

# Study Of Foliar Application Of Nano Urea On Growth And Yield Of Mustard (*Brassica Juncea L.*) Under Timely And Late Sown Condition

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## Abstract

A field experiment was conducted during the Rabi season of 2022–23 at the Instructional Farm, IIAST, Integral University, Lucknow, to investigate the impact of foliar-applied nano urea on the growth, yield, and quality performance of mustard under timely and late sowing conditions. The experiment was laid out in a split plot design with two sowing times (timely and late) in the main plots and five nitrogen management treatments in the subplots, using the RH-749 mustard variety. The nitrogen treatments included 100% recommended dose of nitrogen (RDN) through conventional urea, 100% RDN via nano urea, and various urea–nano urea combinations. Timely sowing significantly improved all measured parameters, including plant height, biomass accumulation, siliquae per plant, and seed yield. Among nitrogen treatments, 100% RDN through conventional urea yielded the highest values for growth and productivity indicators, with seed yield reaching 15.75 q/ha. A 25% substitution of urea with nano urea performed comparably, indicating enhanced nitrogen use efficiency. However, increasing nano urea beyond 50% adversely affected yield and oil content. The results suggest that partial integration of nano urea (up to 25%) with conventional nitrogen sources under timely sowing conditions is a promising approach for optimizing mustard production and sustaining nitrogen efficiency.

**Keywords:** Nano urea, mustard (*Brassica juncea L.*), nitrogen management, sowing time, seed yield, sustainable agriculture

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## INTRODUCTION

Indian mustard (*Brassica juncea L.*) is a significant oilseed crop in India, ranking second in both acreage and production of rapeseed and mustard in Asia. In India, rapeseed and mustard are the second most produced oilseed crops after soybean. Oilseed crops are grown on 25.5 million hectares, accounting for 13.33% of the total cultivated area. Major mustard-producing states in India include Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat, which collectively contribute over 80% of the area and production. The oil and fats derived from this crop are not only used for food purposes but also serve as essential industrial materials. Generally, the crop consists of 35 to 45% oil, 17 to 25% protein, 8-10% fiber, 6-10% moisture, and 10 to 12% extractable substances. The oil is primarily triglyceride, composed of fatty acids and containing unsaponifiable hydrocarbons such as terpenes, sterols, tocopherols, glycolipids, and phospholipids. However, the oil also contains anti-nutritional components like erucic acid and glucosinolate (Anjali et al., 2022). Mustard production is mostly dependent on the development of high yielding cultivars and fertilizer treatment based on requirement. Nitrogen, a key food source for plants, is a vital component of protein and chlorophyll, which are found in many main organs of the plant body. Nitrogen is essential for a variety of physiological functions (Sharma et al. 2022). Nitrogenous fertilizer application in the soil results in nutrient losses through leaching, volatilization, and fixing, reducing nutrient utilization efficiency. As a result, the crop commonly suffers from nitrogen deficit, which is one of the primary causes of low mustard production. As a result, efforts have been undertaken to boost crop output by foliar nitrogenous fertilizer application, in addition to the required fertilizer dose. Foliar feeding is frequently the most successful and cost-effective method for correcting plant nitrogen shortages or filling crop nitrogen gaps. Several fertilizer companies in India developed nanotechnology-based Nano Urea (Liquid) fertilizer to address the imbalanced and excessive use of conventional pilled urea. Nano-urea consists of nitrogen particles (18-30 nm) with a larger surface area (10,000 times that of a 1 mm urea prill) and a bigger number of particles (55,000 nitrogen particles against 1 mm urea prill). Spraying nano urea at a rate of 2 to 4 ml per litre of water during critical crop growth phases stimulates crop response, satisfies nutritional requirements, and improves nutrient availability in the rhizosphere.

(Arya et al., 2022) Taking note of the facts highlighted above, a field experiment was conducted to effect of foliar application of nano urea on growth parameters and yield of mustard.

## MATERIALS AND METHODS

The experiment was carried out at Instructional Farm, Integral Institute of Agricultural Science and Technology (IIAST), Integral University, Lucknow, U.P. in Rabi 2022-23. Site was located in the longitude/latitude (26° 57' 23.7024" N, 81° 0' 12.0384" E), average rainfall of 827 mm.

The study focused on “Study of Foliar Application of Nano Urea on growth and yield of Mustard under timely and late sown condition”. The soil at the experiment site was silt loam in texture, with a pH of 8.10 and an EC of 0.25 dS/m. Two land-use systems (T1: Timely seeded and T2: Late sown) served as the main plot treatments in the experiment, whereas subplot treatments included varying concentrations of Foliar spray of Nano urea. Three replications of the experiment were set up using a split plot design. With the mustard variety RH-749. The crop was sown for timely in 22 October 2023, and for Late sown in 7 November 2023 at row spacing of 30 cm × 15 cm with recommended irrigated condition. The treatments included various combinations given in table 1. In mustard (*Brassica juncea* L.) var. RH-749, the plant growth parameters as well as crop yields were highly influenced by different treatments.

## RESULTS AND DISCUSSION

**Table 1: Effect of different treatments on growth parameters of mustard**

Treatments	Initial plant population/ha		Plant population at harvest/ha		Days to 50% flowering		Days to 50% pod formation		Days to Physiological Maturity	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
<b>Sowing time</b>										
Timely sown	170553.8	164482.2	172258.8	166126.6	54.45	55.53	81.67	82.64	138.83	139.94
Late sown	169384	171683.87	171077.47	173400.27	56.83	57.96	82.44	83.42	140.14	141.26
<b>SEm±</b>	253.38	61.12	255.86	61.62	0.02	0.02	0.03	0.03	0.06	0.06
<b>CD (P=0.5)</b>	NS	371.86	NS	374.89	0.13	0.14	0.2	0.2	0.34	0.35
<b>Foliar spray of Nano urea</b>										
100 % RDN through Urea	175164.3	174348	176915.5	176091	53.26	54.32	78.88	79.82	134.09	135.16
100 % RDN through Nano Urea	164072	160887.17	165712.17	162495.67	57.71	58.86	85.06	86.07	144.6	145.75
75 % RDN through Urea + 25 % RDN through Nano Urea	173239.3	171791.17	174971.33	173508.67	54.11	55.19	79.66	80.61	135.42	136.5
50 % RDN through Urea + 50	171275	169915.83	172987.33	171614.5	56.25	57.37	82.87	83.86	140.87	141.99

% RDN through Nano Urea										
25 % RDN through Urea + 75 % RDN through Nano Urea	166093.8	163473	167754.33	165107.33	56.87	58	83.8	84.8	142.45	143.59
SEm±	517.26	847.55	522.43	856.04	0.28	0.29	0.42	0.43	0.72	0.72
CD (P=0.5)	1550.5	2540.58	1566	2566.02	0.85	0.86	1.27	1.28	2.15	2.17

**Table 2: Effect of different treatments on growth parameters of mustard**

Treatments	Plant Height									
	30 DAS		60 DAS		90 DAS		120 DAS		At harvest	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
<b>Sowing time</b>										
Timely sown	27.3	28.39	114.67	115.83	194.93	196.91	210.52	212.66	211.57	213.72
Late sown	25.03	26.03	105.12	106.19	180.71	183.19	195.16	197.84	196.13	198.82
SEm±	0.26	0.27	1.07	1.09	1.83	1.38	1.97	1.49	1.98	1.5
CD (P=0.5)	1.56	1.62	6.54	6.61	11.11	8.37	12.01	9.05	12.07	9.1
<b>Foliar spray of Nano urea</b>										
100 % RDN through Urea	28.14	29.26	118.2	119.39	200.93	202.96	217	219.19	218.08	220.28
100 % RDN through Nano Urea	26.53	27.59	111.41	112.54	189.39	191.32	204.54	206.63	205.55	207.65
75 % RDN through Urea + 25 % RDN through Nano Urea	27.51	28.6	115.53	116.7	196.4	198.39	212.11	214.25	213.17	215.32
50 % RDN through Urea + 50 % RDN through Nano Urea	24.63	25.61	103.42	104.47	180.81	184.26	195.27	198.99	196.25	199.98
25 % RDN through Urea + 75 % RDN through Nano Urea	24.03	24.99	100.93	101.96	171.57	173.33	185.3	187.2	186.22	188.13
SEm±	0.46	0.48	1.92	1.94	3.27	2.56	3.53	2.76	3.54	2.78
CD (P=0.5)	1.37	1.43	5.76	5.82	9.79	7.67	10.57	8.29	10.62	8.33

**Table 3: Effect of foliar spray of Nano urea on Dry matter accumulation of mustard at different time of sowing**

Treatments	Dry Matter Accumulation (g m <sup>-2</sup> )									
	30 DAS		60 DAS		90 DAS		120 DAS		At harvest	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
<b>Sowing time</b>										
Timely sown	63.4 7	64.1 1	196.7 5	205.1 5	531.2 4	543.6 5	690.6	701.3 2	695.4 3	704.8 2
Late sown	58.8 4	59.6 4	182.3 9	190.8 5	492.4 6	505.7 5	640.1 9	652.4 3	644.6 8	655.7
SEm±	0.59	0.45	1.84	1.44	4.98	3.81	6.47	4.9	6.52	4.92
CD (P=0.5)	3.61	2.73	11.22	8.74	30.28	23.18	39.37	29.8	39.66	29.95
<b>Foliar spray of Nano urea</b>										
100 % RDN through Urea	65.4 2	66.0 8	202.8 1	211.4 6	547.5 8	560.3 5	711.8 5	722.8 8	716.8 4	726.5
100 % RDN through Nano Urea	61.6 6	62.2 9	191.1 7	199.3 3	516.1 6	528.2 1	671	681.4	675.6 9	684.8
75 % RDN through Urea + 25 % RDN through Nano Urea	63.9 4	64.5 9	198.2 3	206.6 8	535.2	547.7	695.7 6	706.5 1	700.6 2	710.0 5
50 % RDN through Urea + 50 % RDN through Nano Urea	58.8 7	59.9 9	182.5	191.9 6	492.7 3	508.7	640.5 5	656.2 5	645.0 3	659.5 3
25 % RDN through Urea + 75 % RDN through Nano Urea	55.8 6	56.4 3	173.1 8	180.5 8	467.5 7	478.5 4	607.8 3	617.3 3	612.0 9	620.4 2
SEm±	1.06	0.83	3.3	2.67	8.9	7.06	11.57	9.11	11.65	9.15
CD (P=0.5)	3.19	2.5	9.88	7.99	26.67	21.17	34.67	27.3	34.91	27.44

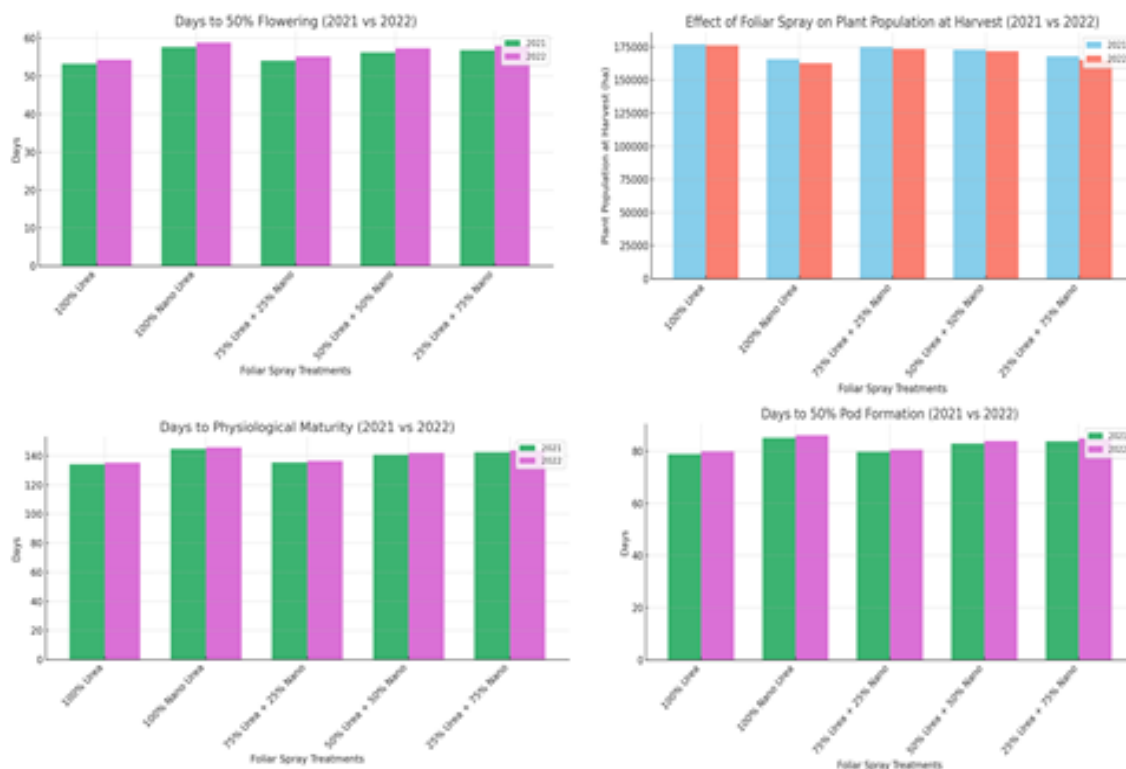


Fig.1 Effect of different treatments on growth parameters of mustard

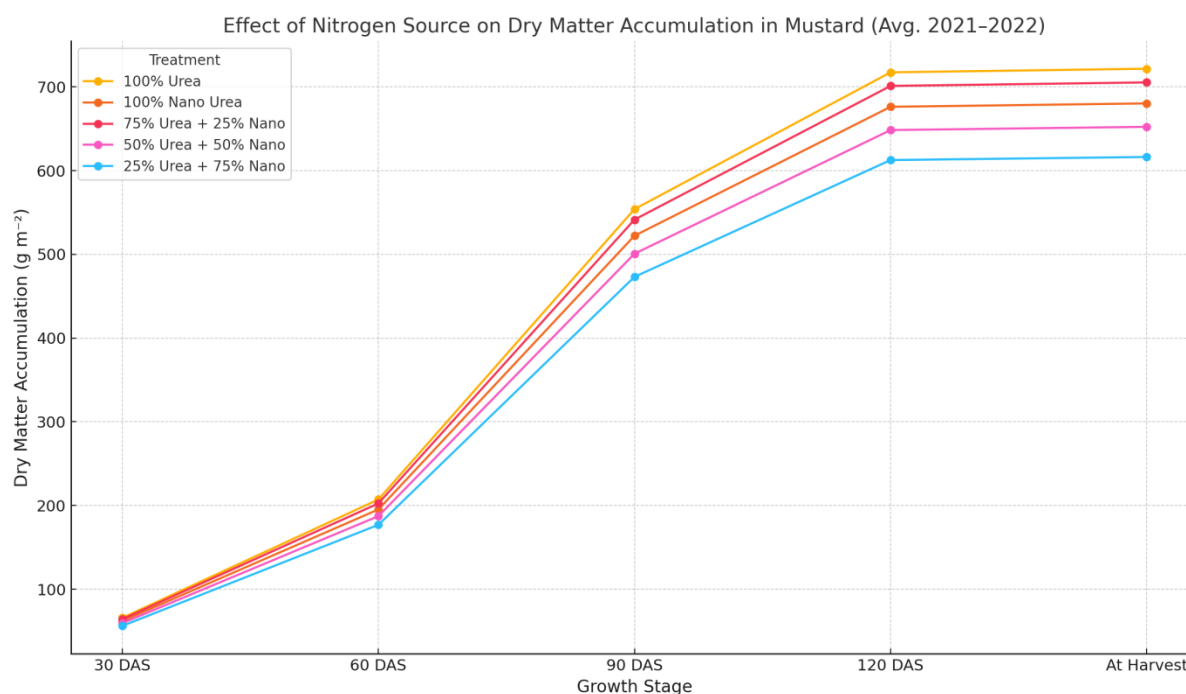


Fig.2 Effect of foliar spray of Nano urea on Dry matter accumulation of mustard at different time of sowing

### Plant population

The initial and harvest plant populations of mustard were influenced by sowing time and nitrogen management across both years. In the main plot, timely sowing generally resulted in slightly higher initial plant populations (170,553.80/ha in 2021) compared to late sowing (169,384.00/ha), whereas in 2022,

late sowing marginally outperformed timely sowing (171,683.87/ha vs. 164,482.20/ha). A similar trend was observed at harvest: timely sowing maintained higher populations in 2021 (172,258.80/ha) but was surpassed by late sowing in 2022 (173,400.27/ha vs. 166,126.60/ha). In the subplot, significant differences were observed among nitrogen treatments. The highest plant populations at both initial and harvest stages were consistently recorded with 100% RDN through urea (175,164.33/ha and 176,915.50/ha in 2021; 174,348.00/ha and 176,091.00/ha in 2022). Conversely, the lowest populations were observed under 100% RDN through nano urea (164,072.00/ha and 165,712.17/ha in 2021; 160,887.17/ha and 162,495.67/ha in 2022).

#### **Days to 50% flowering**

Timely sown mustard reached 50% flowering earlier (54.45 days in 2021; 55.53 days in 2022) than late sown (56.83 and 57.96 days, respectively). Among treatments, 100% RDN through urea resulted in the earliest flowering (~53 days), while 100% nano urea delayed flowering (~58 days).

#### **Days to 50% pod formation**

Timely sown crops formed pods faster (81.67 and 82.64 days) compared to late sown (82.44 and 83.42 days). 100% RDN through urea promoted the quickest pod formation (~79 days), while nano urea treatments extended the duration (~85–86 days).

#### **Days to physiological maturity**

Timely sowing reduced maturity duration (138.83 and 139.94 days), compared to late sowing (140.14 and 141.26 days). 100% RDN through urea matured fastest (134.09 and 135.16 days), with nano urea again extending the growth cycle (up to 145.75 days).

#### **Plant height (cm.)**

Timely sown mustard exhibited significantly greater plant height across all growth stages, culminating in 211.57 cm (2021) and 213.72 cm (2022) at harvest, compared to ~196 cm in late sown crops. In subplots, 100% RDN through urea produced the tallest plants (218.08 cm and 220.28 cm), followed by 75% urea + 25% nano urea (~213–215 cm). Treatments with higher nano urea proportions resulted in shorter plants, with 25% urea + 75% nano urea producing the lowest heights (186.22 cm and 188.13 cm).

#### **Dry matter accumulation**

Higher dry matter accumulation was consistently recorded in timely sown crops, reaching 695.43 g/m<sup>2</sup> (2021) and 704.82 g/m<sup>2</sup> (2022), compared to late sown crops (644.68 and 655.70 g/m<sup>2</sup>). Among nitrogen treatments, 100% urea led to the highest accumulation (716.84 and 726.50 g/m<sup>2</sup>), followed by 75% urea + 25% nano urea (~700–710 g/m<sup>2</sup>), while 25% urea + 75% nano urea showed the lowest (612.09 and 620.42 g/m<sup>2</sup>).

The results of the study underscore the significant influence of both sowing time and nitrogen source on mustard growth, development, and productivity. Timely sowing consistently promoted superior crop performance, primarily due to favorable environmental conditions during early germination and vegetative growth stages. This timing enhanced parameters such as plant population, plant height, leaf area development, and overall biomass accumulation. Although the effect of sowing time on initial and harvest plant population was marginal, timely sown plots tended to support slightly higher stands, likely due to optimal soil moisture and temperature at the time of sowing (Akhtar et al., 2025). In contrast, the source of nitrogen had a more pronounced effect. The application of 100% RDN through urea resulted in the highest plant population at both initial and harvest stages, reflecting its efficacy in supporting early establishment and vigor. Conversely, 100% nano urea resulted in lower stand densities, potentially due to its slower nitrogen release and delayed early availability (Upadhyay et al., 2025). Phenological development was notably impacted by the treatments. Days to 50% flowering and pod formation were reduced under timely sowing and 100% urea application, suggesting a faster transition to reproductive stages facilitated by immediate nitrogen availability (Navya et al., 2021; Agrawal et al., 2022). In contrast, higher proportions of nano urea delayed these stages, likely reflecting limited early nitrogen uptake and prolonged vegetative growth. Similarly, days to physiological maturity were shortest in timely sown and urea-fed plots, pointing to more efficient crop development. Crops receiving nano urea, especially in higher proportions, showed extended maturity durations, potentially exposing them to late-season environmental stresses (Riar et al., 2020). Plant height and dry matter accumulation followed a parallel trend. Taller plants and higher biomass were observed under timely sowing and full urea application, attributable to optimal nitrogen supply supporting vigorous vegetative growth. Increased substitution with nano urea gradually reduced both parameters, indicating that nano urea alone may not meet the full nitrogen demand for sustained growth (Singh et al., 2023; Samanta & Dutta, 2024). Leaf Area Index

(LAI), a key indicator of canopy development, was also maximized under timely sowing and 100% urea, reflecting better foliage expansion and light interception. Increasing the nano urea proportion beyond 50% led to a decline in LAI, suggesting inadequate nitrogen to maintain leaf growth (Meena et al., 2024).

## CONCLUSION

The findings of the study clearly indicate that timely sowing significantly enhances the growth, yield components, and quality attributes of mustard, primarily by providing optimal environmental conditions during critical growth stages. Among the nitrogen management strategies, the application of 100% recommended dose of nitrogen (RDN) through conventional urea consistently resulted in superior performance across all measured parameters, including plant height, dry matter accumulation, leaf area index, seed and stover yield, and oil content. Notably, the partial substitution of conventional urea with nano urea up to 25% produced outcomes comparable to full urea application, highlighting its potential to improve nitrogen use efficiency without compromising crop productivity. However, increasing the proportion of nano urea beyond 50% led to a marked reduction in physiological, agronomic, and quality traits. This decline suggests that nano urea, when applied as a sole or major nitrogen source, is insufficient to meet the crop's nitrogen demand under field conditions. Therefore, nano urea may be best utilized as a complementary component in integrated nitrogen management strategies rather than a full substitute for conventional nitrogen fertilizers.

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