et al* [15]. Biological systems are therefore preferred over chemical fertilizers, as they are not only eco-friendly and economical in approach, but also involved in improving the soil quality and maintenance of natural flora.Next to nitrogen and phosphorus, potassium is the third important plant nutrient. Potassium is essential macronutrient for plant growth and plays significant roles in activation of several metabolic processes. Potassium though present as abundant element in soil or is applied to fields as natural or synthetic fertilizers, only one to two per cent of this is available to plants, the rest being bound with other minerals and therefore unavailable to plants. The most common soil components of potassium, 90 to 98%, are feldspar and mica[3].Soil micro-organisms influence the availability of soil minerals, playing a central role in ion cycling and soil fertility revealed by Bin *et al*[3]. At Coimbatore (Tamil Nadu) *Frateuria aurantia* belonging to the family Pseudomonaceae obtained from the agricultural soils was found to solubilize K considerably and promoted the crop yield have been reported by Ramarethinam and Chandra[11]. This solubilization effect is generally due to the production of certain organic acids and enzymes by potash solubilizing bacteria (KSB). So, bacterial inoculation to solubilize phosphate and potash seem very important and essential to be studied for wheat crop.

MATERIALS AND METHODS

In view of the above facts, a field experiment was conducted on a clayey soil at Department of Agronomy, College of Agriculture, Junagadh Agricultural University,Junagadh (Gujarat) in *rabi* season of 2014-15 to study the effect of phosphate and potash solubilizing bacterial inoculations on growth and yield of wheat. The experimental soil was medium black calcareous clayey and slightly alkaline in reaction with pH 7.9 and EC 0.33 dS/m, medium in available nitrogen (254-269 kg/ha), available phosphorus (28.4-30.7 kg/ha) and available potash (183-185 kg/ha). The mean maximum and minimum temperature during the crop growth and development period (47^{th} to 8^{th} std. week) ranged between 27.4 to 35.6˚C and 9.5 to 17.2˚C, respectively. The other weather parameters *viz*., average relative humidity (43.0-63.0%), wind speed (1.6-5.9 km/h), bright sun shine (6.9-9.5 h) and daily evaporation (3.5-6.2 mm) were more or less congenial for growth and development of wheat. The experiment comprise of 16 treatment combinations consisting of four levels of PSB (P_0: Control, P_1: 60 kg P_2O_5/ha, P_2: 45 kg P_2O_5/ha + PSB seed inoculation, P_3: 45 kg P_2O_5/ha + PSB seed inoculation + PSB soil application) and four levels of KSB (K_0: Control, K_1: 60 kg K_2O/ha, K_2: 45 kg K_2O/ha + KSB seed inoculation, K_3: 45 kg K_2O/ha + KSB seed inoculation + KSB soil application). These treatments were replicated thrice in a randomized block design. The wheat variety 'GW 496' was sown on November 20, 2014 at row spacing of 22.5 cm using seed rate of 120 kg/ha. The gross and net plot size was 5.0 m x 2.7 m and 4.0 m x 1.8 m, respectively. Dose of nitrogen *i.e.*120 kg N/ha in two equal splits at sowing and 25 DAS was applied uniformly to all the plots. Entire dose of phosphorus and potash as per treatments was applied in form of diammonium phosphate and muriate of potash, respectively at sowing. Liquid formulation of PSB (*Bacillus coagulans*) and

KSB (*Frateuria aurantia*) were used for seed treatment as well as for soil application. For seed treatment, seeds were spreaded and PSB/KSB culture (10^8 viable cells/g) @ 30 mL/kg of seed was sprinkled on the seeds and then dried in shade. For soil application, PSB/KSB culture (10^8 viable cells/g) @ 3000 mL/ha was applied in furrows just after sowing before irrigation. Thecrop was raised as per the recommended package of practices.The expenses incurred for all the cultivation operations from preparatory tillage to harvesting including the cost ofinputs *viz*., seeds, PSB, KSB, fertilizers, irrigation, pesticides, *etc*. applied to each treatment was calculated on the basis of prevailing local charges. The gross realization in terms of rupees per hectare was worked out taking into consideration the grain and straw yields from each treatment and local market prices. Net return of each treatment was calculated by subtracting the total cost of cultivation from the gross returns. The benefit:cost ratio (B:C) was computed by dividing gross return with cost of cultivation.

RESULTS AND DISCUSSION

PSB

The results revealed that different treatments of PSB manifested significant influence ongrowth and yield of wheat (Table 1). Application of 45 kg P_2O_5/ha + PSB seed inoculation + PSB soil application(P_3), being statistically at par with applicationof 45 kg P_2O_5/ha + PSB seed inoculation (P_2), significantly enhanced growth and yield attributes *viz*., dry matter per plant, number of effective tillers, number of grains/spike and 1000-grain weight, and ultimately increased grainyield by 20.18 and 15.44% and straw yield by 20.54 and16.88%, respectively over the control(P_0). Various levels of PSB did not influence the grain protein content. Application of 45 kg P_2O_5/ha + PSB seed inoculation + PSB soil application(P_3) accrued higher net returns (`45256/ha) and B:C (2.10), followed by application of 45 kg $P_2O_5$/ha + PSB seed inoculation ($P_2$),having net returns of` 42348/ha and B:C of 2.05 (Table1). The improvement in growth and yield parameters with application of 45 kg P_2O_5/ha + PSB seed inoculation + PSB soil application (P_3) and 45 kg P_2O_5/ha + PSB seed inoculation (P_2) might have been attributed to the production of higher quantities of growth promoting substances and complementary effect of enhanced phosphate availability for their utilization by plants as judged from phosphorus content in grain and straw. The results are in conformity with those reported by Kushare[7], Banerjee[1], Davari[4] and Saxena[12].

KSB

Potassium fertilization did influence growth and yield of wheat (Table 1). Significantly higher values of growth and yield attributes *viz*., dry matter per plant, number of effective tillers and 1000-grain weight were registered with application of 45 kg K_2O/ha + KSB seed inoculation +

KSB soil application (K_3), which remained statistically at par with application of 45 kg K_2O/ha + KSB seed inoculation(K_2), and significantly increased grain yield by 20.99 and 13.08% and straw yield by 18.81 and 13.08%, respectively over the control (K_0). KSB treatments have non-significant effect on number of grains/spike and grain protein content. Application of 45 kg K_2O/ha + KSB seed inoculation + KSB soil application(K_3) gave higher net returns (`46946/ha) and B:C (2.15), closely followed by application of 45 kg $K_2O$/ha + KSB seed inoculation($K_2$) with net returns of `41771/ha and B:C of 2.03. The response of KSB may be attributed to solubilization of K from soil because of secretion of organic acids by the bacterial strains, thereby enhanced plant growth. Notably K also played an important role in the synthesis of chlorophyll by taking part in various enzyme activities Senthurpandian[13] Since K is found to influence the total chlorophyll and carotenoid contents of the leaves it may also directly and/or indirectly improved crop yield through increased photosynthesis. Similar observations were also recorded by Panwar[12], Mikhailouskaya[8], Basak and Biswas[2] and Min[10]

Interaction between treatments of PSB and KSB was found non-significant for all the characters under study.

Table 1: Growth, yield, quality and economics of wheat under different treatments of PSB and KSB

Treatment	Dry matter/ plant (g)	Effective tillers/m row length	Grains/ spike	1000-grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Grain protein content (%)	Net returns (`/ha)	B:C
PSB									
P_0 : Control	19.7	57.8	26.4	41.8	33.3	49.9	10.8	33988	1.90
P_1 : 60 kg P_2O_5/ha	22.4	61.3	27.6	43.5	36.5	57.6	11.0	37778	1.92
P_2 : 45 kg P_2O_5/ha + PSB seed inoculation	23.9	62.4	28.8	43.4	38.5	58.4	11.2	42348	2.05
P_3 : 45 kg P_2O_5/ha + PSB seed inoculation + PSB soil application	25.3	66.4	29.9	44.5	40.1	60.2	11.2	45256	2.10
S.Em.±	0.5	1.5	0.8	0.5	1.1	1.9	0.2	2291	0.06
CD (P=0.05)	1.5	4.2	2.3	1.5	3.3	5.4	NS	6618	0.16
KSB									
K_0 : Control	20.2	57.3	26.9	41.8	33.7	51.2	10.7	34042	1.88
K_1 : 60 kg K_2O/ha	22.8	60.6	28.1	43.5	35.8	56.3	11.1	36612	1.90
K_2 : 45 kg K_2O/ha + KSB seed inoculation	23.9	64.3	28.3	43.7	38.1	57.8	11.2	41771	2.03
K_3 : 45 kg K_2O/ha + KSB seed inoculation + KSB soil application	24.5	65.8	29.5	44.2	40.8	60.8	11.3	46946	2.15
S.Em.±	0.5	1.5	0.8	0.5	1.1	1.9	0.2	2291	0.06
CD (P=0.05)	1.5	4.2	NS	1.0	3.3	5.4	NS	6618	0.16

CONCLUSION

Seed inoculation with PSB and KSB each @ 30 mL/kg seeds well as PSB and KSB @ 3000 mL/ha soil application each gave higher production and net returns from irrigated wheat (var. GW-366) along with saving of 25% P and K fertilizers on clayey soil having medium status of available N, P and K under South Saurashtra Agro-climatic Zone of Gujarat.

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