

ISSN Print: 2618-060X
 ISSN Online: 2618-0618
 NAAS Rating (2026): 5.20
 IJRA 2026; 9(10): 282-288
www.agronomyjournals.com
 Received: 08-08-2026
 Accepted: 21-09-2026
 Published: 06-10-2026

Gouraram Manoj Kumar Goud

College of Agriculture,
 PJTAU, Rajendranagar,
 Hyderabad, Telangana, India

Dr. Kasbe Sudhanshu Sudhakar

College of Agriculture,
 PJTAU, Rajendranagar,
 Hyderabad, Telangana, India

Dr. Md. Latheef Pasha

College of Agriculture,
 PJTAU, Rajendranagar,
 Hyderabad, Telangana, India

Santanu Kundu

College of Agriculture,
 PJTAU, Rajendranagar,
 Hyderabad, Telangana, India

Corresponding Author:
Gouraram Manoj Kumar Goud

College of Agriculture,
 PJTAU, Rajendranagar,
 Hyderabad, Telangana,
 India

Nutrient uptake dynamics, yield and post-harvest soil nutrient status of rabi mustard (*Brassica juncea* L.) under conventional and nano-urea-based nitrogen management

Gouraram Manoj Kumar Goud¹, Kasbe Sudhanshu Sudhakar², Md. Latheef Pasha³, Santanu Kundu⁴

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i10d.6800>

ABSTRACT

A field experiment was conducted in mustard to evaluate the influence of conventional and nano-N-based nitrogen management on plant N, P and K uptake, yield and post-harvest soil nutrient status. Eight nitrogen management treatments comprising ½ recommended dose of nitrogen (RDN) at sowing with different concentrations and timings of foliar nano-N were evaluated. Application of ½ RDN at sowing followed by nano-N @ 4 ml L⁻¹ at rosette and flowering stages (T8) recorded the highest N, P and K uptake at flowering (40.0, 15.2 and 24.0 kg ha⁻¹) and harvest (45.2, 27.0 and 36.1 kg ha⁻¹, respectively). T8 also recorded the highest seed yield (1126 kg ha⁻¹) and was statistically comparable with conventional split-N management (T2) for several parameters. Post-harvest soil available P and K were not significantly affected by nitrogen management. However, T2 recorded the highest ammoniacal-N (33.0 mg kg⁻¹) and nitrate-N (18.0 mg kg⁻¹), followed by T8 (29.0 and 15.5 mg kg⁻¹, respectively). Overall, ½ RDN at sowing supplemented with foliar nano-N at rosette and flowering stages improved plant nutrient uptake and productivity without significant changes in post-harvest soil available P and K, indicating its potential as an efficient nitrogen management strategy for mustard.

Keywords: Nano-fertilizers, Nano-Urea, Split application, Nitrogen management, Oilseeds

Introduction

Oilseed crops are important for India's agricultural economy, nutritional security and edible oil supply. Despite being a major oilseed producer, India depends considerably on edible oil imports to meet domestic demand. Increasing consumption and import dependence emphasize the need to enhance domestic oilseed productivity through improved varieties, efficient agronomic practices, balanced nutrient management and supportive policies (Thapa *et al.*, 2019) [1]. India's total oilseed production reached 429.89 lakh tonnes (42.99 million tonnes) for the 2024–25 crop year. Cultivation area expanded to 304.40 lakh hectares. (Department of Agriculture & Farmers Welfare, 2026) [2]. Rapeseed and mustard production in India was 126.67 lakh tonnes during 2024–25 (PIB, 2025) [3].

Indian mustard (*Brassica juncea* L.) is one of India's major edible oilseed crops and contributes substantially to domestic edible oil production (Sahoo *et al.*, 2018) [4]. Mustard seed contains about 30–33 per cent oil and 17–25 per cent protein, while its oil is widely used for human consumption and other industrial purposes. Although predominantly cultivated in northern and north-western India, mustard has considerable potential in Telangana, particularly during *rabi* under irrigated and rice-fallow systems. Rao *et al.* (2021) [5] reported good mustard productivity under the Northern Telangana Zone, indicating scope for expanding the crop in the region. Nitrogen is a key nutrient governing chlorophyll formation, photosynthesis, biomass production and yield in mustard. However, inefficient application of conventional urea can result in substantial N losses, particularly through ammonia volatilization (Faria *et al.*, 2014) [6], thereby reducing nitrogen-use efficiency. Difficulty in uniform top-dressing under a developed mustard canopy further emphasizes the need for efficient N-management approaches.

Nanotechnology-based fertilizers, particularly nano-N, offer a potential approach for improving nutrient-use efficiency through targeted foliar nutrient delivery (Kundu *et al.*, 2025; Singh, 2017; Seleiman *et al.*, 2021) [7, 8, 9]. Foliar application at critical growth stages may improve crop N status, nutrient acquisition and physiological activity while reducing dependence on soil-applied N. However, the response depends on application concentration and growth stage, and information on nano-N management in mustard under Telangana conditions remains limited. Plant N, P and K uptake and post-harvest soil nutrient analysis provide important information on nutrient acquisition and soil fertility status. However, limited studies have evaluated these parameters together to assess nano-N-based nitrogen management in mustard. Therefore, the present study

was conducted to evaluate the effect of foliar nano-N applied at critical growth stages in combination with reduced soil-applied N on N, P and K uptake, yield and post-harvest soil nutrient status of mustard, with the aim of identifying an efficient nitrogen-management strategy for mustard cultivation under the conditions of Telangana.

Materials and methods

Experimental site and soil

A field experiment was conducted during *rabi* 2021–22 at the Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana,

India (17°19'44" N latitude, 78°23'55" E longitude and 523 m above mean sea level). The experimental site falls under the semi-arid tropical (SAT) region. The soil was Vertisol, with a pH of 7.9, low organic carbon (0.32%) and available nitrogen (145 kg ha⁻¹), medium available phosphorus (27.31 kg ha⁻¹) and high available potassium (395 kg ha⁻¹). During the crop growth period, weekly mean maximum temperature ranged from 27.4 to 38.4 °C (mean 30.59 °C), while mean minimum temperature ranged from 9.6 to 22.2 °C (mean 16.91 °C) (Fig. 1).

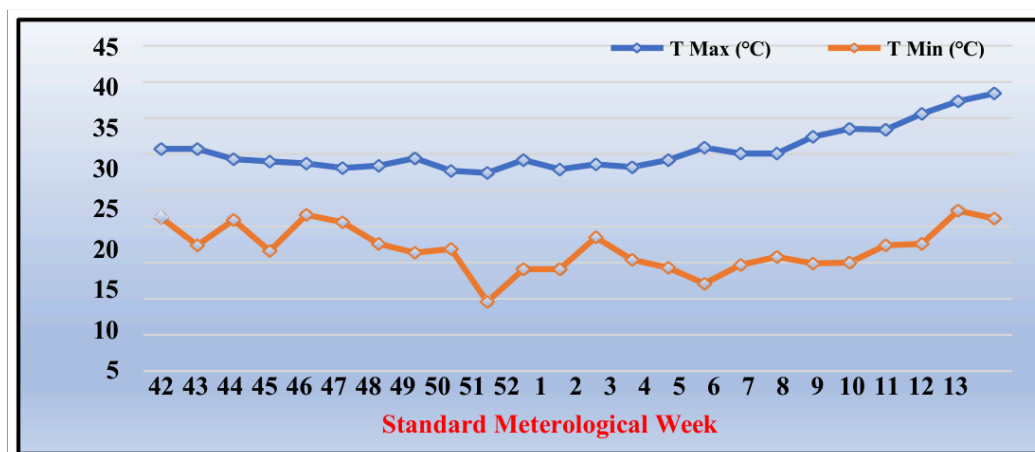


Figure 1. Weekly maximum and minimum atmospheric temperatures (°C) during the crop growth period.

Experimental design and treatments

The experiment consisted of eight nitrogen management treatments, laid out in a Randomized Block Design (RBD) with three replications. The recommended dose of fertilizer (RDF) was 75:90:30 kg N: P₂O₅: K₂O ha⁻¹. The treatments were:

- **T1:** No nitrogen application
- **T2:** ½ RDN at sowing + ½ RDN at flowering
- **T3:** ½ RDN at sowing + foliar nano-N @ 4 ml L⁻¹ at flowering
- **T4:** ½ RDN at sowing + foliar nano-N @ 2 ml L⁻¹ at rosette and flowering
- **T5:** ½ RDN at sowing + foliar nano-N @ 2.5 ml L⁻¹ at rosette and flowering
- **T6:** ½ RDN at sowing + foliar nano-N @ 3 ml L⁻¹ at rosette and flowering
- **T7:** ½ RDN at sowing + foliar nano-N @ 3.5 ml L⁻¹ at rosette and flowering
- **T8:** ½ RDN at sowing + foliar nano-N @ 4 ml L⁻¹ at rosette and flowering

Mustard was grown at a spacing of 45 × 20 cm and harvested at 100 DAS.

Fertilizer and nano-N application

Neem-coated urea was used as the source of soil-applied nitrogen, while single super phosphate (SSP) and muriate of potash (MOP) were used as sources of phosphorus and potassium, respectively. The full recommended doses of P and K were applied at sowing. Nano-N was supplied through Nano Urea (liquid) manufactured by Indian Farmers Fertiliser Cooperative Limited (IFFCO), containing 4% N. Foliar sprays were applied at the specified growth stages using a knapsack sprayer. A spray volume of 312 L ha⁻¹ was used for each application.

Observations and nutrient analysis

Plant samples were collected at rosette, flowering and harvest stages for estimation of N, P and K content in samples, analysis was conducted as per the standard procedure followed by Kundu *et al.* (2026a) [10]. Nutrient uptake was obtained by multiplying nutrient concentrations with dry matter yield (ha⁻¹) (Kundu *et al.*, 2026b) [11]. Post-harvest soil samples were analysed for ammoniacal-N, nitrate-N and available P and K. Samples were analyzed for N, P and K using the Kjeldahl, vanadomolybdo phosphoric yellow colour and digital flame photometer methods, respectively (Piper, 1966) [12]. Crop yield was recorded from the net plot area and subsequently converted to yield per hectare (kg ha⁻¹).

Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA) appropriate for a Randomized Block Design. Treatment means were compared using the Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$, and significant differences were expressed using alphabetic notation at the appropriate level of significance following Gomez *et al.* (1984) [13].

Results and Discussion

Nitrogen uptake

Nitrogen uptake by mustard was significantly influenced by different nitrogen management practices, and the data are presented in Table 1. At the rosette stage, no significant difference was observed among the N-supplied treatments, as neither split urea application nor nano-urea foliar spray had been applied by this stage. T1 recorded the lowest N uptake. At flowering, the highest N uptake was recorded in T8 (40.0 kg ha⁻¹) with conventional urea at sowing + nano urea spray @ 4 ml L⁻¹, which was on par with T7 (38.3 kg ha⁻¹). T1 recorded the lowest uptake (14.0 kg ha⁻¹). At harvest, T8 (45.2 kg ha⁻¹) was statistically at par with T7 (43.1 kg ha⁻¹) and T2 (43.0 kg ha⁻¹). Higher N uptake was mainly attributed to improved nutrient availability, dry matter accumulation and efficient nutrient absorption under nano-urea application. Qureshi *et al.* (2018) [14] reported that the smaller particle size and larger surface area of nano-fertilizers enhance nutrient pene

tration, uptake and nutrient-use efficiency, thereby promoting crop growth.

Phosphorus uptake

Phosphorus uptake by mustard varied significantly with different nutrient management practices, and the data are presented in Table 2. At the rosette stage, no significant differences were observed among N-supplied treatments, while T1 recorded the lowest uptake. At flowering, T8 recorded the highest P uptake (15.2 kg ha^{-1}), which was statistically similar to T7 (14.3 kg ha^{-1}), whereas T1 recorded the lowest (4.7 kg ha^{-1}). At harvest, T8 (27.0 kg ha^{-1}) recorded the highest P uptake and was at par with T7 (26.3 kg ha^{-1}) and T2 (26.0 kg ha^{-1}). The higher P uptake may be attributed to greater P availability, full application of recommended P at sowing and enhanced nutrient absorption. Van *et al.* (2013) [15] reported that chitosan nanoparticles enhanced N, P, K, Mg and Ca uptake and photosynthesis, thereby improving the growth of coffee seedlings. Lahari *et al.* (2021) [16] reported that 50% conventional nitrogen fertilizer combined with foliar application of nano-nitrogen (4 mL L^{-1}) significantly enhanced N, P, K and Zn uptake by the crop.

Potassium uptake

Potassium uptake was significantly influenced by nutrient management practices and it is depicted in Table 3. At the rosette stage, no significant differences were observed among N-supplied treatments, while T1 recorded the lowest uptake. At flowering, T8 recorded the highest K uptake (24.0 kg ha^{-1}), followed by T7 (23.0 kg ha^{-1}), while T1 recorded the lowest (10.0 kg ha^{-1}). At harvest, T8 (36.1 kg ha^{-1}) recorded the highest K uptake, which was statistically similar to T7 (35.0 kg ha^{-1}) and T2 (33.4 kg ha^{-1}). The higher K uptake under T8, T7 and T2 may be attributed to improved K availability and efficient nutrient absorption. Sharma *et al.* (2022) [17] reported that foliar application of nano-urea @ 4 mL L^{-1} significantly enhanced K uptake in pearl millet compared with the control. Sahu *et al.* (2022) [18] reported that application of 75% RDN combined with two foliar sprays of nano-urea significantly increased K uptake. Alimohammadi *et al.* (2020) [19] similarly reported enhanced K uptake with nano-fertilizer application.

Table 1. Influence of foliar application of nano urea on nitrogen uptake of mustard.

Treatments	N uptake (kg ha^{-1})		
	Rosette (30 DAS)	Flowering (60 DAS)	At harvest
T1 : No Nitrogen application	10.0 ^b	14.0 ^c	21.0 ^c
T2: $1/2\text{RDN}$ at sowing + $1/2 \text{ RDN}$ at flowering	24.0 ^a	29.0 ^b	43.0 ^a
T3: $1/2\text{RDN}$ at sowing + foliar spray of nano-N @ 4 mL L^{-1} at flowering	25.0 ^a	30.0 ^b	30.3 ^b
T4: $1/2\text{RDN}$ at sowing + foliar spray of nano-N @ 2 mL L^{-1} at rosette stage and flowering	27.7 ^a	31.3 ^b	32.1 ^b
T5: $1/2\text{RDN}$ at sowing + foliar spray of nano-N @ 2.5 mL L^{-1} at rosette stage and flowering	24.0 ^a	32.0 ^b	34.1 ^b
T6: $1/2\text{RDN}$ at sowing + foliar spray of nano-N @ 3 mL L^{-1} at rosette stage and flowering	27.2 ^a	32.3 ^b	35.0 ^b
T7: $1/2\text{RDN}$ at sowing + foliar spray of nano-N @ 3.5 mL L^{-1} at rosette stage and flowering	24.0 ^a	38.3 ^a	43.1 ^a
T8: $1/2\text{RDN}$ at sowing + foliar spray of nano-N @ 4 mL L^{-1} at rosette stage and flowering	26.2 ^a	40.0 ^a	45.2 ^a
SEm±	1.3	1.5	1.6
CD ($p = 0.05$)	3.9	4.4	5.0
CV%	9.4	8.2	8.1

(continued on next page)

Table 2. Influence of foliar application of nano urea on phosphorus uptake of mustard.

Treatments	P uptake (kg ha ⁻¹)		
	Rosette (30 DAS)	Flowering (60 DAS)	At harvest
T1 : No Nitrogen application	0.49 ^b	4.7 ^e	10.0 ^d
T2: 1/2RDN at sowing + 1/2 RDN at flowering	1.80 ^a	7.0 ^d	26.0 ^a
T3: 1/2RDN at sowing + foliar spray of nano-N @ 4 ml L ⁻¹ at flowering	1.62 ^a	7.0 ^d	17.0 ^c
T4: 1/2RDN at sowing + foliar spray of nano-N @ 2 ml L ⁻¹ at rosette stage and flowering	1.79 ^a	9.3 ^c	17.5 ^c
T5: 1/2RDN at sowing + foliar spray of nano-N @ 2.5 ml L ⁻¹ at rosette stage and flowering	1.72 ^a	9.4 ^c	18.0 ^c
T6: 1/2RDN at sowing + foliar spray of nano-N @ 3 ml L ⁻¹ at rosette stage and flowering	1.62 ^a	11.5 ^b	22.5 ^b
T7: 1/2RDN at sowing + foliar spray of nano-N @ 3.5 ml L ⁻¹ at rosette stage and flowering	1.48 ^a	14.3 ^a	26.3 ^a
T8: 1/2RDN at sowing + foliar spray of nano-N @ 4 ml L ⁻¹ at rosette stage and flowering	1.73 ^a	15.2 ^a	27.0 ^a
SEm±	0.1	0.7	1.0
CD (<i>p</i> = 0.05)	0.2	2.0	3.1
CV%	8.5	11.4	8.5

Table 3. Influence of foliar application of nano urea on potassium uptake of mustard.

Treatments	K uptake (kg ha ⁻¹)		
	Rosette (30 DAS)	Flowering (60 DAS)	At harvest
T1 : No Nitrogen application	7.3 ^b	10.0 ^c	13.0 ^c
T2: 1/2RDN at sowing + 1/2 RDN at flowering	13.2 ^a	15.3 ^b	33.4 ^a
T3: 1/2RDN at sowing + foliar spray of nano-N @ 4 ml L ⁻¹ at flowering	12.0 ^a	15.3 ^b	17.0 ^d
T4: 1/2RDN at sowing + foliar spray of nano-N @ 2 ml L ⁻¹ at rosette stage and flowering	15.3 ^a	16.0 ^b	21.0 ^c
T5: 1/2RDN at sowing + foliar spray of nano-N @ 2.5 ml L ⁻¹ at rosette stage and flowering	13.0 ^a	17.0 ^b	22.4 ^c
T6: 1/2RDN at sowing + foliar spray of nano-N @ 3 ml L ⁻¹ at rosette stage and flowering	13.9 ^a	17.7 ^b	27.0 ^b
T7: 1/2RDN at sowing + foliar spray of nano-N @ 3.5 ml L ⁻¹ at rosette stage and flowering	13.6 ^a	23.0 ^a	35.0 ^a
T8: 1/2RDN at sowing + foliar spray of nano-N @ 4 ml L ⁻¹ at rosette stage and flowering	12.2 ^a	24.0 ^a	36.1 ^a
SEm±	0.8	0.9	1.2
CD (<i>p</i> = 0.05)	2.3	2.5	3.8
CV%	10.3	8.2	8.4

Ammoniacal and nitrate soil nitrogen

Table 4 shows that ammoniacal (NH₄-N) and nitrate (NO₃-N) nitrogen were significantly influenced by different nutrient management practices. Soil-applied N at sowing and top dressing recorded the highest NH₄-N (33.0 mg kg⁻¹) and NO₃-N (18.0 mg kg⁻¹), followed

by T8 (29.0 and 15.5 mg kg⁻¹, respectively), while T1 recorded the lowest values. The higher soil N under split urea application was mainly due to greater mineral N input, increasing NH₄-N and NO₃-N availability. Foliar nano-urea treatments were statistically similar among themselves. Similar findings were reported by Venugopal *et al.* (2017) [20].

Available soil phosphorus and potassium

Available soil phosphorus was not significantly influenced by different nutrient management practices, indicating that variation in N sources did not appreciably affect soil P availability. Available soil

potassium was also not significantly influenced by different nutrient management practices, indicating that the different N management practices had no appreciable effect on soil K availability.

Table 4. Influence of foliar application of nano urea on post-harvest soil available NPK status of mustard.

Treatments	Ammoniacal N (mg kg ⁻¹)	Nitrate N (mg kg ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
T1: No Nitrogen application	15.0 ^c	8.0 ^c	24.0	331
T2: 1/2RDN at sowing + 1/2 RDN at flowering	33.0 ^a	18.0 ^a	23.5	366
T3: 1/2RDN at sowing + foliar spray of nano-N @ 4 ml L ⁻¹ at flowering	26.6 ^b	13.4 ^b	25.3	373
T4: 1/2RDN at sowing + foliar spray of nano-N @ 2 ml L ⁻¹ at rosette stage and flowering	26.8 ^b	13.5 ^b	26.3	383
T5: 1/2RDN at sowing + foliar spray of nano-N @ 2.5 ml L ⁻¹ at rosette stage and flowering	27.0 ^b	13.7 ^b	22.1	355
T6: 1/2RDN at sowing + foliar spray of nano-N @ 3 ml L ⁻¹ at rosette stage and flowering	27.7 ^b	14.0 ^b	25.3	343
T7: 1/2RDN at sowing + foliar spray of nano-N @ 3.5 ml L ⁻¹ at rosette stage and flowering	28.0 ^b	15.3 ^b	26.2	324
T8: 1/2RDN at sowing + foliar spray of nano-N @ 4 ml L ⁻¹ at rosette stage and flowering	29.0 ^b	15.5 ^b	27.1	351
SEm±	1.2	0.7	1.3	18.9
CD (<i>p</i> = 0.05)	3.7	2.2	ns	ns
CV%	8.0	8.9	8.8	9.2

pH, EC, and organic C

Data regarding soil revealed that soil pH did not vary significantly due to different nitrogen management practices. It could be because of the short term of the experiment which may not be enough to bring significant changes in soil chemical property like pH. The data on

electrical conductivity presented in Table 5, revealed that EC of soil was not significant influenced due to different nitrogen management practices. Perusal of the data in Table 5 on organic carbon content in soil presented in table revealed that variations in organic carbon in soil were found to be non-significant due to various nitrogen management practices.

Table 5. Influence of foliar application of nano urea on post-harvest soil pH, EC and OC of mustard.

Treatments	pH	EC (dSm-1)	OC (%)
T1 : No Nitrogen application	7.69	0.28	0.28
T2: 1/2RDN at sowing + 1/2 RDN at flowering	7.50	0.30	0.30
T3: 1/2RDN at sowing + foliar spray of nano-N @ 4 ml L ⁻¹ at flowering	7.50	0.29	0.28
T4: 1/2RDN at sowing + foliar spray of nano-N @ 2 ml L ⁻¹ at rosette stage and flowering	7.51	0.31	0.31
T5: 1/2RDN at sowing + foliar spray of nano-N @ 2.5 ml L ⁻¹ at rosette stage and flowering	7.65	0.30	0.27
T6: 1/2RDN at sowing + foliar spray of nano-N @ 3 ml L ⁻¹ at rosette stage and flowering	7.80	0.29	0.29
T7: 1/2RDN at sowing + foliar spray of nano-N @ 3.5 ml L ⁻¹ at rosette stage and flowering	7.53	0.28	0.29
T8: 1/2RDN at sowing + foliar spray of nano-N @ 4 ml L ⁻¹ at rosette stage and flowering	7.57	0.29	0.28
SEm±	0.4	0.01	0.01
CD (<i>p</i> = 0.05)	ns	ns	ns
CV%	8.3	8.5	8.7

(continued on next page)

Seed yield

The influence of nano-N and RDF on mustard seed yield is presented in (Table 6). The highest seed yield (1126 kg ha^{-1}) was recorded with $\frac{1}{2}$ RDN at sowing + nano-N @ 4 ml L^{-1} at rosette and flowering, which was statistically at par with $\frac{1}{2}$ RDN + nano-N @ 3.5 ml L^{-1} at rosette and flowering (985 kg ha^{-1}) and $\frac{1}{2}$ RDN at sowing + $\frac{1}{2}$ RDN through urea at flowering (975 kg ha^{-1}). Application of nano-N @ 3 ml L^{-1} at rosette and flowering produced 885 kg ha^{-1} , comparable with the recommended N treatment (975 kg ha^{-1}), indicating the potential of two nano-N sprays to partially substitute the 50% RDN top dressing. Lower nano-N concentrations of 2 and 2.5 ml L^{-1} resulted in 694 and 704 kg ha^{-1} , respectively, while a single spray of nano-N @ 4 ml L^{-1} at flowering produced only 529 kg ha^{-1} . Thus, two foliar

applications at rosette and flowering were more effective than a single application at flowering. The control without external N produced 367 kg ha^{-1} .

The higher seed yield under nano-N treatments may be associated with improved growth and yield attributes, particularly siliqua m^{-2} , seed weight siliqua $^{-1}$ and test weight, through enhanced N uptake, photosynthetic activity and translocation of assimilates towards reproductive sinks. Drostkar *et al.* (2016) [21] reported that foliar application of NPK nano-fertilizers improved growth, yield and yield attributes in chickpea. Tarafdar *et al.* (2012) [22] reported that foliar application of nano-fertilizers significantly enhanced crop yield. Kumar *et al.* (2021) [23] reported that 50% reduction in nitrogen fertilizer combined with two foliar sprays of nano-nitrogen produced higher yield in mustard.

Table 6. Influence of foliar application of nano urea on yield of mustard.

Treatments	Seed yield (kg ha^{-1})
T1: No Nitrogen application	367 ^e
T2: $\frac{1}{2}$ RDN at sowing + $\frac{1}{2}$ RDN at flowering	975 ^{ab}
T3: $\frac{1}{2}$ RDN at sowing + foliar spray of nano-N @ 4 ml L^{-1} at flowering	529 ^d
T4: $\frac{1}{2}$ RDN at sowing + foliar spray of nano-N @ 2 ml L^{-1} at rosette stage and flowering	694 ^c
T5: $\frac{1}{2}$ RDN at sowing + foliar spray of nano-N @ 2.5 ml L^{-1} at rosette stage and flowering	704 ^c
T6: $\frac{1}{2}$ RDN at sowing + foliar spray of nano-N @ 3 ml L^{-1} at rosette stage and flowering	885 ^b
T7: $\frac{1}{2}$ RDN at sowing + foliar spray of nano-N @ 3.5 ml L^{-1} at rosette stage and flowering	985 ^{ab}
T8: $\frac{1}{2}$ RDN at sowing + foliar spray of nano-N @ 4 ml L^{-1} at rosette stage and flowering	1126 ^a
SEm $\pm$	52
CD ($p = 0.05$)	157
CV%	11

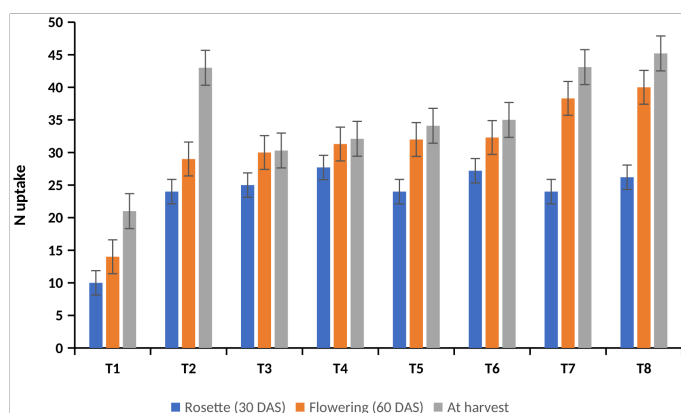


Figure 2. Influence of foliar application of nano urea on N uptake (kg ha^{-1}) at critical growth stages.

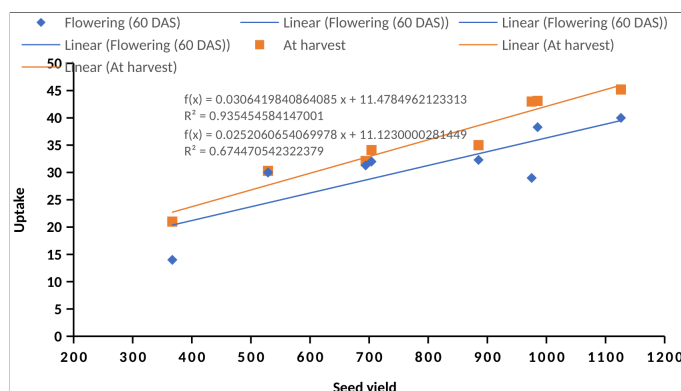


Figure 3. Relationship between seed yield and N uptake at flowering and harvest stages of mustard under different nitrogen management practices.

Seed yield showed a positive relationship with N uptake at both flowering and harvest stages, with a stronger association at harvest ($R^2 = 0.9355$) than at flowering ($R^2 = 0.6745$). This indicates that N uptake at harvest was more strongly associated with seed yield under different nitrogen management practices.

Conclusion

The study demonstrated that integrating foliar nano-urea with reduced soil-applied nitrogen can improve nutrient acquisition and productivity of *rabi* mustard. Among the nitrogen management treatments, $\frac{1}{2}$ RDN applied at sowing followed by nano-urea @ 4 ml L^{-1} at rosette and flowering (T8) recorded the highest N, P and K uptake at harvest (45.2 , 27.0 and 36.1 kg ha^{-1} , respectively) and maximum seed yield (1126 kg ha^{-1}). The conventional split-N treatment (T2) also performed well, particularly in maintaining higher residual soil mineral nitrogen, with 33.0 mg kg^{-1} ammoniacal-N and 18.0 mg kg^{-1} nitrate-N after harvest. However, the higher nutrient uptake and productivity under T8, together with comparatively lower residual mineral N, suggest greater utilization of applied nitrogen by the crop. Nitrogen management did not significantly alter post-harvest soil available P and available K, indicating no measurable changes in these soil nutrient pools during the experimental period.

Thus, under the conditions of the present study, supplementing $\frac{1}{2}$ RDN applied at sowing with nano-urea @ 4 ml L^{-1} at rosette and flowering (T8) was an effective nitrogen management strategy for improving nutrient uptake and mustard productivity. However, the findings should be validated across seasons, locations and soil types before making broader recommendations.

References

- Thapa S, Baral R, Thapa S. Status, challenges and solutions of oil-seed production in India. *Res Rev J Agric Allied Sci*. 2019;8(1):27-34.

2. Department of Agriculture & Farmers Welfare. Final estimates of production of major agricultural crops for 2024–25. Ministry of Agriculture & Farmers Welfare, Government of India; 2026.
3. Press Information Bureau. Record foodgrain output breaks all previous highs, adding new chapters of success in agriculture. Ministry of Agriculture & Farmers Welfare, Government of India; 2025.
4. Sahoo GC, Santra GH, Biswas PK, Mishra S. Influence of doses and source of sulphur on yield, quality and economics of mustard (*Brassica campestris* var toria) in red soil of Odisha. *Ann Plant Soil Res.* 2018;20(1):46-51.
5. Rao PM, Sagar GV, Suresh K, Padmaja G, Reddy SN. Influence of organic and inorganic sources of nitrogen on nutrient uptake and yield of maize in maize-mustard cropping system in Northern Telangana zone. *Pharma Innov J.* 2021;10(10):1351-1357.
6. Faria LDA, Nascimento CACD, Ventura BP, Florim GP, Luz PHDC, Vitti GC. Hygroscopicity and ammonia volatilization losses from nitrogen sources in coated urea. *Rev Bras Cienc Solo.* 2014;38:942-948.
7. Kundu S, Kuma SV, Reddy BM, Kasbe SS, Goud GMK, Pooniya V, Banoth SK, Shah MH, Ali S, Pramanik K. Effect of doses, particle shape, size and composition of nanofertilizers on yield of crops. In: Kumar P, Dubey RC, editors. *Nanofertilisers in agriculture.* Springer; Cham; 2025. p. 291-310.
8. Singh MD. Nano-fertilizers is a new way to increase nutrients use efficiency in crop production. *Int J Agric Sci.* 2017.
9. Seleiman MF, Almutairi KF, Alotaibi M, Shami A, Alhammad BA, Battaglia ML. Nano-fertilization as an emerging fertilization technique: why can modern agriculture benefit from its use. *Plants.* 2021;10:2.
10. Kundu S, Sudhakar SK, Gade KR, Kumar SV, Banoth SK, Goud GMK. Appraisal of Dual-mode Application of Potassium Solubilizing Bacteria (*Bacillus amyloliquefaciens*) in K-rich Sandy Loam Soil: Insights from Sweet Corn. *Int J Bio-resource Stress Management.* 2026;17(7):1.
11. Kundu S, Sudhakar SK, Gade KR, Laxminarayana P, Kumar SV, Goud GMK, Banoth SK, Erapuram P. Potassium-solubilizing bacteria mediated soil potassium dynamics in sweet corn. *Plant Sci Today.* 2026;13(sp1):1-7.
12. Piper CS. Soil and plant analysis. International Science Publication. New York; 1966. p. 47-49.
13. Gomez KA, Gomez AA. Statistical procedure for agricultural research. John Wiley and Sons, New York; 1984.
14. Qureshi A, Singh DK, Dwiwedi S. Nano fertilizers: A novel way for enhancing nutrient use efficiency and crop productivity. *Int J Curr Microbiol Appl Sci.* 2018;7(2):3325-3335.
15. Van NS, Minh DH, Anh ND. Study on chitosan nanoparticles on biophysical characteristics and growth of *Robusta coffee* in greenhouse. *Biocatal Agric Biotechnol.* 2013;2(4):289-294.
16. Lahari S, Hussain SA, Parameswari YS, Sharma SHK. Grain yield and nutrient uptake of rice as influenced by the nano forms of nitrogen and zinc. *Int J Environ Clim Change.* 2021;10(8):45-50.
17. Sharma SK, Sharma PK, Mandeewal RL, Sharma V, Chaudhary R, Pandey R, Gupta S. Effect of foliar application of nano-urea under different nitrogen levels on growth and nutrient content of pearl millet (*Pennisetum glaucum* L.). *Int J Plant Soil Sci.* 2022;34(20):149-155.
18. Sahu TK, Kumar M, Kumar N, Chandrakar T, Singh DP. Effect of nano urea application on growth and productivity of rice (*Oryza sativa* L.) under midland situation of Bastar region. *Pharma Innov J.* 2022;11(6):185-187.
19. Alimohammadi M, Panahpour E, Naseri A. Assessing the effects of urea and nano-nitrogen chelate fertilizers on sugarcane yield and dynamic of nitrate in soil. *Soil Sci Plant Nutr.* 2020;66(2):352-359.
20. Venugopal G, Sharma SHK, Qureshi AA, Sagar GCV. Inorganic fractions of nitrogen and phosphorus in soils and nitrogen, phosphorus uptake by sorghum under long term fertilization and manuring. *Res J Agric Sci.* 2017;8(5):1122-1126.
21. Drostkar E, Talebi R, Kanouni H. Foliar application of Fe, Zn and NPK nano fertilizers on seed yield and morphological traits in chickpea under rainfed condition. *J Res Ecol.* 2016;4(2):221-228.
22. Tarafdar JC, Sharma S, Raliya R. Nano-technology: interdisciplinary science of applications. *Afr J Biotechnol.* 2012;12(3):219-226.
23. Kumar Y, Tiwari KN, Singh T, Raliya R. Nanofertilizers and their role in sustainable agriculture. *Ann Plant Soil Res.* 2021;23(3):238-255.
24. Directorate of Oilseeds Development. Ministry of Agriculture & Farmers Welfare; 2021.
25. Ministry of Agriculture & Farmers Welfare. Directorate of Oilseeds Development; 2021.

How to cite this article: Goud GMK, Sudhakar KS, Pasha ML, Kundu S. Nutrient uptake dynamics, yield and post-harvest soil nutrient status of rabi mustard (*Brassica juncea* L.) under conventional and nano-urea-based nitrogen management. *International Journal of Research in Agronomy.* 2026;9(10):282-288. doi: <https://www.doi.org/10.33545/2618060X.2026.v9.i10d.6800>