



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(9): 261-264
Received: 29-06-2026
Accepted: 31-07-2026

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Effect of nano-urea and nano-DAP on growth attributes of mustard (*Brassica juncea* L.)

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i9d.6508>

Abstract

A field experiment was conducted at farm of the All India Co-ordinated Research Project on Mustard, College of Agriculture, Nagpur. The experiment was laid out in factorial randomized block design with three RDF levels and four nano-fertilizer levels and replicated three times. The treatments consisted of three RDF levels viz., F₁ - 100% RDF, F₂ - 75% RDF and F₃ - 50% RDF, and four nano-fertilizer levels viz., N₁ - Control, N₂ - Two spray of nano-urea @4 ml L⁻¹, N₃ - Two spray of nano-DAP @4 ml L⁻¹ & N₄ - Two spray of nano-urea @4 ml L⁻¹ + nano-DAP @4 ml L⁻¹. The soil of the experimental site was vertisol and clayey in texture, slightly alkaline in reaction (pH - 7.3), low in available nitrogen (279.67 kg ha⁻¹), medium in available phosphorous (24.30 kg ha⁻¹) and high in available potassium (374.62 kg ha⁻¹). The result of the experiment revealed that among different RDF levels the growth attributes was significantly higher with F₁ - 100% RDF that is in plant height, no. of branches, chlorophyll content and dry matter accumulation plant⁻¹. Among nano-fertilizer levels, N₄ - Two spray of nano-urea @4 ml L⁻¹ + nano-DAP @4 ml L⁻¹ recorded plant height, no. of branches, chlorophyll content and dry matter accumulation plant⁻¹. Interaction effect between RDF level and nano-fertilizer levels was found non-significant in all the parameters.

Keywords: Mustard, RDF levels, nano-fertilizer levels, growth attributes, growth

1. Introduction

Indian mustard (*Brassica juncea* L.), commonly referred to in the subcontinent as rai, represents the predominant winter (*Rabi*) oilseed crop in India (Shekhawat *et al.*, 2012) ^[9]. It is primarily grown in India's smallholder and marginal farming systems, often in rain-fed, low-input regions, making productivity and profitability improvements vital for inclusive agricultural growth and enhancing farmers' livelihoods. The crop group includes eight varieties: toria, brown sarson, yellow sarson, gobhi sarson, raya (Indian mustard), karan rai, black mustard, and taramira. It is predominantly cultivated in states like Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, West Bengal, Jharkhand, Assam, Gujarat, Bihar, Punjab, Jammu & Kashmir, Manipur, Chhattisgarh, Maharashtra, Uttarakhand, Odisha, and Himachal Pradesh. Studies, such as (Patel *et al.*, 2024) ^[5]. As mustard is the major oilseed crop in India the oil content in Indian mustard varies from 37-49 per cent, carbohydrate 14-15 per cent, protein 25-30 per cent, fibre 10-12 per cent, minerals and vitamins 1-1.5 per cent, glucosinolate 2-3 per cent. Mustard oil contains about 40-60 per cent of erucic acid, linolenic acid 4.5 to 13 per cent and oleic acid 25-30 per cent. Linoleic acid has a higher nutritive value (Jat *et al.* 2023) ^[1]. Mustard oil should be nutritious and more palatable by reducing the erucic acid and linolenic acid. The seeds of mustard are used for flavouring curries and vegetables also used as condiments in the preparation of pickles.

Conventional fertilizers offer nutrients in chemical forms that are not often fully accessible to plants. Additionally, inversion of these chemical fertilizers to sparingly soluble forms in soil is the reason for the very low utilization of most of the added micronutrients. These problems make it imperative to go in for the repeated use of fertilizers. It is fairly well known that the yield of many crops has begun to drop as a result of imbalanced fertilization and decrease in soil organic matter. Nano-urea and nano-DAP is a source of Nitrogen and Phosphorus, a major essential nutrient required for better growth and development of crops. Nanotechnology, an emerging and rapidly growing field with wide ranging applications, has significantly impacted agriculture, especially through the creation of nano-fertilizers. These advanced fertilizers, designed at the nanoscale, enhance nutrient delivery and improve plant growth and productivity.

This cutting-edge method tackles key issues in traditional agriculture, such as nutrient depletion, soil degradation, and environmental pollution, by offering more efficient and sustainable solutions for nutrient management (Shang *et al.*, 2019)^[10].

2. Materials and Methods

A field trial was conducted at the All India Co-ordinated Research Project on Mustard, College of Agriculture, Nagpur, during the year 2025-26 *rabi* season to study effect of nano-urea and nano-DAP on growth attributes of mustard (*Brassica juncea* L.). The soil of the experimental site was vertisol and clayey in texture, slightly alkaline in reaction (pH - 7.3) low in available nitrogen (279.67 kg ha⁻¹), medium in available phosphorous (24.30 kg ha⁻¹) and high in available potassium (374.62 kg ha⁻¹). The design of experiment was factorial randomized block design with three replications and twelve treatment combinations, consisting of three RDF levels as factor I viz., F₁ - 100% RDF, F₂ - 75% RDF

and F₃ -50% RDF, and factor II as four nutrient levels viz., N₁ - Control, N₂ - Two spray of nano-urea @4 ml L⁻¹, N₃- Two spray of nano-DAP @4 ml L⁻¹ & N₄ - Two spray of nano-urea @4 ml L⁻¹ + nano-DAP @4 ml L⁻¹. Mustard variety (PDKV Kartik) was sown at spacing of 45 x 10 cm with full dose of phosphorous along with 50% nitrogen was applied as basal dose and remaining 50% was applied as top dressing according to the Recommended dose of fertilizer (RDF) levels that is 80:40:00 as per treatment. Foliar spray of nano-fertilizer was given at 25 DAS and 2nd spray of nano fertilizer was given at 50 DAS. Data pertaining to yield attributes were recorded from randomly selected five plants from each net plot and the mean value was calculated. Cost of cultivation was worked out with help of prevailing market prices of mustard. The data was statistically analyzed with standard method outlined for randomized block design. Statistically significance was tested by F- value at 5% level of probability and critical difference was worked out wherever the effect was significant.

Table 1: Details of the experimental treatments

Factor A: RDF levels	
F ₁	100% RDF
F ₂	75% RDF
F ₃	50% RDF
Factor B: Nano-fertilizers	
N ₁	Control
N ₂	Two spray of nano-urea @4 ml L ⁻¹
N ₃	Two spray of nano-DAP @4 ml L ⁻¹
N ₄	Two spray of nano-urea @4 ml L ⁻¹ + nano-DAP @4 ml L ⁻¹

3. Results and Discussion

In mustard (*Brassica juncea* L.) the plant growth attributes highly influenced by different treatments. Shown in table no. 2 & 3

Table 2: Mean growth attributing characters of mustard as influenced by RDF & nano-fertilizers

Treatments	Plant height (cm)				Dry matter accumulation plant ⁻¹ (g)			
	30 DAS	30 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Factor A - RDF								
F ₁	30.84	105.44	158.98	163.50	7.50	23.40	44.58	56.84
F ₂	29.81	90.25	142.72	146.00	6.40	22.84	41.72	54.05
F ₃	27.75	64.83	117.06	121.17	5.20	20.49	37.93	50.10
SE (m) ±	0.34	2.06	1.86	1.86	0.03	0.42	0.98	0.35
CD at 5%	1.00	6.03	5.44	5.43	0.08	1.21	2.87	1.01
Factor B - Nano-fertilizer								
N ₁	29.34	75.80	127.89	131.67	6.13	19.84	37.36	49.25
N ₂	29.44	82.18	135.20	144.33	6.30	22.10	40.63	52.86
N ₃	29.56	88.57	140.71	139.00	6.50	23.17	42.56	54.56
N ₄	29.67	100.82	154.54	159.22	6.53	25.01	45.08	57.97
SE (m) ±	0.40	2.38	2.15	2.15	0.03	0.48	1.14	0.40
CD at 5%	NS	6.96	6.28	6.27	NS	1.40	3.32	1.17
Interaction (A x B)								
SE (m) ±	0.69	4.13	3.73	3.72	0.06	0.83	1.97	0.69
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
GM	29.50	86.84	139.59	143.56	6.37	22.41	41.41	53.66

3.1 Growth attributes

3.1.1 RDF levels

Among the different RDF levels growth attributes i.e. plant height (cm) was recorded maximum with the application of 100% RDF (F₁). This increase in plant height with higher fertility levels might be attributed to the adequate availability and supply of nutrients, which enhanced cell division, cell elongation, this result are in conformity with (Yadav *et al.*, 2025; Jat *et al.*, 2023)^[14, 1].

Application of 100 % RDF recorded the highest dry matter accumulation plant⁻¹ (g) at harvest (56.84 g), which was significantly superior to 50% RDF (F₃) at all stages and statistically at par with 75% RDF (F₂) at 60 (22.84 g) DAS and 90 (41.70) DAS. This finding is in conformity with (Jat *et al.*, 2023; Verma *et al.*, 2024)^[1, 13].

Table 3: Mean growth attributing characters of mustard as influenced by RDF & nano-fertilizers

Treatments	No. of branches plant ⁻¹			Chlorophyll content (SPAD value)			
	30 DAS	60 DAS	90 DAS	1 st Spray		2 nd Spray	
				Before	After	Before	After
Factor A - RDF							
F ₁	5.58	11.88	17.86	38.55	41.63	39.82	43.83
F ₂	5.41	10.92	16.89	36.35	41.47	38.16	42.98
F ₃	5.30	9.92	15.96	33.00	40.40	37.66	42.67
SE (m) ±	0.01	0.28	0.33	0.58	0.26	0.96	0.28
CD at 5%	NS	0.83	0.95	1.69	0.75	NS	0.82
Factor B - Nano-fertilizer							
N ₁	5.10	8.44	13.87	35.32	40.30	37.24	42.23
N ₂	5.33	9.93	15.94	35.91	41.28	38.91	43.05
N ₃	5.53	11.64	17.92	36.62	41.31	38.28	43.16
N ₄	5.74	13.60	19.99	36.03	42.18	39.77	44.20
SE (m) ±	0.02	0.33	0.38	0.67	0.30	1.11	0.33
CD at 5%	NS	0.96	1.10	NS	0.86	NS	0.95
Interaction (A x B)							
SE (m) ±	0.17	0.57	0.65	1.16	0.51	0.93	1.93
CD at 5%	NS	NS	NS	NS	NS	NS	NS
GM	5.39	10.81	16.91	35.97	41.22	38.54	43.16

Number of branches plant⁻¹ at 60 and 90 DAS are significant but remained non-significant at 30 DAS. Adequate nutrient availability supported better vegetative frame and branching initiation, in agreement with the findings of (Jat *et al.*, 2023; Varma *et al.*, 2021) ^[1, 12]. Chlorophyll content was significantly influenced by RDF levels i.e. before 1st spray and after both the 1st and 2nd sprays, while it remained non-significant before 2nd spray. Application of 100% RDF (F₁) registered the highest SPAD value before the 1st spray (35.97), after the 1st spray (41.22), and after the 2nd spray (43.16), which was significantly superior to 50% RDF (F₃) and at par with 75% RDF (F₂) after the 1st spray. Optimum supply of nitrogen and phosphorus enhances nitrogen metabolism and the synthesis of porphyrin rings necessary for chlorophyll formation. These findings are in conformity with Navya *et al.* (2022) ^[4].

3.1.2 Nano-fertilizer levels

The plant height was significantly influenced by foliar application of nano-fertilizers at 60, 90 DAS and at harvest, while the effect was found non-significant at 30 DAS. The maximum and significantly superior plant height was recorded with two spray of nano-urea @4 ml L⁻¹ + nano-DAP @4 ml L⁻¹ (N₄) at 60 DAS (100.82 cm), 90 DAS (154.54 cm), and at harvest (159.22 cm) over sole sprays of nano-DAP (N₃), nano-urea (N₂), and control (N₁) these results confirm with the findings of (Singh *et al.*, 2024; Bhedela *et al.*, 2024; Pandav *et al.*, 2022) ^[7, 2, 15] in mustard. Foliar application of nano-fertilizers exerted a significant influence on dry matter accumulation plant⁻¹ at 60 DAS, 90 DAS & at harvest, while the effect remained non-significant at 30 DAS. Application of two sprays of nano-urea @4 ml L⁻¹ + nano-DAP @4 ml L⁻¹ (N₄) registered the maximum dry matter accumulation i.e. at 60 DAS (25.01 g), 90 DAS (45.08 g), and at harvest (57.97 g), which was significantly superior to the the control (N₁) at all stages and statistically at par with two sprays of nano-DAP (N₃) at 90 DAS (42.56 g). Rapid stomatal penetration and targeted delivery of nanoscale nitrogen and phosphorus enhanced metabolic activity, photosynthetic rates, and overall biomass accumulation. These results corroborate the findings of (Pandav *et al.*, 2022; Pisal *et al.*, 2024) ^[15, 6].

Application of nano-fertilizers exerted a significant influence on the number of branches plant⁻¹ at 60 and 90 DAS, but remained non-significant at 30 DAS. Treatment N₄ (Two spray of nano-urea @4 ml L⁻¹ + nano-DAP @4 ml L⁻¹) registered the maximum

number of branches plant⁻¹ at 60 DAS (13.60) and 90 DAS (19.99), proving significantly superior to sole nano-fertilizer sprays and control (N₁). The rapid cellular uptake of nanoscale nitrogen and phosphorus boosted metabolic processes and auxiliary shoot growth. Similar positive responses to nano-fertilizer application were reported by (Pandav *et al.*, 2022; Pisal *et al.*, 2024) ^[15, 6]. Foliar application of nano-fertilizers exerted a significant influence on SPAD values after both the 1st and 2nd sprays. Whereas values recorded before spraying were non-significant. The maximum chlorophyll content was recorded with two sprays of nano-urea @4 ml L⁻¹ + nano-DAP @4 ml L⁻¹ (N₄) after the 1st spray (42.18) and after the 2nd spray (44.20), being significantly superior to the control (N₁). Rapid foliar penetration and targeted absorption of nanoscale nitrogen and phosphorus stimulated chlorophyll biosynthesis and delayed senescence. Similar positive impacts of nano-fertilizers on chlorophyll content was documented by (Khule *et al.*, 2023; Sharma *et al.*, 2022) ^[3, 11].

Interaction effect

Growth attributes were not significantly influenced by the interaction effect of RDF levels and nano-fertilizers levels of mustard. (Table 2 and 3).

Conclusion

Based on the experimental results of the present investigation, it can be concluded that, the combine application of two spray of nano-urea @4 ml L⁻¹ + nano-DAP @4 ml L⁻¹ is found best in respect of growth attributes viz. plant height (cm), dry matter accumulation plant⁻¹ (g), No. of branches plant⁻¹ and chlorophyll content as compare to it's individual application.

Acknowledgement

I express my sincere gratitude to Dr. J. R. Katore, Senior Scientist & Head, KVK Selsura, Wardha, Maharashtra. For his continuous guidance, encouragement, and support throughout this research, which were instrumental in the successful completion of this work.

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