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Impact of combined organic and inorganic fertilization on soil fertility and wheat (*Triticum aestivum* L.) yield

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Abstract
A research investigation titled "Impact of Combined Organic and Inorganic Fertilization on Soil Fertility and Wheat (*Triticum aestivum* L.) Yield" was carried out during the Rabi season of 2023-24 at the Agricultural Research Farm of Rama University, Kanpur, Uttar Pradesh, India (209217). The experiment was designed using a Randomized Block Design (RBD) comprising 12 treatments, each replicated three times. The treatments included: T_1 (Control), T_2 (100% Recommended Dose of Fertilizer [RDF] with Nitrogen, Phosphorus, Potassium at 120:60:40 kg/ha), T_3 (100% RDF Nitrogen + 25% Nitrogen from Farmyard Manure), T_4 (75% RDF Nitrogen + 25% Nitrogen from Poultry Manure), T_5 (75% RDF Nitrogen + 25% Nitrogen from Press Mud), T_6 (75% RDF Nitrogen + 25% Nitrogen from Vermicompost), T_7 (50% RDF Nitrogen + 25% Nitrogen from Farmyard Manure + 25% Nitrogen from Press Mud), T_8 (50% RDF Nitrogen + 25% Nitrogen from Farmyard Manure + 25% Nitrogen from Poultry Manure), and T_9 (50% RDF Nitrogen + 25% Nitrogen from Farmyard Manure + 25% Nitrogen from Vermicompost). Results indicated that Treatment T_9, which combined 50% RDF Nitrogen with 25% Nitrogen from Farmyard Manure and 25% Nitrogen from Vermicompost, outperformed other treatments. It exhibited superior performance in parameters such as biological yield, grain yield, straw yield, harvest index, economics and benefit-cost ratio.

Keywords: N phosphorus, K, FYM, poultry manure, vermicompost, PSB and pressmud

Introduction
Wheat ranks as the most widely cultivated staple crop globally, with India being the second-largest producer after China, contributing approximately 12% to the world's total wheat output. In India, wheat is the second most consumed grain after rice, valued for its high nutritional profile, including elevated protein levels, niacin, thiamine, and gluten, which is essential for baking (Ahmad *et al*., 2015) [10]. Major wheat-producing countries include China, India, the United States, Canada, Australia, and Russia.

India's wheat production for the 2023-24 crop year (July-June) is estimated to reach a record 115.3 million metric tonnes from 25.1 million hectares, according to the Ministry of Agriculture and Farmers Welfare (Anonymous, 2024) [11]. Increasing grain and fodder production can be achieved either by expanding cultivated land, which is limited, or by enhancing productivity through high-yielding seed varieties, balanced nutrient application, reliable irrigation, and effective weed and pest management.

In South Asia, farmyard manure (FYM) is a commonly used organic amendment in wheat-based cropping systems, often applied to summer crops like rice or maize, with residual benefits for winter wheat. Studies, such as Alam *et al*. (2015) [12], demonstrated that applying 25% of recommended nitrogen through FYM to wheat achieved yields comparable to 100% inorganic fertilizer use. Similarly, Choudhary *et al*. (2015) [13] in Bangladesh found that 10 t/ha FYM combined with 75% of the recommended fertilizer dose (100 kg N/ha, 26 kg P/ha, 33 kg K/ha) produced wheat yields equivalent to 100% inorganic fertilizer. Higher FYM applications (10 t/ha) with full recommended doses of nitrogen, phosphorus, and potassium (120 kg N/ha, 26 kg P/ha, 25 kg K/ha) resulted in wheat yields matching those from 150% fertilizer doses. In a maize-wheat rotation, FYM applied to maize at 10 t/ha alongside full fertilizer doses maximized yields for both crops. On calcareous soils, FYM at 12 t/ha with 80 kg N/ha and 17.5 kg P/ha significantly outperformed inorganic-only treatments (120 kg N/ha) for wheat following rice (Choudhary *et al*., 2015) [13].

Green manures, such as Leucaena leucocephala leaves, are often incorporated into soils or used as mulch for wheat. Applying 3.14 t/ha of Leucaena leaves (3% nitrogen on dry weight) 15 days before wheat planting increased yields equivalent to 100 kg N/ha from urea, boosting grain production by 11.7%. In maize-wheat systems, Leucaena green manure supplying 60 kg N/ha before wheat planting showed significant residual benefits. Summer legumes like cowpea and green gram applied to maize contributed 18-23 kg N/ha to subsequent wheat crops, with up to 27 kg N/ha residual effects in some cases (Chouhan; Choudhary *et al*., 2015) [13].

Materials and Methods

Field tests were conducted at the Students Instructional Farm of Rama University in Kanpur during Rabi (2023-24). The main campus of the institution is where the farm is situated. The alluvial Gangetic tract in Uttar Pradesh is the site of the experiment. A reliable irrigation system was in operation. The trial site was situated in a secure region.

Grain yield (kgha^{-1})

A mini-plot thresher was used to separate the grains from the biological yield of each net-plot. The net-plot's grain yield was measured and expressed in kg per hectare.

Straw yield (kgha^{-1})

By deducting the grain yield from the total amount of food gathered and converting it to kilograms per hectare, the straw yield from the net-plot area was calculated.

Biological yield (kgha^{-1})

Following harvesting, the wheat crop was allowed to sun-dry for a week before the weight of the net harvested area of wheat in each plot was measured and converted to kilograms per hectare.

Harvest index (HI)

The harvest index, which is determined using Donald's (1962) formula, is economic yield expressed as a percentage of biological yield.

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Economics of treatments

Accredited marketplace costs for inputs are used to calculate the value of cultivating different treatments. By multiplying the grain yield by the minimal aid price and the straw yield by the current market price of straw, the gross returns sum of revenue from grain and straw yields was determined. The calculation of net return (Rs ha^{-1}) involved deducting the entire cost of growing each remedy from the gross income of that remedy.

Benefit Cost Ratio (B: C.)

Benefit Cost Ratio was calculated by formula given below:

$$\text{Benefit cost ratio} = \frac{\text{Gross return Rs/kg}}{\text{Total cost of preparation Rs/kg}}$$

Experimental finding

Grain Yield, Straw yield

Table 1 show the observations on grain yield and straw yield that were made throughout the experiment period.

The application of the various treatments had a significant impact on grain yield. T9 (50% RDF from nitrogen +25% Recommended Nitrogen from farm yard manures +25% Recommended Nitrogen from vermicompost) had the highest grain yield (4469 kg ha^{-1}), followed by T6 (75% RDF from nitrogen +25% Recommended Nitrogen from vermicompost) with 4379 kg ha^{-1}. These treatments were significantly better than T_1 (Control) with 3874 kg ha^{-1}.

Straw yield varied significantly depending on the treatment. T9 (50% RDF from nitrogen +25% Recommended Nitrogen from farm yard manures +25% Recommended Nitrogen from vermicompost) had the highest yield (6141 kg ha^{-1}), followed by T6 (75% RDF from nitrogen +25% Recommended Nitrogen from vermicompost) with 5700 kg ha^{-1}. These treatments were significantly higher than T_1 (Control) with 5470 kg ha^{-1}.

Harvest Index

Table 2 show the Harvest index observation that was made during the experiment time. Treatment T9 (50% RDF from Nitrogen +25% Recommended Nitrogen from farm Yard Manures +25% Recommended Nitrogen from vermicompost) had the highest Harvest index of any treatment, with 42.14, followed by T7 (50% RDF from Nitrogen +25% Recommended Nitrogen from vermicompost) with 42.05, both of which were significantly higher than T_1 (Control) with (40.10) Harvest index.

Summary and Conclusion

Available nitrogen, phosphorus, potassium, zinc, iron, and organic carbon in the soil were measured both before and after the wheat crop was harvested. To arrive at a reliable result, the data gathered throughout the experiment was statistically analyzed. Lastly, the benefit: cost ratio, net return, and gross return of the various therapies were examined. The following is a summary of the key findings of the study that were discussed and presented in the earlier chapters. This chapter also presents the conclusion drawn from the experiment's findings.

Effect of organic and inorganic manures and fertilizers on wheat

The application of 50% RDF through nitrogen and 25% RDF through farm yard manures and 25% RDF through vermicompost increased the 15% recommended nitrogen from farm yard manures and 25% recommended nitrogen from vermicompost, along with 50% RDF via nitrogen, improved wheat production characteristics and yield at harvest. With 50% RDF through nitrogen and 25% recommended nitrogen through farm yard manures and 25% recommended nitrogen through vermicompost, the spike length, number of seeds spike-1, test weight, harvest index, and grain yield all sharply rose. Additionally, the treatment greatly improved the overall absorption and nutritious content of wheat grain and straw.

Table 1: Effect of different organic and inorganic source of nutrient on grain yield, straw yield and harvest index of Wheat

Treatment	Grain yield Kg ha^{-1}	Straw Yield kg ha^{-1}	Harvest Index%
T_1-Control	3874	5470	40.11
T_2-100% RDF from Nitrogen, Phosphorus and Potasic Fertilizers (120:60:40) kg/ha	3899	5578	40.59
T_3-100% RDF from Nitrogen +25% Recommended Nitrogen from farm Yard Manures	3907	5485	41.68
T_4-75% RDF from Nitrogen +25% Recommended Nitrogen from Poultry manure	3897	5590	41.15
T_5-75% RDF from Nitrogen +25% Recommended Nitrogen from press mud	3956	5639	41.72
T_6-75% RDF from Nitrogen +25% Recommended Nitrogen from vermicompost	4379	5700	42.00
T_7-50% RDF from Nitrogen +25% Recommended Nitrogen from farm Yard Manures + 25% Recommended Nitrogen from pressmud	4201	5755	42.05
T_8-50% RDF from Nitrogen +25% Recommended Nitrogen from farm Yard Manures +25% Recommended Nitrogen from Poultry manure	4334	6071	41.83
T_9-50% RDF from Nitrogen +25% Recommended Nitrogen from farm Yard Manures +25% Recommended Nitrogen from vermicompost	4469	6141	42.14
T_{10}-50% RDF from Nitrogen +25% Recommended Nitrogen though Press Mud +25% Recommended Nitrogen from Poultry manure	3913	5514	41.22
T_{11}-50% RDF from Nitrogen +25% Recommended Nitrogen from Presmud +25% Recommended Nitrogen from vermicompost	4122	5324	41.54
T_{12}-50% RDF from Nitrogen +25% Recommended Nitrogen from Vermicompost +25% Recommended N from Poultry manure	4210	5469	41.15
S.Em.	1.139	2.217	1.137
C.D.	2.456	4.894	2.458

Table 2: Cost of Cultivation, Gross income, Net income and Benefit cost ratio of the wheat ha^{-1}

Sr. No.	Treatment Combination	Cost of Cultivation	Gross income	Net income	B:C Ratio
1.	T_1-Control	12588	33462	20874	1:1.65
2.	T_2-100% RDF from Nitrogen, Phosphorus and Potasic Fertilizers (120:60:40) kg/ha	12968	33535	20567	1:1.58
3.	T_3-100% RDF from Nitrogen +25% Recommended Nitrogen from farm Yard Manures	11968	32277	20309	1:0.58
4.	T_4-75% RDF from Nitrogen +25% Recommended Nitrogen from Poultry manure	11905	32208	20303	1:1.70
5.	T_5-75% RDF from Nitrogen +25% Recommended Nitrogen from press mud	14911	34406	19495	1:1.30
6.	T_6-75% RDF from Nitrogen +25% Recommended Nitrogen from vermicompost	13709	33919	20210	1:1.47
7.	T_7-50% RDF from Nitrogen +25% Recommended Nitrogen from farm Yard Manures + 25% Recommended Nitrogen from pressmud	13777	33990	20213	1:1.46
8.	T_8-50% RDF from Nitrogen +25% Recommended Nitrogen from farm Yard Manures +25% Recommended Nitrogen from Poultry manure	14790	34389	19599	1:1.32
9.	T_9-50% RDF from Nitrogen +25% Recommended Nitrogen from farm Yard Manures +25% Recommended Nitrogen from vermicompost	13679	32893	19214	1:1.40
10.	T_{10}-50% RDF from Nitrogen +25% Recommended Nitrogen though Press Mud +25% Recommended Nitrogen from Poultry manure	12557	33088	20531	1:1.63
11.	T_{11}-50% RDF from Nitrogen +25% Recommended Nitrogen from Presmud +25% Recommended Nitrogen from vermicompost	13562	32452	18890	1:1.39
12.	T_{12}-50% RDF from Nitrogen +25% Recommended Nitrogen from Vermicompost +25% Recommended Nitrogen from Poultry manure	12810	33846	21036	1:1.64

Conclusion

The aforementioned experimental results indicate that the application of 50% RDF through nitrogen and 25% recommended nitrogen through farm yard manures and 25% recommended nitrogen through vermicompost proved advantageous for wheat cultivation in terms of grain yield, grain weight, straw yield, harvest index, benefit cost ratio, and soil properties.

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