RESEARCH ARTICLE Legume Research- An International Journal, Volume 45 Issue 6: 756-761 (June 2022)

Effect of PROM and Microbial Inoculants on Growth, Yield and Nutrient Uptake of Mungbean [*Vigna radiata* (L.) Wilczek]

Anju Kanwar Khangarot, S.S. Yadav, Sumanth Prabhu Shyanabhoga,
Ram Singh Verma, Rajendra Jakhar, Akshika Bhawariya

10.18805/LR-4865

Abstract

Background: In conventional agriculture, expensive phosphatic fertilizers were applied in huge quantities to reduce phosphorus deficiency in mungbean. Disproportionate application of these chemical fertilizers over long periods has damaged the natural properties of soils by killing soil micro flora and fauna, leading to reduced agricultural production. Sustainable agriculture based on organics and biological fertilizers is an effective solution for overcoming these problems. Therefore, keeping the above information in view, the present study was undertaken to assess the effect of PROM and microbial inoculants on the growth and yield of mungbean.

Methods: In this field-laboratory experiment which was conducted at agronomy farm of Sri Karan Narendra Agriculture University, Jobner, during *Kharif* season of 2019, 12 treatments involving control, PROM, PSB, VAM, *Pseudomonas fluorescens* (PF) and their respective combinations were included which was laid out in randomized block design with three replications. The collected samples were determined for growth and yield attributes in the field and laboratory.

Result: The results showed that combined application of PROM+PSB+VAM+PF reported the maximum values of most of the growth and yield attributing characters *i.e.* plant height, number of branches/plant, dry matter accumulation, total and effective number of root nodules per plant, fresh and dry weight of nodules per plant, crop growth rate, chlorophyll content, number of pods/plant, number of seeds/pod, test weight, seed, straw and biological yield of mungbean as compared to other combinations and control, but it was at par with PROM+PSB+VAM.

Key words: Dry matter accumulation, PF, PROM, PSB, Seed yield, VAM.

Introduction

Mungbean [*Vigna radiata* (L.) Wilczek] alternatively also recognized as moong, mung, mungo, green gram, golden gram, celera bean, chickasaw pea and oregon pea is one of the crucial pulse crop grown in arid and semi-arid regions of India. It is a short duration pulse crop of *Kharif* season that can be grown as a compensational crop between *rabi* and *Kharif* seasons. Mungbean is an admirable source of protein (25%) with high quality of lysine (460 mg/g) and tryptophan (60 mg/g) and it also contains about 1.3 per cent fat, 3.5 per cent minerals, 4.1 per cent fiber and 56.7 per cent carbohydrate (Rekha *et al.*, 2018). The sprouted seeds of green gram enclose an astonishing quantity of ascorbic acid (Vitamin C), riboflavin and Thiamine (Dhakal *et al.*, 2016).

Despite being such a crucial crop, the average productivity of mungbean in the state is pretty low compared to its production potential, which is a matter of thoughtful concern. Unsatisfactory or no use of fertilizers, cultivation on marginal lands of poor fertility under rainfed condition, poor cultivation practices, heavy responsiveness to pests and diseases, weed infestation, non-availability of convenient varieties particularly of determinate type and poor knowledge of farmers about seed treatment are the major obstacles in *Kharif* pulses including mungbean. Since it is a leguminous crop, it requires lesser nitrogen except a starter dose at the beginning of the life cycle to establish the crop. While, phosphorus application to pulses is of paramount significance on account of its participation in metabolic processes and enzymatic reactions needed for growth and development of plants. In conventional agriculture, expensive phosphatic fertilizers were applied in huge quantities to enrich its deficiency. Disproportionate application of these chemical fertilizers over long periods has damaged natural properties of soils by killing soil micro flora and fauna, leading to reduced agricultural production. Proper phosphorus management is an important part of environmental protection in any agricultural system, especially in systems that use manures or composts as nutrient sources, P inputs to fresh water ecosystems are a primary cause of eutrophication and water quality degradation. Therefore, organic farming systems should be designed to limit P losses by properly managing P inputs, cropping systems and soil resources.

Department of Agronomy, SKN Agriculture University, Jobner-303 329, Rajasthan, India.

Corresponding Author: Anju Kanwar Khangarot, Department of Agronomy, Swami Keshwanand Rajasthan Agriculture University, Bikaner-334 006, Rajasthan, India.
Email: anjukhangarot1997@gmail.com

How to cite this article: Khangarot, A.K., Yadav, S.S., Shyanabhoga, S.P., Verma, R.S., Jakhar, R. and Bhawariya, A. (2022). Effect of PROM and Microbial Inoculants on Growth, Yield and Nutrient Uptake of Mungbean [*Vigna radiata* (L.) Wilczek]. Legume Research. 45(6): 756-761. DOI: 10.18805/LR-4865.

Submitted: 06-01-2022 **Accepted:** 10-03-2022 **Online:** 30-03-2022

Organic production systems seek to improve soil organic matter and biological diversity, which may impact P cycling and P uptake by crops. Phosphorus fertilization in the organic production system entails balancing the P inputs with crop removal by selecting and managing both nitrogen and P inputs.

Phosphate rich organic manure (PROM) also known as "green chemistry phosphatic fertilizer" is an efficient source of P to replace the costly chemical phosphatic fertilizers and ensures a better source for phosphorus application (Katewa *et al.*, 2012). PROM is a mix of well-composted organic manure and high-grade rock phosphate mineral in very fine size *i.e.* d80 from 74 to 20 microns or organic matter may be co-composted with high-grade rock phosphate in fine size. PROM works as efficiently as DAP and further shows equal residual effect, that is, it works for the subsequent second crop also. Its constituents and specifications are organic manure -55 -60 per cent, P_2O_5-14-16 per cent, C: N ratio-15:1, pH 7-7.5. PROM is very effective even in saline soils where other phosphatic fertilizers fail.

Phosphate solubilizing bacteria (PSB) are beneficial bacteria accomplishing in solubilizing inorganic phosphorus from insoluble compounds (Chen *et al.*, 2006). The mechanism of mineral phosphate solubilization by PSB strains is associated with the release of organic acids in the soil. These low molecular weight organic acids have hydroxyl and carboxyl groups that can chelate the cations bound to phosphate, resulting in the conversion of insoluble Phosphorus to its soluble forms. The collaboration of PSB and pulses enhances soil fertility and is a cost effective way of phosphate fertilization in legumes.

The symbiotic relationship between plant roots and certain soil fungi *e.g.* vesicular arbuscular mycorrhiza (VAM) contributes a significant role in P cycling and uptake of P by plants (Biswas *et al.*, 2007). Through symbiotic linking with plant roots, VAM helps mobilizing Phosphorus. These fungi can save P -fertilizer by 25 30 per cent (Somani *et al.*, 1990).

Certain phosphate solubilizing bacteria acts as Plant Growth Promoting Rhizobacteria (PGPR) *i.e.* one of the classes of beneficial bacteria residing in the rhizosphere (Kloepper *et al.*, 1989). *Pseudomonas fluorescens* (PF) is a gram-negative bacterium that colonizes roots of agricultural crops; provide essential services to the agro-ecosystem as they encourage plant growth and health by overpowering soil-borne diseases, by stimulating plant immune defences and by improving nutrient accessibility in soil. *Pseudomonas fluorescens* has the capacity to mobilize inorganic phosphate in agricultural soils (Browne *et al.*, 2009). It solubilizes about 30 per cent of soil phosphorus.

MATERIALS AND METHODS

An attempt was made to study the effect of PROM and Microbial Inoculants on growth, yield and nutrient uptake of mungbean. A field experiment was conducted during *Kharif* season of 2019 at agronomy farm, SKN agriculture university, Jobner (Rajasthan) Fig 1. The soil was loamy sand with pH 8.2, available N 128.0 kg ha^{-1} (Subbiah and Asija, 1956), P 16.63 kg ha^{-1} (Olsen *et al.,* 1954), K 154.1 kg ha^{-1} (Jackson, 1967) and 0.15% organic carbon (Jackson, 1973). The twelve treatments comprised of control, PROM, PSB, VAM, *Pseudomonas fluorescens* (PF) and their respective combinations were laid out in randomized block design with three replications. PROM (10.4% P_2O_5) applied as basal equivalent to 40 kg P_2O_5 ha^{-1} and was incorporated well into the soil at the time of sowing as per treatments. Mungbean seed was inoculated with liquid PSB culture *i.e. Bacillus megatherium* @ 2 ml kg^{-1} seed and with PGPR *Pseudomonas fluorescens* (PF) @10 ml kg^{-1} seed as per routine procedure 2-3 hours before sowing as per treatments. The soil-based VAM (*Trichoderma viride*) containing hyphae, spores and sporocarp was incorporated into the soil in crop rows at the time of sowing @ 5 kg ha^{-1} VAM was mixed with 8-10 kg vermi-compost as per treatment and thoroughly mixed manually in the treated plots. Seeds of the mungbean variety, IPM-02-3 were sown on 10^{th} July, 2019 in rows spaced at 30 cm apart at the depth of 4-5 cm with the help of '*kera*' method using a seed rate of 16 kg ha^{-1}. Prior to sowing, the seed was treated with *Rhizobium* culture, uniformly under all the treatments. The experimental data recorded for growth, yield and other characters were subjected to statistical analysis in accordance with the "Analysis of Variance" technique suggested by (Fisher, 1950). Appropriate standard error for each of the factor was worked out. Significance of differences among treatment effects was tested by "F" test. Critical difference (CD) was worked out, wherever the difference was found significant at 5.0 or 1.0 per cent level of significance.

RESULTS AND DISCUSSION

Effect on growth parameters

Application of different treatments of PROM, PSB, VAM and PF applied either alone or in different combinations significantly improved the various growth characters (Table 1) *viz.*, plant height, number of branches/plant, crop dry matter accumulation/m row length at all the stages, total and effective number of nodules/plant, fresh weight and dry weight of nodules/plant, CGR, RGR, leaf area index and chlorophyll content of mungbean crop. Results revealed that significantly taller plants were observed under the treatment PROM+PSB+VAM+PF, which was at par with PROM+PSB+VAM. Combined application of PROM+PSB+VAM+PF also attained the maximum number of branches/plant and crop dry matter accumulation at all the stages among all the treatments. However, it was found at par with PROM+PSB+VAM, wherein, 56.9 and 42.0 per cent increase in branches/plant and 57.3, 54.7 and 57.2 per cent higher crop dry matter was obtained at all the stages than control, respectively. Being at par with each other, these two treatments also registered significant improvement in number of total and

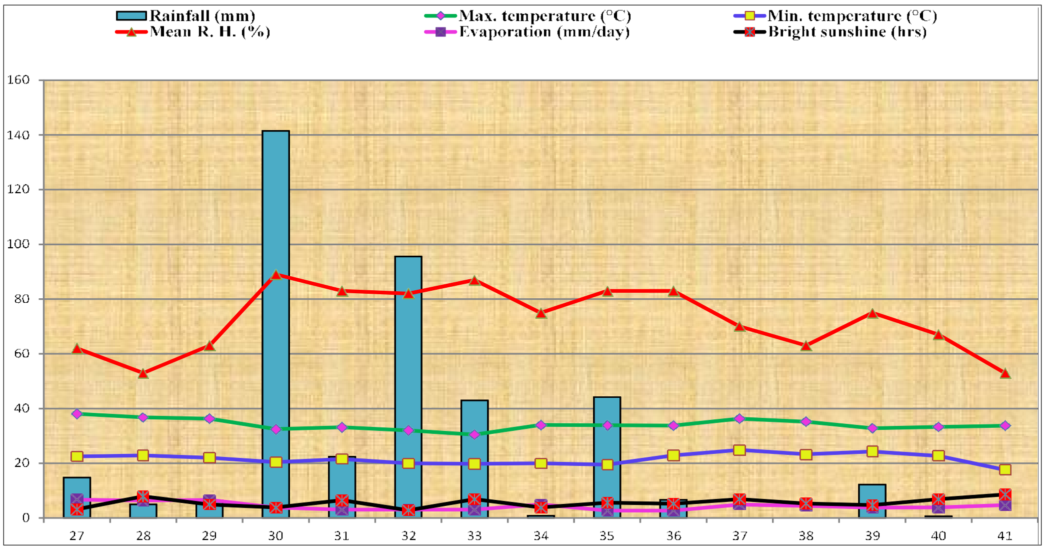

Fig 1: Mean weekly meteorological observations for crop season (*Kharif,* 2019).

Table 1: Effect of PROM and microbial inoculants on growth attributes of green gram.

Treatments	Plant height (cm)	Branches /plant	Dry matter accumulation (g/m row length)	Number of nodules/plant: Total nodules	Number of nodules/plant: Effective nodules	Weight of nodules/plant (mg): Fresh weight	Weight of nodules/plant (mg): Dry weight	CGR (g/m^2/ day)	Chlorophyll content (mg/g)
Control	43.0	6.38	86.06	27.13	22.67	100.80	52.23	4.13	1.76
PROM	53.5	7.87	107.23	29.43	26.20	115.80	60.48	5.21	2.27
PSB	50.0	7.69	99.89	29.33	24.68	107.67	56.44	4.79	2.08
VAM	46.9	7.32	93.39	29.13	24.34	107.33	56.40	4.49	1.93
Pseudomonas fluorescens (*PF*)	47.0	7.41	93.50	29.20	24.42	107.90	56.25	4.52	1.94
PROM + PSB	61.3	8.41	121.51	33.66	29.94	117.67	60.97	5.98	2.77
PROM + VAM	57.9	8.21	114.67	31.43	28.22	117.33	60.79	5.63	2.60
PROM + PF	57.0	8.31	114.08	31.66	27.90	117.00	60.62	5.55	2.43
PROM + PSB + VAM	66.9	9.06	135.33	36.50	32.55	124.70	64.61	6.70	3.10
PROM + PSB + PF	64.0	8.72	128.44	35.80	31.84	122.67	63.56	6.32	3.02
PROM + VAM + PF	60.5	8.55	121.91	33.93	30.08	119.00	61.66	6.02	2.86
PROM + PSB + VAM + PF	67.8	9.30	135.61	37.80	33.02	128.17	66.34	6.71	3.18
SEm ±	1.80	0.27	3.41	1.06	0.85	3.79	1.90	0.23	0.09
CD (p = 0.05)	3.73	0.57	7.08	2.19	1.76	7.87	3.93	0.48	0.19
CV (%)	7.83	8.31	7.42	8.07	7.43	8.04	7.73	10.23	8.85

PROM: Phosphate rich organic manure, PSB: Phosphate solubilizing bacteria, VAM: Vesicular arbuscular mycorrhiza.

effective nodules/plant, fresh and dry weight of nodules/ plant as well as CGR during all the stages of crop. On the other hand, RGR of mungbean during all the growth stages remained uninfluenced. Significantly higher LAI and chlorophyll content were also recorded under treatment PROM+PSB+VAM+PF which was at par with PROM+PSB+VAM.

The significant increase in the above growth characters might be associated with the better nutritional environment in the root zone for growth and development of crop as well as in plant system under the influence of improved availability of different nutrients due to application of PROM and microbial inoculants. Phosphorus plays an important role in an array of cellular processes, including maintenance of membrane structures, synthesis of biomolecules and formation of high-energy molecules (ADP and ATP). It also helps in cell division, enzyme activation/inactivation and carbohydrate metabolism (Razaq *et al.*, 2017).

Effect on yield attributes and yield

The results pertaining to number of pods/plant, number of grains/pod, test weight, grain, straw and biological yields given in Table 2 indicated that application of PROM and microbial inoculants either alone or in different combinations

Table 2: Effect of PROM and microbial inoculants on yield attributes of green gram.

Treatments	Number of pods/plant	Number of grains/pod	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)
Control	21.50	7.25	31.83	624	1231	1854
PROM	30.78	8.09	34.51	830	1666	2496
PSB	28.93	7.90	34.20	754	1460	2214
VAM	26.20	7.81	34.27	697	1400	2097
Pseudomonas fluorescens (*PF*)	24.90	7.67	33.00	683	1361	2044
PROM + PSB	35.37	8.68	37.20	979	1999	2978
PROM + VAM	33.09	8.32	35.51	918	1869	2786
PROM + PF	32.17	8.36	34.57	887	1795	2682
PROM + PSB + VAM	41.10	9.43	38.83	1077	2250	3327
PROM + PSB + PF	38.47	8.90	37.47	1060	2156	3215
PROM + VAM + PF	36.20	8.96	36.29	1002	2031	3033
PROM + PSB + VAM + PF	39.78	9.17	38.10	1119	2302	3422
SEm ±	1.06	0.24	0.98	27.17	59.26	85.80
CD (p = 0.05)	2.20	0.51	2.03	56.35	122.89	177.93
CV (%)	8.04	7.13	6.77	7.51	8.09	7.84

PROM: Phosphate rich organic manure, PSB: Phosphate solubilizing bacteria, VAM: Vesicular arbuscular mycorrhiza.

was found significantly better than control in increasing yield attributes and yield of mungbean. The highest values of these parameters were recorded under PROM+PSB +VAM+ PF that was accompanied by PROM+PSB+VAM. Marked improvement in pods/plant, grains/pod and test weight under the influence of PROM and microbial inoculants can be ascribed to the overall improvement in vigour and crop growth as reflected in plant height, dry matter accumulation and number and weight of nodules/ plant. The application of PROM and microbial inoculants increased the grain yield due to increased availability of P through PROM as well as solubilization of fixed phosphorus by PSB, VAM and *Pseudomonas fluorescens* (PF) by secreting some acids in soils like, glutamic, succinic, lactic, oxalic and formic. PROM also helps in complexing Fe and Al in soil, which leads to reduction in P fixing capacity of soil (Tisdale *et al.*, 1990). The combined application of PROM and microbial inoculants might have resulted in increased availability of nutrients due to increase in micro fauna which bring about transformation of nutrients. Increased availability of P might have improved the uptake of N due to synergistic relationship, resulting in more growth and yield attributes of the crop. So, greater partitioning of assimilates, as well as adequate supply and translocation of metabolites and nutrients towards reproductive structure (*i.e.* sink) matching to their demand for growth and development, could be the most probable reason of improvement in yield attributing parameters of mungbean.

Straw yield of mungbean was also improved significantly due to application of PROM+PSB+VAM+PF over alone and control. This increase was the consequence of a corresponding increase in growth and development of plant in sense of plant height, number of branches and dry matter as an outcome of enhanced nutritional environment in the root zone and plant system leading to greater plant metabolism and photosynthetic activity (Kumar *et al.*, 2015 and Kumar *et al.*, 2018).

Effect on nutrient concentration and uptake

A significant increase in the concentration of N and P in grain and straw of mungbean was found due to the application of PROM and microbial inoculants (Table 3), whereas, concentration of K in grain and straw remained uninfluenced due to these treatments. The PROM+PSB+ VAM+PF application recorded the highest total uptake of N, P and K/ha but found at par with PROM+PSB+VAM (Table 3). As discussed in preceding paragraphs that nutritional environment in the root zone as well as in plant system improved due to application of PROM and different microbial inoculants, which leads to greater uptake and translocation of nutrients especially of N and P in reproductive structures which led to higher concentration and uptake.

The increased availability of nitrogen and Phosphorus in the root zone coupled with improved metabolic activity at cellular level might have increased the nutrient uptake and their accumulation in the vegetative plant parts (Dutta *et al.,* 2021 and Kumar *et al.*, 2021). Increased accumulation of nutrients in vegetative parts of the plant with improved metabolism led to greater translocation of these nutrients to reproductive organs of crop and ultimately the nutrient contents of seed and straw of crop plant enhanced at harvest. Significantly higher N, P and K uptake is directly associated with the higher nutrient content in seed and straw and higher grain and straw yield obtained under these superior treatments (Baljeet *et al.,* 2020 and Kumar *et al.,* 2018).

Table 3: Effect of PROM and microbial inoculants on nutrient concentration and uptake of green gram.

Treatments	N concentration (%)		Total N uptake	P concentration (%)		Total P uptake	K concentration (%)		Total K uptake
	Grain	Straw	(kg/ha)	Grain	Straw	(kg/ha)	Grain	Straw	(kg/ha)
Control	3.22	1.52	38.87	0.329	0.182	4.29	0.841	1.86	28.19
PROM	3.54	1.59	55.86	0.373	0.195	6.34	0.908	1.96	40.05
PSB	3.42	1.61	49.15	0.349	0.183	5.30	0.875	1.99	35.63
VAM	3.34	1.51	44.21	0.343	0.171	4.75	0.845	1.90	32.70
Pseudomonas fluorescens (*PF*)	3.33	1.56	43.93	0.351	0.177	4.82	0.860	1.95	32.40
PROM + PSB	3.73	1.75	71.39	0.409	0.215	8.30	0.975	2.12	52.08
PROM + VAM	3.55	1.65	63.52	0.397	0.199	7.37	0.955	2.00	46.27
PROM + PF	3.50	1.69	61.43	0.389	0.210	7.23	0.931	2.02	44.75
PROM + PSB + VAM	3.95	1.86	84.26	0.440	0.239	10.11	0.992	2.29	62.26
PROM + PSB + PF	3.86	1.79	79.66	0.426	0.230	9.46	0.967	2.19	57.27
PROM + VAM + PF	3.63	1.74	71.54	0.433	0.223	8.86	0.953	2.09	51.99
PROM + PSB + VAM + PF	3.99	1.84	87.04	0.454	0.227	10.31	0.982	2.25	62.72
SEm ±	0.11	0.06	2.33	0.01	0.01	0.23	0.03	0.07	1.95
CD (p = 0.05)	0.23	0.11	4.83	0.03	0.02	0.48	NS	NS	4.05
CV (%)	7.65	8.06	9.11	8.14	9.45	7.84	7.56	8.71	10.51

PROM: Phosphate rich organic manure, PSB: Phosphate solubilizing bacteria, VAM: Vesicular arbuscular mycorrhiza.

CONCLUSION

Based on the results of one-year experimentation, it may be concluded that application of PROM+PSB+VAM+PF was found the most superior treatment combination for obtaining higher values of growth, yield and nutrient uptake in mungbean.

Conflict of interest: None.

REFERENCES

Baljeet, Meena, B.L., Singh, M., Kumar, S., Bhattacharjee, S. and Onte, S. (2020). Effect of potassium and foliar spray of zinc on yield, nutrient biofortification and economics of fodder maize (*Zea mays* L.). Annals of Agricultural Research. 42(4): 382-390.

Biswas, A. and Patra, A.P. (2007). Study on the Effect of Phosphorus, VAM and PSB on the Performance of Summer Greengram. In: National Symposium on Legumes for Ecological Sustainability: Emerging Challenges and Opportunities held during 3-5 Nov. 2007 at IIPR, Kanpur.

Browne, P., Rice, O. and Miller, S.H. (2009). Superior inorganic phosphate solubilization is linked to phylogeny within the Pseudomonas fluorescens complex. Applied Soil Ecology. 43: 131-138.

Chen, Y.P., Rekha, P.D., Arun, A.B. and Young, C.C.V. (2006). Phosphate solubilizing bacteria from subtropical soil and their tricalcium phosphate solubilizing abilities. Applied Soil Ecology. 34: 33-41.

Dhakal, Y., Meena, R.S and Kumar, S. (2016). Effect of INM on nodulation, yield, quality and available nutrient status in soil after harvest of green gram. Legume Research. 39: 590-594.

Dutta, S., Singh, M., Meena, R. K., Onte, S., Basak, N., Kumar, S., and Meena, V. K. (2021). Effect of organic and inorganic nutrient sources on growth, yield, nutrient uptake and economics of fodder cowpea [*Vigna unguiculata* (L.) Walp.]. Legume Research: An International Journal. 44(9): 1046-1052.

Fisher, R.A. (1950). Statistical Methods for Research Workers. Oliver and Boyd. Edinburg, Landon. 57-63.

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

Jackson, M.L. (1973). Soil Chemical Analysis.Prentice Hall of India Pvt. Ltd. New Delhi, pp. 498.

Katewa, M.K., Sekhar, D.M.R. and Shaktawat, M.S. (2012). PROM khad an efficient source of P to replace the costly chemical phosphatic fertilizer. Nature Precedings. 6848.

Kloepper, J.W., Lifshitz, R. and Zablotowicz, R.M. (1989). Free living bacterial inocula for enhancing crop productivity. Trends in Biotechnology. 7: 39-44.

Kumar, S., Shiva Dhar, Barthakur S., Kumar, S., Mondal, B., Kumar, D., Kochewad, S.A., Meena, L.R., Rajawat M.V.S., Singh, M., Chandrakala, M. and Chet Ram (2018). Integrated k management exhibit a key role in potassium uptake transporter (ZmKUP) expression to improve growth and yield of corn. International Journal of Current Microbiology and Applied Sciences. 7(12): 1867-1887.

Kumar Sanjeev, Shiva Dhar, Yadav, R.S., Chandrakala, M., Kochewad, S.A., Meena, L.R., Meena, L.K., Singh, M. and Bhowmik, A. (2018). Effect of integrated K management on productivity and nutrient use efficiency of maize-wheat cropping system. International Journal Current Microbiology Applied Sciences. 7(08): 1052-1061.

Kumar, S., Dhar, S., Barthakur, S., Rajawat, M.V.S., Kochewad, S.A., Kumar, S., and Meena, L.R. (2021). Farmyard manure as k-fertilizer modulates soil biological activities and yield of wheat using the integrated fertilization approach. Frontiers in Environmental Science. 9: 1-15.

Kumar, S., Dhar, S., Om, H., and Meena, R.L. (2015). Enhanced root traits and productivity of maize (*Zea mays*) and wheat (*Triticum aestivum*) in maize-wheat cropping system through integrated potassium management. Indian Journal of Agricultural Sciences. 85(2): 251-5.

Olsen, S.R., Cole, C.W., Watanable, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with $NaHCO_3$. Circular, United States Department of Agriculture. 939.

Razaq, M., Zhang, P., Shen, H-l., Salahuddin. (2017). Influence of nitrogen and phosphorus on the growth and root morphology of Acer mono. PLoS One. 12: 1-13.

Rekha, K., Pavaya, R.P., Malav, J.K., Chaudhary, N., Patel, I.M. and Patel, J.K. (2018). Effect of FYM, phosphorus and PSB on yield, nutrient content and uptake by green gram [*Vigna radiata* (L.) Wilckzek] on loamy sand. International Journal of Chemical Studies. 6: 1026-1029.

Somani, L.L., Bhandari, S.C., Saxena, S.N. and Vyas, K.K. (1990). Biofertilizers. Scientific Publication. Jodhpur. 142-145.

Subbiah, B.V. and Asija, G.C. (1956). A rapid procedure for the estimation of available nitrogen in soils. Current Science. 25: 259-260.

Tisdale, S.L., Nelson, W.L. and Beaton, J.D. (1990). Soil Fertility and Fertilizers. Macmillan Publishing Company, New York.