Journal of Basic and Applied Research International

Volume 30, Issue 6, Page 20-27, 2024; Article no.JOBARI.12470
ISSN: 2395-3438 (P), ISSN: 2395-3446 (O)

Influence of Different Sources and Levels of Phosphorus on Yield and Quality of Soybean in Low Calcareous Soil

Pranali Meshram [a++*], Abhay Patil [a#], Anand Jadhav [a#] and Avinash Gosavi [a†]

[a] Division of Soil Science, College of Agriculture, Pune (MS), Mahatma Phule Krishi Vidyapeeth, Rahuri, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/jobari/2024/v30i68932

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.ikprress.org/review-history/12470

Original Research Article

Received: 27/08/2024
Accepted: 30/10/2024
Published: 06/11/2024

ABSTRACT

A field experiment was conducted during the *kharif* season of 2023 at Post Graduate Instructional Farm, College of Agriculture, Pune, to study the impact of different phosphorus sources and levels on soybean yield and quality of soybean in low calcareous soil. The experiment was laid out in randomized block design having eight treatments with three replications. The experiment was planned with the objective to study the efficacy of different phosphorous sources and their level of

[++] *M.Sc. (Agri) Student;*
[#] *Assistant Professor of Soil Science;*
[†] *Associate Professor of Soil Science*
**Corresponding author: E-mail: pranali.meshram2709@gmail.com;*

Cite as: *Meshram, Pranali, Abhay Patil, Anand Jadhav, and Avinash Gosavi. 2024. "Influence of Different Sources and Levels of Phosphorus on Yield and Quality of Soybean in Low Calcareous Soil". Journal of Basic and Applied Research International 30 (6):20-27. https://doi.org/10.56557/jobari/2024/v30i68932.*

application to soybean crop. The treatments comprised **T_1**- Absolute control, **T_2**- RDF (50:75:45 kg ha^{-1} N: P_2O_5: K_2O), **T_3**- 50% P_2O_5 through PROM, **T_4**- 75% P_2O_5 through PROM, **T_5** -100% P_2O_5 through PROM, **T_6**- 100% P_2O_5 through DAP + FYM @12.5 t ha^{-1}, **T_7** - 100% P_2O_5 through SSP + FYM @12.5 t ha^{-1} and **T_8**- 100% P_2O_5 through vermicompost. The soil of the experimental site was clay loam in texture. The findings of the present investigation revealed that the higher pods per plant (49.66), seeds per plant (149), seed yield (27.63 q ha^{-1}) and straw yield (33.43 q ha^{-1}) were recorded in treatment 100% P_2O_5 through SSP + FYM @12.5 t ha^{-1}. The application of 100% P_2O_5 through PROM recorded significantly higher number of pods per plant (47.33), number of seeds per plant (142), grain yield (22.62 q ha^{-1}) and straw yield (24.88 q ha^{-1}) than the application recommended dose of fertilizers to the soybean crop. In respect of quality parameter, the treatment with 100% P_2O_5 through vermicompost showed significantly higher protein content in soybean grain (38.77 %).

In general, the application of organic fertilizers, FYM, PROM, and vermicompost, significantly enhanced soybean yield and quality, indicating their potential as sustainable alternatives to conventional chemical fertilizers in low calcareous soil.

Keywords: FYM; PROM; quality; soybean; vermicompost and yield.

1. INTRODUCTION

Phosphorus (P) is a vital macronutrient that plays a central role in plant growth, development, and overall productivity. It is involved in numerous physiological processes, such as root development, photosynthesis, energy transfer, and protein synthesis, all of which are crucial for plant health. Phosphorus is particularly important for nodulation and nitrogen fixation, both of which contribute to higher yields and better crop quality. In leguminous crops like soybean (Glycine max), maximizing the production of legume crops is an imperative and pressing task (Awad et al., 2022). Soybean, often referred to as a "wonder crop," is a major oilseed and protein source in India, contributing significantly to the country's agricultural economy. Phosphorus is essential for plant growth, ranking just below nitrogen as a limiting nutrient. However, phosphorus is largely immobile in soil, with only 1-3% of total phosphorus and 15-25% of applied fertilizer phosphorus accessible to plants. This leads to an accumulation of phosphorus in the soil from fertilizer use. The situation is further complicated by the depletion of rock phosphate (RP), the primary material for phosphorus fertilizers, which is a non-renewable resource largely extracted in just three countries: the USA, China, and Morocco. Excessive phosphorus application can also result in environmental pollution, while rising fertilizer costs may impact farmers' profitability. Improving the efficiency of phosphorus use in various crops and cropping systems presents an environmentally friendly and economically viable solution for phosphorus management. Technologies exist for producing phosphate-rich compost from low-grade RP, yet phosphorus deficiency and efficiency issues in Indian soils hinder crop yield and quality. Advancements in technology and the effective use of resources are essential for ensuring food security in India. The Indian Government has implemented policies to enhance the availability and use of fertilizers, resulting in significant growth in fertilizer production over the past four and a half decades. India has become nearly self-sufficient in nitrogen and phosphorus, though recent years have seen increased imports of these nutrients due to insufficient production capacity expansions (Tiwari, 2024).

Despite the widespread use of inorganic fertilizers to supply phosphorus, only 15-20% of applied phosphorus is effectively utilized by crops, with the majority being immobilized due to soil fixation (Malhotra et al., 2018). This challenge calls for innovative strategies to improve phosphorus availability and use efficiency in agricultural systems.

In the majority of soils, phosphorus fixation reduces the bioavailability of this essential nutrient. This makes phosphorus management in such soils particularly challenging, especially for crops like soybean, which have high phosphorus demands. The phosphorus-supplying chemical fertilizers have their own limitations. To address these challenges, various phosphorus sources such as rock phosphate (RP), farmyard manure (FYM), and vermicompost (VC) have been explored for their ability to improve phosphorus availability in soils. The integration of organic manures like FYM and VC with RP, along with the use of phosphorus-solubilizing bacteria (PSB), has been shown to enhance phosphorus

solubilization, making it more accessible to plants. Phosphate-rich organic manure (PROM), created by combining rock phosphate with organic matter and microbial inoculants, has emerged as a promising alternative to conventional fertilizers. PROM provides a slow-release source of phosphorus, improving soil health, crop yield, and quality while reducing the reliance on synthetic fertilizers (Kumar et al,. 2020).

For soybean production, improving phosphorus use efficiency is crucial for maximizing both yield and quality. Soybean requires a significant amount of phosphorus (75 kg ha^{-1}) to support its high protein and oil content. Inadequate phosphorus availability in such soils can result in poor seed set, delayed maturity, and reduced oil content. Recent research suggests that the application of PROM, along with other integrated nutrient management strategies, can significantly enhance phosphorus bioavailability, leading to improved root development, stronger plant structures, and higher crop yields. In turn, this contributes to better soybean quality, including higher protein content and improved oil yield. As sustainable agriculture becomes increasingly important, optimizing phosphorus management using organic amendments and biofertilizers presents a viable path forward for ensuring food security and long-term agricultural productivity.

2. MATERIALS AND METHODS

A field experiment was conducted at the Post Graduate Instructional Farm, Division of Soil Science, College of Agriculture, Pune (MS) during *the kharif* season of 2023. A representative soil sample from the 0–30 cm layer was collected from the field. The soil of the experimental field was slightly alkaline (pH 7.8), with a low electrical conductivity (EC) (0.3 dS m^{-1}), moderate in organic carbon (0.61%) and calcium carbonate (6.42%), low in available nitrogen (263.42 kg ha^{-1}) and available phosphorus (20.17 kg ha^{-1}), but high available potassium levels (697.76 kg ha^{-1}) and sufficient micronutrients.

The soybean variety KDS-726 (*Phule Sangam*) was grown as a test crop. The PROM was prepared at Vermicompost Yard, Division of Soil Science, College of Agriculture, Pune. The recommended dose of fertilizer (50:75:45 kg ha^{-1} of N, P_2O_5, and K_2O) was applied except to absolute control. The recommended dose of phosphorus was supplied through different sources, such as PROM and vermicompost as organic sources and DAP and SSP as inorganic sources. The nitrogen and potassium were supplied through urea and muriate of potash, respectively. PROM, FYM, and vermicompost were applied at sowing. The proximate analysis of PROM, Farmyard manure (FYM), and vermicompost was done before the start of the experiment (Table 1).

Plant samples were collected at the harvest of the soybean crop. The PROM, FYM, VC, and plant samples were analyzed using standard analytical methods. The observations for yield parameters of soybean recorded. The yield data was recorded, and the protein content in seed was calculated by multiplying the nitrogen content with a conversion factor of 6.25. A randomized block design (RBD) with analysis of variance (ANOVA) was employed to assess treatment effects on all studied characteristics (Panse and Sukhatme, 1985).

Table 1. Proximate analysis of PROM, FYM and vermicompost

Sr. No	Parameters	PROM	FYM	Vermicompost
1	pH (1:10)	7.18	7.49	6.91
2	EC (dS m^{-1})	1.74	1.66	2.12
3	Moisture (%)	24.02	23.50	25.45
4	Organic Carbon (%)	21.06	22.26	30.79
5	Total N (%)	0.78	0.69	1.48
6	Total P (%)	14.57	0.39	0.79
7	Total K (%)	0.37	0.38	0.81
8	Total Fe (mg kg^{-1})	12.70	186	388
9	Total Mn (mg kg^{-1})	0.67	35.7	65.7
10	Total Zn (mg kg^{-1})	2.69	14.8	18.3
11	Total Cu (mg kg^{-1})	0.46	4.39	15.2
12	C:N ratio	24:1	39:1	20:1
13	C:P ratio	1.44:1	57.07:1	38.97:1

3. RESULTS AND DISCUSSION

3.1 Influence of Sources and Levels of Phosphorus on Yield Parameters of Soybean (Table 2)

3.1.1 Number of pods per plant

The application of 100% P_2O_5 through SSP + FYM @12.5 t ha^{-1} registered a significantly higher number of pods $plant^{-1}$ (49.66). But this treatment was at par with T_6 (49.00), T_8 (48.33), and T_5 (47.33). It could be seen from the data that these treatments were significantly superior over the recommended dose of fertilizer (41.66) in respect of the number of pods $plant^{-1}$ at the harvest stage of soybean. It was interesting to note that the application with 100% P_2O_5 through PROM recorded a significantly higher number of pods $plant^{-1}$ (47.33) than the recommended dose of fertilizers (46.66). The number of pods $plant^{-1}$ was ranged from 32.33 to 49.66.

3.1.2 Number of seed per pod

There was no significant influence of different sources and levels of phosphorus on number of seed per pod of soybean at harvest stage.

3.1.3 Number of seeds per plant at harvest stage

There was no significant influence of different sources and levels of phosphorus on the number of seeds per pod of soybean at the harvest stage.

3.1.4 Number of seeds per plant at harvest stage

Among different treatments, the application of 100% P_2O_5 through SSP + FYM @12.5 t ha^{-1} registered a significantly higher number of seed $plant^{-1}$ (149). This treatment was at par with treatment T_6 (147), T_8 (145), and T_5 (142), and all these treatments were significantly superior over the remaining treatments. It was interesting to note that the application with 100% P_2O_5 through PROM recorded a significantly higher number of seeds $plant^{-1}$ (142) than the recommended dose of fertilizers (125).

These results might be because of adequate supplementation of nutrients through these sources and levels of phosphorus to soybean crop. The balanced nutrient supply provided essential nutrients throughout different growth stages, with chemical fertilizers offering an initial nutrient boost and organic manure ensuring a sustained release of N, P, and K throughout the growing season. This integrated approach likely improved the plant's nutritional status, contributing to a higher number of pods and grains per plant. Additionally, organic manures like FYM and PROM enhanced microbial activity, facilitating nutrient transformation and fixation while promoting processes like cell division, expansion, and photosynthesis, which ultimately improved plant growth and yield. These findings were supported by (Konthoujam et al., 2013; Pati and Udmale 2016; Verma et al., 2017; Bairwa et al., 2019; Muindi et al., 2019; Pandey et al., 2019; Rana et al., 2020; Yadav et al., 2021; Rao et al. 2021; Harish et al., 2023).

Table 2. Influence of sources and levels of phosphorus on yield parameters of soybean at harvest stage

Treat. No.	Treatments	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	No. of seeds $plant^{-1}$ at harvest stage
T_1	Absolute control	32.33	2.6	86
T_2	RDF (50:75:45 kg ha^{-1} N: P_2O_5: K_2O)	41.66	3.0	125
T_3	50% P_2O_5 through PROM	41.00	3.0	123
T_4	75% P_2O_5 through PROM	41.33	3.0	124
T_5	100% P_2O_5 through PROM	47.33	3.0	142
T_6	100% P_2O_5 through DAP + FYM @12.5 t ha^{-1}	49.00	3.0	147
T_7	100% P_2O_5 through SSP + FYM @12.5 t ha^{-1}	49.66	3.0	149
T_8	100% P_2O_5 through Vermicompost	48.33	3.0	145
	SE(m) ±	1.15	0.1	5.00
	CD (0.05)	3.52	NS	15.31

3.2 Influence of Sources and levels of Phosphorus on Yield and Quality of Soybean (Table 3)

3.2.1 Yield

The application of 100% P_2O_5 through SSP + FYM @12.5 t ha^{-1} to soybean registered significantly higher grain yield (27.63 q ha^{-1}) but was at par with treatment 100% P_2O_5 through DAP + FYM @12.5 t ha^{-1} (26.64 q ha^{-1}) and 100% P_2O_5 through vermicompost (26.38 q ha^{-1}). The application of 100% P_2O_5 through PROM registered significantly higher grain yield (22.62 q ha^{-1}) over the treatment application of the recommended dose of fertilizer (50:75:45 kg ha^{-1} N: P_2O_5: K_2O) (18.58 q ha^{-1}). It was interesting to note that 100% P_2O_5 through vermicompost registered significantly higher grain yield (26.38 q ha^{-1}) over 100% P_2O_5 through PROM (22.62 q ha^{-1}).

In general, it could be revealed from the data that application of 100% P_2O_5 through DAP or SSP along with FYM @ 12.5 t ha^{-1} might be effective for supply of essential nutrients to soybean crop. The application of 100% P_2O_5 through vermicompost had a significantly demarkable effect over 100% P_2O_5 through PROM. This might be due to the quantity of vermicompost required to supply 100% P_2O_5 (75 kg ha^{-1}) was higher (4.1 t ha^{-1}) as compared to 100% P_2O_5 through PROM (224 kg ha^{-1}). This higher quantity of vermicompost might have supplied other essential nutrients in sufficient quantity at the proper growth stage of soybean compared with the application of PROM and ultimately resulted in increasing the yield of the soybean crop. The superiority of treatment with 100% P_2O_5 through PROM (22.62 q ha^{-1}) over RDF (18.58 q ha^{-1}) might be attributed to the addition of organic manure, which helped to improve soil bio-physicochemical health compared with the application of chemical fertilizers only to soybean crop. It could be inferred that the integration of chemical fertilizers and organic manures might have helped for improvement in soil biological physical health, which is favorable for healthy growth of the soybean crop.

The significant increase in grain yield through the combined application of organic and inorganic phosphorus fertilizers can be attributed to improved soil fertility and enhanced plant growth, leading to greater photosynthetic production and efficient partitioning of photosynthates towards yield attributes like pod and seed number. The integration of inorganic, organic, and biofertilizers may have stimulated microbial activity, improved root development, and increased nutrient uptake, resulting in higher seed and haulm production. Vermicompost also contributed to improving crop yield by enhancing microbial activity and nutrient availability, leading to better resource allocation within plants. The application of 100% P_2O_5 through DAP or SSP along with FYM was found to effectively supply essential nutrients, while the higher quantity of vermicompost required for P_2O_5 delivery may have provided additional nutrients, further increasing yield. Moreover, the integration of chemical fertilizers and organic manures improved soil bio-physicochemical health, promoting healthy soybean growth. Phosphorus played a key role in root development, nutrient uptake, and straw yield, while increased soil organic matter content positively influenced soybean vegetative growth. These findings were supported by (Pandey et al., 2019; Yadav et al., 2021; Rao et al., 2021; Harish et al., 2023; Sharma et al., 2017; Chavan et al., 2019; Dev et al., 2020; Makwana et al., 2020).

Table 3. Influence of sources and levels of phosphorus on yield and quality of soybean

Treat. No.	Treatments	Grain Yield (q ha^{-1})	Protein content (%)
T_1	Absolute control	7.80	20.21
T_2	RDF (50:75:45 kg ha^{-1} N: P_2O_5: K_2O)	18.58	39.08
T_3	50% P_2O_5 through PROM	17.79	38.79
T_4	75% P_2O_5 through PROM	19.06	38.54
T_5	100% P_2O_5 through PROM	22.62	38.66
T_6	100% P_2O_5 through DAP + FYM @12.5 t ha^{-1}	26.64	38.60
T_7	100% P_2O_5 through SSP + FYM @12.5 t ha^{-1}	27.63	38.50
T_8	100% P_2O_5 through Vermicompost	26.38	38.77
	SE(m) ±	1.19	0.24
	CD (0.05)	3.66	0.75

3.2.2 Protein content

Perusal of the data revealed that the application of different phosphorus levels and sources and inorganic fertilizers registered significantly higher protein content over absolute control. The treatment with 100% P_2O_5 through vermicompost showed significantly higher protein content in soybean grain (38.77%). This treatment was at par with the rest of the treatment except absolute control.

The increase in protein content in soybean seeds can be attributed to the integrated use of RDF and organic sources like vermicompost, PROM, and FYM, which enhanced nutrient availability in the root zone through the solubilization of nutrients by organic acids from decaying organic matter. The association of soybean roots with mycorrhizal filaments also improved nutrient uptake by increasing the root's absorbing area. Additionally, the presence of sulfur in SSP contributed to fatty acid synthesis and improved protein quality by promoting the production of sulfur-containing amino acids like cysteine, cystine, and methionine. The rise in nitrogen levels from organic sources further enhanced seed protein content, as nitrogen is a key component of proteins. These findings were supported by (Konthoujam et al., 2013; Verma et al., 2017; Yadav et al., 2021; Harish et al., 2023; Jakhar et al., 2020; Meena et al., 2022).

4. CONCLUSION

The study investigated the effects of various phosphorus sources and levels on soybean pod number, seed number, grain yield, and protein content. Supplying 100% P_2O_5 through SSP along with FYM resulted in the highest number of pods and seeds per plant, as well as the higher grain yield. This treatment was equally effective with DAP + FYM and vermicompost at 100% P_2O_5. Interestingly, 100% P_2O_5 through PROM showed a significant increase in grain yield compared to the recommended fertilizer dose. Vermicompost, despite requiring a larger quantity to supply the same P_2O_5 level, delivered a significantly higher grain yield than PROM. Notably, vermicompost also led to the highest protein content in soybean grains. Overall, the study suggests that supplying 100% P_2O_5 through inorganic fertilizers (DAP or SSP) with FYM is effective for soybean, while PROM shows promises to use as a phosphorus source for soybean crop.

Future Thrust: The studies on use of PROM (phosphate-rich organic Manure) as a source of phosphorus under different soil types and different crops need to be undertaken to know its efficacy as compared with other organic manures. The efficiency of phosphorus when applied through PROM and other phosphatic fertilizers needs to be studied.

Limitations: The study provides valuable insights into the effects of different phosphorus sources on soybean yield and quality, but it has certain limitations that should be considered: First, the experiment was conducted over a single growing season, which may not capture the long-term effects of phosphorus sources on soybean yield and quality. Second, the variability in soil types and conditions across different regions was not accounted for, which may limit the generalizability of the results. Lastly, potential interactions between phosphorus sources and other nutrients were not thoroughly investigated, which could influence overall crop health and productivity.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Awad, M., Fouda, O., El-Raheem, S., Al-Gezawe, A., Cottb, M., & Okasha, M. (2022). A new seed drill for planting peas on a raised-bed. *INMATEH-Agricultural Engineering*, *68*(2).

Bairwa, P. C., Sammauria, R., & Gupta, K. C. (2019). Direct and residual effect of PROM on productivity, nutrient uptake, soil properties and economics under clusterbean-wheat cropping system. *Journal of Soil Salinity and Water Quality*, *11*(1), 84-89.

Chavan, A. R., Chavan, S. A., Yadav, A. M., & Chavan, V. G. (2019). Effect of vermicompost, rock phosphate, PSB and

different bio-products on yield and economics of groundnut (*Arachis hypogea* L.). *International Journal of Current Microbiology and Applied Sciences*, *8*(12), 2031-2039.

Dev, T. A., Devi, N. S., Sarangthem, I., Lhungdim, J., Singh, N. O., & Das, H. (2020). Effect of rock phosphate, PSB and FYM on P concentration and dry matter yield of soybean (*Glycine max*). *International Journal of Chemical Studies*, *8*(6), 627-630.

Harish, A., Singh, P. K., Sharma, Y. K., & Singh, A. P. (2023). Effect of different sources of nutrients on growth, yield and quality of mung bean (*Vigna radiata* L.). *International Journal of Environment and Climate Change*, *13*(10),1390-1401.

Jakhar, M., Sharma, P. K., Mandeewal, R. L., & Choudhary, R. (2020). Effect of integrated nutrient management on growth attributes, nitrogen content, nitrogen uptake and quality of chickpea (*Cicer arietinum* L.). *International Journal of Chemical Studies*, 8(6), 1125-1127.

Konthoujam, N. D., Singh, T. B., Singh, A. H., Singh, N. B., & Shamurailatpam, D. (2013). Influence of inorganic, biological and organic manures on nodulation and yield of soybean (*Glycine max* Merril L.) and soil properties. *Australian Journal of Crop Science*, *7*(9),1407-1415.

Kumar, R., Singh, V., Sharma, S. N., & Yadav, A. (2020). Role of phosphate-rich organic manure in enhancing phosphorus use efficiency and soybean yield in calcareous soils. *Journal of Sustainable Agriculture*, *12*(3),78-90.

Makwana, S. N., Patel, G. G., Patel, H. K., Shiyal, V. N., & Patel, B. K. (2020). Effect of inorganic and organic nutrients on growth and yield of summer green gram (*Vigna radiata* L.). *International Journal of Current Microbiology and Applied Sciences*, 1(11), 730-738.

Malhotra, H., Vandana, Sharma, S., & Pandey, R. (2018). Phosphorus nutrition, plant growth in response to deficiency and excess. *Plant Nutrient Management*, 2(1), 33-50.

Meena, N., Sharma, M. K., Meena, D. S., Choudhary, S., Bhil, K., & Danga, N. (2022). Effect of organic and inorganic sources of nutrients on growth, yield attributes and nutrient uptake of soybean in Vertisol of Rajasthan. *Legume Research - An International Journal*, *46*(8), 1020-1026.

Muindi, E. M., Muindi, C. M., & Ndiso, J. (2019). The effects of combining farm yard manure, starter nitrogen, phosphorus and zinc on growth and yield of green grams. *Journal of Agriculture and Ecology Research International*, *20*(4), 1-9.

Pandey, O. P., Shahi, S. K., Dubey, A. N., & Maurya, S. K. (2019). Effect of integrated nutrient management of growth and yield attributes of green gram (*Vigna radiata* L.). *Journal of Pharmacognosy and Phytochemistry*, *8*(3), 2347-2352.

Panse, V. A., & Sukhatme, P. V. (1985). Statistical methods for Agricultural workers, Revised Edition. ICAR, New Delhi.

Pati, H. M., & Udmale, K. B. (2016). Response of different organic inputs on growth and yield of soybean on Inceptisol. *International Journal of Recent Scientific Research*, *7*(11), 14116-14120.

Rana, K., Singh, J., & Shilpa. (2020). Productivity, profitability and quality of soybean (*Glycine max*) as influenced by tillage, organic manures and fertilizer doses. *Indian Journal of Agricultural Sciences*, *90*(2), 376-380.

Rao, D., Sachan, C. P., Pashwan, V. R., & Sakpal, A. V. (2021). Effect of organic manure, biofertilizer, phosphorus and nitrogen on growth, seed yield, seed quality attributes of green gram (*Vigna radiata* L.). *Seed Research*, *49*(1), 45-53.

Sharma, J. K., Jat, G., Meena, R. H., Purohit, H. S., & Choudhary, R. S. (2017). Effect of vermicompost and nutrients application on soil properties, yield, uptake and quality of Indian mustard (*Brassica juncea*). *Annals of Plant and Soil Research*, 19(1),17-22.

Tiwari, P. (2024). Fertilizer consumption and production in India. *International Journal of Agriculture and Animal Production*, *4*(4).

Verma, S. N., Sharma, M., & Verma, A. (2017). Effect of integrated nutrient management on growth, quality and yield of soybean (*Glycine max*). *Annals of Plant and Soil Research*, *19*(4), 372-376.

Yadav, K. K., Meena, M. K., & Mali, N. L. (2021). Impact of graded levels of fertility and biofertilizers on yield attributes and yields of mungbean (*Vigna radiata* (L.) Wilczek). *International Research Journal of Humanities and Interdisciplinary Studies*, *2*(6), 280-289.

Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.ikprress.org/review-history/12470