INTEGRATED NUTRIENT MANAGEMENT IN MUNGBEAN (*VIGNA RADIATA* L.) THROUGH NPK AND BIOFERTILIZERS

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Abstract: *To evaluate the effect of nutrient management in mungbean through NPK and bio-fertilizers, an experiment was conducted during 2016 and 2017. The treatments contained along and combinations and two levels of control viz. control without Rhizobium (T_1) + Control with Rhizobium (T_2) with replicated thrice in factorial RBD. Results showed that the application of treatment T_8 (RII-4+NC) increased plant height significantly i.e. (27.30 cm), primary branches (3.67), effective pods plant^{-1} (18.00), no. of leaves/plant (8.33), test weight (36.31 g), seed and stover yield (13.05 and 30.93 q ha^{-1}), nitrogen uptake (root 100.80 and shoot 159.04 g kg^{-1}), phosphorus uptake (root 1.04 and shoot 1.14 g kg^{-1}) and K uptake (root 58.15 and shoot 185.24 g kg^{-1}) and growth characters such as dry weight of root (0.65 gm) dry weight of shoot (6.76 g). Application of T_1 (Control without rhizobium) significantly and linearly decreased the growth characters such as plant height (26.30 cm), number of leaves per plant (6.67), number of branch per plant (2.67) and number of pods per plant (13.67), seed weight of 1000 grains (33.24 g), seed yield (12.09 q ha^{-1}), stover yield (23.21 qha^{-1}). Combination treatments T_6 (R I – 3 + RIII -4), T9 (RIII– 4 + NC-1) and T10 (RIII– 4 + NC-9) also showed significant response to all the parameters and showed better response.*

Key words: Nutrient management, mungbean, *Rhizobium* and bio-fertilizers

INTRODUCTION

NPK a key element of higher pulse production is required in the formation of proteins, vitamins, and enzymes and is a constituent of the amino acids- cystine, cysteine, and methionine. NPK is also involved in the different metabolic and enzymatic processes including photosynthesis, respiration, and the formation of biological nitrogen. Deficiency of NPK in Indian soil is widespread due to extensive use of NPK free fertilizer coupled with cultivation of high NPK demanding crops. NPK deficiency has been found in 41 per cent soils of the country (Singh, 2011). *Rhizobium* root nodule bacterium has the ability to fix atmospheric nitrogen in symbiotic association with legume crops. They normally enter the root hairs, multiply there and form nodules. The fixation of nitrogen fixed varies with the strains of *Rhizobium*, species of plants and environmental conditions. Legumes are self-dependent for their N requirement due to their ability to fix nitrogen and play a vital role in maintaining the nitrogen balance in the soils. They also help in improving the physical and biological properties of soil.

Pulses in India have long been considered as the poor man's source of protein. Pulses are being grown on about 23 million hectares of area with an annual production of 15 MT.

Nutrient management is one of the most important factors that affect the growth and yield of mungbean. Phosphorus is also essential for both parts of plant structure compound and as catalysis in the conversion of key biochemical reactions in the plant. It is a vital component of ATP, the "energy unit" of plants, and is also involved in controlling key enzyme reactions and in the regulation of metabolic pathways (Theodorou and Plaxton, 1993). Sulphur is essential for the synthesis of vitamins (biotine and thiamine), sulphur containing amino acids - cystine, cysteine, and methionine and helpful in the promotion of nodulation in legumes. Sulphur is the key nutrient for improving the productivity of legume crops (Patel and Patel, 1994). Pandey and Singh (2001) also reported that the highest seed and straw yield of mungbean was obtained by use of sulphur. Generally, soil with less than 22 kg/ha of available sulphur is said to be deficient in sulphur. 'S' deficiency has been reported over 70 countries worldwide, of which India is one (Balasubramanian *et al.*, 1990). The decreasing trends in per capita availability of pulses in the country have been a serious concern and to make up this shortfall, it is necessary to boost up the pulse production. Therefore, proper nutrient management is essentially required to enhance productivity.

The efficiency of phosphatic fertilizer is very low ranges from 15- 20% due to its fixation in soil. Phosphorus in the soil is mostly unavailable to crops because of its low solubility. The introduction of an efficient P solubilizer in the rhizosphere has been found to increase the availability of phosphorus. The phosphorus, which gets fixed in the soil, is made available to crops by the actions of microorganisms, which solubilize insoluble/ fixed forms of phosphate in the form which are readily taken up by the plants.

MATERIALS AND METHODS

The field trial was laid out at Students Instructional Farm, C. S. Azad University of Agriculture and Technology, Kanpur during 2017-18. The experimental plot having sandy loam soil, pH 7.9, and EC 0.34. The treatment of the experiment was three levels of combinations and five levels of alone and two levels of control *viz.* control without *Rhizobium* (T1) + control with *Rhizobium* (T2). The design of the experiment was Factorial RBD with 3 replications and crop variety 'shweta'. DAP was applied @ 100 kg ha-1, which provided 18 kg N and 46 kg P2O5. Elemental sulphur and DAP were applied as basal at the time of sowing of seed. After preparation of field, sowing of the seed of mungbean @ 20 kg ha-1 was done keeping 30 cm distance from row to row and maintained 10 cm from plant to plant. Thinning of plants ensured proper spacing. After harvesting of mungbean, seed and stover yield was recorded. In seed and stover, nitrogen content was determined by modified Kjeldahl's method as described by Jackson (1967), for phosphorus, the finally grind samples were taken and digested with tri- acid mixture of conc. nitric acid, sulphuric acid and perchloric acid in the ratio of 9:4:1 and determined by the method described by Chapman and Pratt (1961) colorimetrically and for sulphur, plant samples were digested in di-acid (HNO3+ HClO4) in the ratio of 4:1 and sulphur was estimated by the turbidimetric method as described by Chaudhary and Cornfield (1966). The rhizospheric population of bacteria, Actinomycetes, *Azotobacter,* and phosphate solubilizing bacteria were analyzed by dilution and plate count methods using specific media at 45 days of sowing. The interaction effect of NPK was positive in all the cases, so it was not given in the results and discussion.

Treatment details

The best performing treatment T8 comprises of consortia of bacterial strains Bacillus subtilis subsp. stercoris RII-4 and Klebsielllasp; T6 : Bacillus subtilis subsp. Stercoris RI-3 and

Bacillus subtilis subsp. Inaquosorum RIII-4 ; T9 : Bacillus subtilis subsp. Stercoris RI-3 and Bacillus subtilis subsp. Inaquosorum RIII-4 and Klebsielllasp; T 10 : Bacillus subtilis subsp. Inaquosorum RIII-4 and Stenotrophomonas maltophilia and T5 : Stenotrophomonas maltophilia.

RESULTS AND DISCUSSION

Table 1: Growth parameter of Mungbean

TREATMENT	Plant height (cm)	No . of leaves per plant	No. of branches per plant	No. of pod clusters per plant	No. of pods per plant	Seed weight per plant (g)	Seed weight of 1000 grain (g)
T1(Control without rhizobium)	26.30	**6.67**	**2.67**	4.67	**13.67**	10.88	**33.24**
T2(Control with rhizobium)	**25.44**	**6.67**	2.00	**4.33**	15.33	**9.00**	34.76
T3(RII-4)	27.06	7.33	2.67	5.00	15.67	10.68	34.78
T4(NC-1)	26.93	7.67	2.67	4.67	15.00	9.85	34.15
T5(NC-9)	27.01	7.33	2.67	5.00	15.67	11.42	35.17
T6(RI-3+RIII-4)	**27.26**	**8.00**	**3.00**	**5.33**	**17.67**	11.74	**35.82**
T7(RI-3+NC-5)	26.38	7.00	2.67	5.00	15.67	9.96	35.35
T8(RII-4+NC-1)	**27.30**	**8.33**	**3.67**	**5.33**	**18.00**	**11.75**	**36.38**
T9(RIII-4+NC-1)	27.18	8.00	3.00	5.00	17.00	11.54	35.53
T10 (RIII-4+NC-9)	27.18	8.00	3.00	5.00	16.33	11.49	35.43
SE(d)	0.80	0.97	0.56	0.69	1.72	0.72	0.51
CD (P=0.05)	NS	NS	NS	NS	NS	1.53	1.08

Growth parameter: Results obtained from the experiment indicated that application of T_8 ha^{-1} noticed significant increase in the plant height (27.30 cm), primary branches (3.67), pods plant^{-1} (18.00), leaves plant^{-1} (8.33), 1000 grain wt. (36.38 g) in comparison to T_1 showing the value of 26.30 cm, 2.67, 13.67, 6.67 and 33.24 g. Further increase in combination treatment did increase significantly the yield attributing characters of mungbean. In case of bio-fertilization, combination treatment significantly increased the plant height, primary branches, pods, leaves plant^{-1}, and 1000-grain weight in comparison to control. However, maximum response was also recorded with dual inoculation of T_6 showing the value of plant height (27.26 cm), primary branches (3.00), pods plant^{-1} (17.67), leaves plant^{-1} (8.00) and 1000-grain weight (35.82). Dual inoculation of bioagents exhibit that these biofertilizers are compatible with each other and have produced synergistic effect (Table 1).

Table 2: Seed and straw yield of Mungbean

TREATMENT	**Root length (cm)**	**Dry weight of root (g)**	**Fresh weight of shoot (g)**	**Dry weight of shoot (g)**	**Husk / straw of per plants of pod (g)**	**Seed Yield (q/ha)**	**Straw Yield (q/ha)**
T1(Control without rhizobium)	**9.66**	**0.52**	22.73	**5.33**	3.26	12.09	23.21
T2(Control with rhizobium)	10.03	**0.52**	**22.28**	5.51	3.70	**10.00**	21.10
T3(RII-4)	10.48	0.58	25.86	5.84	4.18	11.87	25.88
T4(NC-1)	10.78	0.55	24.96	5.82	5.00	10.94	24.18
T5(NC-9)	10.61	0.59	25.59	6.06	5.00	12.69	28.42
T6(RI-3+RIII-4)	**11.19**	**0.62**	**26.59**	**6.52**	5.59	13.05	30.14
T7(RI-3+NC-5)	10.87	0.58	24.13	5.93	4.73	11.07	24.46
T8(RII-4+NC-1)	**11.26**	**0.65**	**26.89**	**6.76**	5.82	**13.05**	30.93
T9(RIII-4+NC-1)	11.13	0.59	25.73	6.46	5.23	12.82	29.36
T10(RIII-4+NC-9)	10.91	0.61	25.77	6.46	5.22	12.76	29.10
SE(d)	0.41	0.04	0.60	0.27	0.77	0.86	0.88
CD (P=0.05)	0.87	0.07	1.28	0.56	1.62	1.82	1.86

Yield and yield attributing characters:

The results of the present study showed that T_8 was responsible for overall improvement in the growth and development of the plant, which had a favourable effect on grain yield. The response of dual inoculation in the case of seed yield of mungbean, further dual dose of bio-agents as in case of treatments T_6, T_9 and T_{10} numerically increased the grain yield but it could not reach up to the level of significance (Table 2).

Maximum seed yield (13.05 q ha^{-1}) was recorded with T_8 as compared to control (10.00q/ha). Significant increase in seed yield due to dual application has been suggested in another research as well. The findings of this investigation are in line with those of Aulakh and Chhibba (1992), Singh and Tarafdar (2002).

Single combination also significantly increased seed yield of mungbean. Treatment T_3, T_4 and T_5 inoculation showed the seed yield (11.87, 10.94 and12.69 q ha^{-1}) as compared to un-inoculated T_2 (1000q/ha). Increased seed yield in legumes due to *Rhizobium* inoculation has also been reported by Singh and Tarafdar (2002). There was further increase in seed yield when *Rhizobium* and PSB inoculants were combined together showing the value of 13.05 q ha^{-1} which was significantly higher than single inoculation of *Rhizobium* or PSB or no inoculation.

The compatibility between bio-agent and biofertilization suggested that direct nutrition of plant by applied dual combination and indirect through utilization by nitrogen fixing organism for their growth and activity. Similar to seed yield, stover yield was also affected by T8 application. Significant stover yield (28.1 q ha^{-1}) was obtained by sulphur application up to the level of 30 kg S ha^{-1}. This was significantly higher than 15 kg S ha^{-1} (30.93 q ha^{-1}) and without *Rhizobium* application (23.21 q ha^{-1}). However, further increase in stover yield due to T_1 application was not effective (Table 1,2). The increase in crop yield due to dual inoculation application has also been reported by Singh *et al*. (1992). Corresponding to seed yield, stover yield was also significantly increased by *dual* inoculation. *Rhizobium* inoculation exhibit the stover yield of 29.10 q ha^{-1} over 23.21 q ha^{-1}, with no inoculation. Significant increase in grain and stover yield due to *Rhizobium* inoculation might be due to higher nitrogen fixing capacity and better nitrogen assimilation than native *Rhizobia*. *Rhizobium i*noculation of seed increased the nodulation, which resulted in higher nitrogen fixation and consequently higher grain and stover yield. Single inoculation also indicates significant increase in stover yield of mungbean with the value of 28.42 q ha^{-1} over control (Table 2). Single inoculation produces organic acids, which convert nitrates to nitrites with the net result of the enhanced availability of N &P to the nutrition and improvement of root uptake of N and P. The inoculations increase P availability not only to the plants but also increases the efficiency of rhizobia for higher nitrogenase activity. Further increase in stover yield (30.93 q ha^{-1}) was recorded with dual inoculation of T_8 treatment followed by T_6, T_9,T_{10} and T_5 as compared to control.

N-content and uptake in seed and stover: Seed serves as a storage organ for nutrients of the plant. It is well known that the seeds are rich in protein content and therefore, the nitrogen of seed is expected to be quite high. Results revealed that dual application showed an increase in nitrogen content ha^{-1}, that is significantly higher than either or without rhizobium application. However, dual application affects the nitrogen content significantly in seed and stover. This treatment indicates that the dual combination was sufficient for protein synthesis in seed. The higher doses of dual combination appeared to be for vegetative growth and plant vigour. It also suggested that NPK is the first requirement for synthesis of protein in seed and stover yield which, required additional amount of NPK for growth. Increased nitrogen content in seed and stover of the pulse crop due to Sulphur application has also been observed by earlier workers, (Jat and Rathore, 1994, Singh and Agrawal, 1998). Significantly increase the nitrogen content in grain and stover was recorded due to *Rhizobium* inoculation showing the value of 3.82 per cent over 3.66 per cent with no inoculation in grain and 1.67 per cent with inoculation over 1.49 per cent without inoculation in stover of mungbean. Our result falls in the line reported by Jat and Rathore (1994). Nodules are phenotypic expression of two genotypes host-legume (macrosymbiont) and *Rhizobium* (microsymbiont), which serve as the seat of nitrogen fixation. The number of nodules of the root system also governs the extent of nitrogen fixation. Similar to dual combination inoculation significantly increased nitrogen content in seed and stover, as compared to without inoculation showing the value of 3.78 per cent in seed and 1.62 per cent in stover. The increased nitrogen content in grain and stover of legumes due to NPK & PSB inoculation has also been reported by another worker (Romesh and Sabale, 2001). There was further increase of nitrogen content in seed and stover when the both inoculants were combined together. The nitrogen content in grain (3.89 per cent) with *dual* combination was noted as compared to 3.66 per cent without inoculation. The higher nitrogen content in seed and straw due to dual inoculation has also been reported by Dubey (1997). Similar trend was also recorded in the case of nitrogen uptake in grain and stover.

NPK-content and uptake in grain and stover: NPK application also significantly increased the NPK-content in seed and stover up to T_8 treatment showing the value of 0.425 per cent in seed and 0.214 per cent in stover which was significantly higher than that of without *Rhizobium* application. Further increase in rate of dual combination was not beneficial so far as NPK-content is concerned. The increase in NPK-content due to dual application has also been supported by Jat and Rathore (1994); Singh and Aggarwal (1998). It might be due to increasing the NPK containing amino-acid in plant body which ultimately increased the NPK-uptake. There was significant increase in NPK content in seed and stover due to *Rhizobium* inoculation showing the values of 0.408 per cent as compared to 0.394 per cent without inoculation in seed while the value was 0.208 per cent with *Rhizobium* inoculation followed by 0.201 per cent without inoculation in stover. The increase in nitrogen content in seed and stover due to *Rhizobium* inoculation has also been reported by Jat and Rathore (1994). Dual inoculation also significantly increased NPK-content in seed and stover showing the value of 0.420 per cent in seed and 0.214 per cent in stover as compared to without inoculation. These results are also supported by the finding of Romesh and Sabale (2001). There was further increase in P-content in seed and stover when both inoculants were combined together. P content of 0.428 per cent in seed and 0.218 per cent in stover were noted which was significantly higher than single inoculation of *Rhizobium* or without inoculation. Higher NPK-content due to dual inoculation of *Rhizobium* and PSB was also recorded by Dubey (1997). Similar trend was also recorded in the case of phosphorus uptake in seed and stover.

S-content and uptake in seed and stover: There was a linear increase in the nitrogen content in plants with increasing doses of nitrogen. Further increase in dual application increase NPK-content in seed and stover. Increase in nitrogen content due to nitrogen application in nitrogen deficient soil is well understood. The increase in S content due to sulphur application has also been reported by Singh *et al.* (1992). In case of bio-fertilization, there were no significant differences recorded in S-content in seed and stover by the single inoculation of *Rhizobium* or PSB. Significant difference in S-content in seed was recorded by dual inoculation of *Rhizobium* and PSB showing the value of 0.386 per cent as compared to 0.363 per cent in control.

The increase in sulphur uptake due to applied sulphur has been reported by Singh *et al.* (1992), Kachhave *et al.* (1997) and Singh and Aggrawal (1998). In case of bio-fertilization, *Rhizobium* and PSB inoculation did not increase the sulphur uptake in seed and stover. These findings are in accordance with the result of Singh and Singh (2004), Deshbhratar *et al.* (2010) and Meena *et al,* (2013), (Kaisher, *et al.*, 2010).

Conclusion

On the basis of results of experimentation, it is concluded that the consortia of Bacillus subtilis subsp. stercoris RII-4 and Klebsielllasp has been tested and can be adopted with *Rhizobium* in Chickpea @ 75% recommended dose of fertilizers, which saves about Rs. 1700/- per hectare in cost of cultivation and obtained B:C ratio 2.59. Also the formulations of best performing treatments T8 comprising of consortia of bacterial strains Bacillus subtilis subsp. Stercoris RII-4 and Klebsielllasp; T6 : Bacillus subtilis subsp. Stercoris RI-3 and Bacillus subtilis subsp. Inaquosorum RIII-4 ; T9 : Bacillus subtilis subsp. Stercoris RI-3 and Bacillus subtilis subsp. Inaquosorum RIII-4 and Klebsielllasp; T 10 :Bacillus subtilis subsp. Inaquosorum RIII-4 and Stenotrophomonas maltophilia and T5 : Stenotrophomonas maltophilia can be tested on other crops for plant growth promotion and nutrient uptake.

REFERENCES

Aulakh. M.S. and Chhibba, I.M. (1992). Sulphur in soils and response of crops to its application in Punjab. *Fertil. News* **37**: 33-45.

Balasubramania, P.M., Babu, K.A. and Ragupathy, B. (1990). Influence of soil parameters on the forms of sulphur in benchmark soil of Chidambaram Taluk, Tamil Nadu. *In the Proceeding of the 1990UAS-FACT seminar on sulphur*, Bangalore.

Chapman, H.D. and Pratt, P.F. (1961). Methods of Analysis for Soils, Plants and Waters. *University of California*, USA.

Chaudhary, I.A. and Cornfield, A.H. (1966). The determination of total sulphur in soil and plant material. *Analyst* **91** : 528-530.

Deshbhratar, P.B., Singh, P.K., Jambhulkar, A.P., Ramteke, D.S. (2010). Effect of sulphur and phosphorus onyield, quality and nutrient status of pigeon pea (*Cajanus cajan*). *Journal of Environmental Biology*. **31**: 933- 937.

Dubey, S.K. (1997). Co-inoculation of phosphate solubilizing bacteria with *Bradyrhizobium japonicum* to increase phosphate availability to rainfed soybean on Vertisol. *J. Indian Soc. Soil Sci.* **45**: 506-509.

Gupta, S.B., Vyas, M.K. and Patil, S.K. (1992). Effect of phosphorus solubilizing bacteria and thiram at different levels of phosphorus on soybean and soil microflora. *J. Indian Soc. Soil Sci.* **40**: 854-856.

Horn, M.J., Jones, D.B. and Blum, A.E. (1946). Colorimetric determination of methionine in protein and food. *J. Biol. Chem.* **166**: 313-320.

Jackson, M. L. (1967) Soil Chemical Analysis. Prentice Hall of India, Pvt. Ltd. Delhi.

Jat, R.L. and Rathore, P.S. (1994). Effect of sulphur, molybdenum and *Rhizobium* inoculation on green gram (*Phaseolus radiatus*). *Indian J. Agron.* **39**: 651-654.

Kaisher, M.S., Rahman, M.A., Amin, M.H.A., Amanullah, A.S.M. (2010). Effect of sulphur and boron on the seed yield and protein content of mungbean. *Bangladesh Research Publication Journal* **3 :** 1181-1186.

Meena, K. K., Meena, R.S. and Kumawat, S. M. (2013). Effect of sulphur and iron fertilization on yield attributes, yield and nutrient uptake of mungbean (*Vigna radiate. Indian Journal of Agricultural Sciences.* **84** (4):472-6.

Pandey, S. P. and Singh, R.S. (2001). Response of phosphorus and sulphur on yield and quality of summer moong (*Vigna radiate* L.) *Crop Research* **22** : 206-209.

Patel, P.C. and Patel, J.R. 1994. Effect of phosphorus andsulphur on forage yield and nutrient uptake bylucerne. *Journal of the Indian Society of Soil Science.* **41**:154-156.

Singh, Y.P. and Singh, R. 2004. Interaction effect of sulphur and phosphorus on growth and nutrient uptake of black gram. *Journal of the Indian Societyof Soil.* **52**: 266- 269.

Singh, Y. V, Dhar D.W. and Agrawal, B, 2011. Infuence of Organic nutrient Management on Basmati rice (oryza sativa)- wheat (Triticum astivum) – Green gram (Vigna radiata) Cropping system. Indian Journal of Agronomy **56**(3):169-75.

Tarafdar S.C., Tripathi K.P. and Mahesh Kumar, (2008). Organic Agriculture. S*cientific publisher, Jodhpur*., 372 pp

Theodorou, M.E. and Plaxton W.C. 1993. Metabolicadaptations of plant respiration to nutritionalphosphate deprivation. *Plant Physiology*. **101**: 339-344.