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Influence of phosphorus and Biofertilizers on nutrient content and uptake by Mung bean [*Vigna radiata* (L.) wilczek]

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Abstract
A field experiment was conducted during *kharif* season of 2015 at the Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) which consisted of four levels of phosphorus (Control, 20, 40 and 60 kg P_2O_5 ha^{-1}) and four levels of biofertilizers (Control, PSB, *Aspergillus awamori* and PSB+*Aspergillus awamori*) thereby, making sixteen treatment combinations and replicated thrice. Results indicated that N, P_2O_5 and K_2O content in grain and straw and their uptake after harvest were observed significantly maximum upto 40 kg P_2O_5 ha^{-1} level of phosphate application over control. Results further indicated that seed inoculation with the PSB and *Aspergillus awamori* significantly increased N, P_2O_5 and K_2O content in grain and straw and their uptake after harvest over the rest of the treatments. The protein content was increased significantly with 40 kg P_2O_5 ha^{-1} level of phosphate application and seed inoculation with PSB and *Aspergillus awamori* over control

Keywords: Phosphorus, Nutrient content, Uptake, Protein content

Introduction

Pulses are important source of dietary protein and have unique ability of maintaining and restoring soil fertility through biological nitrogen fixation as well as addition of ample amount of residues to the soil. Pulse crops leave behind reasonable quantity of nitrogen in soil to the extent of 30 kg ha^{-1}. Mungbean [*Vigna radiata* (L.) Wilczek] is one of the important pulse crop grown in arid and semi-arid regions in India. It is a short duration pulse crop which can be grown as catch crop during kharif and rabi seasons.

Phosphorus is an important nutrient next to nitrogen. At present 5% of the Indian soils have adequate available P, 49.3% are under low category, 48.8% under medium and 1.9% under high category (Pattanyak *et al.*, 2009) [7]. Only 25% to 30% of the applied P is available to crops and remaining P is converted into insoluble P (Sharma and Khurana, 1997) [12]. Its deficiency is the most important single factor, which is responsible for poor yield of mungbean on all types of soil. It is indispensable constituent of nucleic acids, ADP and ATP. It has beneficial effects on nodule stimulation, root development and growth and also hastens maturity as well as improves quality of crop produce. Thus, the response of P to legumes is more important than N as later is being fixed by symbiosis with *Rhizobium* bacteria.

Biofertilizers, a component of integrated nutrient management and are considered to be cost effective, eco-friendly and renewable source of non-bulky, low cost plant nutrient supplementing fertilizers in sustainable agriculture system in India. Therefore, the role of biofertilizers assumes a special significance in present context of very high costs of chemical fertilizers. The seed of pulses are inoculated with *Phosphorus solublizers* with an objective of increasing their number in the rhizosphere and substantial increase in the P availability for the plant growth.

Phosphorus solubilizing microorganisms (bacteria and fungi) enable P to become available for plant uptake after solubilization. Several soil bacteria, particularly those belonging to the genera *Bacillus* and *Pseudomonas*, and fungi belonging to the genera *Aspergillus* and *Penicillium* possess the ability to bring insoluble phosphates in soil into soluble forms by secreting organic acids such as formic, acetic, propionic, lactic, glycolic, fumaric, and succinic acids. These acids lower the pH and bring about the dissolution of bound forms of phosphates. Some of the hydroxyl acids may chelate with calcium and iron resulting in effective solubilisation and utilization of phosphates. The phosphate solubilizing microorganisms improved phosphorus uptake over control with and without chemical fertilizers. There is lack of information on the use of PSM for mungbean under semi-arid region of Rajasthan. Thus, looking towards increasing need of use of biofertilizers with phosphatic fertilizers for optimizing crop yield, maintenance of soil fertility at sustainable level of production, the present have been undertaken.

Material and Methods

A field experiment was conducted during *kharif* season of 2015 at the Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) in randomized block design with four replications. The soil was loamy sand in texture, alkaline in reaction (pH 8.2), low in organic carbon (1.9 g kg^{-1}), available nitrogen (130.10 kg ha^{-1}), available phosphorus (15.87 kg ha^{-1}) and medium in available potassium (140.02 kg ha^{-1}) content. The experiment consisted sixteen treatment combinations by taking four levels of phosphorus (Control, 20, 40 and 60 kg P_2O_5 ha^{-1}) and four treatments of biofertilizers (Control, PSB, *Aspergillus awamori* and PSB + *Aspergillus awamori*). The mungbean seed (var. RMG-492) was sown on 18th July, 2015 using seed rate 20 kg/ha with a row spacing of 30 cm. The crop was harvested on 8th October, 2015.

As per treatments, seed was inoculated with PSB, *Aspergillus awamori* and PSB + *Aspergillus awamori* before sowing using standard method and dried shade (Paul *et* al. 1971) [8]. Thinning was carried out at 10-20 DAS. A uniform basal dose of 25 kg N ha^{-1} was applied through DAP and urea to the soil. Urea was used to make up the quantity of N to 25 kg ha^{-1} in addition to N supplied through DAP. However, in control plots whole N was applied only through urea. The phosphorus was applied through DAP as per the treatment details. For estimation of nitrogen, phosphorus, potassium content, representative samples of grain and straw were taken at the time of threshing. Each dried straw sample was ground to a fine powder in Wiley Mill for estimation of nutrient content likewise each grain sample was ground in electric grinder. Nutrient content in grain and straw were estimated by using standard methods. The N, P and K content was expressed as per cent in grain and straw and its uptake in kg ha^{-1} was calculated. Protein content in seed was calculated by multiplying per cent nitrogen content in the grain with a constant factor 6.25 was reported by Angelo and Mann (1973) [1].

Results and Discussion

Effect of Phosphorus

Application of 40 kg P_2O_5 brought significant improvement in N, P and K content and uptake over rest of the treatments (Table 1). Application of P increased total biomass (grain and straw) and the nutrient (N, P and K) content in mungbean by providing balanced nutritional environment inside the plant and higher photosynthetic efficiency. This might be due to readily available nitrogen and phosphorus applied through chemical fertilizers with *Rhizobium* and also the ability of PSB and *Aspergillus awamori* to transform insoluble phosphate in soil into soluble forms by secreting organic acids and supplying to plants through the hyphae of fungi. Phosphorus application had shown remarkable improvement on content and uptake of N, P and K by grain and straw of mungbean crop (Table 1) which were found to be similar with findings of Rathore *et al.* (2010) [9], Malik *et al.*(2013) [5] and Singh *et al.* (2013) [13].

In present study, since the available P status in soil was low. PSB and *Aspergillus awamori* might have helped in reducing P fixation by its effect and also solubilized the unavailable form of P leading to more uptake of nutrient and reflected in better growth and yield attributes *viz.* number of pods per plant, number of seeds per pod. and test weight. The increase in grain and straw yield was due to the cumulative effect of increased growth and yield attributes.

Increase in grain protein content might be due to enhanced uptake and translocation of nitrates which provide nitrogen for amino acid synthesis. Moreover, phosphorus is involved in the synthesis of ATP that is required in nitrogen uptake and protein synthesis. Higher grain protein content in mungbean in response to N and P applications have also been reported by Dewangan (1992) [3] and Nazir (1993) [6]. The similar findings were also reported by Khan *et al.* (2015) [4] and Senthilkumar and Sivagurunathan (2012) [11].

Effect of Biofertilizers

Application of PSB + *Aspergillus awamori* significantly increased the N, P and K content and uptake in grain and straw (Table 1) which might be due to nitrogen fixation and releasing P from native as well as protecting fixation of applied phosphorus which rendered more available P for the plant leading to increased nutrient content. Further increase in uptake of N, P and K by the crop seems to be resultant of significant increase in grain and straw yield (Malik *et al.* 2013) [5]. PSB and *Aspergillus awamori* with phosphorus had shown positive response with respect to uptake of N, P and K by the grain and straw. Higher grain and straw yield with higher dose of phosphorus contributed more removal of N, P and K by the crop (Bhatt *et al.*, 2013) [2]. The inoculation of PSB with *Aspergillus awamori* also significantly increased the uptake of phosphorus which might be due to enhanced availability of phosphorus, which is known to be positively related with phosphorus uptake. Significant role of these treatments in root enlargement, better microbial activities resulted in more availability and uptake of nitrogen and thereby increased protein content in grain (Rathour *et al.* 2015) [10]. The observations recorded were found similar with Meena *et al.* (2015) and Yadav (2011).

Table 1: Nutrient content and uptake by mungbean and protein content in grain influenced by phosphorus and biofertilizers

Treatments	N content (%)		N uptake (kg ha^{-1})		P content (%)		P uptake (kg ha^{-1})		K content (%)		K uptake (kg ha^{-1})		Protein content
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	%
Phosphorus levels													
P_0 (Control)	2.92	1.222	25.11	26.07	0.333	0.193	2.87	4.11	0.380	0.819	3.29	17.34	18.25
P_1 (20 kg P_2O_5 ha^{-1})	3.34	1.405	36.32	37.93	0.385	0.222	4.20	5.99	0.447	0.895	4.90	23.98	20.88
P_2 (40 kg P_2O_5 ha^{-1})	3.55	1.599	43.84	48.53	0.429	0.240	5.31	7.28	0.512	0.961	6.38	28.95	22.19
P_3 (60 kg P_2O_5 ha^{-1})	3.61	1.620	44.95	51.42	0.439	0.245	5.48	7.77	0.552	0.973	6.93	30.66	22.56
SEm±	0.07	0.033	1.04	1.31	0.008	0.004	0.15	0.20	0.016	0.015	0.30	0.79	0.44
CD (P = 0.05)	0.19	0.096	3.00	3.79	0.022	0.013	0.42	0.57	0.048	0.045	0.87	2.30	1.28

Biofertilizers													
B_0 (Control)	2.93	1.221	25.12	26.34	0.335	0.188	2.88	4.04	0.379	0.831	3.27	17.82	18.31
B_1 (PSB)	3.36	1.416	37.93	39.43	0.394	0.225	4.46	6.25	0.446	0.908	5.07	25.12	21.00
B_2 (*Aspergillus awamori*)	3.41	1.509	39.76	43.95	0.408	0.229	4.77	6.65	0.486	0.922	5.71	26.69	21.31
B_3 (PSB + *Aspergillus awamori*)	3.72	1.700	47.41	54.23	0.449	0.258	5.74	8.21	0.580	0.987	7.45	31.30	23.25
SEm±	0.07	0.033	1.04	1.31	0.008	0.004	0.15	0.20	0.016	0.015	0.30	0.79	0.44
CD (P = 0.05)	0.19	0.096	3.00	3.79	0.022	0.013	0.42	0.57	0.048	0.045	0.87	2.30	1.28

Conclusion

Based on the results of the experiment, it could be concluded that the application of phosphorus @ 40 kg P_2O_5 ha^{-1} and dual inoculation of biofertilizers (PSB + *Aspergillus awamori*) had significant effect on increasing nutrient content and uptake by the crop and also protein content in grain after harvest over the rest of the treatments.

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