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Assessing the effect of precision nitrogen management on nutrient content, nutrient uptake, and nutrient use efficiency of Indian mustard (*Brassica juncea* L.) in western U.P.

Archana Verma, RB Yadav, Vivek, Gajjela Indira and Sushmita

Abstract
A field experiment was conducted in Meerut, Uttar Pradesh, to assess the influence of diverse nitrogen management practices on the growth, yield attributes, and yield of Indian mustard (*Brassica juncea* L.). The study aimed to evaluate the impact of various nitrogen combinations as top dressings on the growth, yield attributes, and yield of Indian mustard. An Integrated Nitrogen Management approach was standardized, utilizing Nano urea, urea spray, and Sagarika as alternatives to conventional nitrogen application methods. The experiment followed a Randomized Block Design (RBD) with 12 treatments, including control (T_1), 100%NF (50:25:25%N) (T_2), 50% NF + 1 spray Nano urea (T_3), 50% NF + 2 spray Nano urea (T_4), 50% NF + Sagarika (T_5), 50% NF + 1 spray Nano urea + Sagarika (T_6), 50% NF + 2 spray Nano urea + Sagarika (T_7), 50% NF + Beejamruta + Jeewamruta (T_8), 50% NF + 1 spray Urea (T_9), 50% NF + 2 spray Urea (T_{10}), 50% NF + 1 spray Nano urea + Sagarika (T_{11}), and 50% NF + 2 spray Nano urea + Sagarika (T_{12}). The cultivar used was GIRIRAJ (DRMR IJ-31) in an irrigated ecosystem. Results highlighted the significant influence of treatments T_7 (50% NF + 2 spray Nano urea + Sagarika) and T_{12} (50% NF + 2 spray Urea + Sagarika) on nutrient content, uptake and nutrient use efficiency.

Keywords: Nitrogen management, Sagarika, Nano urea, Urea spray, Jeewamrutha, Veejamrutha

Introduction
Indian mustard, often referred to as rai or laha, is a member of the brassica family and may be produced in a variety of agroclimatic conditions. Since practically every component of the plant is consumed by either humans or animals depending on the crop and its growing stage, it plays a crucial role in Indian agriculture. An major oilseed crop in the Indian subcontinent, Indian mustard accounts for more than 80% of the nation's total rapeseed-mustard production. Indian mustard has an oil level that ranges from 37 to 49%. When making pickles and flavoring curries and vegetables, the seed and oil are used as a condiment. In northern India, the oil is used for frying and cooking and is consumed by people. Rapeseed-mustard (Brassica spp.), one of the seven edible oil seeds grown in India, accounts for 28.6% of all oilseed output. After Canada and China, India is third in the world for rapeseed-mustard output, making up around 11% of the total. After peanuts, it is the second-most significant edible oilseed in India. Rapeseed-mustard accounts for 3% of the 14.1% of oilseeds that are grown in India's total cultivated land. About 37.19 million hectares (mha) of land are used to cultivate mustard worldwide, with 6.9 mha coming from India and 0.7 mha coming from Uttar Pradesh. Mustard production figures stand at 69.09 mt globally and 73.41mt in India. Productivity rates for mustard are recorded as 1900 kg/ha globally and1.0375 kg/ha in India. (Anonymous 2021) [1].

Lack of water supply, insufficient soil fertility, and weed control are the main factors for mustard output to be low. Crops experience nutrient stress if they are typically produced on marginal areas with low fertility levels. Rapeseed mustard, a cruciferous crop, reacts unusually well to nitrogen fertilization among the three essential elements (N, P, and K), mostly because of its labor-intensive character and extensive root system. Currently, the majority of farmers are growing mustard using labor-intensive, high yielding cultivars, which has resulted in significant nutrient removal from the soil and fertilizer usage that has stayed far below removal. Nitrogen application promotes crop growth and development and increases seed production.

The most essential nutrient, nitrogen (N), is a component of protoplasm and protein and participates in a number of metabolic processes that have a significant impact on crop development, productivity, and quality (Kumar *et al*., 2000) [8]. The use of N fertilizer contributes significantly to crop production costs. Due to the higher N content in seeds and plant tissues, the rapeseed-mustard group of crops have a considerably higher requirement for N than many other crops (Malagoli *et al*., 2005) [9]. With nitrogen application rates as high as 150 kg/ha or higher, yield gains in Indian mustard have been seen in a number of Indian locales (Singh *et al*., 2008) [12]. Low nitrogen utilization efficiency is caused by poor N translocation from vegetative portions to seed during reproductive development. According to (Bhari *et al*. 2000) [2], until blooming, brassicas are known to remove a larger quantity of nitrogen than they take up throughout the reproductive development period. Poor NUE is a major problem since expensive N fertilizers are used, thus efforts must be made to increase the amount of applied N that contributes to grain production. This strategy will lower agricultural productivity and environmental costs.

Materials and Methods

The experiment was conducted at the Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, located in Meerut, Uttar Pradesh. The university is situated in the Indo-Gangetic plains of Western Uttar Pradesh. The geographical coordinates of the farm are approximately 29° 13' 96" N latitude and 77° 68' 43" E longitude, with an elevation of 228 meters above mean sea level. The experiment was comprised of 12 treatments which are T_1 Control, T_2 100% NF (50:25:25), T_3 50% NF + 1spray NU, T_4 50% NF +2 spray NU, T_5 50%NF+ Sagarika, T_6 50% NF +1 spray NU+ Sagarika, T_7 50% NF +2 spray NU+ Sagarika, T_8 50% NF +Beejamrutha+ Jeewamrutha, T_9 50% NF + 1 spray U, T_{10} 50% NF + 2 spray U, T_{11} 50% NF +1 spray U+ Sagarika and T_{12} 50% NF +2 spray U+ Sagarika laid out in Randomized Block Design with three replications. Seeds of mustard Giriraj (DRMR IJ 31) @ 5 kg ha^{-1} were sown on 19-10-2022 in rows spaced at 45 cm apart. The doses of nitrogen are applied as per the treatment. The whole quantity of potassium (40 kg ha^{-1}) was applied as basal dose through Muriate of Potash at 8-10 cm depth along with half dose of nitrogen prior to sowing. Phosphorous was applied as basal dose (60kg ha^{-1}) through SSP. The soil texture was determined to be sandy loam. The soil was found to be low in available nitrogen with a concentration of 220.7 kg ha^{-1}, and the organic carbon content was measured at 0.48%. Available phosphorus was determined to be at a medium level with 13.8 kg ha^{-1}, while the available potassium content was 247.2 kg ha^{-1}. The soil's pH indicated a slightly alkaline reaction with a value of 7.8. Follow the standard procedures and observations were recorded. Indian mustard plants were collected treatment wise for determination of N, P, K content in grain and stover. Five Indian mustard plants with dry and green leaves were chosen at random from the sample row (the second row of the plot) of each plot. The plants were homogenized and diced into 2mm pieces. A representative sample was then dried at 70 °C for 72 hours to remove all moisture. A similar process was used to analyze the grain sample samples as well. Kjeldahl's technique, as reported by Piper (1960), was used to determine nitrogen levels. The P content in the extract was determined calorimetrically using the method as reported by Chapman and Pratt (1961) using well-ground seed and straw samples that had been digested in a diacid combination of HNO_3 and $HClO_4$ (4:1). According to the method described by Black (1965) [4], the amount of potassium in the diacid extract was measured using flame photometry. The amount of sulfur in the extract may also be calculated colorimetrically using barium chromate. Samples were digested using a di-acid combination and double-distilled water. Nutrient content was multiplied with yield and the correction factor was divided by 100 to determine nutrient absorption. The formula below can be used to calculate agronomic efficiency.

$$AE = \frac{Yt - Y0}{A_t}$$

Where,
AE = Agronomic Efficiency (AE) (kg grain yield increase kg^{-1} nutrient applied)
Y_t = Yield under test treatment (kg ha^{-1})
Y_0 = Yield under control (kg ha^{-1})
A_t = Units of nutrient applied in the test treatment (kg ha^{-1})
The Physiological efficiency (PE) indicates the ability of crop to transform acquired nutrient into economic yield and expressed as kg of grains produced per kg of nutrient absorbed. It is calculated by the following formula.

$$PE = \frac{Yt - Y0}{Ut - U0}$$

Where,
PE = Physiological efficiency (kg yield increase kg^{-1} nutrient uptake)
Yt = Yield under test treatment (kg ha^{-1})
Y_0 = Yield under control (kg ha^{-1})
Ut = Uptake of nutrient in test treatment (kg ha^{-1})
U_0 = Uptake of nutrient in control (kg ha^{-1})
Partial factor productivity indicates productions of a crop in comparison to its nutrient input. It is expressed ask g of grains produced per kg of nutrient applied and is worked out as

$$PFP = \frac{Y}{N}$$

Where,
PFP= Partial factor productivity
Y= Grain yield (kg ha^{-1})
N= Amount of nutrient applied (kg ha^{-1})

Statistical analysis of the data was done as per the standard analysis of variance technique for the experimental designs following SPSS software-based programme, and the treatment means were compared at $P < 0.05$ level of probability using t-test and calculating CD values.

Results and Discussions

Analysis of Nutrient Content in Seed and Stover: Table 1 provides data on the impact of various nitrogen management practices on the percentage of nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) content in both seed and stover for the mustard crop during the 2022-23 *rabi* season.

Table 1: Effect of different nitrogen management on seed and Stover content in Indian mustard (*Brassica juncea* L.)

S. No.	Treatments	Seed yield (kg/ha)	N content (%)		P content (%)		K content (%)		S content (%)	
			Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
T_1	Control (0% N)	8.80	3.36	1.36	0.51	0.22	0.96	1.33	0.51	0.20
T_2	100% NF (50:25:25)	22.17	3.54	1.39	063	0.30	1.25	1.58	0.54	0.24
T_3	50% NF + 1spray NU	15.26	3.34	1.37	0.56	0.24	0.98	1.35	0.51	0.21
T_4	50% NF +2 spray NU	18.25	3.42	1.38	0.57	0.26	1.14	1.50	0.53	0.23
T_5	50%NF+ Sagarika	16.35	3.35	1.37	0.54	0.24	1.08	1.36	0.52	0.22
T_6	50% NF +1 spray NU+ Sagarika	17.37	3.39	1.37	0.56	0.26	1.10	1.40	0.52	0.22
T_7	50% NF + 2 spray NU + Sagarika	21.68	3.52	1.39	0.61	0.30	1.21	1.57	0.54	0.24
T_8	50% NF+ *beejamruta* + *jeewamruta*	18.82	3.46	1.39	0.57	0.27	1.16	1.52	0.54	0.23
T_9	50% NF + 1 spray U	14.57	3.31	1.37	0.53	0.23	0.98	1.34	0.51	0.21
T_{10}	50% NF+ 2 spray U	16.77	3.42	1.38	0.56	0.26	1.13	1.48	0.53	0.22
T_{11}	50% NF+ 1sprayU + Sagarika	17.50	3.37	1.37	0.57	0.27	1.08	1.50	0.53	0.23
T_{12}	50% NF +2 spray U + Sagarika	20.83	3.48	1.39	0.60	0.29	1.16	1.55	0.54	0.24
SEM+-		1.37	0.05	0.008	0.04	0.04	0.05	0.14	0.006	0.006
CD		4.04	0.14	0.02	0.12	0.12	0.16	0.41	0.01	0.01

Nutrient Content in Seed and Stover

Treatment T_7 (50%NF+2spray NU+ Sagarika) exhibited the maximum nitrogen (N) content in seeds and stover with 3.52% and 1.39% respectively, which was statistically similar to T_{11} (50% NF+ 1sprayU + Sagarika) and T_{12} (50% NF+ 2sprayU + Sagarika. In terms of phosphorus (P) content in seeds and stover, T_7 displayed a higher value of 0.61 and 0.30 respectively. Additionally, T_7 demonstrated the maximum potassium (K) content in seeds and stover with 1.21% and 1.57% respectively which was statistically similar to T_{11} and T_{12}.Similarly T_7 (50% NF + 2 spray NU + Sagarika) exhibited the highest S content that is 0.54% and 0.23% in seed and stover respectively, which is statistically similar to T_{11} and T_{12}.

Nutrient Uptake: Table 2 showed that treatment T_7 (50% NF + 2 spray NU + Sagarika) exhibited maximum nitrogen uptake by seed (65.55kg ha-1) and total uptake (165.10 kg ha-1) which was found to remain at par with T_{11} and T_{12}. Maximum phosphorous uptake by seed (11.33kg ha-1) was exhibited by T_7 which was found to remain at par with T_{11} and T_{12}. Total uptake (30.11 kg ha-1). was significantly higher in treatment T7 which was found to remain at par with T12. Among the various treatments, T7 exhibited maximum potassium uptake in seed (24.71 kg ha-1) and total uptake (124.26 kg ha-1) which was at par with T11 and T12. The maximum sulphur uptake by seed (10.04 kg ha-1) and total uptake (25.18 kgha-1) was found in treatment T_7 which was significantly higher than other treatments.

Table 2: Effect of different nitrogen management practices on nutrient uptake in Indian mustard (*Brassica juncea* L.)

S. No.	Treatments	N uptake		P uptake		K uptake		S uptake	
		Seed	Total	Seed	Total	Seed	Total	Seed	Total
T_1	Control (0% N)	24.70	73.16	3.86	11.77	5.60	54.07	3.85	11.30
T_2	100% NF (50:25:25)	69.47	170.44	12.63	31.50	26.48	127.45	10.83	26.21
T_3	50% NF + 1spray NU	43.94	115.37	7.31	19.90	12.52	83.03	6.70	18.06
T_4	50% NF +2 spray NU	53.71	141.97	8.94	24.41	17.62	106.36	8.30	22.04
T_5	50%NF+ Sagarika	47.09	119.82	7.49	20.31	14.21	86.57	7.26	18.77
T_6	50% NF +1 spray NU+ Sagarika	50.75	126.43	8.34	22.06	15.34	91.02	7.25	19.70
T_7	50% NF + 2 spray NU + Sagarika	65.55	165.10	11.33	30.11	24.71	124.26	10.04	25.18
T_8	50% NF+ *beejamruta*+ *jeewamruta*	55.94	146.12	9.26	25.06	19.72	108.99	8.67	22.62
T_9	50% NF + 1 spray U	41.69	112.23	6.64	19.02	9.50	80.72	6.42	17.63
T_{10}	50% NF+ 2 spray U	51.57	136.48	8.45	23.26	16.31	101.22	7.92	20.69
T_{11}	50% NF+ 1sprayU + Sagarika	48.58	137.77	8.21	22.72	14.50	94.54	7.61	20.99
T_{12}	50% NF +2 spray U + Sagarika	62.57	157.78	10.87	28.66	22.18	117.40	9.67	24.40
SEM+-		2.9	7.15	0.5	1.2	2.2	6.6	0.7	0.7
CD(P=0.05)		8.7	20.9	1.6	3.7	6.5	19.4	2.3	2.3

Nutrient Use Efficiency

Nitrogen

In Table 3, it is evident that the highest agronomic efficiency of nitrogen (21.47) was achieved through the application of 50% NF + 2 spray NU + Sagarika (T_7), while the lowest agronomic efficiency (9.71) was observed in the case of 50% NF + 1 spray U (T_9). Maximum partial factor productivity (36.13) was obtained by the application 50% NF + 2 spray NU + Sagarika. However, the lowest partial factor productivity was recorded in T_2 (100% NF). Highest physiological efficiency of Nitrogen (34.38) was recorded by the application of 50% NF + 1 spray U (T9) followed by T_3 and T_5. The lowest was physiological efficiency was obtained in T_2 (50% NF + 1 spray U).

In case of phosphorus highest (211.4) was recorded in T_9 (50%NF+1 spray U) and the lowest was in T_2 (100%NF). In potassium the highest K was in T_9 (50% NF + 1 spray U) and the lowest was in T_5 (50% + Sagarika). The recommended dose of phosphorus and potassium was uniformly applied across all treatments, thus omitting the need to calculate agronomic efficiency and partial factor productivity for these nutrients.

Table 3: Effect of different nitrogen management practices on nutrient use efficiency of Indian mustard (*Brassica juncea* L.).

S. No.	Treatments	Agronomic efficiency	Physiological Efficiency			Partial Factor productivity
			N	P	K	
T1	Control (0% N)	-	-	-	-	-
T2	100% NF (50:25:25)	11.70	31.37	164.0	31.3	19.03
T3	50% NF + 1spray NU	10.77	33.84	179.3	33.8	25.43
T4	50% NF +2 spray NU	15.75	32.50	183.4	32.5	30.42
T5	50%NF+ Sagarika	12.58	33.75	205.2	33.1	27.25
T6	50% NF +1 spray NU+ Sagarika	14.28	33.19	194.5	31.4	28.94
T7	50% NF + 2 spray NU + Sagarika	21.47	31.48	172.8	31.4	36.13
T8	50% NF+ beejamruta+ jeewamruta	16.70	32.05	188.1	32.0	31.37
T9	50% NF + 1 spray U	9.71	34.38	211.4	34.3	24.37
T10	50% NF+ 2 spray U	14.50	32.5	193.2	32.5	29.95
T11	50% NF+ 1sprayU + Sagarika	13.28	33.5	186.5	33.5	27.95
T12	50% NF +2 spray U + Sagarika	20.14	31.89	177.0	31.8	34.8
SEm ±		1.5	0.9	12.7	0.9	1.5
C D (P=0.05)		4.4	2.7	37.4	2.7	4.4

Conclusion

It can be concluded that different sources of nitrogen fertilizers can lead to improved productivity in Indian mustard. Among the various nitrogen management practices, treatments T_7 (50% NF + 2 spray NU + Sagarika) and T_{12} (50% NF + 2 spray U + Sagarika) have shown significant impacts on nutrient content, nutrient uptake, nutrient use efficiency, and the productivity of Indian mustard. These findings suggest that treatments T_7 and T_{12} could be considered as promising alternatives to the conventional method of nitrogen application, such as top dressing.

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