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Response of soybean (*Glycine max* L. Merrill) to phosphate rich organic manures and fertilizers

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Abstract
A field experiment was conducted during the kharif season of 2019 at AICRP farm, SAS, Medziphema, Nagaland University to studythe response of soybean to phosphate rich organic manures and fertilizers. Phosphorus was supplied through phosphate rich organic manure and single super phosphate. The research revealed that the number of pods plant^{-1}, filled pods plant^{-1}, nodulation, protein and oil content were greatly improved when 78 kg P_2O_5 ha^{-1} was applied through SSP @ 100 kg ha^{-1} + PROM @ 600 kg ha^{-1} under T_8.
This treatment also gave maximum seed yield (22.35 q ha^{-1}), stover yield (30.52 q ha^{-1}), nutrient content and uptake in seed and stoverby the crop. The available N, K and S were also improved with the application of SSP @ 100 kg ha^{-1} + PROM @ 600 kg ha^{-1}. Application of SSP @ 100 kg ha^{-1} + PROM @ 400 kg ha^{-1} resulted in highest plant height at 30 DAS, dry weight at 30 and 45 DASand maximum available phosphorus at harvest. The experiment also revealed that all the yield and quality attributing characters improved up to 78 kg P_2O_5 ha^{-1} when applied through SSP @ 100 kg ha^{-1} + PROM @ 600 kg ha^{-1}.

Keywords: Soybean, Phosphate rich organic manures, SSP, Yield

Introduction

Soybean (*Glycine max*) is an important legume crop containing about 17-22 % oil and 38-42 % protein. It also contains minerals, vitamins particularly thiamine, riboflavin and salts. The sprouting grains also contain vitamin C. Because of its high nutritive value, soybean is also called the "Golden Bean" of the 20th century (Khader, 2019). Soybean can be productively grown in the Northeast region of India. It is an important oilseed crop of Nagaland and is grown in almost every district. Phosphorus plays an important role for the overall growth and development of plants and its importance is highest during the initi al growth stages of the crops (Araújo *et al*., 2020). In soybean, it increases the formation of root nodules, stimulates flowering, decreases lodging tendency etc. Since phosphorus forms complexes with certain ions in soils and may get fixed, certain combinations of phosphorus with other compounds have been made to overcome this problem. One such product is the Phosphate Rich Organic Manure (PROM). Phosphate rich organic manure can be defined as a special type of fertilizer or a value added product produced by the mixture of high grade rock pho sphate mineral with organic manure. It is very efficient in adding phosphorus to the soil and also can be used as a replacement for

diammonium phosphate, single super phosphate and other chemical fertilizers (Sekhar *et al*., 2021). Phosphate rich organic manure contains 10.4% P_2O_5, 0.4% N, 7.9 % OC and has a C:N ratio less than 20:1 (Mihir *et al.,* 2016). The benefit of using phosphate rich organic manure is that it shows equal residual effect, high yield and quality of crops, improves the soil physical properties , soil fertility and soil health. Keeping these benefits and importance in mind, an experiment was conducted to study the response of soybean to phosphate rich organic manures and fertilizers.

Materials and methods

A field experiment was carried out in the experimental research farm of the AICRP soybean research project area in 2019 to study the response of soybean to phosphate rich organic manures (PROM) and fertilizers .The experimental site has a very high relative humidity of about 70-80% and average rainfall ranging from 2000-2500 mm per annum. The soil was clay loam in texture, acidic in soil reaction and low in N, P, S and medium K content. The experimental field trial was laid out in Randomized Block Design (RBD) with 11 treatments and 3 replications. The treatments were T_1-Control, T_2-SSP @400 kg ha^{-1}, T_3-PROM @200 kg ha^{-1}, T_4-PROM @400 kg ha^{-1}, T_5-PROM @600 kg ha^{-1}, T_6-SSP @100 kg ha^{-1} + 200 kg PROM, T_7-SSP @100 kg ha^{-1} + 400 kg PROM, T_8-SSP @100 kg ha^{-1} + 600 kg PROM, T_9- SSP @200 kg ha^{-1} + 200 kg PROM, T_{10}- SSP @200 kg ha^{-1} + 400 kg PROM and T_{11}- SSP @200 kg ha^{-1} + 600 kg PROM. The recommended dose of PROM (250 kg $acre^{-1}$) was applied in different levels along with SSP in all the treatment combinations except control. Recommended fertilizer doses of 20:60:40:30 kg ha^{-1} N: P_2O_5: K_2O: S were applied as basal through Urea, SSP, MOP and Sulphur powder respectively. Soybean variety used was JS 97-52. The recommended package of practices were adopted for raising the crops. Parameters recorded were plant height at 30, 45 and at 60 DAS, nodulation at flowering stage, number of pods $plant^{-1}$, seed yield and stover yield. After the crop harvest, plant analysis were done to determine the nutrient content and uptake in seeds and stovers. The total N was analyzed using modified kjeldhal method as described by Black,1965. P analysis was done through wet digestion method using a di-acid mixture (HNO_3: $HClO_4$:: 3:1) (Baruah and Barthakur, 1997). Jackson (1967) method was used to determine the total P calorimetrically. The total K was determined by wet washing method (Chapman and Pratt, 1961) and the total S content was analyzed using turbidimetric method as given by Chesnin and Yien (1950). The oil content in seeds were estimated using a soxhlet extraction unit as per the methods described by AOAC, 1960. The recorded datas were statistically analyzed by F- test (Gomez and Gomez, 1984).

Results

Growth attributes

Application of PROM and fertilizers increased the plant height in all the treatments over control (Table 1). The lowest plant heightwas recorded from control and the maximum plant height at 30 DAS was observed in T_7 (25.69 cm). At 45 and 60 DAS, the maximum plant height was recorded in T_8 (43.47 and 58.27 cm) where 78 kg P_2O_5 was supplied through SSP @100kg/ha and PROM @600 kg/ha. Similar results were achieved by Shahid *et al.* (2009) and Rajput *et al*. (2023) where the maximum plant height was obtained at increasing level of P_2O_5 in soybean and mungbeans. The data in Table 1, exhibits that all the treatments significantly influenced the nodules plant^{-1}. The increase in nodules might be due to the fact that P helps in promoting nodule formation and thereby fixes atmospheric nitrogen (Das *et al.* 2013). Tanko *et al*. (2021) also observed significant increase in number of nodules with increasing P levels. T_8 obtained the highest number of nodules (31.27) and dry weight of nodules (0.32 g) plant^{-1}. These significant increase in the growth attributes of soybean might be correlated to overall good nutrient management as well as improving its nutrient availability for the plant growth and development through addition of PROM and microbial inoculant sources (Khangarot *et al*., 2022). P is involved in maintaining the membrane structure, carbohydrate metabolism, biomolecules synthesis, cell division, enzyme activation and formation of ADP and ATP molecules which leads to overall development of plant growth attributes (Razaq *et al*., 2017).

Yield attributes

There was significant improvement in the number of pods plant^{-1}, number of filled pods plant^{-1}, seed yield, stover yield, oil and protein content over control (Table 2). The highest number of pods (68.00) and number of filled pods plant^{-1} (22.35) were observed in T_8 where P_2O_5 @ 78 kg ha^{-1} was applied through SSP @ 100 kg ha^{-1} + PROM @ 600 kg ha^{-1}. Similar results were also reported by Devi *et al.* (2012) in soybean and Poudel *et al*. (2024) in cow pea. This increased in the number of pods plant^{-1} might be due to P fertilization which enhances nodulation, pod formation (Buttery, 2010) leading to formation of seeds (Zewdie *et al*., 2021). All the treatments significantly influenced the seed yield over control where T_8 showed the maximum seed yield (22.35 q ha^{-1}). This improvement in seed yield might be due to the reason that P plays an important role in overall growth and yield attributing characters (Khan *et al*., 2023). Application of PROM along with SSP also reduced the P fixation in soil and enhanced its nutrient availability to plants which leads to increase in seed yield (Yadav *et al*., 2017). The highest stover yield (30.52 q ha^{-1}) and the highest oil content (18.88%) was also observed in T_8. The increase in oil content with P application could be because of the importance of P in synthesis of fatty acids and their esterification by accelerating bio- chemical reactions in glyoxalate cycle (Dwivedi & Bapat, 1998 and Peng *et al*., 2022). Protein content significantly increased in all the treatments over control and its maximum was observed in T_8 (42.37%). Myo *et al.* (2010) also observed significant increase in protein content in soybean varieties with increasing levels of P.

Quality attributes

The total nutrients uptake by soybean increased with the application of PROM and fertilizers in all the treatments over control (Table 3). T_8 exhibited the highest N uptake by the crop (206.94 kg ha^{-1}). This increased in total N uptake in all the treatments maybe due to the reason that increasing levels of P resulted in better nodulation, more N fixation by the nodules and more N uptake by the crop (Agarwal & Mishra, 1994 and Li *et al*., 2022). Total P and K uptake also significantly increased with the application of PROM and fertilizers and highest results were obtained in T_8 (17.93 and 67.13 kg ha^{-1}). Similar result was also reported by Anju *et al.* (2022) in mungbean. All the treatments significantly improved the total S uptake. Singh *et al.* (2017) and Sepat *et al*. (2008) also reported increased in S uptake with increased in P levels in cowpea and mothbean. This could be because of increased root growth and increase in the activity of S-solubilizing bacteria, which resulted in better S absorption (Singh *et al.* 1986).

Conclusion

From this experiment, it is evident that combined application of PROM and SSP fertilizer help in improving the growth, yield and quality of soybean crop. The P supplied at all levels improved all the parameters over control. PROM can also be used as an alternative for various P fertilizers because of its P supplying capacity and environment friendly character. Through this research it is clear that overall soybean performed best when P_2O_5 @ 78 kg ha^{-1} was applied through SSP @ 100 kg ha^{-1} + PROM @ 600 kg ha^{-1}. This treatment combination increased the plant height, nodulation, number of pods $plant^{-1}$, seed and stover yield, oil content, protein content and total nutrients uptake in soybean. Hence it is observed that the application of P_2O_5 @ 78 kg ha^{-1} when applied through SSP@ 100 kg ha^{-1} + PROM @ 600 kg ha^{-1} gave the most productive result for soybean crop.

References:

Agarwal, H.P., Mishra, A.K., 1994. Sulphur nutrition of Soybean. Communications in Soil Science and Plant Analysis. 25: 1302-1312.

Anju, K.K., Yadav, S.S., Sumanth, S.P., Ram, V.S., Rajendra, J., Akshika, B., 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.

AOAC. 1960. Official Methods of analysis (18^{th} ed.). Association of Official Agricultural Chemists, Washington.

Araújo, W.A.D., Santana, R.S., Mauad, M., Silva, R.S.D., 2020. Dry matter accumulation and nutrient uptake in determinate and indeterminate soybeans. Journal of Plant Nutrition. DOI: 10.1080/01904167.2020.1845371.

Baruah, T.C., Barthakur, H.P., 1997. A text book of soil analysis. Vikas publishing House Pvt. Ltd. 576, Masjid road, Jangpura, New Delhi – 110014.

Black, C.A., 1965. Methods of soil analysis. Vol I. Am. Soc. Agron., Madison, Wisconsin, U.S.A.

Buttery, B.R., 2010. Analysis of the growth of soybeans as affected by plant population and fertilizer. Canadian Journal of Plant Science. 49: 675-684.

Chapman, H.D., Pratt, P.F., 1961. Methods of analysis for soils, plants and water. Univ, California, Berkeley, CA, USA.

Chesnin, L., Yien, C.H., 1950. Turbidimetric determination of available sulphur. Soil Science Society of American Proceedings. 15:149-151.

Das, S., Pareek, B.L., Kumawat, A., Dhikwal, S.R., 2013. Effect of phosphorus and biofertilizers on productivity of Chickpea (*Cicerarietinum* L.) in north western Rajasthan, India. Legume Research. 36 (6): 511-514.

Devi, K.N., Singh, L.N.K., Devi, T.S., Devi, H.N., Singh, T.B., Singh, K.K., Singh, W.M., 2012. Response of Soybean [*Glycine max*
(L.) Merrill] to Sources and Levels of Phosphorus. Journal of Agricultural Science. 4(6): 44-53.

Dwivedi. A.K., Bapat. P.N. 1998. Sulphur phosphorus interactions on the synthesis of nitrogenous fractions and oil in soybean.Journal of the Indian Society of Soil Science. 46 (2): 254-257.

Gomez, K.A., Gomez, A.A., 1984. Statistical Procedures for Agricultural Research. 2nd Edition, John Wiley and Sons, New York,680 p.

Jackson, M.L., 1967. Soil chemistry analysis. Prentice Hall of India Pvt Ltd., New Delhi. pp: 503.

Khader, V., 2019. Soybean the Miracle Golden Bean in Indian Foods. Acta Scientific Nutritional Health. 3(3): 44-49.

Khan, F., Siddique, A. B., Shabala, S., Zhou, M., Zhao, C., 2023. Phosphorus plays key roles in regulating plants' physiologicalresponses to abiotic stresses. Plants. 12, 2861.

Khangarot, A.K., Yadav, S.S., Shyanabhoga, S.P., Verma, R.S., Jakhar, R., Bhawariya, A., 2022. Effect of PROM and microbialinoculants on growth, yield and nutrient uptake of mungbean [*Vigna radiata* (L.) Wilczek]. Legume Research, 45(6): 756-761

Li, H., Wang, L., Zhang, Z., Yang, A., Liu, D., 2022. Effect of phosphorus supply levels on nodule nitrogen fixation and nitrogenaccumulation in soybean (*Glycine max* L.). Agronomy. 12, 2802.

Mihir, D.M., Jagadeesh, K., 2016. A brief review of phosphate rich organic manure. Research & Reviews: Journal of AgriculturalScience and Technology. 6(1): 34-38.

Myo, W., Sutkhet, N., Sarobol, Ed., 2010. Effects of phosphorus on seed oil and protein contents and phosphorus use efficiency insome soybean varieties. Kasetsart Journal - Natural Science. 44.

Peng, L., Chen, G., Tu, Y., Wang, J., Lan, Y., Hu, M., Li, C., He, X., Li, T., 2022. Effects of phosphorus application rate on lipidsynthesis and eating quality of two rice grains. Agriculture, 12: 667.

Poudel, B., Chaudhary, G., Bhatt, A., Neupane. S., 2024. Effect of spacing and different levels of phosphorus on growth and yield of malepatan-1 variety of cowpea (*Vigna unguiculata* (Linn.) Walp.) in Dang District, Nepal. Advances in Agriculture. doi.org/10.1155/2024/9394237.

Rajput, A., Memon, M., 2023. Phosphorus application on grain yield, uptake and P utilization efficiency of mungbean (*Vigna radiata*
L.). Sarhad Journal of Agriculture. 39(1): 268.

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

Sekhar, D.M.R., 2021. PROM Technology Progress Review 2011. http://www.researchgate.net/publication/235922490.

Sepat, S., Yadav, S. S., 2008. Phosphorus and sulphur management in mothbean (*Vigna aconitifolia*) under rainfed condition. Annals of Agriculture Research. 29:38-42.

Shahid, M.Q., Saleem, M.F., Khan, H.Z., Anjum, S.A., 2009. Performance of Soybean (*Glycine max* L.) under different Phosphorus levels and inoculation. Pak. J. Agri. Sci. 46 (4): 1-5.

Singh, R, Singh, A.P., 2017. Effect of phosphorus, sulphur and biofertilizer on yield, quality and uptake of nutrients in cowpea (*Vigna unguiculata*). Annals of Plant and Soil Research. 19(2):175 – 179.

Singh, V., Mehta, V.S., Singh, B., 1986. Individual and interaction effect of sulphur, phosphorus and molybdenum in mustard. Journal of the Indian Society of Soil Science. 39: 535-538.

Tanko, M. U., Momohjimoh, Y., 2021. Effect of phosphorus and zinc on the growth, nodulation and tield of soybean (*Glycine max* L. Merril). International journal of plant breeding and crop science. 8(2): 1069-1079.

Yadav, K.R., Manohar, R.S., Kumawat, S.R., Yadav, V.K., 2017. Effect of phosphorus sources and phosphorus solubilizing microorganism on growth and yield of mungbean [*Vigna Radiata* (l.) wilczek]. Chemical Science Review and Letters. 6(22): 1152- 1155.

Zewdie, T., Hassen, E., 2021. Review on effects of phosphorus fertilizer rates on growth, yield components and yield of common bean (*Phaseolus vulgaris* L.). Journal of Current Research in Food Science. 2(1): 34-39.

Table 1: Effect of PROM and Fertilizers on growth attributes of soybean

Treatments	**Plant height (cm)**			**Number of nodules at flowering stage**	**I no**
	30 DAS	***45 DAS***	***60 DAS***		
T_1: Control	19.43	29.96	41.03	15.36	
T_2: SSP @400 kg ha^{-1}	20.79	31.75	43.24	24.67	
T_3: PROM @200 kg ha^{-1}	21.92	34.14	45.79	22.13	
T_4: PROM @400 kg ha^{-1}	23.74	34.92	48.26	25.46	
T_5: PROM @600 kg ha^{-1}	24.52	40.55	53.28	27.28	
T_6: SSP @100 kg ha^{-1} + 200 kg PROM	22.56	39.75	51.04	24.71	
T_7: SSP @100 kg ha^{-1} + 400 kg PROM	25.69	40.73	55.37	30.33	
T_8: SSP @100 kg ha^{-1} + 600 kg PROM	23.59	43.47	58.27	31.27	
T_9: SSP @200 kg ha^{-1} + 200 kg PROM	24.77	40.81	56.00	28.23	
T_{10}: SSP @200 kg ha^{-1} + 400 kg PROM	23.43	38.61	49.55	31.04	
T_{11}: SSP @200 kg ha^{-1} + 600 kg PROM	23.63	39.92	48.83	27.67	
SEm±	*1.64*	*1.32*	*1.74*	*1.14*	
CD (p=0.05)	*NS*	*3.89*	*5.13*	*3.36*	

DAS = Days after sowing

Table 2: Effect of PROM and fertilizers on yield attributes of soybean

Treatments	**No. of pods plant^{-1}**	**Seed yield (q ha^{-1})**	**Stover yield (q ha^{-1})**	**Oil content (%)**	**Protein content (%)**
T_1: Control	40.92	10.51	14.20	15.32	35.71
T_2: SSP @400 kg ha^{-1}	48.52	12.24	20.91	17.42	40.83
T_3: PROM @200 kg ha^{-1}	51.95	12.44	20.14	16.29	36.46
T_4: PROM @400 kg ha^{-1}	53.83	16.81	21.47	16.90	39.83
T_5: PROM @600 kg ha^{-1}	55.67	18.64	22.76	17.38	41.46
T_6: SSP @100 kg ha^{-1} + 200 kg PROM	53.33	18.65	23.90	17.04	35.87
T_7: SSP @100 kg ha^{-1} + 400 kg PROM	61.33	22.17	29.57	17.93	42.31
T_8: SSP @100 kg ha^{-1} + 600 kg PROM	68.00	22.35	30.52	18.88	42.37
T_9: SSP @200 kg ha^{-1} + 200 kg PROM	60.33	19.17	25.57	17.51	40.68
T_{10}: SSP @200 kg ha^{-1} + 400 kg PROM	60.00	20.78	29.37	18.45	41.70
T_{11}: SSP @200 kg ha^{-1} + 600 kg PROM	58.00	18.69	22.63	16.92	39.46
SEm±	*1.97*	*1.16*	*1.30*	*0.33*	*0.98*
CD (p=0.05)	*5.81*	*3.42*	*3.84*	*0.98*	*2.88*

Treatments	**Nutrients uptake (kg ha^{-1})**			
	N	**P**	**K**	**S**
T_1: Control	77.09	5.58	19.22	5.31
T_2: SSP @400 kg ha^{-1}	115.71	9.14	31.66	8.36
T_3: PROM @200 kg ha^{-1}	103.54	7.79	28.15	7.28
T_4: PROM @400 kg ha^{-1}	139.83	9.93	35.85	8.99
T_5: PROM @600 kg ha^{-1}	159.85	12.08	45.20	10.10
T_6: SSP @100 kg ha^{-1} + 200 kg PROM	143.57	11.30	38.75	9.56
T_7: SSP @100 kg ha^{-1} + 400 kg PROM	199.70	15.96	56.30	13.06
T_8: SSP @100 kg ha^{-1} + 600 kg PROM	206.94	17.93	67.13	14.27
T_9: SSP @200 kg ha^{-1} + 200 kg PROM	161.80	13.35	46.91	10.84
T_{10}: SSP @200 kg ha^{-1} + 400 kg PROM	186.81	16.33	60.08	13.22
T_{11}: SSP @200 kg ha^{-1} + 600 kg PROM	152.92	13.14	41.59	9.54
SEm±	*10.20*	*0.74*	*2.67*	*0.52*
CD (p= 0.05)	*30.09*	*2.18*	*7.88*	*1.52*

Table 3: Effect of PROM and fertilizers on total nutrients uptake by soybean