LR-5021
[1-5]

RESEARCH ARTICLE Legume Research- An International Journal, Volume Issue : ()

Productivity, Profitability and Quality of Soybean [*Glycine max* (L.) Merrill] Influenced by Phosphorus and Sulphur Fertilization

Manoj[1], M.K. Sharma[2], Harphool Meena[2], R.K. Yadav[2],
V.K. Yadav[1], Bahnu Pratap Ghasil[1], Sangeeta Danga[1]

10.18805/LR-5021

ABSTRACT

Background: Soybean is an important legume as well as oil seed crop grown in a varied range of climate and soils. Phosphorous and sulphur is an important macronutrient required for plants. Their deficiency in soil is a worldwide concern for production of food crops. Therefore, present investigation was done to study influence of phosphorus and sulphur fertilization on productivity, profitability and quality of soybean.

Methods: An experiment conducted during *kharif* 2021 and laid out in factorial randomized block design with three replications having four levels of phosphorous (0, 20, 40 and 60 kg ha^{-1}) and three levels of sulphur (15, 30 and 45 kg ha^{-1}). The data was recorded, analysed and computed statistically.

Result: The results indicated that application of 60 kg P_2O_5 ha^{-1} and 45 kg S ha^{-1} gave significantly higher yield, monetary returns and quality of soybean over rest of phosphorous and sulphur levels. However, it was found at par with 40 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1}

Key words: Economics, Phosphorus, Soybean, Sulphur, Yield.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is an important oilseed and food grain legume crop. It has paramount importance in human and animal nutrition, because it is a major source of edible vegetable oil and high protein feed as well as food in the world. It is highly nutritious containing higher amount of 22-24% protein, 1.3% fat and 60% carbohydrates on dry weight basis and it is rich source of calcium and iron. On the national basis, soybean occupied an area of 12.09 million ha with production and productivity of 11.22 metric tonnes and 928 kg ha^{-1}, respectively (Anonymous, 2020). Soybean is grown as a major oilseed crop mainly in south-eastern parts of Rajasthan during *kharif* season. It covers 1.12 million ha with an annual production and productivity of 0.52 metric tonnes and 469 kg ha^{-1}, respectively in the state (DAC and FW, 2019-20).

Emergence of multiple-nutrient deficiencies due to poor recycling of organic resources and unbalanced use of fertilizers are important factors to be considered for low productivity of soybean (Chaturvedi *et al*., 2010 and Jadon *et al*., 2019). It is an established fact that amongst nutrients, NPK and S are considered to be the most important for exploiting genetic potential of soybean crop.

Improved application technology of phosphorus fertilizer are required to optimize crop yields and reduce the environmental impacts of phosphorus. The soybean yield attributes were significantly influenced by the phosphorus fertilizer source in addition to zinc. Its uptake and utilization by soybean are essential for ensuring proper nodule formation and improving yield and quality of the crop. Phosphorus fertilizer sources have been shown to positively influence on soybean yields (Gonyane and Sebetha, 2022).

Sulphur is essential for synthesis of proteins, vitamins and sulphur containing essential amino acids and is also associated with nitrogen metabolism. The good yield of soybean can be achieved by balanced and adequate supply of phosphate, sulphur and other deficient, nutrients (Suman *et al*., 2018). Sulphur is used as soil amendment for amelioration, as plant nutrient for increasing yield and quality of crop produce. Still the studies on effect of sulphur in soybean are very meagre. The sulphur is required in high amount by the oilseeds and hence has been identified as key nutrient responsible for high production. The present investigation was therefore initiated to work out the response of phosphorous and sulphur levels on productivity, yield and quality of soybean.

[1]College of Agriculture, Ummedganj, Kota-324 001, Rajasthan, India.
[2]Agricultural Research Station, Ummedganj, Kota-324 001, Rajasthan, India.

Corresponding Author: Manoj, College of Agriculture, Ummedganj, Kota-324 001, Rajasthan, India. Email: manoj180519@gmail.com

How to cite this article: Manoj, Sharma, M.K., Meena, H., Yadav, R.K., Yadav, V.K., Ghasil, B.P. and Danga, S. (2023). Productivity, Profitability and Quality of Soybean [*Glycine max* (L.) Merrill] Influenced by Phosphorus and Sulphur Fertilization. Legume Research. doi: 10.18805/LR-5021.

Submitted: 01-08-2022 **Accepted:** 14-02-2023 **Online:** 06-04-2023

MATERIALS AND METHODS

The experiment conducted during *kharif* 2021 at Instructional Farm, College of Agriculture, Ummedganj, Kota (Rajasthan), which is situated at Humid South Eastern Plains of

Rajasthan. This zone possesses typical sub-tropical conditions with maximum and minimum temperatures ranged between 30.2°C to 42.3°C and 20.3°C to 23.0°C during *kharif*, 2021. The total rainfall received during crop season was 1229 mm. The soil of experimental site was clay loam in texture, slightly saline in reaction. Soil was medium in available nitrogen (264 kg ha^{-1}) and phosphorus (21.7 kg ha^{-1}) while high in potassium (388 kg ha^{-1}) and sufficient in DTPA extractable micronutrients with pH (7.61) and EC (0.52 dS m^{-1}). Recommended dose of fertilizer 20:40:40:30 (NPKS kg ha^{-1}) along with *Rhizobium japonicum* culture seed inoculation. Among these nitrogen and potassium was applied as basal dose through urea and muriate of potash, whereas phosphorus and sulphur were applied through TSP and elemental sulphur according to treatments as basal dose.

An experiment was laid out in factorial randomized block design with three replications The twelve treatments combinations was comprised four levels of phosphorus *viz*., 0, 20, 40 and 60 kg ha^{-1} and three levels of sulphur *viz*., 15, 30 and 45 kg ha^{-1}. Data on yield parameters like number of pods per plant, seed per pod, seed index, straw yield, biological yield and grain yield were recorded as per standard procedures. Plant samples (grain and straw) were collected after harvesting from each plot. Protein content in seed was obtained by multiplying the per cent nitrogen content by 6.25 (Simson *et al*., 1965). Oil content in soybean seed was determined by Soxhlet's Ether Extraction method (A.O.A.C., 1965). The data were statistically analysed by adopting appropriate method of standard analysis of variance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of phosphorus application

Yield attributes and yield

Data regarding to the yield attributes and yields of soybean was significantly increased with increasing levels of phosphorus up to 60 kg ha^{-1} (Table 1). The maximum pods (45.72 $plant^{-1}$) were recorded with the application of 60 kg P_2O_5 ha^{-1} in soybean over 20 kg P_2O_5 ha^{-1} (36.06 $plant^{-1}$) and control (32.00 $plant^{-1}$). However, it was found at par with 40 kg P_2O_5 ha^{-1} (43.33 $plant^{-1}$). Application of 60 kg P_2O_5 ha^{-1} gave significantly higher number of seeds (2.52 pod^{-1}) which was found at par with 40 kg P_2O_5 ha^{-1} (2.39 pod^{-1}). Application of 60 and 40 kg P_2O_5 ha^{-1} were found at par in respect of test weight (128.56 and 126.26 g) of soybean. However, it was found significantly superior over 20 kg P_2O_5 ha^{-1} and control, respectively. The application of 60 kg P_2O_5 ha^{-1} produced maximum seed yield (1942 kg ha^{-1}) which was statistically superior over 20 kg P_2O_5 ha^{-1} and control (1566 and 1462 kg ha^{-1}), respectively. The seed yield (1839 kg ha^{-1}) remained at par with 40 kg P_2O_5 ha^{-1} of soybean. The highest straw yield (3305 kg ha^{-1}) was observed under application of 60 kg P_2O_5 ha^{-1} which was remained at par with 40 kg P_2O_5 ha^{-1} (3137 kg ha^{-1}), but it was found significantly superior over 20 kg P_2O_5 ha^{-1} and control, respectively. Application of 60 kg P_2O_5 ha^{-1} gave maximum biological yield (5247 kg ha^{-1}) over 20 kg P_2O_5 ha^{-1} and control. However, it was found at par with 40 kg P_2O_5 ha^{-1} (4976 kg ha^{-1}) biological yield of soybean.

Phosphorous application accelerated the production of photosynthates and their translocation from source to sink, which ultimately gave the higher values of yield contributing characters. Increase in yield contributing characters has also been reported by Meena *et al*. (2006) and Kumar *et al*. (2007). This was mainly due to fact that the better availability of nitrogen and phosphorus caused well developed root system having higher nitrogen fixing capacity resulting better growth and development of plants and better diversion of photosynthates towards sink to source (Singh *et al*., 2017).

Quality parameters

A reference to data presented in Table 2 revealed that the maximum protein content (41.41 per cent) in soybean seed was recorded with application of 60 kg P_2O_5 ha^{-1} over 20 kg P_2O_5 ha^{-1} and control. However, it was found at par with 40 kg P_2O_5 ha^{-1} (41.18 per cent) protein content. The application

Table 1: Effect of phosphorus and sulphur on yield attributes and yield of soybean.

Treatments	Pods (No. $plant^{-1}$)	Seeds (No. Pod^{-1})	Test weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Phosphorus (kg ha^{-1})						
0	32.00	2.00	119.95	1462	2502	3963
20	36.06	2.20	122.45	1566	2674	4240
40	43.33	2.39	126.26	1839	3137	4976
60	45.72	2.52	128.56	1942	3305	5247
SEm±	0.89	0.05	0.95	40	76	116
CD at 5%	2.61	0.16	2.78	117	224	340
Sulphur (kg ha^{-1})						
15	34.69	2.06	118.38	1464	2507	3971
30	40.54	2.33	126.11	1773	3028	4800
45	42.60	2.45	128.43	1870	3179	5048
SEm±	0.77	0.05	0.82	35	66	100
CD at 5%	2.26	0.14	2.41	102	194	294

of 40 and 60 kg P_2O_5 ha^{-1} was found at par with each other in terms of protein yield (807 and 760 kg ha^{-1}) over 20 kg P_2O_5 ha^{-1} and control. The highest oil content (20.53 per cent) was recorded with application of 60 kg P_2O_5 ha^{-1}. It registered remarkable increase in oil content in soybean seed to the tune of 3.47 and 4.53 per cent higher over 20 kg P_2O_5 ha^{-1} and control. However, it was found at par with 40 kg P_2O_5 ha^{-1} (20.32 per cent) oil content. Significantly highest oil yield (400 kg ha^{-1}) was recorded with application of 60 kg P_2O_5 ha^{-1} over 20 kg P_2O_5 ha^{-1} and control. However, it was found at par with 40 kg P_2O_5 ha^{-1} (375 kg ha^{-1}) soybean oil yield.

The increase in oil content with phosphorus application could be due to the fact that phosphorus helped in synthesis of fatty acids and their esterification by accelerating biochemical reactions in glyoxalate cycle (Dwivedi and Bapat, 1998). The maximum protein and oil content were recorded with a treatment combination of 80 kg P_2O_5 and 40 kg sulphur ha^{-1}. Similar findings were also observed on soybean by Jahangir *et al*. (2009).

Economics

It is obvious from the data presented in Table 2 that the application of 60 kg P_2O_5 ha^{-1} provided the highest net returns (` 48497 ha$^{-1}$). It registered remarkable increase in net returns to the tune of 46.2 and 66.73 per cent higher over 20 kg $P_2O_5$ ha$^{-1}$ and control, respectively. However, it was found at par with 40 kg $P_2O_5$ ha$^{-1}$ (` 44575 ha^{-1}). Significantly highest B: C ratio (1.39) fetched under application of 60 kg P_2O_5 ha^{-1}. It registered remarkable increase in B:C ratio to the tune of 43.2 and 53.0 per cent higher over 20 kg P_2O_5 ha^{-1} and control, respectively. However, it was found at par with 40 kg P_2O_5 ha^{-1} (1.29).

Application of 60 kg P_2O_5 ha^{-1} showed mark improvement in seed yield and thus gaining more profit in terms of net returns and benefit: cost ratio. The findings are in agreement with that of similarly, the monetary gains in terms of gross return and net return increased consistently and significantly with varying levels of phosphorus (Dhage *et al*., 2014). The computation of cost of cultivation is important because it decides the option for the farmers to choose the production practices, according to their investment capacity. Similar findings were also reported by Munda *et al*. (2018) and Raghuveer *et al*. (2017).

Effect of sulphur application

Yield attributes and yield

Data pertaining to various yield attributes and yields were presented in Table 1. Aapplication of 45 kg sulphur ha^{-1} produced the maximum pods (42.60 plant^{-1}) which was higher of 22.8 per cent over 15 kg sulphur ha^{-1}. However, it was found at par with 30 kg sulphur ha^{-1} (40.54 plant^{-1}) pods of soybean. Significantly higher number of seeds pod^{-1} (2.45) was recorded under application of 45 kg sulphur ha^{-1} which was found at par with 30 kg sulphur ha^{-1} (2.33 seeds pod^{-1}) over application of 15 kg sulphur ha^{-1}. The application of 45 kg sulphur ha^{-1}gave significantly higher test weight (128.43 g) by 8.4 per cent over 15 kg sulphur ha^{-1}. However, it was found at par with 30 kg sulphur ha^{-1} (126.11 g) test weight of soybean. Application of 45 kg sulphur ha^{-1} gave significantly higher seed yield (1870 kg ha^{-1}) over 15 kg sulphur ha^{-1}. The seed yield (1773 kg ha^{-1}) remained at par with 30 kg sulphur ha^{-1}. Application of 45 kg sulphur ha^{-1} attained the maximum straw yield of soybean (3179 kg ha^{-1}) and remained at par with 30 kg sulphur ha^{-1} (3028 kg ha^{-1}) over 15 kg sulphur ha^{-1}. Application of 45 kg sulphur ha^{-1} gave significantly higher biological yield (5048 kg ha^{-1}) over 15 kg sulphur ha^{-1} (3971 kg ha^{-1}). However, it was found at par with 30 kg sulphur ha^{-1} (4800 kg ha^{-1}) biological yield of soybean.

The yield increased under sulphur fertilization might be ascribed to increased pods plant^{-1} and seeds pod^{-1} with heavier seeds. Thus, significant improvement in yield obtained under sulphur fertilization seems to have resulted owing to increased concentration of sulphur in various parts of plant that helped maintain the critical balance of other essential nutrients in the plant and resulted in enhanced metabolic processes. Vyas *et al*. (2006) also noticed increased yield of soybean with application of sulphur. Sulphur plays a vital role in improving vegetative structure

Table 2: Effect of phosphorus and sulphur on economics and quality of soybean.

Treatments	Net returns (`/ha)	B:C ratio	Protein content (%)	Protein yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
Phosphorus (kg ha^{-1})						
0	29086	0.86	36.56	536	19.64	288
20	33150	0.97	38.73	610	19.84	311
40	44575	1.29	41.18	760	20.32	375
60	48497	1.39	41.41	807	20.53	400
SEm±	1732	0.05	0.31	16.43	0.16	9.16
CD at 5%	5079	0.15	0.92	48.18	0.46	26.86
Sulphur (kg ha^{-1})						
15	30420	0.94	37.16	547	19.58	287
30	41868	1.22	40.55	723	20.15	358
45	44193	1.23	40.70	764	20.53	384
SEm±	1500	0.04	0.27	14.23	0.14	7.93
CD at 5%	4398	0.13	0.79	41.72	0.40	23.27

for nutrient absorption, strong sink strength through development of reproductive structures and production of assimilates to fill economically important sink (Sharma and Singh, 2005).

Quality parameters

A perusal of data presented in Table 2 showed that the maximum protein content was recorded under application of 45 kg sulphur ha^{-1} (40.70 per cent), which was found at par with 30 kg sulphur ha^{-1} (40.55 per cent) over 15 kg sulphur ha^{-1} (37.16 per cent) in soybean seed. Significantly higher protein yield (764 kg ha^{-1}) was recorded with application of 45 kg sulphur ha^{-1}, which was found at par with 30 kg sulphur ha^{-1} (723 kg ha^{-1}) over 15 kg sulphur ha^{-1} (547 kg ha^{-1}). The maximum oil content (20.53 per cent) was recorded with application of 45 kg sulphur ha^{-1}which was found at par with 30 kg sulphur ha^{-1} (20.15 per cent). The extent of increase in oil content in soybean seed due to application of 45 kg sulphur ha^{-1} was 4.8 per cent higher than application of 15 kg sulphur ha^{-1}. Significantly highest oil yield (384 kg ha^{-1}) was recorded with application of 45 kg sulphur ha^{-1} over 30 and 15 kg sulphur ha^{-1} (358 and 287 kg ha^{-1}) in soybean seed.

It might be due to involvement of sulphur in the synthesis of fatty acids and also increases protein quality through the synthesis of certain amino acids such as cysteine, cystine and methionine. The results supported to the earlier findings of (Pable and Patil, 2011) and (Devi *et al*., 2012) in soybean. Increase in oil content due to sulphur application can be attributed to the key role played by sulphur in biosynthesis of oil in oilseed plants. The increase in protein content may be accounted for the increase in synthesis of sulphur containing amino acids. Such beneficial effects of sulphur fertilization were also reported by Nath *et al*. (2018).

Economics

A critical examination of data presented in Table 2 showed that the maximum net returns (` 44193 ha$^{-1}$) were recorded under application of 45 kg sulphur ha$^{-1}$ which was closely followed by 30 kg sulphur ha$^{-1}$ (` 41868 ha^{-1}). The extent of increase net returns due to application of 45 kg sulphur ha^{-1}was 45.2 per cent higher over 15 kg sulphur ha^{-1}. Significantly highest B:C ratio (1.23) was recorded under application of 45 kg sulphur ha^{-1}, which was closely followed by 30 kg sulphur ha^{-1} (1.22). The extent of increase in B:C ratio due to application of 45 kg sulphur ha^{-1}was 30.8 per cent higher over 15 kg sulphur ha^{-1}.

The determination of economics is the most important to evaluate the effect of treatments from farmers as well as planners' point of view. Application of 45 kg sulphur ha^{-1} showed mark improvement in seed yield and thus gaining more profit in terms of net returns and B:C ratio over application of 15 kg sulphur ha^{-1}. The findings are in agreement with the sulphur application is highly profitable as shown by value cost ratio in soybean under field condition (Tandon *et al*., 2007).

CONCLUSION

It is concluded that the application of 40 kg phosphorus ha^{-1} and 30 kg sulphur ha^{-1} is profitable dose for obtaining higher seed yield of soybean, net returns and B: C ratio in the experiment. The quality parameters of soybean also showed considerable increment due to application of 40 kg phosphorus ha^{-1} and 30 kg sulphur ha^{-1}. Hence this dose of phosphorus and sulphur is proved as productive and beneficial. These levels of phosphorus and sulphur fertilizer may be passed on to the farmers for obtaining higher returns in the clay loam soils of zone Vth of Rajasthan.

Conflict of interest: None.

REFERENCES

Anonymous. (2020). Directorate of Economics and Statistics, Govt. of India, New Delhi. pp.75.

AOAC. (1965). Official Methods of Analysis. (10th ed.) Association of Official Agricultural Chemists, Washington.

Chaturvedi, S., Chandel, A.S., Dhyani, A.S. and Singh, A.P. (2010). Productivity, profitability and quality of soybean (*Glycine max*) and residual soil fertility as influenced by integrated nutrient management. Indian Journal of Agronomy. 55(2): 133-137.

D.A.C. and F.W. (2019-20). Directorate of Economics and Statistics, Govt. of India, New Delhi. pp.75.

Devi, K.N., Singh, L.N.K., Singh, M.S., Singh, S.B. and Singh, K.K. (2012). Influence of sulphur and boron fertilization on yield, quality, nutrient uptake and economics of soybean [*Glycine max* (L.) Merrill] under upland conditions. Journal of Agriculture Science. 4(4): 1-10.

Dhage, S.J., Patil, V.D. and Patange, M.J. (2014). Effect of various level of Phosphorus and Sulphur on yield, plant nutrient content, uptake and availability of nutrient at harvest stages of soybean. International Journal of Current Microbiology and Applied Science. 3(12): 833-844.

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

Gomez, K.A. and Gomez, V.A. (1984). Statistical Procedure for Agriculture Research. John Wiley and Sons Inc., New York, USA.

Gonyane, M.B. and Sebetha, E.T. (2022). The Effect of Plant Density, Zinc added to phosphorus fertilizer sources and location on selected yield parameters of soybean. Legume Research-An International Journal. 45(2): 196-202.

Jadon, C.K., Dashora, L.N., Meena, S.N. and Singh, P. (2019). Growth, yield and quality of soybean [*Glycine max* (L.) Merr.] as influenced by weed management and fertility levels in vertisols of SE Rajasthan. International Journal of Bio-resource and Stress Management. 10(2): 177-180.

Jahangir, A.A., Mondal, R.K., Nada, K., Sarkar, M.A., Moniruzzaman, M. and Hossain, M.K. (2009). Response of different levels of nitrogen and phosphorus on grain yield, oil quality and nutrient uptake of soybean. Bangladesh Journal Science and Industrial Research. 44(2): 187-192.

Kumar, V., Chauhan, R.S., Yadav A.S., Upadhyay, M.K. and Rajput, R.K. (2007). Effect of rhizobium and phosphorus application on growth, yield and economic of chickpea (*Cicer arietinum* L.). Advances in Plant Science. 20(2): 89-90.

Meena, L.R., Singh, R.K., Gautam, R.C. (2006). Effect of moisture conservation practices, phosphorus levels and bacterial inoculation on growth, yield and economics of chickpea (*Cicer arietinum* L.). Legume Research-An International Journal. 29(1): 68-72.

Munda, S., Kumar, B.G.S., Rana, D.S., Gangaiah, B., Manjaiah, K.M., Dass, A., Lakshman, K., Layek, J. and Laxman, K. (2018). Inorganic phosphorus along with bio fertilizers improves profitability and sustainability in soybean [*Glycine max* (L.) Merrill]-potato (*Solanum tuberosum*) cropping system. Journal of the Saudi Society of Agriculture Science. 17(2): 107-113.

Nath, S., Kannaujiya. S.K., Kumar, S., Sonkar, S.P., Gautam, A.D. and Singh, A. (2018). Effect of sulphur fertilization on yield, sulphur uptake and oil content in Indian mustard under sandy loam soil of eastern Uttar Pradesh. Journal Krishi Vigyan. 6(2): 81-83.

Pable, D. and Patil, D.B. (2011). Effect of sulphur and zinc on nutrient uptake and yield of soybean. International Journal of Agriculture Science. 7(1): 129-132.

Raghuveer, Hosmath, J.A., Keerti and Chandranath, H.T. (2017). Effect of different levels of nitrogen and phosphorus on growth and yield parameter of soybean [*Glycine max* (L.) Merrill]. International Journal of Pure Applied Bio Science. 5(4): 1686-1690.

Sharma, O.P. and Singh, G.D. (2005). Effect of sulphur in conjunction with growth substances on productivity of cluster bean and their residual effect on barley. Indian Journal of Agronomy. 50(1): 16-28.

Simson, T.E., Adair, C.R., Kohler, G.P., Dabald, H.A., Kestar, F.B., Hlick, J.T. (1965). Quality evaluation studies of foreign and domestic rices. Technical Bulletin No. 1331, USDA. 1-16.

Singh, D., Raghuvanshi, K., Chaurasiya, A. and Dutta, S.K. (2017). Bio fertilizers: Non-chemical source for enhancing the performance of pearl millet crop (*Pennisetum glaucum* L.). Bulletin of Environment, Pharmacology and Life Sciences. 6(11): 38-42.

Suman, J., Uhlik, O., Viktorova, J. and Macek, T. (2018). Phytoextraction of heavy metals: A promising tool for clean-up of polluted environment. Frontiers in Plant Science. 9: 1476.

Tandon, H.L.S. and Messick, D.L. (2007). Practical Sulphur Guide, Sulphur Institute, Washington, D.C. pp.1-22.

Vyas, A.K., Billore, S.D., Joshi, O.P. and Pachlania, N. (2006). Productivity of soybean (*Glycine max* L.) genotypes as influenced by nitrogen and sulphur nutrition. Indian Journal of Agriculture Sciences. 76(4): 272-283.