REVIEW ARTICLE Indian Journal of Agricultural Research, Volume 59 Issue 4: 517-522 (April 2025)

Impact of Integrated Nutrient Management on Soil Health and Yield of Mungbean: A Review

Hemant Choudhary[1], Naorem Diana Devi[1], Vishal Rinwa[1], Anupam Singh[1], Anamika Roy[1], Shilpa[1], Navjot Rana[1], Ravi Verma[1]

10.18805/IJARe.A-6260

ABSTRACT

Sustainable agriculture is increasingly recognized as a vital strategy to combat soil pollution and degradation, particularly in the face of climate change. This review highlights Integrated Nutrient Management (INM) as an effective approach that combines both inorganic and organic fertilizers to enhance soil health and boost crop productivity. Key components of INM, including Nano DAP, vermiwash, vermicompost and traditional fertilizers, have been examined for their impact on mungbean growth and yield. The integration of these fertilizers not only improves soil fertility but also enhances nutrient uptake, which is crucial for adapting to fluctuating climate conditions. By fostering a balance between organic and inorganic inputs, INM supports sustainable agricultural practices that can mitigate the adverse effects of climate change on food security. To determine the "Impact of integrated nutrient management (nano dap, vermiwash, vermicompost and inorganic fertilizer) on soil health and mungbean yield," 41 research papers were examined. This particular review paper read and explained the results from all the reviews. In conclusion, adopting INM strategies represents a promising path forward for sustainable agriculture. These practices not only promote high crop productivity but also contribute to long-term soil health, thereby addressing the challenges posed by climate change and soil degradation. As we move forward, the continued exploration and implementation of INM can play a pivotal role in creating resilient agricultural systems that ensure food security while preserving our environmental resources for future generations. By investing in such sustainable practices, we can pave the way for a more sustainable and productive agricultural landscape.

Key words: Biofertilizer, Nano DAP, Organic farming, Soil health, Vermicompost, Vermiwash.

Mung bean is a warm-season legume enriched with nutrients like protein, minerals and vitamins. Asia produces about 90% of the world's mungbean crop, with Thailand, China, India and Pakistan being the top producers (Schreinemachers *et al.,* 2019). Mungbean is grown in almost every state of India however; Rajasthan is the leading contributor to mungbean cultivation, accounting for 46% of the area and 45% of production. Other key contributors include Madhya Pradesh (9% area, 14% production), Maharashtra (9% area, 8% production), Karnataka (9% area, 6% production), Odisha (5% area, 4% production), Bihar (4% area, 5% production), Tamil Nadu (4% area, 3% production), Gujarat (3% area, 4% production) Andhra Pradesh (3% for both area and production) and Telangana (2% for both area and production) (Anonymous, 2022). Currently, the average yield of 482 kg/ha has been achieved as a result of the introduction of semi-determinate and early maturing varieties such as PS-16, Pusa-105, Pant and PDM selection, which is still much below the productivity level obtained in nations like the Philippines, Taiwan, Thailand, *etc* (Mishra *et al.,* 2022). Mungbean production and productivity are quite low in India despite the fact that many varieties have been produced and advised for cultivation (Narasimhulu *et al.,* 2013). As a result, there is a need for increment in yield. The absence of high yielding, disease-resistant mungbean cultivars that are suited to various climates, seasons, cropping systems and agronomic circumstances is the primary cause of low production (Das and Barua, 2015; Meena *et al.,* 2021).

Using organic materials in crop production has been a long-standing practice in agriculture, where substances like farmyard manure, compost, neem cake, vermicompost and poultry manure are used to replace or supplement chemical fertilizers (Singh *et al.,* 2020). Organic manures offer a balanced source of macro and micro nutrients, which contribute to soil fertility and promote the mineralization process enhancing the availability of nutrients for plants (Dhaliwal *et al.,* 2021). The adoption of organic manures in traditional farming thus not only serves as an eco-friendly alternative to synthetic fertilizers but also

[1]Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara-144 401, Punjab, India.

Corresponding Author: Naorem Diana Devi, Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara-144 401, Punjab, India.
Email: diananaorem0303@gmail.com

How to cite this article: Choudhary, H., Devi, N.D., Rinwa, V., Singh, A., Roy, A., Shilpa, Rana, N. and Verma, R. (2025). Impact of Integrated Nutrient Management on Soil Health and Yield of Mungbean: A Review. Indian Journal of Agricultural Research. 59(4): 517-522. doi: 10.18805/IJARe.A-6260.

Submitted: 26-05-2024 **Accepted:** 19-01-2025 **Online:** 15-03-2025

helps maintain the long-term productivity and sustainable agriculture (Meena *et al.,* 2016; Soni *et al.,* 2022).

In order to maintain soil fertility and plant nutrient delivery at an optimal level for maintaining the desired productivity, integrated nutrient management is the process of optimizing the benefits from all possible sources of organic, inorganic and biological components in an integrated way (Gupta *et al.,* 2022). Most legume crops, including mungbean, are grown in marginal, poor and less fertile soil in India; also, a lack of organic and inorganic resources further contributed to the crop's low yield (Kumar *et al.,* 2018). Lack of proper understanding of the concept of integrated nutrient management, the overuse and inappropriate application of inorganic fertilizers further exacerbates the lower output and has a significant negative impact on the ecosystem of healthy soil (Shukla *et al.,* 2022).

Components of integrated nutrient management (INM)

It is a holistic approach that combines sources of nutrients (organic and inorganic) for improved growth and high output of the crop. These components have been discussed below:

Organic nutrient sources

Biofertilizers

In the study by Bahadur and Tiwari (2014), the effects of biofertilization through Rhizobium and phosphate-solubilizing bacteria (PSB) inoculation were thoroughly investigated. The results indicated that both biofertilizers significantly enhanced various growth parameters, including plant height, number of primary branches, effective pods per plant, grains per pod and the weight of 1,000 grains compared to the control group. Notably, the dual inoculation of Rhizobium and PSB demonstrated compatibility, leading to a synergistic effect that further improved plant growth. The compatibility between sulfur application and biofertilization highlighted an interesting interaction: sulfur provided direct nutritional benefits to the plants while also supporting the growth and activity of nitrogen-fixing organisms (Chaudhary *et al.,* 2023). This dual mechanism not only enhances the efficiency of nutrient uptake but also contributes to overall plant health and productivity.

Vermiwash

Vermiwash is a type of organic liquid fertilizer created with the help of earthworms. Vermiwash contains a wide range of nutrients and beneficial substances, including vitamins, decomposing bacteria, bioavailable minerals, enzymes, antimicrobial peptides and plant growth hormones. according to Leifeld and Fuhrer (2010), this special composition has various advantages for agriculture, including increasing soil fertility and encouraging plant development and productivity and also reducing greenhouse gas emissions from farming. Vermiwash is also effective in controlling plant diseases and managing pests (Gudeta *et al.,* 2021), adding to its utility as a natural pesticide and soil conditioner. Moreover, vermiwash is less expensive to produce and easier to make than chemical fertilizers and it can be used as a foliar spray for a variety of crops (Jandaik *et al.,* 2015).

Compost

Compost, as a crucial component of integrated nutrient management (INM), significantly improves the health of the soil and boosting the productivity of mung bean crops. Compost offers a consistent supply of vital nutrients including potassium, phosphorus and nitrogen when combined with other organic and inorganic fertilizers thereby supporting the overall growth and development of mung beans (Islam *et al.,* 2024). INM not only improves mung bean yield and quality but furthermore encourages environmentally friendly farming methods by lowering the use synthetic fertilizers and promoting soil conservation.

Vermicompost

Vermicompost is an organic fertilizer rich in nutrients that is created when earthworms break down organic waste. It strengthens the structure, aeration and water-holding capacity of the soil thereby increasing the ability of Mungbean to withstand circumstances of moisture stress brought on by climate change, hence it is an effective soil conditioner (Ceritoglu *et al.,* 2023). By offering a slow-release source of vital nutrients, vermicompost helps to lessen the reliance on artificial fertilizers and the corresponding greenhouse gas emissions (Rajkhowa *et al.,* 2017). It encourages the development of helpful soil microorganisms that can aid in the mobilization of nutrients and the stimulation of plant growth (Toor *et al.,* 2023). Fig 1 illustrating how soil and plant health is enhancing through vermicompost.

Fig 2 illustrated the use of vermicompost in legume cultivation, focusing on its unique advantages over traditional cereal-based applications. Experimental findings from Todawat (2018) suggested that combining vermicompost at a rate of 7.5 tonnes per hectare with zinc at 6 kilograms per hectare can lead to enhanced growth and yield of *kharif* Greengram (variety SML-668).

The use of vermicomposting in legume cultivation can enhance seed germination, increase plant height, improve chlorophyll content and boost overall crop yield.

Green manure

Crops cultivated with the intention of adding organic matter and nutrients to the soil are known as "green manures". Sesbania and Crotalaria are the two leguminous green manure crops that fix atmospheric nitrogen, which helps to lessen greenhouse gas emissions by eliminating the demand for synthetic nitrogen fertilizers (Meena *et al.,* 2018). Mungbean plants become more drought- and waterlogging-tolerant when green manures are added to the soil to enhance its structure, drainage and water retention capacity. They can also lessen the need for

chemical inputs by suppressing diseases, pests and weeds (Bista and Dahal, 2018).

Crop residues

Adding crop wastes such as wheat straw, stubbles *etc.* can improve the soil's organic matter content and nutrient availability (Kaur *et al.,* 2019). In order to cultivate Mungbean in water-stressed conditions brought on by climate change, crop residues function as a mulch, lowering soil evaporation and preserving soil moisture (Ranaivoson *et al.,* 2017). In addition to improving soil health, they help to sequester carbon in the soil (Yang *et al.,* 2021) and reduce greenhouse gas emissions.

Inorganic nutrient sources

Nano-DAP

Nano DAP (di-ammonium phosphate), a type of nano fertilizer, offers a significant advancement in nutrient management for mung bean cultivation as part of Integrated Nutrient Management (INM). Unlike conventional chemical fertilizers, Nano DAP releases nutrients gradually over a period of 40-50 days, providing a steady supply of essential

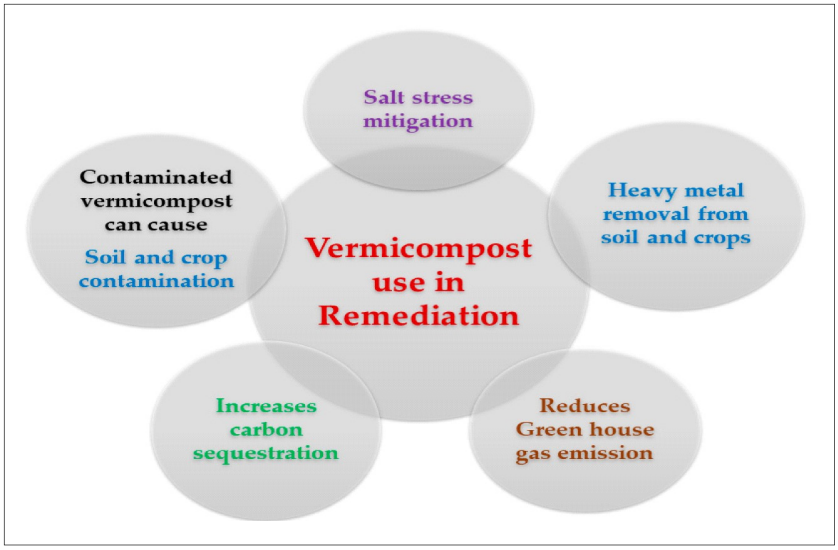


Fig 1: Enhancing soil and plant health through vermicompost.

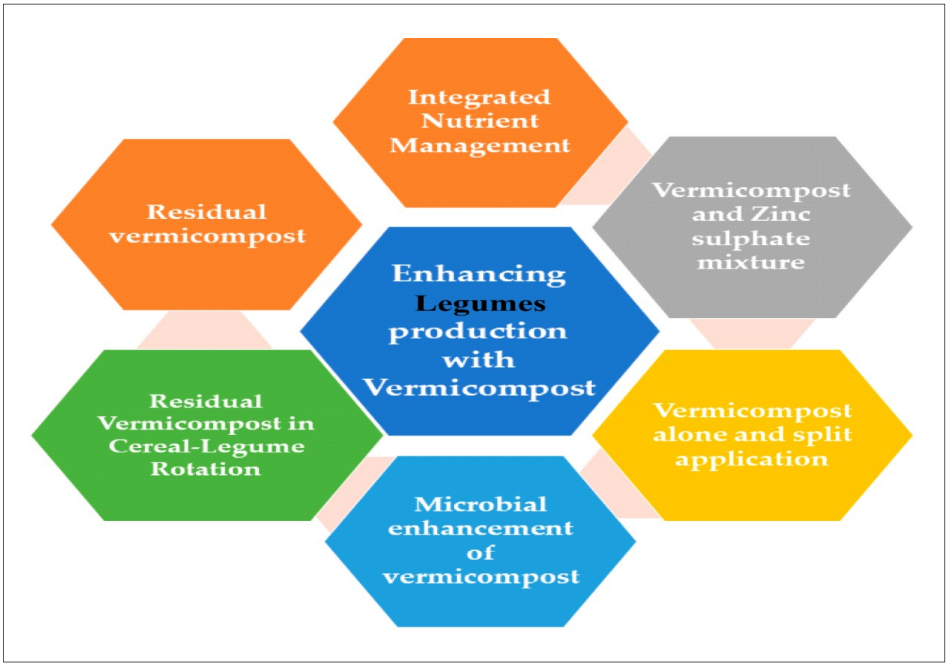


Fig 2: Techniques used to enhance the efficiency of vermicompost for crop production.

nutrients to mung beans. By slowly releasing nutrients, Nano DAP minimizes the risk of environmental pollution that can result from the overuse of traditional chemical fertilizers, which tend to release nutrients too quickly (Jakhar *et al.,* 2022).

The study by Hossain *et al.* (2018) demonstrates the positive impact of combining vermicompost with recommended inorganic fertilizers on soil health and mungbean yield. The synergy between these two types of fertilizers enhances various soil properties, creating favorable conditions for plant growth. Specifically, parameters such as bulk density, particle density, pH, electrical conductivity (EC) and remaining pore space were observed to be significantly low to medium. The soil analyzed was characterized as yellowish-brown, sandy loam, with a neutral to alkaline pH and non-saline nature. These attributes, coupled with improved water holding capacity (WHC), organic carbon (OC) and nutrient content (NPK), contributed to increased yield-related parameters in mungbean, including plant height, pod formation and grain weight. The application of inorganic fertilizers alone also demonstrated notable effects on mungbean growth, enhancing nutrient availability and supporting higher productivity (Shukla and Tyagi, 2009). However, the combination with vermicompost not only improved nutrient uptake but also fostered better soil structure and microbial activity.

Effect of INM on yield attributes and yield of mungbean

Integrated nutrient management (INM) has a substantial effect on yield attributes and final yields in mungbean cultivation. Sheoran *et al.* (2008) found that applying 12.5 kg N and 40 kg P_2O_5 ha^{-1} under rainfed conditions increased mungbean seed yield by 4.3%. Aslam *et al.* (2024) reported that adding 5 tonnes of vermicompost per hectare yielded 16-17% more seeds in mungbean compared to the control.

Incorporating organic fertilizers such as vermicompost and poultry manure into INM practices further enhances nutrient availability and uptake. Rajkhowa *et al.* (2017) showed that applying vermicompost at 2.5 t/ha along with 100% recommended dose of fertilizers (RDF) improved soil organic carbon, available nitrogen, phosphorus and potassium levels, which in turn promoted higher seed yield in mungbean. Similarly, Tarafder *et al.* (2020) observed that 3 tonnes per hectare of poultry manure, combined with 70% of soil test-based inorganic fertilizers, increased yield attributes in mungbean, including pods per plant and weight of 100 seeds. Additionally, Gurjar *et al.* (2022) highlighted the positive impact of inoculating mungbean seeds with biofertilizers such as PSB and Rhizobium, resulting in higher nutrient uptake and seed yield. The application of micronutrients like molybdenum and cobalt are also essential for optimizing plant growth and yield, given their impact on physiological processes such as nitrogenase enzyme activity and stem elongation (Chaudhary *et al.,* 2018; Dhaliwal *et al.,* 2021).

Effect of INM on soil health

Several studies by different researchers have concluded its beneficial effect on soil health which ultimately enhances the performance of crop. Some of the case studies have been highlighted below:

Chakraborty *et al.* (2024) conducted research to examined effect of integrated nutrient management on both soil health and the yield of mungbean (*Vigna radiata* L.) in the northeastern region of India. Paramesh *et al.* (2023) evaluated multiple studies and concluded that integrated nutrient management can increase soil health in Mungbean. A study by Tripathi *et al.* (2022) on “Integrated nutrient management approaches for growth, production and quality in mungbean revealed that techniques such as agricultural waste management, the use of organic manures and biofertilizers increased the yield and quality of mungbean as a result of better soil health brought about by INM.

Vigneshvarraj *et al.* (2020) conducted a research titled “Integrated nutrient management on growth, yield and nutrient uptake in Mungbean” found that integrated nutrient management techniques raised the pH, organic matter content and nutrient availability of the soil, all of which benefited soil health which in turn led to higher yield. Kumari *et al.* (2023) examined the effects of integrated nutrient management strategies on the economy and soil health of in mungbean. The team analyzed diverse integrated nutrient management techniques and discovered that methods like applying biofertilizers and organic manures enhanced soil health and decreased production costs. According to Sinha *et al.* (2023) analysis on “Integrated nutrient management for sustainable soil health and crop productivity in mungbean, concluded that by utilizing integrated nutrient management techniques, such as crop residue management, biofertilizers and organic manures, improves the overall yield and quality of mung bean. According to a study on “Impact of Integrated Nutrient Management in Mungbean” for enhancing soil health discovered that Mungbean productivity and soil health were enhanced by integrated nutrient management techniques, particularly when the techniques were adapted to the local soil and climate by Sarkar *et al.* (2023).

Conclusion

The integration of organic and inorganic fertilizers, such as nano DAP, vermiwash, vermicompost and traditional inorganic fertilizers emerged as a promising approach to sustainable agriculture, particularly in the context of climate resilience and soil health. This strategy not only enhances soil fertility and nutrient uptake but also contributes to the robustness of crops like Mungbean against changing climatic conditions. The use of Nano DAP fertilizers allows for efficient nutrient delivery with reduced environmental impact, while vermiwash and vermicompost offer organic alternatives that support soil health and biodiversity. This combined approach can lead to improved crop yields and

reduced reliance on synthetic fertilizers, ultimately supporting sustainable practices. By adopting Integrated Nutrient Management, farmers can improve the resilience of their crops to climate variability, ensuring consistent production and contributing to the sustainable agriculture.

Conflict of interest

All authors declared that there is no conflict of interest.

REFERENCES

Anonymous. (2022). https://iipr.icar.gov.in/mungbean/ dated 22.10.2024.

Aslam, Z., Ahmad, A., Mushtaq, Z., Liaquat, M., Hussain, T., Bellitürk, K. and Du, Z. (2024). Evaluating the integration of vermicompost with synthetic fertilizer and compost on mung bean (*Vigna radiata* L.). Archives of Agronomy and Soil Science. 1-14.

Bahadur, L. and Tiwari, D.D. (2014). Nutrient management in mung bean (*Vigna radiata* L.) through sulphur and biofertilizers. Legume Research-An International Journal. 37(2): 180-187. doi: 10.5958/j.0976-0571.37.2.027.

Bista, B. and Dahal, S. (2018). Cementing the organic farming by green manures. International Journal of Applied Sciences and Biotechnology. 6(2): 87-96.

Ceritoglu, M., Erman, M., Cıg, F., Ceritoglu, F., Ucar, O., Soysal, S. and Sabagh, A.E. (2023). Enhancement of root system architecture, seedling growth and germination in lentil under salinity stress by seed priming with silicon and salicylic acid. Polish Journal of Environmental Studies. 32(5): 4481-4491.

Ceritoglu, M., Şahin, S. and Erman, M. (2018). Effects of vermicompost on plant growth and soil structure. Selcuk Journal of Agriculture and Food Sciences. 32(3): 607-615.

Chakraborty, R., Sharma, V.K., Das, D., Biswas, D.R., Mahapatra, P., Shahi, D.K. and Chakraborty, D. (2024). Change in phosphorus availability, fractions and adsorption-desorption by 46-years of long-term nutrient management in an Alfisol of eastern India. Soil and Tillage Research. 236: 105940.

Chaudhary, S., Sindhu, S.S., Dhanker, R. and Kumari, A. (2023). Microbes-mediated sulphur cycling in soil: Impact on soil fertility, crop production and environmental sustainability. Microbiological Research. 271: 127340.

Chaudhary, M., Singh, S., Babu, S. and Prasad, M. (2018). Effect of integrated nutrient management on productivity, nutrient acquisition and economics of blackgram (*Phaseolus mungo* L.) in an inceptisol of eastern Uttar Pradesh. Legume Research. 41(5): 759-762. doi: 10.18805/lr.v0i0.7850.

Das, R.T. and Barua, P.K. (2015). Association studies for yield and its components in green gram. International Journal of Agriculture, Environment and Biotechnology. 8(3): 561-565.

Dhaliwal, S.S., Sharma, V., Mandal, A., Naresh, R.K. and Verma, G. (2021). Improving soil micronutrient availability under organic farming. In Advances in organic farming Woodhead Publishing. (pp. 93-114).

Gudeta, K., Julka, J.M., Kumar, A., Bhagat, A. and Kumari, A. (2021). Vermiwash: An agent of disease and pest control in soil: A review. Heliyon. 7(3): e06434. https://doi.org/10.1016/j.heliyon.2021.e06434.

Gupta, G., Dhar, S., Kumar, A., Choudhary, A.K., Dass, A., Sharma, V.K. and Rajawat, M.V.S. (2022). Microbes-mediated integrated nutrient management for improved rhizo-modulation, pigeonpea productivity and soil bio-fertility in a semi-arid agro-ecology. Frontiers in Microbiology. 13: 924407.

Gurjar, R., Tomar, D., Singh, A. and Kumar, K. (2022). Integrated nutrient management and its effect on mungbean [*Vigna radiata* (L.) Wilczek]: A revisit. Pharma Innov. J. 11: 379-384.

Hossain, M.E., Islam, M.S. and Rahaman, M.S. (2018). Growth performance and development attributes of mungbean (*Vigna radiata* L.) as influenced by organic manure and inorganic fertilizer. Asian J Adv Agric. 7(2): 1-13.

Islam, M.R., Sarker, U., Azam, M.G., Hossain, J., Alam, M.A., Ullah, R. and Islam, M.S. (2024). Potassium augments growth, yield, nutrient content and drought tolerance in mung bean [*Vigna radiata* (L.) Wilczek.]. Scientific Reports. 14(1): 9378.

Jakhar, A.M., Aziz, I., Kaleri, A.R., Hasnain, M., Haider, G., Ma, J. and Abideen, Z. (2022). Nano-fertilizers: A sustainable technology for improving crop nutrition and food security. NanoImpact. 27: 100411.

Jandaik, S., Kumar, V. and Thakur, P. (2015). Vermiwash: Plant growth enhancer and antifungal agent. International Journal of Extensive Research. 2: 38-41.

Kaur, K., Kaur, P. and Sharma, S. (2019). Management of crop residue through various techniques. Journal of Pharmacognosy and Phytochemistry. 8(1S): 618-620.

Kumar, N., Hazra, K.K., Nath, C.P., Praharaj, C.S. and Singh, U. (2018). Grain legumes for resource conservation and agricultural sustainability in South Asia. Legumes for Soil Health and Sustainable Management. pp 77-107.

Kumari, S., Kumar, R., Chouhan, S. and Chaudhary, P.L. (2023). Influence of various organic amendments on growth and yield attributes of mung bean (*Vigna radiata* L.). International Journal of Plant and Soil Science. 35(12): 124-130.

Leifeld, J. and Fuhrer, J. (2010). Organic farming and soil carbon sequestration: What do we really know about the benefits?. Ambio. 39(8): 585-599.

Meena, R.S. and Lal, R. (2018). Legumes and sustainable use of soils. Legumes for Soil Health and Sustainable Management. pp 1-31.

Meena, S., Swaroop, N. and Dawson, J. (2016). Effect of integrated nutrient management on growth and yield of green gram (*Vigna radiata* L.). Agricultural Science Digest-A Research Journal. 36(1): 63-65. doi: 10.18805/asd.v35i1.9314.

Meena, H., Bharati, V., Dwivedi, D.K., Singh, S.K., Choudhary, R. and Singh, H. (2021). Effect of integrated nutrient management on yield attributes and yield of black gram cv. pu-31. Legume Research-An International Journal. 44(11): 1353-1357. doi: 10.18805/LR-4635.

Mishra, G.P., Dikshit, H.K., Tripathi, K., Aski, M.S., Pratap, A., Dasgupta, U. and Gupta, S. (2022). Mungbean Breeding. Fundamentals of Field Crop Breeding. 1097.

Narasimhulu, R., Naidu, N.V., Shanthi Priya, M., Govardhan, G., Reddy, D.M., Reddy, K.H.P. and Raja Rajeswari, V. (2013). Genetic divergence studies in greengram (*Vigna radiata* L. Wilczek). Int. J. Appl. Biol.Pharmaceutical Tech. 4(4): 277-280.

Paramesh, V., Mohan Kumar, R., Rajanna, G.A., Gowda, S., Nath, A.J., Madival, Y. and Toraskar, S. (2023). Integrated nutrient management for improving crop yields, soil properties and reducing greenhouse gas emissions. Frontiers in Sustainable Food Systems. 7: 1173258.

Rajkhowa, D.J., Sarma, A.K., Mahanta, K., Saikia, U.S. and Krishnappa, R. (2017). Effect of vermicompost on greengram productivity and soil health under hilly ecosystem of North East India. Journal of Environmental Biology. 38(1): 15.

Ranaivoson, L., Naudin, K., Ripoche, A., Affholder, F., Rabeharisoa, L. and Corbeels, M. (2017). Agro-ecological functions of crop residues under conservation agriculture. A review. Agronomy for Sustainable Development. 37: 1-17.

Sarkar, P., David, A.A., Thomas, T. and Reddy, I.S. (2023). Integrated nutrient management in green gram (*Vigna radiata* L.) for enhancing soil health. International Journal of Environment and Climate Change. 13(8): 815-819.

Schreinemachers, P., Sequeros, T., Rani, S., Rashid, M.A., Gowdru, N.V., Rahman, M.S. and Nair, R.M. (2019). Counting the beans: Quantifying the adoption of improved mungbean varieties in South Asia and Myanmar. Food Security. 11: 623-634.

Sheoran, P., Sardana, V., Singh, S. (2008). Effect of nutrient levels on the productivity of mungbean genotypes under subhumid rainfed condition of Punjab. Journal of Food Legume. 21(2): 117-118.

Shukla, A.K., Behera, S.K., Chaudhari, S.K. and Singh, G. (2022). Fertilizer use in Indian agriculture and its impact on human health and environment. Indian J. Fertil. 18(3): 218-37.

Shukla, L. and Tyagi, S.P. (2009). Effect of integrated application of organic manures on soil parameters and growth of mungbean (*Vigna radiata*). Indian Journal of Agricultural Sciences. 79(3): 174.

Singh, S.P., Patel, C.R. and Paikra, K.K. (2020). Organic Farming: Prospects, constraints, opportunities and strategies for sustainable agriculture in chhattisgarh-A review. International Journal of Plant and Soil Science. 32(4): 35-50.

Sinha, A.K., David, A.A., Thomas, T. and Jabeen, F. (2023). Response of integrated nutrient management on soil physico-chemical properties of green gram (*Vigna radiata* L.) var. samrat. International Journal of Plant and Soil Science. 35(18): 773-780.

Soni, R., Gupta, R., Agarwal, P. and Mishra, R. (2022). Organic farming: A sustainable agricultural practice. Vantage: Journal of Thematic Analysis. 3(1): 21-44.

Tarafder, S., Rahman, M.A., Hossain, M.A. and Chowdhury, M.A.H. (2020). Yield of *Vigna radiata* L. and post-harvest soil fertility in response to integrated nutrient management. Agricultural and Biological Sciences Journal. 6(1): 32-43.

Todawat, A. (2018). Response of greengram [*Vigna radiata* (L.)] to levels of vermicompost and zincunder loamy sand soil. International Journal of Agricultural Science and Research. 8(2): 33-38.

Toor, M.D., Kizilkaya, R., Ullah, I., Koleva, L., Basit, A. and Mohamed, H.I. (2023). Potential role of vermicompost in abiotic stress tolerance of crop plants: A review. Journal of Soil Science and Plant Nutrition. 23(4): 4765-4787.

Tripathi, A. and Tiwari, A.S. (2022). Integrated nutrient management of growth, yield and quality of green gram (*Vigna radiata* L.). The Pharma Innovation Journal. 11(7): 2480-2482.

Vigneshvarraj, A., Elayaraja, D., Arivukkarasu, K. and Jawahar, S. (2020). Effect of integrated nutrient management on growth, yield and nutrient uptake by greengram (*Vigna radiata* L.) in coastal saline soil. Plant Archives. 20(2): 4601-4607.

Yang, Q., Masek, O., Zhao, L., Nan, H., Yu, S., Yin, J. and Cao, X. (2021). Country-level potential of carbon sequestration and environmental benefits by utilizing crop residues for biochar implementation. Applied Energy. 282: 116275.