Minireview Article

Effect of Organic and Inorganic Fertilizers on Crop Yield and Soil Fertility: A Comprehensive Review

Abstract

Adopting sustainable nutrient management solutions becomes essential as the farming sector faces issues such soil degradation, climate change, and growing global food demands. Insights from field research and recent developments in fertilizer application techniques are used to inform sustainable farming approaches that strike a balance between environmental preservation and productivity. Sustainable agriculture is critical for meeting the growing global demand for food while minimizing the environmental impact of farming practices. Among the factors influencing agricultural productivity, soil fertility plays a pivotal role. The use of fertilizers, both organic and inorganic, has long been a cornerstone of strategies aimed at improving soil fertility and crop yield. Organic fertilizers, such as farm yard manure, compost and green manure, are rich in organic matter and enhance soil structure, microbial activity, and nutrient availability. This investigation highlights the complimentary functions that organic and inorganic fertilizers play in integrated systems by examining their effects on crop productivity and soil fertility.

Introduction

In the developing world, achieving food security through sustainable systems is a big task, yet it is vital for poverty alleviation. To get around this problem, farmers have resorted to overusing specific inputs like chemical fertilizers and pesticides, which have already begun to harm the ecosystem. In most countries of agrarian background, manufacturing and service of chemical fertilizers have been practiced as a prime agenda in securing nations food and nutritional security. India, a populous agrarian country, is the world's second- largest producer (48.7M tonnes of production) (Anonymous[1] 2022 world population review) and Consumer of chemical fertilizers with 29.84 million metric tonnes (Anonymous[2] 2022 statista). As per recent reports, the Indian fertilizer market reached a value of Rs. 887 billion and is expected to grow at a compound annual growth rate of 5.5% by 2026 (International Fertilizers Association, 2020). Food production must increase significantly while agricultures environmental impact must decrease greatly to fulfill the

worlds future food security and sustainability needs (Foley *et al.,* 2011) The primary challenge is to enhance agricultural productivity while preserving soil fertility to achieve higher crop yields and meet the growing population's food demand in the coming decades in a cost effective and environmentally sustainable manner (Ghosh *et al.,* 2022). Integrated Nutrient Management, which combines the use of inorganic and organic fertilizers, is becoming a viable way to maintain soil fertility. INM combines the long-term advantages of organic additions for soil health with the rapid nutrient release of inorganic fertilizers. Crop rotation, cover crops, and limited tillage are examples of soil conservation techniques that enhance soil fertility by lowering erosion, enhancing nutrient retention, and preserving soil organic matter levels. These actions are especially crucial in areas where agricultural productivity is severely hampered by nutrient depletion and soil degradation. Farmers can maximize yields while maintaining the long-term sustainability of soil ecosystems by implementing this technique. Managing soil fertility is important for protecting the environment for next generations as well as increasing productivity. (Paramesh *et al*., 2023). Kumar *et al*., (2024) Organic fertilizers /Manures are readily obtainable mineral bases that have a diffident concentration of vital natural resources for plants. They have the capability to decrease problems carried on by artificial fertilizers.

The foundation of sustainable agricultural systems is soil fertility, which stands for the soil's capacity to promote plant growth and maximize crop production. It depends on the structure, nutrient content, microbial activity, and water-retention ability of the soil, among other physical, chemical, and biological characteristics. Fertile soil maintains ideal soil texture and pH levels, supports microbial health, and provides vital nutrients like nitrogen, phosphorus and potassium. Compost, manure and crop wastes are examples of organic fertilizers that are essential for restoring soil fertility. They improve the structure of the soil, increase its capacity to store water, and aid in the accumulation of soil organic matter. Additionally, these materials encourage microbial activity, which increases soil biodiversity and accelerates nutrient cycling. For example, it has been demonstrated that incorporating organic fertilizers into farming methods greatly increases soil organic carbon levels, which are essential for long-term soil production (Shi *et al*., 2024). Conversely, inorganic fertilizers provide instant nutrient availability, which makes them essential for intensive farming systems. However, an over dependence on chemical fertilizers frequently results in negative consequences, including nutrient loss, soil acidification, and disturbance of soil microbial communities. It has been demonstrated that distributing the use of inorganic and organic fertilizers evenly can lessen these adverse effects, offering a sustainable method of managing

nutrients. (Mamatha *et al*., 2024). Both organic and inorganic fertilizer sources are used in the Integrated Nutrient Management agronomy system. Using as little chemical fertilizer as possible is the primary goal of INM. Additionally, it lowers environmental risks and increases earnings. Plant roots control microbial activity, nutrition uptake, and nutrient conversion. (Kumar *et al.,* 2023[b]). Integrated agricultural systems have emerged as a viable and sustainable solution to the complex issues facing modern farming. They offer several environmental, financial, and social benefits while promoting resource efficiency, biodiversity conservation, and resilience (Kumar *et al.,* 2023[a]). In order to meet the increasing demand for food worldwide while reducing the negative effects of farming techniques on the environment, sustainable agriculture is essential. Soil fertility is one of the key elements affecting agricultural productivity. Fertilizers are essential for increasing agricultural yields. However, depending only on organic fertilizers might not be able to supply the immediate crop nutrient demand, and relying too much on inorganic fertilizers can harm soil health. (Lu *et al*., 2017; Sapkota *et al*., 2018). Kumar *et al*., (2023[c]). Stated that the vermicompost, crop wastes, and organic manures are said to be necessary for healthy soil and higher yields, in addition to inorganic fertilizers.

Theoretical review

A lot of work has shown that when we use organic sources along with inorganic fertilizers, the yield as well as soil fertility is maintained. Some review points are given in this study.

Effect of Organic and Inorganic fertilizers on the crop yields.

The combination of 75% RDF + 25% N through vermicompost + humic acid and fulvic acid resulted in the highest rice yield attributes, such as the number of productive tillers m^{-2}, the number of filled grains $panicle^{-1}$ the grain yield ha^{-1}, and the straw yield ha^{-1}). On the other hand, the treatment that contained 100% RDF had the lowest yield and yield attribute metrics. Sujit Thakur *et al*., (2023). For instance, in the rice-chickpea system, applying 75% NPK with 5 t ha^{-1} farmyard manure and bio fertilizers significantly increased grain yields (4,429 kg ha^{-1} for rice and 1,538 kg ha^{-1} for chickpea) compared to conventional practices. The highest yield attributes of maize, including the number of cobs $plant^{-1}$ (2.93 cobs $plant^{-1}$), cob length (29.80 cm), and number of seeds cob^{-1} (414.70 seeds cob^{-1}) were achieved with the combination of 50% Poultry Manure + 50% Vermicompost + 6 kg ha^{-1}. In contrast, the lowest yield attributes, including the number of cobs $plant^{-1}$ (1.61 cobs $plant^{-1}$), cob length (16.94 cm), and number of seeds cob^{-1} (310.53 seeds cob^{-1}) Raj *et al*., (2023) and Thakur *et al*., (2022) observed during the experiment on the rice-chickpea cropping system that the highest yields of rice (4,429 Kg ha^{-1}) and chickpea (1,538 Kg

ha^{-1}), respectively, were achieved with the application of 75% NPK + 5 t ha^{-1} + biofertilizers, while the lowest yields of rice and chickpea were recorded under farmer practices. Mamuye *et al*., (2021) stated that the maximum grain yield (7.90 t ha^{-1}) and Stover yield (24.4 t ha^{-1}) were recorded with the combination of 4 t compost + 50% RIF (Recommended Inorganic Fertilizer), whereas the minimum grain (6.0 t ha^{-1}) and Stover yield (18.4 t ha^{-1}) were recorded with 100% RIF. The superior performance of the 4-t compost + 50% RIF treatment is because combining organic and inorganic fertilizers improves soil quality, ensures nutrients are released steadily, and enhances plant growth. Dhaliwal *et al*., (2023) observed that the highest grain yield (44.53 q ha^{-1}) was achieved with the combination of Poultry manure 6 t ha^{-1} + 75% N, whereas lowest yield (25.57 q ha^{-1}) was observed in the control treatment. Furthermore, it was noted that all treatments combining organic and inorganic fertilizers outperformed the sole fertilizer treatments. The superior performance of the Poultry manure 6 t ha^{-1} + 75% N, which resulted in the highest grain yield, can be attributed to several factors, including the highest nutrient content of poultry manure and its gradual nutrient release. Pandey *et al*., (2023). found that vermicompost, crop residue, and organic manures are necessary in addition to inorganic fertilizers for improved soil health and yield. Combined with crop residue, organic manures, and bio-fertilizers, inorganic fertilizers can improve soil health and speed up nutrient use. Pal *et al*., (2024) Treatment T_4 (75% NPK + Vermicompost @ 0.34 t ha-^{1} + Rhizobium + PSB) was found to increase plant height (59.7 & 61.5 cm), number of branches per plant (4.65 & 4.75), number of trifoliate leaves per plant at 40 DAS (11.1 & 11.4), dry matter accumulation per plant (15.4 & 15.7 g), leaf area index at 40 DAS (4.9 & 5.2), and number of effective nodules per plant (43.8 & 46.4) insignificantly compared to the other approaches.

Effect of organic and inorganic fertilize on the Soil fertility.

The excessive use of fertilizers to increase crop production has led to devastating effects, including soil degradation and reduced soil organic matter (Chaudhary *et al*., 2024). Another significant issue is nutrient imbalance, which has a notable impact on yields. To address these challenges, the integration of organic and inorganic fertilizers has emerged as a critical strategy for enhancing crop yields and maintaining soil fertility. Recent studies emphasize the benefits of combining these inputs to improve nutrient availability, promote soil health, and boost crop yields across various cropping systems. (Dutta *et al*., 2023).Kumawat *et* al.,(2021) Stated that the combination of RDF + 5 FYM t ha^{-1} + Rhizobium + PSB recorded the highest organic carbon (0.40%), available nitrogen (174 kg ha^{-1}), available phosphorus (18.67 kg ha^{-1}), available

potassium (488.0 kg ha^{-1}), and significantly improving overall soil fertility. In contrast, the lowest carbon (0.32%), available nitrogen (143.0 kg ha^{-1}), available phosphorus (14.83 kg ha^{-1}), available potassium (478.0 kg ha^{-1}). similar finding was reported by Kumar *et al*., (2023). Was found that the application of 75% RDF + 25% FYM-N +25 kg ZnSO4 ha-^{1} soil application has significantly influenced Organic carbon, Available N, P, K and Zn in soil. The highest organic carbon (7.3 g kg^{-1}), available nitrogen (265.4 kg ha^{-1}), available phosphorus (37.9 kg ha^{-1}) and available potassium (136.6 kg ha^{-1}) were observed in the combination of 75% RDF + bio compost (7.5 t ha^{-1}) + Acetobacter + PSB. Sinha *et al*., (2024)The combination of RDF@ 100% + VC @ 100% + Rhizobium @100% resulted in the highest soil organic carbon (0.495% at 0-15 cm and 0.512% at 15-30 cm), available nitrogen (328 .52% kg ha^{-1} at 0-15 cm and 360.62 kg ha^{-1} at 15-30 cm), available phosphorus(34.87 kg ha^{-1} at 0-15 and 37.78 kg ha^{-1} at 15-30 cm),available potassium (196.81 kg ha^{-1} at 0-15 cm and 207.93 kg ha^{-1} at 15-20 cm). In contrast, the lowest values for soil organic carbon, available nitrogen, available potassium, and available phosphorus were recorded in control treatment. Kumar *et al*., (2023)Dutta *et al*., (2023) stated that the lowest bulk density (1.112 Mg m^{-3}), lowest pH (7.15), highest electrical conductivity (0.26 dS m^{-1}), organic carbon (0.65%), available nitrogen (281.39 kg ha^{-1}), available phosphorus (27.89 kg ha^{-1}), available potassium (158.15 kg ha^{-1}), and the highest water holding capacity (52.31%) were recorded with the treatment comprising 100% NPK + 100% Neem cake. Kumar and Tripathi, (2022) observed that the lowest pH (7.0) was recorded with the application of 25% RDF + 3 t ha^{-1} vermicompost + Azospirillum, while the highest organic carbon (0.57%), available nitrogen (240.71 Kg ha^{-1}), available Phosphorus (16.14 kg ha^{-1}) and available potassium (185.06 kg ha^{-1}) were recorded with the treatment of 75% RDF + 1 t ha^{-1} vermicompost + Azospirillum. In contrast, the highest pH, lowest organic carbon, and lowest availability of NPK were observed in the control treatment. Thakur *et al*., (2022) Stated that the lowest pH (7.0), highest organic carbon content (7.2 g kg^{-1}), available nitrogen (309.8 kg ha^{-1}), available phosphorus (20.4 kg ha^{-1}), available potassium (274.1 kg ha^{-1}), and available zinc (0.73 mg kg^{-1}) were recorded with the treatment of 75% NPK + FYM + BF, whereas the lowest values for these parameters were observed with the farmer practice. This combination improved nutrient uptake and post-harvest soil nutrient levels, proving effective for sustainable agriculture. (Thakur *et al*., 2023). Similarly, research on cowpea reported that applying 100% NPK with 100% neem cake resulted in the highest improvements in soil physico-chemical properties. These include a significant increase in organic carbon content (0.65%), water holding capacity (52.31% at 0–15 cm), and nutrient availability, with available nitrogen, phosphorus, and

potassium reaching 281.39 kg ha^{-1}, 27.89 kg ha^{-1}, and 158.15 kg ha^{-1}, respectively. This combination also minimized bulk density (1.12 Mg m^{-3} at 0–15 cm) and improved pore space (57.32%). These integrations enhance soil health and crop yields, highlighting the potential of combining organic and inorganic inputs for sustainable farming. (Dutta *et al*., 2023). Kumar *et al*., (2023[e]). conducted an experiment at Student's "Instructional farm of Acharya Narendra Deva University of Agriculture and Technology Kumarganj, Ayodhya (U.P.) during *rabi* season 2019-2020 and found that the organic carbon, Available Nitrogen, Phosphorus, Potassium & Zinc was found best with the application of 50% N from urea + 50% N from Poultry manure (N3)followed by 50% N from urea +50% N from FYM (N2). Long-term experiments in various cropping systems, including rice wheat and maize-wheat rotations, have demonstrated the effectiveness of INM in improving soil organic matter, nutrient retention, and overall productivity. For instance, combining FYM with recommended doses of nitrogen, phosphorus, and potassium (NPK) has been shown to increase crop yields by up to 20% while improving SOC levels and microbial biomass (Singh *et al*., 2022; Choudhary *et al*., 2021). Kumar *et al*., (2023[d]). reported that he application of N, P, K and vermicompost would have also helped in increasing N, P and K content and uptake in plants. The maximum Zn and Fe, content and uptake were recorded in Treatment T7 which may have happened due to better soil and foliage application availability of nutrients in it.

Conclusion

Based on the explanation above, it can be considered that applying inorganic fertilizers in along with organic fertilizers increases soil fertility and production of crops by maintaining an adequate and balanced supply of macro and micronutrients, which raises crop productivity. adding organic matter to improve aeration, water retention, and soil structure. encouraging the microbial activity of the soil, which facilitates the cycling of nutrients and their availability for plant absorption. supplying the critical crop nutrient needs while maintaining the long-term health of the soil. An integrated strategy is therefore a crucial suggestion for contemporary farming systems since it optimizes agricultural productivity, maintains soil quality, and promotes environmental sustainability.

References

[1]Anonymous 2022, world population review; https://worldpopulationreview.com.

[2]Anonymous 2022, Statista; https://www.statista.com.

Chaudhary, C., Yadav, D. B., Yadav, A., Chaudhary, A., and Hooda, V. S. (2024). Influence of crop residue and nitrogen management on nutrient uptake, yield, and economics of rice-wheat cropping system. *Journal of Plant Nutrition*. **47**(3): 376-391.

Choudhary, M., Datta, A., and Jat, H. S. (2021). Long-term effects of integrated nutrient management on soil health and crop productivity in rice-wheat cropping system. *Archives of Agronomy and Soil Science*, **67**(5), 631-645.

Dhaliwal, S. S., Sharma, V., Shukla, A. K., Verma, V., Kaur, M., Singh, P., gabber A and Hossain, A. (2023). Effect of addition of organic manures on basmati yield, nutrient content and soil fertility status in north-western India. *Heliyon*, **9**(3).

Dutta, S., Swaroop, N., Thomas, T., and Mistri, T. (2023). Impact of Different Levels of NPK and Neem Cake on Soil Health under Cowpea (*Vigna unguiculata* L.) Var. Gomati. *International Journal of Plant & Soil Science*, **35**(18), 2195-2203.

Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., Mueller, N. D., O'Connell, C., Ray, D. K., West, P. C., Balzer, C., Bennett, E. M., Carpenter, S. R., Hill, J., Monfreda, C., Polasky, S., Rockström, J., Sheehan, J., Siebert, S., Tilman, D., and Zaks, D. P. M. (2011). Solutions for a cultivated planet. *Nature*, **478**(7369), 337–342.

Ghosh, D., Brahmachari, K., Skalický, M., Roy, D., Das, A., Sarkar, S., Moulick, D., Brestič, M., Hejnak, V., and Vachova, P. (2022). The combination of organic and inorganic fertilizers influence the weed growth, productivity and soil fertility of monsoon rice. *PLOS ONE*, **17**(1), e0262586.

Kumar, A., & Tripathi, S. K. (2022). Effect of Integrated use of Organic, Inorganic and Bio-Fertilizers on Soil Fertility and Productivity of Wheat (*Triticum aestivum* L.) in Alluvial Soil. The Journal of Phytopharmacology 2022; **11**(2):92-96.

Kumar, A., David, A. A., Thomas, T., Bharose, R., Swaroop, N., Serawat, R.,. reddy, S.I., and Toppo, N. (2023). Response of Inorganic Fertilizers Organic Manure and Biofertilizer on Soil Health and Yield Attributes of Chick Pea (*Cicer aretinum* L.) Cv. Aruna. *International Journal of Environment and Climate Change*, **13**(12), 1166-1176.

Kumar, D., Shahi, U. P., Shekhar, C., Kumar, A., Pal, S., & Kumar, S. (2023[d]). Effect of soil and foliar application of Zn and fe on nutrient status of hybrid maize (Zea mays L.). *International Journal of Plant & Soil Science*, *35*(19), 1110-1119.

Kumar, M., Singh, A., Wamiq, M., Kumar, R., Singh, S., Rai, A., Kumar, S., and Kumar, A. (2023[b]). Integrated farming for long-term viability of agriculture: A review. *The Pharma Innovation Journal*.12 (6): 4771-477

Kumar, S., Agrawal, S., Jilani, N., Kole, P., Kaur, G., Mishra, A., & Tiwari, H. (2023[a]). Effect of integrated nutrient management practices on growth and productivity of rice: A review. *The Pharma Innovation Journal*, *12*(5), 2648-2662.

Kumar, S., Kumar, S., Kumar, R., Pathak, D., Kumar, D., Kumar, A., ... & Tiwari, H. (2023[e]). Assessment of physico-chemical properties of soil as influenced by different moisture regimes and nitrogen sources in wheat crop. *International Journal of Plant & Soil Science*, *35*(19), 765-772.

Kumar, S., Sharma, A., Pandey, S., Paul, S., Mishra, H., Kesarwani, A., ... & Tiwari, H. (2023[c]). Response of Different Moisture Regimes and Nitrogen Sources on Soil Health, Growth and Yield Attributes of Wheat: A Comprehensive Review. *International Journal of Plant & Soil Science*, *35*(20), 541-548.

Kumar, S., Singh, S., Kumar, S., Tomar, T., Singh, A., Singh, O, and Prashar D, (2024). Impact of different moisture regimes and sources of nitrogen on plant height and economics feasibility of wheat crop. *International Journal of Research in Agronomy*; 7(3): 219-222.

Kumar, U., Kumar, S., Kumar, N., Yadav, R., Pandey, P., Kumar, S., ... & Maurya, A. (2023). Response of Graded Fertility Levels and Zinc Application Method with and without Farm Yard Manure on Physicochemical and Biological Properties of Soil under Rice Crop. *International Journal of Plant & Soil Science*, *35*(20), 1113-1123.

Kumawat, N., Tiwari, S. C., Bangar, K. S., Khandkar, U. R., Ashok, A. K., and Yadav, R. K. (2021). Influence of different sources of plant nutrients on soil fertility, nutrient uptake and productivity of soybean under Vertisols. *Legume Research-An International Journal*, **44**(5), 556-561.

Lu, C., Zhang, J., and Zhang, Q. (2017). Effects of long-term fertilization on soil organic carbon and total nitrogen in paddy soils in subtropical China. *Soil and Tillage Research*, 168, 1-8.

Mamatha , Bommireddy, Chandana Mudigiri, Guguloth Ramesh, Pakala Saidulu Saidulu, Nayaki Meenakshi, and Chuncha Laxmi Prasanna. (2024). “Enhancing Soil Health and Fertility Management for Sustainable Agriculture: A Review”. *Asian Journal of Soil Science and Plant Nutrition*, **10** (3):182-90.

Mamuye, M., Nebiyu, A., Elias, E., and Berecha, G. (2021). Combined use of organic and inorganic nutrient sources improved maize productivity and soil fertility in southwestern Ethiopia. *International Journal of Plant Production*, **15**, 407-418.

Pal, R., Singh, S. P., Kumar, S., Kumar, Y., Singh, A., & Kumar, S. Growth Parameter of Mung Bean (Vigna radiata L.) under Different Integrated Nutrient Management Practices in Western Uttar Pradesh, India. *Asian Journal of Soil Science and Plant Nutrition*, 10, (3), 495-504.

Pandey, P. R., Singh, S. P., Dhyani, B. P., Kumar, Y., Singh, A., Kumar, A., & Kumar, S. (2023). Impact of different nutrient management practices on the nutrient dynamics of wheat crop in western Uttar Pradesh, India. *International Journal of Plant & Soil Science*, *35*(19), 560-571.

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

Raj, A., Mehera, B., Kumar, P., and Saharsh, M. (2023). Effect of organic manure and zinc on growth, yield attributes and economics of maize. *International Journal of Environment and Climate Change*, **13**(10), 454-460.

Sapkota, T. B., Vetter, S. H., Jat, M. L., Sirohi, S., Shirsath, P. B., Singh, R., Jat, H. S., Smith, P., & Hillier, J. (2018). Cost-effective opportunities for climate change mitigation in Indian agriculture. *Science of The Total Environment*, 655, 1342-1354.

Shi, T. S., Collins, S. L., Yu, K., Peñuelas, J., Sardans, J., Li, H., and Ye, J. S. (2024). A global meta-analysis on the effects of organic and inorganic fertilization on grasslands and croplands. *Nature Communications*, 15(1), 3411.

Singh, R., Kumar, S., and Sharma, P. (2022). Integrated nutrient management in rice-wheat cropping system: A review. *Journal of Pharmacognosy and Phytochemistry*, **11**(1), 126-132.

Sinha, S. K., Kumar, A. D., Kumari, A., and Singh, A. K. (2024). The Integrated Effect of Organic Manure, Biofertilizer and Inorganic Fertilizer on Soil Properties, Yield and Quality in Sugarcane Plant-ratoon System under Calcareous Soil of Indo-gangetic Plains of India. *Journal of Scientific Research and Reports*, **30**(5), 193-206.

Sujithkumar, P., Rao, G. B., Immanuel, R. R., and Vidhya, S. (2023). Effect of various organic inputs on the yield attributes and yield of transplanted rice (*Oryza sativa L.*). *Crop Research*, **58(**3and4), 124-128.

Thakur, R. K., Bisen, N. K., Shrivastava, A. K., Rai, S. K., and Sarvade, S. (2023). Impact of integrated nutrient management on crop productivity and soil fertility under rice (*Oryza sativa*)-chickpea (*Cicer arietinum*) cropping system in Chhattisgarh plain agro-climatic zone. *Indian Journal of Agronomy*, **68**(1), 9-13.

Thakur, R. K., Bisen, N. K., Shrivastava, A. K., Rai, S. K., and Sarvade, S. (2023). Impact of integrated nutrient management on crop productivity and soil fertility under rice (*Oryza sativa*)-chickpea (*Cicer arietinum*) cropping system in Chhattisgarh plain agro-climatic zone. *Indian Journal of Agronomy*. **68**(1): 9-13.