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Effect of sole and conjoint use of Nitrogen on Nutrient uptake and protein content in wheat: Moongbean cropping system

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Abstract
This study was conducted from mid-2023 to 2025, under this study major focus on the sustainability of crop yields and maintaining the soil fertility. This research was conducted at the research form of Janta Mahvidyalay Ajitmal, Auraiya under the department of soil science and agricultural chemistry, CSJMU, Kanpur nagar, INDIA. In this study taking two factor (factor A contain different levels of RDN combination with nano urea while factor B contain combination of rhizobium and vermicompost) three replication and 28 treatments was employed with factorial randomized block design. This study was totally based on the RDN doses with organic fertilizer and bio-inoculant which are best for the crop as well as soil health and reduce the cost of cultivation in wheat moongbean cropping system.

Keywords: RDN, Vermicompost, Bio-inoculant, Nano urea

1. Introduction

Studies show that combining 50% inorganic fertilizers with 50% organic amendments and biofertilizers improves plant growth, yield, and stress tolerance by enhancing root biomass and plant vigor (Gao *et al*., 2020; Ullah *et al*., 2021) [3, 5]. This integrated nutrient management approach supports long-term soil sustainability, reduces input costs, and maintains ecological balance while ensuring optimal crop productivity.

This study aims to enhance the sustainability and productivity of the wheat-moongbean cropping system by evaluating the effects of organic, inorganic, and bio-inoculant-based nutrient management strategies. Integrated nutrient use can improve soil fertility, microbial activity, and nutrient availability, directly influencing crop yield and nutrient uptake. The findings will support resource-efficient, eco-friendly farming by optimizing input use, reducing reliance on chemical fertilizers, and promoting continuing soil health, ultimately improving farm productivity and profitability.

Wheat is nutritionally rich in carbohydrates and protein, making it essential for global food security. Economically, it plays a pivotal role in international trade, with major production centered in India, China, Russia, and the United States. However, intensive monocropping of wheat has led to soil nutrient depletion, reduced organic matter, and excessive dependence on synthetic fertilizers highlighting the urgency for sustainable nutrient management (Belete *et al*., 2023) [2]. Wheat requires substantial inputs of nitrogen, phosphorus, and potassium to support its growth and imbalanced fertilizer use can degrade soil health, contaminate groundwater, and reduce microbial diversity. Integrating wheat with leguminous crops like moongbean in rotational systems offers a sustainable alternative (Pahalvi *et al*., 2021) [4].

2. Methodology

2.1 Experimental Site

2.1.1 Geographic location

The present field experiment was conducted at the Research Farm of the Department of Soil Science and Agricultural Chemistry, Janta Mahavidyalaya, Ajeetmal, situated in Auraiya district, Uttar Pradesh (U.P.), India. This experimental site is geographically located in the semi-arid region of the Indo-Gangetic Plains, which is a significant agricultural belt of North India. The region holds importance due to its diverse cropping systems and the ongoing challenges related to sustainable nutrient management.

2.1.2 Agro-climatic conditions

The experimental site is located under a subtropical climate, marked by sultry summers and cool winters. The place receives nearly 850 mm of annual rainfall, most of which is received during the southwest monsoon, from June to September. Climatic extremes also characterize the area; atmospheric temperature in summer would reach as high as 42 °C to cause heat stress, whereas in winter, temperature falls to as low as 5 °C and thus might inhibit activities of microbes and nutrient transformation in soils. The influence of these agro-climatic conditions is thus, quite pronounced on nutrient dynamics, microbial activities, and cropping systems, making it a very suitable site for studying nutrient management in diverse seasonal environments.

2.1.3 Experimental year and season

The experiment was conducted over two complete agricultural years (2023 - 2025), covering two cropping seasons: Rabi (wheat) and Zaid (moongbean). The seasonal approach permitted evaluation of the direct effects during the wheat season and the residual effects during the moongbean season-on real field conditions.

2.1.4 Crop grown

The cropping system followed was some wheat-moongbean sequence, which is prevalent in the Indo-Gangetic Plains. During the Rabi season, wheat (Triticum aestivum) was cultivated, and in the Zaid season, moongbean (Vigna radiata) was grown. These two crops were selected due to their complementary nutrient requirements and their suitability for evaluating nutrient management strategies in a sequential cropping system.

2.1.5 Layout and replication

The study entailed a Factorial Randomized Block Design to test the separate and combined effects of inorganic nitrogen and biological nutrient sources on soil health and crop production. There were two factors in the experimental design: Factor A, which has 7 levels of inorganic nitrogen treatments, and Factor B, which has 4 levels of biological nutrient sources, making 28 treatment combinations in all. This treatment combination acquired three replications to assure accuracy and reliability. Each plot was 3.5 m wide and 4.0 m long, with buffer strips negotiated between plots to avoid runoff of nutrients and cross-contamination. All the agronomic operations were established alike across experimental plots with a sole exception made for nutrient treatment applications, which were in line with the experimental design.

Design	F- RBD
Number of replication	3
Total number of treatment	(7 x 4) = 28
Total number of plot	28 x 3 = 84
Gross plot size	4 x 2=8 m^2
Net plot Size	8 - 1.2 = 6.8 m^2
Irrigation channel	30 cm
Crop	Wheat - moongbean

Table 1: Factor A - Inorganic Nitrogen Treatments

Codes	Treatment Descriptions
F0	Control (No nitrogen application)
F1	50% Recommended Dose of Nitrogen (RDN)
F2	75% Recommended Dose of Nitrogen (RDN)
F3	100% Recommended Dose of Nitrogen (RDN)
F4	50% RDN + 2 foliar sprays of 2% Nano-Urea
F5	75% RDN + 2 foliar sprays of 2% Nano-Urea
F6	100% RDN + 2 foliar sprays of 2% Nano-Urea

Table 2: Factor B - Biological Nutrient Sources

Codes	Treatment Descriptions
B0	Control (No biological input)
B1	25% RDN through Vermicompost
B2	Rhizobium inoculation
B3	Rhizobium + 25% RDN through Vermicompost

2.2 Protein Content in Plant

In grain and straw, protein content represents a parameter for assessing the quality of produce in wheat and moongbean. Total nitrogen content for these materials was first estimated by the Kjeldahl digestion and distillation method, a standard method for measuring organic nitrogen from plant tissues. The nitrogen content measure was then multiplied by 6.25 to obtain the protein content, based on the generalized assumption that all proteins contain roughly 16% nitrogen (Brady, 1984) [1].

2.3 N, P, and K Uptake

The nutrient accumulation in the plant biomass was evaluated by determining the contents of nitrogen, phosphorus, and potassium in the grain and straw of wheat and moongbean. While nitrogen in the plant sample was estimated by Kjeldahl digestion, phosphorus was determined by the vanado-molybdate yellow colorimetric method, and potassium was estimated by flame photometry method. Total nutrient uptake of a crop was calculated by multiplying the nutrient content of grain and straw with the respective yields (Brady, 1984) [1].

3. Results and Discussion

3.1 Protein content

The protein content of grain and straw of wheat in control plot is 9.82 and 3.24% in first year while in second year 10.29 and 3.24%, while in moongbean control plot first year 20.1% in grain and 8.56% in straw and second year quite different in moongbean as well as wheat protein content. But treatment T4 (100% RDN) is higher than the treatment T2 and T3 while lower than the treatment T11 (100% RDN + 25% RDN through vermicompost). The treatment T27 is significantly higher than all the treatment except treatment T28 because its at par with each other in wheat first year cropping as well as moongbean first year cropping. Similar trend was found in second year cropping system of wheat - moongbean, so we found that treatment T27 for better than all treatment.

Table 3: protein content of straw and grain in wheat with different source of nitrogen

Treatments	Wheat Ist year		Wheat IInd year	
	Protein% (grain)	Protein% (Straw)	Protein% (grain)	Protein% (Straw)
T1	9.820	3.247	10.294	3.247
T2	11.267	4.480	10.730	4.510
T3	12.100	4.480	11.037	4.570
T4	12.500	4.500	11.347	4.580
T5	12.800	4.520	11.650	4.650
T6	11.467	3.887	11.857	3.887
T7	11.300	3.947	12.160	3.947
T8	9.910	3.055	10.657	3.055
T9	10.700	4.210	12.570	4.210
T10	12.167	4.880	13.897	4.880
T11	11.000	4.950	14.027	4.980
T12	11.733	4.970	14.100	4.970
T13	11.467	5.120	13.287	5.120
T14	11.300	5.230	13.387	5.220
T15	9.793	3.359	10.511	3.359
T16	10.767	4.890	13.697	4.890
T17	10.567	4.970	13.797	4.960
T18	10.500	5.240	13.897	5.250
T19	11.800	5.160	13.900	5.140
T20	12.000	5.260	14.047	5.260
T21	12.300	5.160	14.153	5.160
T22	9.520	3.315	10.339	3.315
T23	13.033	4.033	13.830	4.033
T24	13.300	5.090	13.897	5.090
T25	13.533	5.110	14.387	5.110
T26	13.700	5.120	14.787	5.120
T27	13.767	5.240	14.980	5.480
T28	14.467	5.460	15.230	5.580
CD(P>0.05%)	0.75	0.38	0.66	0.36

Treatments	Moongbean Ist year		Moongbean IInd year	
	Protein% (grain)	Protein% (Straw)	Protein% (grain)	Protein% (Straw)
T1	20.140	8.560	20.373	8.193
T2	22.310	8.780	22.000	8.600
T3	22.300	8.910	22.600	8.900
T4	23.40	9.120	23.100	9.100
T5	23.400	9.250	23.567	9.267
T6	24.300	9.600	24.000	9.500
T7	24.300	9.640	24.367	9.600
T8	20.180	8.230	20.513	8.253
T9	24.120	9.640	25.167	9.633
T10	23.100	9.700	24.600	9.700
T11	24.130	8.150	24.933	8.700
T12	25.120	8.420	25.267	8.400
T13	21.450	8.540	21.767	8.500
T14	21.500	8.240	21.200	8.200
T15	20.150	8.150	20.303	8.063
T16	22.310	8.960	22.000	8.967
T17	22.300	9.150	22.600	9.167
T18	23.400	9.350	23.100	9.333
T19	23.150	8.890	23.567	8.867
T20	24.100	8.780	24.000	8.800
T21	24.120	9.033	24.367	9.033
T22	20.120	8.120	20.390	8.287
T23	24.120	9.533	24.133	9.533
T24	24.100	9.740	24.600	9.733
T25	24.120	9.970	24.933	9.933
T26	25.310	10.230	25.267	10.033
T27	26.300	10.510	26.000	10.533
T28	25.540	10.140	25.567	10.167
CD(P>0.05%)	0.41	0.33	0.41	0.33

3.2 Nutrient uptake

The nitrogen, phosphorus and potassium uptake of wheat in control plot is 70.1, 21.3 and 96.23 kg/ha in first year while in second year 69.3, 19.85 and 97.50 kg/ha, while in moongbean control plot first year 16.23, 2.60 and 12.23 kg/ha in first year and second year quite different in moongbean as well as wheat NPK uptake respectively. But treatment T4 (100% RDN) is higher than the treatment T2 and T3 while lower than the treatment T11 (100% RDN + 25% RDN through vermicompost). The treatment T27 is significantly higher than all the treatment except treatment T28 because it's at par with each other in wheat first year cropping as well as moongbean first year cropping. Similar trend was found in second year cropping system of wheat - moongbean, so we found that treatment T27 for better than all treatment.

Table 4: nutrient uptake of wheat with different source of nitrogen

Treatments	Wheat Ist year			Wheat IInd year		
	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
T1	70.120	21.327	96.320	69.320	19.850	97.250
T2	75.120	22.723	122.533	74.120	22.723	102.500
T3	80.250	22.267	108.633	80.230	22.430	108.633
T4	83.450	23.133	105.333	83.120	23.450	107.000
T5	79.250	22.100	103.733	78.700	23.560	103.733
T6	77.250	22.300	118.667	75.433	23.980	120.210
T7	78.250	23.533	115.200	75.933	24.150	122.230
T8	71.850	21.440	93.067	71.210	19.450	94.000
T9	74.293	25.533	125.067	75.120	25.533	127.000
T10	81.120	24.980	125.100	81.230	24.980	128.000
T11	82.230	25.890	128.500	82.230	25.150	131.250
T12	83.210	25.750	134.400	83.210	25.640	134.400
T13	83.830	25.890	138.250	83.830	26.300	137.120
T14	84.120	25.980	140.150	84.120	25.000	141.250
T15	69.320	21.343	99.100	70.120	20.240	98.740
T16	74.120	23.500	108.633	75.230	23.800	108.633
T17	76.930	22.900	105.333	77.400	22.300	105.333
T18	78.120	22.667	103.733	78.230	22.667	103.733
T19	78.850	23.500	119.433	78.960	23.650	119.433
T20	79.120	22.900	123.233	79.350	22.900	123.233
T21	81.230	22.667	131.567	81.230	22.667	131.567
T22	75.230	21.383	100.373	71.967	21.240	100.373
T23	78.250	22.300	126.033	77.520	22.300	126.033
T24	81.230	23.467	132.700	80.800	23.467	135.800
T25	85.967	24.567	137.200	85.967	24.567	137.580
T26	88.667	25.567	139.567	88.667	25.567	139.567
T27	92.120	26.267	142.967	94.500	26.267	149.980
T28	95.120	26.751	148.504	96.502	26.751	152.230
CD(P>0.05%)	3.77	1.07	4.02	2.56	0.84	3.67

Table 5: nutrient uptake of moongbean with different source of nitrogen

Treatments	Moongbean Ist year			Moongbean Ist year		
	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
T1	16.230	2.630	12.300	14.250	2.540	14.520
T2	19.150	2.230	14.230	19.600	2.590	16.320
T3	20.130	2.650	15.600	20.420	2.850	16.320
T4	22.450	2.780	17.250	22.640	2.890	17.250
T5	22.160	2.820	17.600	22.190	2.870	18.314
T6	22.850	2.890	17.300	22.850	2.890	18.230
T7	24.130	2.910	18.300	23.150	2.910	19.230
T8	17.420	2.501	14.520	16.520	2.590	15.630
T9	26.420	2.580	17.230	28.500	2.580	17.230
T10	27.450	2.450	17.420	29.500	2.610	18.520
T11	31.200	2.470	18.100	32.500	2.640	19.320
T12	33.120	2.600	18.500	33.120	2.690	19.850
T13	33.120	2.750	19.100	34.110	2.750	20.010
T14	33.250	2.850	19.300	34.120	2.850	20.120
T15	17.980	2.520	16.200	17.560	2.670	16.520
T16	29.580	2.550	20.300	29.580	2.650	20.350
T17	29.650	2.540	20.900	30.120	2.640	21.450
T18	31.250	2.670	21.000	32.150	2.670	22.310
T19	32.140	2.890	21.200	33.250	2.890	22.350
T20	33.410	2.990	22.100	34.120	2.990	23.410
T21	34.120	3.120	22.540	35.210	3.120	23.500

T22	19.890	2.650	16.500	19.520	2.890	17.250
T23	29.780	2.900	21.300	30.290	3.100	22.360
T24	29.800	3.100	23.100	31.250	3.240	24.230
T25	30.120	3.320	23.400	32.150	3.450	24.360
T26	32.150	3.740	24.500	34.520	3.870	25.610
T27	34.120	4.210	25.360	35.210	4.250	26.140
T28	35.160	4.720	26.120	37.500	4.970	27.150
CD(P>0.05%)	1.48	0.63	4.75	1.48	0.63	4.75

4. Conclusion

In this study we found that the treatment T27is highly significant and better for nutrient uptake while T28 is at par with it. But we are recommend T27 for practical implication because its manage the cost of cultivation and give full dose of nutrient to plant growth as well as enhance the uptake power of nutrient by the using of vermicompost and rhizobium as nitrogen fixer.

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