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Nutrient uptake by Soybean [*Glycine max* (L.) Merrill] as influenced by inorganic fertilizers and biofertilizers

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Abstract

A field experiment was conducted at instructional farm, College of Agriculture, Ummedganj-Kota during Kharif, 2022. Experiment was laid out in Factorial Randomized Block Design comprising twelve treatment combinations with three replications, which includes inorganic fertilizers [50% RDF (10:20:20), 75% RDF (15:30:30) and 100% RDF (20:40:40) kg/ha] and biofertilizers (*Rhizobium* @ 600 g/ha, NPK Consortia @1250 ml/ha and *Rhizobium* @ 600 g/ha + NPK Consortia @1250 ml/ha). Results revealed that application of inorganic fertilizers (100% RDF 20:40:40 kg NPK per ha) significantly improved the nitrogen uptake by seed, straw and total (135.49 kg/ha, 66.46 kg/ha and 201.95 kg/ha, respectively), phosphorus uptake by seed, straw and total (4.77 kg/ha, 5.93 kg/ha and 10.70 kg/ha, respectively) and potassium uptake by seed, straw and total (33.56 kg/ha, 75.67 kg/ha and 109.23 kg/ha, respectively) by soybean than rest of treatments. Also, seed inoculated with *Rhizobium* @ 600 g/ha + NPK Consortia @1250 ml/ha recorded significantly higher nitrogen uptake by seed, straw and total (121.21 kg/ha, 61.52 kg/ha and 182.64 kg/ha, respectively), phosphorus uptake by seed, straw and total (4.35 kg/ha, 5.46 kg/ha and 9.81 kg/ha, respectively) and potassium uptake by seed, straw and total (30.57 kg/ha, 67.96 kg/ha and 98.53 kg/ha, respectively) by soybean than individual inoculation of *Rhizobium* @ 600 g/ha and NPK Consortia @1250 ml/ha.

Keywords: *Bradyrhizobium japonicum*, NPK consortia, nutrient uptake, fertilizers, soybean

Introduction

Soybean [*Glycine max* (L.) Merrill] is an important Kharif oilseed crop among the edible oilseed crops. It has emerged as a potential protein as well as oilseed crop worldwide, as efficient producer of the two scarce nutritional resources i.e., richest source of protein (40%) and oil (20%). It is also a good source unsaturated fatty acids and minerals like Ca and P including vitamins A, B and D that meet different nutritional needs (Rahman, 1982) [12]. As a leguminous crop, it has the capacity to fix atmospheric nitrogen through root nodules bacteria, *Bradyrhizobium* can fix atmospheric nitrogen (about 300 kg/ha/year) in symbiosis with soybean (Keyser, 1992) [7]. Thus, it helps to increase soil fertility and improves crop yield not only for itself but also for succeeding crops grown in rotation thereby reducing the requirement of external use of nitrogenous fertilizers. In India, soybean occupied an area of 12.27 M ha with production of 12.99 MT during 2021-22 (Agricultural Statistics at a Glance, 2022). Rajasthan occupied an area of 1.16 M ha and production of 0.93 MT having hovering productivity of 801 kg/ha (Agricultural Statistics at a Glance, 2022). Hence, Humid South-Eastern plain zone-V and Kota district occupied an area of 7.59 & 1.88 lakh ha and production of 5.48 & 1.88 lakh tons and having productivity of 722 & 999 kg/ha, respectively (Anonymous 2021-2022).

The improvement in quantity and quality of soybean can be achieved by balance nutrition along with N and adequate supply of phosphate and potash is highly important. Nitrogen is an essential constituent of protein and chlorophyll which is present in many other compounds of great physiological importance in plant metabolism such as nucleotides, phosphate alkaloids, enzymes, hormones, vitamins etc. Phosphorus plays important role in growth as well as development and maturity of plant it helps in flowering and seed development. Out of total uptake of phosphorus by soybean plant 60% phosphorus comes into seed therefore, application of Phosphorus is must for soybean crop. Biofertilizers helps to increase microbial activity in soil to solubilize and

mobilize the nutrients to reach the plant roots. The application of biofertilizers enhances the nutrient levels of soil which support plant growth and productivity in agricultural field (Kumar and Meena, 2020) [8]. Liquid biofertilizers have the capacity to replace the traditional chemical fertilizers and carrier based biofertilizers which play a major role in restoring the soil health (Lavanya *et al.*, 2018) [9]. Therefore, use optimum dose of fertilizer and biofertilizer assumes special attention for their economic and environmentally safe, besides improving the physical, chemical and biological properties of soil and in turn crop yield (Mahmud *et al.*, 2021) [10].

Materials and Methods

The experiment was conducted at instructional farm, College of Agriculture, Ummadganj-Kota. the soil of experimental field was clay loam in texture with adequate drainage facility, having moderately alkaline reaction, medium in organic carbon (0.52%), available nitrogen (264.5 kg/ha), phosphorus (21.7 kg/ha) and high in available potassium (388.6 kg/ha). The experiment was laid out with Factorial Randomized Block Design with three replications and twelve treatment combinations, which includes inorganic fertilizers (0% RDF, 50% RDF 10:20:20 kg/ha, 75% RDF 15:30:30 kg/ha, 100% RDF 20:40:40 kg/ha) and biofertilizers (*Rhizobium* @ 600 g/ha, NPK Consortia @ 1250 ml/ha and *Rhizobium* @ 600 g/ha + NPK Consortia @ 1250 ml/ha). The gross plot size and net plot size were 5.0 m × 4.20 m and 4.0 m × 3.0 m, sowing was done at 25 June. Total rainfall during the crop season was 1089 mm. The minimum temperature ranged from 22.7 °C to 28.6 °C and maximum temperature ranged from 31.6 °C to 39.9 °C was observed during growing period, respectively.

The inorganic fertilizers 100% RDF (20:40:40 kg/ha), 75% RDF (15:30:30 kg/ha) and 50% RDF (10:20:20 kg/ha) were applied through urea, diammonium phosphate and murate of potash as basal dose and seed inoculation with *Rhizobium* @ 600 g/ha and NPK Consortia @ 1250 ml/ha before sowing was done as per treatments in the marked plots of the field experiment. The crop was harvested at physiological maturity stage, plot wise separately when pods were fully ripened. The effects of treatments were evaluated in term of yield, nutrient content and uptake, available nutrients status of soil after harvest of crop to find out the nutrient uptake by soybean crop.

Results

Nitrogen uptake by seed, straw and total uptake

Significantly higher nitrogen uptake by seed, straw and total uptake (135.49 kg/ha, 66.46 kg/ha and 201.95 kg/ha, respectively), by soybean was recorded with the application of 100% RDF (20:40:40). The increase in nitrogen uptake due to application of 100% RDF (20:40:40) was 50.61% in seed, 35.36% in straw and 45.22% in total uptake over control, respectively.

Application of *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha proved significantly higher over all other remaining treatments and recorded significantly highest nitrogen uptake by seed, straw and total uptake (121.21 kg/ha, 61.52 kg/ha and 182.64 kg/ha, respectively) by soybean. The corresponding increase in nitrogen uptake due to application of *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha was 26.14 and 13.94% in seed, 17.94 and 8.84% in straw and 23.19 and 12.12% in total uptake, respectively as compared to *Rhizobium* @ 600 g/ha and NPK consortia @ 1250 ml/ha.

Phosphorus uptake by seed, straw and total uptake

The significantly higher phosphorus uptake by seed, straw and

total uptake (4.77 kg/ha, 5.93 kg/ha and 10.70 kg/ha, respectively) was recorded with the application of 100% RDF (20:40:40) which was closely followed by application of 75% RDF (15:30:30) and significantly superior over control and 50% RDF (10:20:20). The increase in phosphorus uptake due to application of 100% RDF (20:40:40) was 41.96 and 18.66% in seed, 42.55 and 14.92% in straw and 42.29 and 16.56% in total uptake over control and 50% RDF (10:20:20), respectively.

Application of *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha recorded maximum phosphorus uptake by seed, straw and total uptake (4.35 kg/ha, 5.46 kg/ha and 9.81 kg/ha, respectively) which proved significantly higher over *Rhizobium* @ 600 g/ha and NPK consortia @ 1250 ml/ha. The *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha increases the phosphorus uptake to the extent of 21.17, 20.53 and 20.81% over *Rhizobium* @ 600 g/ha and 11.53, 10.30 and 10.85% over NPK consortia @ 1250 ml/ha, respectively in seed, straw and total uptake, respectively.

Potassium uptake by seed, straw and total uptake

Results revealed that the significantly higher potassium uptake in seed, straw and total uptake (33.56 kg/ha, 75.67 kg/ha and 109.23 kg/ha, respectively) was obtained with the application of 100% RDF (20:40:40) which was closely followed by application of 75% RDF (15:30:30). The increase in potassium uptake due to application of 100% RDF (20:40:40) was 47.84, 47.19 and 47.39% over *Rhizobium* @ 600 g/ha and 18.59, 14.05 and 15.40% over 50% RDF (10:20:20) and 18.59, 14.05 and 15.40% over application of 75% RDF (15:30:30), respectively in seed, straw and total uptake.

Significantly highest potassium uptake in seed, straw and total uptake was obtained with *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha which was found superior to all other remaining treatments. The corresponding increase in potassium uptake due to *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha was 22.98 and 12.22% in seed, 16.07 and 7.98% in straw and 18.16 and 9.26% in total uptake, respectively as compared to *Rhizobium* @ 600 g/ha and NPK consortia @ 1250 ml/ha.

Discussion

Effect of inorganic fertilizers

The enhanced availability of nutrients in the root zone coupled with accelerated metabolic activities at the cellular level probably might have increased the nutrient uptake and their accumulation in the vegetative parts of plant. Increased accumulation of nutrients especially N, P and K in vegetative plant parts concomitant with improved metabolism led to greater translocation of these nutrients in reproductive structures. It led to higher content and uptake. Chakraborty and Hazari (2016) [5] reported that highest uptake of N, P and K with application of 100% RDF + FYM @ 5 tons/ha. These results are close conformity with the finding of Billore and Ramesh (2016) [3] and Zenawi and Mizan (2019) [15].

Effect of biofertilizers

Rhizobium and NPK consortia enhance the availability of phosphorus to plant which might have been utilized by crop for greater root development and nodulation that in turn resulted in higher nitrogen fixation in the soil by root nodules. Thus, greater increased availability of nitrogen and phosphorus might have resulted in greater uptakes of nutrient uptake by the plant for proper development and ultimately increased their nutrients. The biofertilizers *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha was more beneficial in enhancing all the above parameters due to increased solubility of soil and applied phosphorus and

fixation in of nitrogen root nodules, leading to increased availability of nitrogen and phosphorus. Greater concentration of N, P and K in seed and straw combination with higher seed and straw yield of soybean seems to be directly association with significant higher uptake of these nutrients with microbial

inoculation under triple and dual inoculants than control. These results are in agreement with the findings of Gawali *et al.* (2016)^[6], Morya *et al.* (2018)^[11], Raja and Takankhar, (2018)^[13], Yaduwanshi *et al.* (2019)^[14] and Bochalya *et al.* (2021)^[4].

Table 1: Effect of inorganic fertilizers and biofertilizers on nutrient uptake by soybean

Treatments	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
Inorganic fertilizers									
Control	89.96	49.10	139.06	3.36	4.16	7.52	22.70	51.41	74.11
50% RDF (10:20:20)	110.03	58.43	168.46	4.02	5.16	9.18	28.30	66.35	94.65
75% RDF (15:30:30)	123.61	62.68	186.29	4.46	5.62	10.08	31.66	71.68	103.35
100% RDF (20:40:40)	135.49	66.46	201.95	4.77	5.93	10.70	33.56	75.67	109.23
SEm±	4.01	1.44	5.26	0.14	0.14	0.26	0.89	1.68	2.45
CD (p=0.05)	11.76	4.22	15.43	0.41	0.42	0.77	2.60	4.92	7.17
Biofertilizers									
<i>Rhizobium</i> @ 600 g/ha	96.09	52.16	148.26	3.59	4.53	8.12	24.85	58.55	83.39
NPK consortia @ 1250 ml/ha	106.38	56.52	162.90	3.90	4.95	8.85	27.24	62.94	90.18
<i>Rhizobium</i> @ 600 g/ha + NPK consortia @ 1250 ml/ha	121.21	61.52	182.64	4.35	5.46	9.81	30.57	67.96	98.53
SEm±	3.47	1.21	4.55	0.12	0.12	0.23	0.77	1.45	2.12
CD (p=0.05)	10.18	3.66	13.36	0.35	0.36	0.67	2.25	4.26	6.21

Conclusion

On the basis of experimental results, it may be concluded that the application of inorganic fertilizers (100% RDF) along with seed inoculation of *Rhizobium* @ 600 g/ha + NPK Consortia @1250 ml/ha recorded significantly highest nutrient uptake by soybean over no application of fertilizer. Hence, this combination of inorganic fertilizers (100% RDF) along with seed inoculation of *Rhizobium* @ 600 g/ha + NPK Consortia @1250 ml/h can be proved sustainable for soil health.

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