International Journal of Plant & Soil Science

Volume 36, Issue 7, Page 649-656, 2024; Article no.IJPSS.118320
ISSN: 2320-7035

Effect of Organic and Inorganic Sources of Nitrogen on Growth Parameter and Yield Attribute of Wheat in Inceptisolof Eastern Uttar Pradesh, India

Kajal Singh [a], P.K. Sharma [a], Y.V. Singh [a*], Prabhakar Prasad Barnwal [b] and Shubham Jaiswal [a]

[a] Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221011, India.
[b] Division of Soil Science and Agricultural Chemistry, Indian Council of Agriculture Research, Indian Agriculture Research Institute, New Delhi-110012, 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/10.9734/ijpss/2024/v36i74776

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://www.sdiarticle5.com/review-history/118320

Original Research Article

Received: 15/04/2024
Accepted: 17/06/2024
Published: 25/06/2024

ABSTRACT

The insufficient availability and escalating expenses of fertilizers present significant constraints to crop production, exacerbating the growing disparity between nutrient demand and supply. The overreliance on agrochemicals like synthetic fertilizers, pesticides, herbicides, and fungicides not only endangers human health but also degrades soil quality and environmental integrity. This study

**Corresponding author: E-mail: yvsingh59@rediffmail.com;*

***Cite as:** Singh, Kajal, P.K. Sharma, Y.V. Singh, Prabhakar Prasad Barnwal, and Shubham Jaiswal. 2024. "Effect of Organic and Inorganic Sources of Nitrogen on Growth Parameter and Yield Attribute of Wheat in Inceptisolof Eastern Uttar Pradesh, India". International Journal of Plant & Soil Science 36 (7):649-56. https://doi.org/10.9734/ijpss/2024/v36i74776.*

examined the impact of applying recommended doses of fertilisers (RDF) in conjunction with organic amendments in a pot experiment carried out throughout the 2020–2021 wheat growing season. Significant improvements were found for the following wheat plant attributes: straw and grain yields; height; greenness index; spike count; spike length; and weight of 1000 seeds. The treatment utilizing 50% RDF and 50% poultry manure (T_5) demonstrated the most pronounced improvements across these parameters. These findings highlight integrated nutrient management's crucial importance as a modern agricultural requirement.

Keywords: Inorganic fertilizers; sustainability; poultry manure; sewage sludge; farmyard manure; vermicompost.

1. INTRODUCTION

An increase in and diversification of food production is required due to the projection that India's population would reach 1.7 billion by 2065. The amount of wheat produced worldwide in 2021–2022 was around 778.1 million metric tonnes [1]. Regarded as the Indian Green Revolution region, the Indo-Gangetic Plain (IGP) produces a large amount of rice-wheat rotation, covering around 40% of its entire area. With the use of input-responsive cultivars, guaranteed irrigation, and increased chemical inputs, the so-called "Green Revolution" dramatically increased food grain production. A drawback is that chemical residues may infiltrate the food chain and plant system, compromising the quality of the produce [2]. One of the most significant staple food crops in India is wheat (Triticum Spp.), also referred to as the "king of cereals" [3,4-6]. The economics and food security of India are significantly influenced by wheat, one of the major cereal crops grown there. In 2020–2021, India produced more than 107 MMT of wheat on 31.6 million hectares during the Rabi season, accounting for around 37% of the country's total food grain production [7]. Following the green revolution, wheat productivity rose significantly as a result of increased usage of irrigated regions and plant protection agents. On the other hand, the unbalanced and indiscriminate application of these chemical fertilisers had detrimental effects on factor production, human health, and soil health [8]. Managing fertilization is currently one of the most challenging aspects of field management. Although mineral fertilizers are essential for plant growth, their long-term use poses significant environmental and health risks, such as the contamination of surface and groundwater. In India, however, the fertilizer industry is heavily regulated and monitored by the government [9]. To meet the increasing demand for food, there is a tendency to overuse inorganic fertilizers, which leads to nitrogen losses through pathways such as ammonia volatilization, leaching, and the emission of greenhouse gases. These issues contribute to major environmental problems and disrupt the overall nitrogen balance [10]. Consequently, new agronomic technologies have been adopted to enhance fertilizer efficiency and reduce nitrogen losses through leaching and volatilization, which are critical for achieving sustainable agriculture. At present, the use of organic manures from different animals (pig and cow), poultry manure, compost and crop residues directly or in the form of mixtures is widely investigated by researchers. Organic manures help in maintaining soil fertility by providing important plant nutrients, particularly micronutrients, which increase crop growth [11]. Use of manures also improves the quality of soil physically, chemically and biologically, thus having a long-term impact on subsequent crops [12]. Farmyard manure enhances soil structure, water and nutrient retention capacity, root penetration, microbial activity, and nutrient exchange capacity, thereby improving soil fertility [13]. PM and VC are significant organic sources of soil organic carbon and plant nutrients. Numerous studies, including those by Urmi et al. (2022), have shown that PM and VC supply nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur, which can boost soil fertility and nutrient uptake in grain crops [14]. Furthermore, partially replacing inorganic fertilizers with organic manures can significantly lower production costs [15]. Previous research indicates that substituting chemical fertilizers with organic manure positively impacts crop yield [16]. The use of various manures, such as press mud, poultry manure, compost, and farmyard manure, in rice–wheat systems has been shown to increase crop yields and DTPA-extractable micronutrient concentrations (zinc, copper, iron, and manganese) in the soil in northern India [17]. The combined application of organic and inorganic fertilizers has been reported to improve growth and yield attributes in rice and wheat, as noted by Sarwar et al. [18]. Nitrogen is a crucial metabolic element necessary for plant growth and development. It is essential for synthesizing proteins and other compounds, and it is directly involved in various physiological processes within the plant. Nitrogen is needed throughout the crop's growth period. Phosphorus is the second most important nutrient for crop production, vital for processes such as photosynthesis, cell development, carbohydrate synthesis and breakdown, and energy transfer within the plant. Potassium is critical for maintaining cellular organization [19]. According to Waraich et al. (2002), nitrogen application enhances grain protein content while reducing phosphorus levels. Additionally, split doses of nitrogen affect the protein content and yield of wheat compared to controls [20]. Phosphorus, as the second most essential nutrient after nitrogen, plays numerous roles in plant metabolism and has a structural role in molecules, as noted by Venkatesh et al. [21]. Previous research has suggested various nitrogen fertilizer management strategies, such as using the optimal dosage of conventional fertilizers, employing side-deep placement techniques, and utilizing slow-release fertilizers. However, these methods have been limited due to their labour-intensive nature and the lack of advanced technology. Unlike inorganic fertilizer application, organic manure, a byproduct of animal waste, has been used to boost crop productivity. The slow and gradual nitrogen release from organic manure is more beneficial compared to using only chemical fertilizers, leading to higher nitrogen use efficiency (NUE), better grain yield, and improved rice quality. Additionally, manure fertilization contributes soil organic carbon (SOC) and has a lasting effect by increasing soil nutrient availability for crop growth and development [22].

Currently, there is limited information on how various combinations of organic and inorganic fertilizers affect the growth and yield attributes of wheat. Therefore, this study aims to investigate the impact of different fertilizer management practices, which involve combining organic manures such as farmyard manure, poultry manure, activated sludge and vermicompost with NPK fertilizers, on the growth parameters and yield attributes in wheat.

2. MATERIALS AND METHODS

2.1 Experimental Site

A pot experiment on wheat was conducted on November 25th, 2020-2021, in the Net House of the Department of Soil Science and Agricultural Chemistry at the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. Varanasi, situated at an altitude of 80.71 meters above mean sea level, lies between 25°18' North latitude and 80°36' East longitude. The region has a humid subtropical climate, with an average annual rainfall of approximately 1100 mm and a potential evapotranspiration of around 1525 mm. During the wheat cultivation period (December to March), temperatures ranged from a maximum of 34.5°C to a minimum of 7.5°C. Relative humidity varied between 64-96% at its highest and 34-71% at its lowest.

Table 1. Treatment details of the experiment

Treatments	Treatment details
T_1	Control
T_2	100% RDF
T_3	50%RDN + 50% FYM (14 t ha^{-1})
T_4	50%RDN + 50% VC(5 t ha^{-1})
T_5	50%RDN + 50%N PM(5.26 t ha^{-1})
T_6	50%RDN + 50%N SS (7.5 t ha^{-1})
T_7	100% FYM (28 t ha^{-1})
T_8	100% VC(10 t ha^{-1})
T_9	100% PM(10.53 t ha^{-1})
T_{10}	100% SS (15 t ha^{-1})

RDF, recommended dose of fertilizer*

RDN, recommended dose of Nitrogen through urea*

Recommended dose of fertilizer (RDF) for wheat crop, i.e., N, P_2O_5, and K_2O:: 120, 60 and 60 kg ha^{-1}, respectively

FYM (farmyard manure), VC (vermicompost), PM (poultry manure) and SS (sewage sludge)

2.2 Experimental Setup

The alluvial soils of the Indo-Gangetic plains exhibit a range of textures from clay to sandy loam, are deep, well-drained, possess good water-holding capacity, and are characterized by low levels of available nitrogen, phosphorus, and potassium. Initially, the soil had a sandy clay loam texture with 48.42% sand, 19.83% silt, and 21.74% clay. It was slightly alkaline (pH 7.3), had normal salt content (EC 0.29 dS m-1), low organic carbon content (0.29%), low available nitrogen (208.4 kg ha^{-1}), high available phosphorus (24.8 kg ha-1), and medium available potassium (148.6 kg ha^{-1}). The soil also had DTPA-extractable micronutrients with concentrations of Zn at 0.41 mg kg^{-1}, Cu at 1.27 mg kg^{-1}, Fe at 3.78 mg kg^{-1}, and Mn at 4.01 mg kg^{-1}. During the winter season of 2020 (November to March), a pot experiment was conducted using wheat (HD-2967) as the test crop. The soil for the experiment was collected from the Agro farm at BHU, air-dried, ground, sieved through a 2-mm mesh, and placed in polythene-lined pots. The experiment included five factors with different levels of organic sources (farmyard manure (FYM), poultry manure (PM), vermicompost (VC), and sewage sludge (SS)) and the recommended dose of fertilizer (RDF) applied in ten treatments (as detailed in Table 1). The experiment used a completely randomized design with three replications. The recommended dose of fertilizers (RDF) was 100%, with 50% of the recommended nitrogen dose (RDN) combined with 50% nitrogen from organic sources, and in some treatments, 100% nitrogen was provided through organic sources. For wheat, the RDF rates were 118.56 mg kg^{-1} of N, 170.43 mg kg-1 of P2O5, and 45.45 mg kg-1 of K2O, using urea, single superphosphate (SSP), and muriate of potash (MOP) as sources. For treatments with 100% nitrogen from organic sources, the rates were 126 grams from FYM, 44.70 grams from VC, 47 grams from PM, and 66.5 grams from SS per 10 kg of soil. Inorganic fertilizers were applied in solution form before sowing, while organic fertilizers were incorporated a week prior to sowing. Eight to nine wheat seeds were sown in each pot, but only five plants were maintained for the duration of the experiment. The pots were kept at field capacity throughout the study period.

2.3 Growth and Yield Attributes

Growth attributing characters of wheat mainly plant height, number of tillers, greenness index (SPAD value), were recorded at 30, 60 and 90 days after sowing (DAS). At maturity, number of spike pot^{-1}, spike length, grain yield (g pot^{-1}) straw yield (g pot^{-1}), test weight (g), biological yield (g pot^{-1}) was recorded and harvest index were calculated. Seed treatment was done with carbendazim@ 2 g/kg seeds.

$$\text{Harvest index} = \frac{\text{Economical yield}}{\text{Total biological yield}} \times 100$$

2.4 Statistical Analysis

The research data were analyzed using statistical software SPSS 16.0 for ANOVA (complete randomized design). Duncan multiple range test (DMRT) at p≤0.05 levels of significance was used to evaluate the significant differences among mean values [23].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Table 2 presents the plant height data at 30, 60, and 90 days after sowing (DAS). At 30 DAS, plant height ranged from 31.94 to 34.82 cm, while at 60 DAS, it varied between 43.32 and 55.79 cm, and at harvest time, it ranged from 69.99 to 87.52 cm. Although there was no significant change in plant height at 30 DAS, notable effects were observed at 60 DAS and harvest, with Treatment 5 (T_5) displaying the tallest plants compared to other treatments. The highest plant height of 34.82 cm was recorded at 30 DAS in Treatment 2 (T_2), while at 60 and 90 DAS, the highest plant height was recorded as 55.79 cm and 87.52 cm in T5. These treatments exhibited a respective increase of 9.01%, 28.78%, and 25.04% in plant height over the control (T_1) at 30, 60, and 90 DAS. Regarding the greenness index, SPAD values ranged from 38.12 to 42.97 at 30 DAS, 37.01 to 48.14 at 60 DAS, and 29.12 to 49.04 at 90 DAS. The highest SPAD values of 49.04 and 48.14 at 90 and 60 DAS, respectively, were observed in T_5, which was significantly higher. T_1 (control) recorded the lowest greenness index of 29.12 at 90 DAS. At 30 DAS, the maximum greenness index was observed in T_2, followed by T_5, showing significant increases of 12.72% and 11.83%, respectively, over the control. At 60 and 90 DAS, the maximum greenness index was observed in T_5, with increases of 30.07% and 68.40% over

Table 2. Effect of organic and inorganic sources of nitrogen on plant height and greenness index (SPAD value), of wheat (mean of 3 replications± standard error)

Treatments	Plant height (cm)			Greenness index		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	31.94 ± 1 b	43.32 ± 0.69 d	69.99 ± 3.35 b	38.12 ± 0.76 e	37.01 ± 0.7 b	29.12 ± 0.75 f
T_2	34.82 ± 0.7 a	52.93 ± 0.05 abc	83.13 ± 1.38 a	42.97 ± 0.58 a	45.99 ± 0.29 a	41.54 ± 0.32 c
T_3	33.78 ± 1.07 ab	53.98 ± 0.21 a	83.33 ± 1.96 a	40.84 ± 0.5 bcd	46.31 ± 0.48 a	42.09 ± 0.38 c
T_4	34.17 ± 0.39 ab	54.85 ± 1.61 a	85.36 ± 1.6 a	41.86 ± 0.48 abc	46.5 ± 0.84 a	42.09 ± 0.42 c
T_5	34.59 ± 0.63 a	55.79 ± 1 a	87.52 ± 2.67 a	42.63 ± 0.3 ab	48.14 ± 0.83 a	49.04 ± 0.5 a
T_6	34.55 ± 0.37 a	55.65 ± 2.38 a	85.55 ± 1.14 a	41.87 ± 0.27 abc	46.59 ± 0.48 a	45.19 ± 0.4 b
T_7	32.62 ± 0.21 ab	49.55 ± 0.47 c	72.16 ± 1.45 b	39.14 ± 0.67 de	38.96 ± 0.75 b	33.45 ± 0.61 e
T_8	32.88 ± 0.72 ab	50.04 ± 0.35 cd	73.25 ± 1.67 b	40.47 ± 0.7 cd	40.58 ± 3.17 b	38.34 ± 0.45 d
T_9	33.62 ± 0.07 ab	53.72 ± 0.26 ab	82.1 ± 1.97 a	40.72 ± 0.51 cd	45.01 ± 1.39 a	38.68 ± 0.42 d
T_{10}	33.62 ± 0.77 ab	53.28 ± 1.9 abc	81.98 ± 2.45 a	40.66 ± 0.85 cd	44.65 ± 0.4 a	39.24 ± 0.66 d

Table 3. Effect of organic and inorganic sources of nitrogen on yield attributes and yields of wheat (mean of 3 replications ± standard error)

Treatments	No. of spike per pot	Spike length (g/pot)	Grain yield (g/pot)	Straw Yield	Test weight	Harvest index	Biological yield
T_1	5.66 ± 0.33 e	4.12 ± 0.65 e	5.93 ± 0.29 g	22.37 ± 0.15 g	33.05 ± 0.65 a	20.94 ± 0.85 f	28.3 ± 0.29 g
T_2	7.66 ± 0.33 abc	8.04 ± 0.09 ab	11.8 ± 0.35 d	28.54 ± 0.35 d	33.43 ± 1.29 a	29.25 ± 0.85 c	40.34 ± 0.15 d
T_3	7.66 ± 0.33 abc	8.24 ± 0.08 a	11.96 ± 0.36 d	28.71 ± 0.5 d	33.56 ± 0.76 a	29.4 ± 0.63 c	40.67 ± 0.7 d
T_4	8 ± 0 ab	8.41 ± 0.06 a	13.61 ± 0.33 c	30.46 ± 0.39 c	33.69 ± 0.6 a	30.88 ± 0.41 bc	44.07 ± 0.66 c
T_5	8.33 ± 0.33 a	8.55 ± 0.53 a	16.58 ± 0.22 a	33.6 ± 0.66 a	33.95 ± 0.66 a	33.05 ± 0.67 a	50.18 ± 0.54 a
T_6	8 ± 0 ab	8.51 ± 0.17 a	15.09 ± 0.07 b	32.02 ± 0.22 b	33.82 ± 1.28 a	32.03 ± 0.11 ab	47.11 ± 0.27 b
T_7	6 ± 0 de	5.98 ± 0.1 d	7.49 ± 0.14 f	23.97 ± 0.55 f	33.15 ± 0.65 a	23.83 ± 0.4 e	31.46 ± 0.63 f
T_8	6.66 ± 0.33 de	6.22 ± 0.18 cd	8.08 ± 0.09 f	24.6 ± 0.45 f	33.27 ± 0.71 a	24.74 ± 0.34 e	32.68 ± 0.49 f
T_9	7 ± 0.57 bcd	7.11 ± 0.18 bc	10.1 ± 0.2 e	26.74 ± 0.47 e	33.38 ± 0.59 a	27.44 ± 0.75 d	36.84 ± 0.28 e
T_{10}	6.66 ± 0.33 cde	7.9 ± 0.32 ab	9.72 ± 0.14 e	26.34 ± 0.4 e	33.31 ± 1.21 a	26.96 ± 0.34 d	36.06 ± 0.47 e

the control. Due to higher nitrogen concentration in manures, which influenced plant vegetative growth, may have resulted in the significant effect of various manures on wheat plant height. Additionally, the differences in plant height could have been caused by differences in manure nitrogen composition [24]. As indicated in the results, T_5 had higher plant height, chlorophyll content which is in agreement with the study conducted by Moe et al. [25], Choudhary et al. [26].

3.2 Yield Component

Data pertaining to the number of spikes pot^{-1} and the spike length were presented in Table 3. The number of spikes pot^{-1} varied from 5.66 to 8.33, with T5 having the highest value, increasing by 47.17% over control. The value of spike length varied between 4.12 to 8.55. The highest spike length was in T_5 followed by T_6, T_4, T_3 and T_2 which increased by 107.5, 106.55,104.12, 100, 95.1% over control, respectively. The straw yield varied significantly from 22.37 to 33.60 g pot^{-1} (Table 3). The maximum straw yield (33.60 g pot^{-1}) was found in T_5 followed by T_6 (32.02 g pot^{-1}), T_4 (30.46 g pot^{-1}), T_3 (28.71g pot^{-1}) and T_2 (28.54 g pot^{-1}) with respective increase of 50.20, 43.13, 36.16, 28.34 and 27% than control. Grain yield of wheat significantly varied from 5.93–16.58 g pot^{-1} (Table 3). The maximum grain yield was obtained from T_5 (16.58 g pot^{-1}) followed by T_6, T_4, T_3 and T_2 that corresponds a significant increase of 179.5, 154.4, 129.5, 101.6 and 98.9% over control. The value of test weight (Table 3) ranged from 33.05 to 33.95 g showing that these values were insignificant to the applied treatments. Although test weight of T_5 was higher than other treatments, it was at par and insignificant even to the control condition. Data pertaining to the biological yield (Table 3) showed variation from 28.30 to 50.18 g pot^{-1}. It refers to the sum of grain and straw yield and it was highest for T_5 treatment (50.18 g pot^{-1}) followed by T_6, T_4, T_3 and T_2 which is increased by 77.3, 66.46, 55.72, 43.7, 42.54% over control and was lowest in case of control i.e., T_1 (28.30 g pot^{-1}). It is clear from the data (Table3) that harvest index of the current experiment ranged from 20.94% to 33.05%. It is a derived term for the ratio of economic yield (grain yield) and biological yield. Harvest index was recorded lowest under control condition T_1 whereas highest observed under T_5 followed by T_6, T_4, T_3 and T_2 which resulted significant respective increase of 57.83, 52.96, 47.46, 40.4 and 39.68% over control. Basal RDF has traditionally been broadcast or mixed in a shallow soil layer in the wheat pot. This approach enhances NH_4^-N content in the surface soil layer. RDF resulted in higher growth parameters and greater SPAD values until the active tillering stage due to high N concentration in the soil. After that stage, growth of wheat in RDF decelerated due to a gradual decrease in the supply of N. Consequently, DMs of RDF were significantly lower than those of the integrated RDN50%PM50% treatment at the later growth stages and at harvest. As a result, yield from RDF treatment was relatively lower than that from RDN50%PM50%, but similar to those of RDN50%SS50%, RDN50%VC50% and RDN50%FYM50%. Applying RDF alone could result in N loss and low N recovery, which increases the risk of environmental pollution by eutrophication as well as economic losses. After that stage, the plants from RDN50%PM50% treatment produced higher SPAD values across all the treatments due to a greater mineralizable N supplied from the manure. Manure with a higher total N has more N readily available for wheat plants. SS, VC and FYM may have lower mineralization of nutrients because they contained less total N than PM. It is well documented that manures with high C/N ratios increase the immobilization process due to slower decomposition and nitrification. RDN50%SS50%, RDN50%VC50% and RDN50%FYM50% treatments also resulted in a higher number of spikelets per spike but resulted in the fewest number of spikes [25,27] demonstrated that PM treatment enhances physical grain characteristics due to the good supply of N. For that reason, RDN50%PM50% treatment significantly increased the number of filled grains per spike and maximum spike length, and obtained the maximum yields.

4. CONCLUSION

This study found that integrating PM, FYM, VC, and SS with RDN significantly improved the growth and yield attributes of wheat. The RDN50PM50 (5.26 t ha^{-1}) treatment demonstrated the best results in terms of growth parameters and yields attributes. Therefore, organic manure such as PM, which has high total nitrogen content (> 4%) is well-suited for integration with 50% RDN from urea. This approach not only enhances yield but also reduces the amount of fertilizer required, promoting sustainable agriculture. Combining manures with chemical fertilizers, as opposed to solely using inorganic fertilizers, provides essential nutrients to crops, which can be considered an alternative method to enhance nutritional security and sustain crop productivity. This study focused primarily on the recommended levels of nitrogen, without considering other nutrients present in different manures. Further research is needed to evaluate the interactive effects of manures and fertilizers on soil fertility, particularly regarding soil physical and biochemical properties.

DISCLAIMER

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 writing or editing of manuscripts.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to the Department of Soil Science and Agricultural Chemistry at the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, for providing the infrastructure, conducive working environment, and necessary facilities that supported this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Das B, Pooniya V, Shivay Y. S, Zhiipao RR,Biswakarma N, Kumar D, Critykar J. Twenty-one years' impact of using organic amendments on the productivity of rice-wheat rotation and soil properties. Field Crops Research. 2024;(309):109311.
2. USDA. World agricultural production. Foreign Agricultural Service. Circular Series WAP 7–21 July 2021; 2022.
3. Sahu BK, Singh RN, Sengar S, Sahu M. Effect of integrated nutrient management on physico-chemical properties and yield of wheat crop under Inceptisol; 2022.
4. Singh, Divya, Atish Yadav, Ankur Tripathi, Subhendu Singh, Anil Kumar Singh. Effect of nitrogen levels on growth, yield attributes and yield of hybrid varieties of rice (*Oryza sativa* L.). Asian Journal of Soil Science and Plant Nutrition. 2022;8(4):1-6. Available:https://doi.org/10.9734/ajsspn/2022/v8i4162.
5. Umamaheswari S, Rajesh Singh, Akankhya Pradhan. Effect of nitrogen and crop geometry on growth and yield of baby corn. Journal of Experimental Agriculture International. 2024;46(5):789-94. Available:https://doi.org/10.9734/jeai/2024/v46i52433.
6. Kumar N, Mathpal B, Sharma A, Shukla A, Shankhdhar D, Shankhdhar SC. Physiological evaluation of nitrogen use efficiency and yield attributes in rice (*Oryza sativa* L.) genotypes under different nitrogen levels. Cereal Research Communications. 2015, Mar;43(1):166-77.
7. Singh SK, Beillard MJ. Grain and feed annual report—2021; Office of Agricultural Affairs: New Delhi, India; 2021.
8. Spiegal S. Kleinman PJ. Endale DM. Bryant, RB, Dell C Goslee, S Yang, Q Manure sheds. Advancing nutrient recycling in US agriculture. Agricultural System. 2020;(182):102813.
9. Poudel A, Singh SK, Jiménez-Ballesta R, Jatav SS, Patra A, Pandey A. Effect of nano-phosphorus formulation on growth, yield and nutritional quality of wheat under semi-arid climate. Agronomy. 2023;13(3): 768-777.
10. Raza ST, Wu J, Rene ER, Ali Z, Chen Z. Reuse of agricultural wastes, manure, and biochar as an organic amendment: A review on its implications for vermicomposting technology. Journl of Cleaner Production. 2022;(360):132200.
11. Sharma M, Sharma YK, Dotaniya ML. Effect of press mud and FYM application with zinc sulphate on yield of hybrid rice. Journal of Environment & Agricultural Sciences. 2014;1(8).
12. Dhaliwal SS, Naresh RK, Mandal A, Singh R, Dhaliwal MK. Dynamics and transformations of micronutrients in agricultural soils as influenced by organic matter build-up: A review. Environmental and Sustainability Indicators. 2019;1: 100007.
13. Zhao J, Ni T, Li, Lu Q, Fang Z, Huang Q, Shen Q. Effects of organic–inorganic compound fertilizer with reduced chemical fertilizer application on crop yields, soil biological activity and bacterial community structure in a rice–Wheat cropping system. Applied soil ecology. 2016;1(12):99.
14. Urmi TA, Rahman MM, Islam MM, Islam MA, Jahan NA, Mia MAB, Kalaji HM. Integrated nutrient management for rice

yield, soil fertility, and carbon sequestration. Plants, 2022;11(1):138.
15. Dong D, Li J, Ying S, Wu J, Han X, Teng Y, Jiang P. Mitigation of methane emission in a rice paddy field amended with biochar-based slow-release fertilizer. Science of The Total Environment. 2021;(792): 148460.
16. Bolinder MA, Crotty F, Elsen A, Frac M, Kismányoky T, Lipiec J, Kätterer T. The effect of crop residues, cover crops, manures and nitrogen fertilization on soil organic carbon changes in agroecosystems: A synthesis of reviews. Mitigation and Adaptation Strategies for Global Change. 2020;(25):929-952.
17. Randhawa M, Dhaliwal SS, Sharma V, Toor AS, Sharma S, Kaur M. Ensuring yield sustainability and nutritional security through enriching manures with fertilizers under rice–wheat system in North-western India. Journal of Plant Nutrition. 2021; 45(4):540-557.
18. Sarwar G, Hussain N, Schmeisky H, Muhammad S, Ibrahim M, Safdar E. Use of compost an environment friendly technology for enhancing rice-wheat production in Pakistan. Pakistan Journal Botany. 2007;39(5):1553-1558.
19. Singh V, Pyare R, Singh GK. Yield, economics and quality improvement of wheat (*Triticum aestivum* L.) as affected by integrated nutrient management under late sown condition. Journal of Pharmacognosy and Phytochemistry. 2019;8(3):3266-3268.
20. Madan HS, Renu M. Effect of different level of N on protein content of wheat. Journal of Agriculture and Biological Science. 2009;(4):26-31.
21. Iqbal A, He L, Khan A, Wei S, Akhtar K, Ali I, Jiang L. Organic manure coupled with inorganic fertilizer: An approach for the sustainable production of rice by improving soil properties and nitrogen use efficiency. Agronomy. 2019;9(10):651-659.
22. Yousuf PY, Abd_Allah EF, Nauman M, Asif A, Hashem A, Alqarawi AA, Ahmad A. Responsive proteins in wheat cultivars with contrasting nitrogen efficiencies under the combined stress of high temperature and low nitrogen. Genes. 2017;8(12):356.
23. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John wiley & sons; 1984.
24. Dhaliwal SS, Sharma V, Shukla AK, Gupta RK, Verma V, Kaur M, Singh P. Residual effect of organic and inorganic fertilizers on growth, yield and nutrient uptake in wheat under a basmati rice–wheat cropping system in North-Western India. Agriculture. 2023;13(3):556-563.
25. Moe K, Moh SM, Htwe AZ, Kajihara Y, Yamakawa T. Effects of integrated organic and inorganic fertilizers on yield and growth parameters of rice varieties. Rice Science. 2019;26(5):309-318.
26. Choudhary L, Singh KN, Gangwar K, Sachan R. Effect of FYM and Inorganic fertilizers on growth performance, yield components and yield of wheat (*Triticum aestivum* L.) under indo-gangetic plain of Uttar Pradesh. The Pharma Innovation Journal. 2022;11(4): 1476-1479.
27. Liu X, Wang H, Zhou J, Hu F, Zhu D, Chen Z, Liu Y. Effect of N fertilization pattern on rice yield, N use efficiency and fertilizer–N fate in the Yangtze River Basin, China. Plos One. 2016;11(11):166-172.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/118320