

Effect of nitrogen levels on mustard (*Brassica juncea* (L.) Czern and Coss.) varieties under late sown condition

ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2015-16 to study on the effect of nitrogen levels on growth and yield of mustard (*Brassica juncea* Czern and Coss.) varieties under late sown condition at Main Agronomy Research Station, Narendra Deva University of Agriculture and Technology, Faizabad (Uttar Pradesh). Testing the experiment near alkaline in pH, low EC, Organic carbon and available N, medium in available P and medium available K. The experiment was laid out in factorial randomized block design with fifteen treatments with three replications. Results showed that the all growth parameter like, Plant height, Dry matter accumulation, number of branches, LAI and stover yield highest recorded with 160 kg ha⁻¹ nitrogen and that was at par with 120 kg N ha⁻¹ and with NDR-8510 variety is superior in all growth and yield followed by Vardan and Maya. Highest mustard seed yield recorded with 120 kg N ha⁻¹ and variety NDR-8501. Interaction of nitrogen levels and varieties in case of yield was found significant.

Keywords: Growth, Seed yield, Stover yield, NDR-8501, Vardan, Maya.

1. INTRODUCTION

Brown mustard (*Brassica juncea*) is a variable species cultivated for centuries as a vegetable and oil crop, and is also a widespread weed. It is known by diverse common names, which include Indian mustard, leaf mustard and brown mustard among many others (Grubben and Denton, 2004). In the eastern part of the Uttar Pradesh, especially in the lowland areas, farmer grow the rice which is harvested generally in the month of October last week and sometimes in first week of November. Many times, farmer are interested to take the mustard in these field but research information on this aspect are meagre and it is very pertinent to find out the suitable mustard genotype and nitrogen requirement, which may prove remunerative to the farmer. The Indian soils have generally been reported to be low in nitrogen, phosphorus and sulphur because of the multiple cropping and introduction of high yielding varieties, and the deficiency of these nutrients in soil becoming wider. Fertilizer plays an important role in plant growth and show significant increase in yield (Singh *et al.*, 2017). Nitrogen is the most responsive nutrient for rapeseed-mustard. There are no uniform recommendations by the Agronomists regarding N fertilizer levels for a given unit area. Kumar *et al.* (2007) recommended 120 kg N ha⁻¹ while Singh *et al.* (2008) and Singh and Verma (2007) reported 120 kg N ha⁻¹ for best yield of Indian mustard; and Keerthi *et al.* (2017) recommended 100 kg ha⁻¹. Significant response of nitrogen was obtained when it was applied up to 80 kg under rainfed and 120 kg ha⁻¹ under irrigated conditions (Kumar *et al.*, 2001). Keivanrad and Zandi (2014) reported that all growth and yield parameters of mustard plant were significantly affected by nitrogen fertilization. The highest seed yield and oil yield (2961 and 1159 kg ha⁻¹, respectively) were obtained for the crop utilized with 200 kg N ha⁻¹. While, Rimi *et al.* (2015) reported that higher dose nitrogen 180 kg ha⁻¹ failed to produce better results as other doses. Therefore, there is paucity of information on the fertilizer rates relating to the cited yields in the country. Thus, although the yields cited in literature may be inviting, farmers need more illumination on fertilizer rates. Most farmers in India grow mustard without fertilization while still others argue that brown mustard does not require any fertilization. Thus, although information on N increasing yield of brown mustard has been documented in some places; no reliable statistics are present in India (Grubben and Denton, 2004) and hence there is need to study the potential of N and varieties increasing yield under India conditions.

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2. MATERIAL AND METHODS

The field experiment was carried out during winter season of 2015- 16 at Main Agronomy Research Station, Narendra Deva University of Agricultural and Technology, Faizabad (Uttar Pradesh) during the *rabi* season of 2015-16. The farm is located at 42 km away from Faizabad city on Faizabad- Raebareilly road at 26.47° N latitude, 82.12° E longitude and an altitude of about 113 metres above the mean sea level. Faizabad (Uttar Pradesh) is characterized by sub-tropical, semi-arid type of climate with hot and dry summer during April to June followed by hot and humid period during July to September and cold winter during December and January. The mean maximum and minimum temperatures show considerable variations during different months of the year. Temperature often exceeds 42 °C during summer and sometimes touches above 45 °C with dry spells during May and June. Minimum temperature falls below 5 °C with some frosty spells during the winter months of December and January. The meteorological data recorded during standard meteorological weeks (SMWs) of the crop growing season (*rabi* 2015-16) obtained from meteorological observatory of the university, which is located at a distance of 900 meters from the experimental site. The mean temperature recorded during first week of November (45th SMW) 2015 to fourth week of March (12th SMW) 2016 ranged between 5.2 °C to 33.4 °C. The mean relative humidity varied from 42.7 to 78.8 per cent during crop growth period. A rainfall of 4.8 mm was recorded in the month of March, 2016. The evaporation rate varied from 1.7 mm to 5.8 in the month of November and March, respectively. Daily mean sunshine hours ranged from 2.7 hours in 3rd SMW to 8.1 hours in 9th SMW. The soil of the experimental field belongs to the major group of Indo- Gangetic which is silt loam up to 15 cm depth. (Table 1).

Table 1: Physical and chemical properties of soil of the experimental field at the beginning of the study (2015-16)

S.No.	Particulars	Values
(i)	Sand (%)	25.0
(II)	Silt (%)	49.50
(III)	Clay (%)	25.50
(IV)	Textural class	Silt loam
(I)	pH (1:1.25 soil : water)	8.2
(II)	Organic carbon (%)	0.32
(III)	EC dSm ⁻¹ at 25 °C	0.24
(IV)	Available N (kg ha ⁻¹)	136.5
(V)	Available P ₂ O ₅ (kg ha ⁻¹)	14.5
(VI)	Available K ₂ O (kg ha ⁻¹)	248.5
(VIII)	Available Zn (ppm)	0.54

Comment [F8]: On the same table 1, show results of physical and chemical properties at the end of the experiment.

Experimental details of the research field:

The cropping sequence of the experimental field for the preceding 5 years was rice, blackgram and sorghum followed by mustard, chickpea wheat. The experiment was laid out in Randomized Block Design (RBD), keeping the three varieties viz. vardan, NDRI - 8501 and maya were laid out with five nitrogen levels 0, 40, 80, 120 and 160 kg ha⁻¹ respectively, with three replication. The crop was fertilized with a uniform dose of phosphorus and potassium at the rate of 60 kg and 40 kg ha⁻¹, respectively. Nitrogen was applied as per treatments Urea, DAP and Murate of potash were used as

Comment [F9]: In the abstract, you mentioned having fifteen treatments, here are only five. Where are others? Refer to comment 2 in the abstract and adjust accordingly.

the source of nitrogen, phosphorus and potassium. The full dose of phosphorus and potassium and half dose of nitrogen was applied as basal dose and remaining half dose of nitrogen was given in two equal splits as top dressing each after first and second irrigations. Two irrigations were given in the mustard crop. First irrigation was done at (25 DAS) and second irrigation was done at siliqua formation stage (55 DAS) of the crop. Land preparation was done after harvesting of kharif crop. One ploughing was done by disc plough followed by two ploughings by tractor drawn cultivator and planking was done invariably after each ploughing to get the fine seed bed. Layout was done carefully as per technical programme of the experiment. Thinning was done in two phases. In the first phase dense emerging seedlings were uprooted after 10 days of sowing. Second phase of thinning was completed 25 DAS by maintaining plant to plant and row to row distance as 45 cm and 15 cm, respectively. Mustard seeds were sown in lines at the distance of 45 cm and 15 cm plant to plant with the help of seed drill. The seed rate was used 5 kg ha⁻¹. The crop was harvested at complete maturity as judged by visual observation. The border rows from both the sides and 45 cm from each side width wise were harvested first and kept aside. Thereafter, crop of each net plot was harvested separately and brought to threshing floor after proper tagging. The produce of net plot was weighed individually and recorded before threshing. Threshing was done by wooden sticks and seed weight was recorded for net plot after winnowing the produce. To obtain stover yield the seed weight was subtracted from total biomass recorded from each plot.

91 Estimation of Traits

At 30, 60 90 DAS and at harvest, five plants were selected randomly from each plot and tagged and the following parameters were determined: plant height (cm), number of seeds branches, LAI and reported as dry matter in g plant⁻¹. Main stem length was measured as the plant height. The height was measured in cm with the help of meter scale from the base of the plant to top of the plant and mean value was computed. Total number of primary and secondary branches were counted separately and mean value have been computed for primary and secondary branches plant⁻¹. The leaf area of five plants was measured by automatic leaf area meter at 30th, 60th and 90th day after sowing of the crop. Leaf area index was calculated by using the following formula.

100 Leaf area index = leaf area / ground area

101 The seed yield was measured by harvesting net plot area of each plot at crop full maturity
102 (physiological maturity). After harvesting, the plants were left in the field for sun drying to their
103 constant weight (12% moisture content). Then, the total above ground plant weight after removal seed
104 was computed (stover yield) by a precise scale (0.001 g) and expressed as kg ha⁻¹.

105 Data collection and measurements

106 At physiological maturity, plants from the net area were hand harvested close to the ground surface
107 using sickles. The harvested plants were sun dried in open air, weighted the above ground biomass
108 yield and then threshed and weighed to determine the grain yield for each treatment and the yield
109 were adjusted at 12.5% moisture content. The straw yield was calculated as the difference between
110 total yield and grain yield. Total N uptake by the straw and grains was calculated by multiplying the N
111 concentrations by the respective straw and grain yields per hectare (kg ha⁻¹). The total N uptake by
112 the whole plant was determined by summation of the respective grain and straw N uptakes on a
113 hectare basis as described by Woldeyesus et al.(2004).

114 **Protein yield (kg ha⁻¹):** - the protein yield was calculated from protein concentration (%) × grain yield
115 (kg ha⁻¹)

116 **Nitrogen Uptake (kg ha⁻¹):** the nutrient uptake was calculated as seed/ stover yield (kg ha⁻¹) ×
117 nitrogen content (%)

118 Nitrogen Uptake efficiency:

119 N-uptake efficiency (%) =

120 Where N-recovery= total N-uptake (kg ha⁻¹) - control N-uptake (kg ha⁻¹).

121 Statistical analysis:

122 The data was analysed statistically according to Factorial Randomized Block design. The significance
123 of the overall differences among the treatments was determined by using the 'F' test. Conclusion was
124 drawn at 5 per cent probability level. When 'F' value in the analysis of variance table was found to be
125 significant, the critical difference (CD) was computed to test the significance of the difference between

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Comment [F11]: How did you determine the sample size, why five plants and not any other number? Is there a formula to determine sample size? Which formula did you use?

Comment [F12]: How were the various parameters determined? Clearly outline the methodology used to collect data for each variety? And how often were the measurements taken? Outline them under various headings.

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two treatment means (Fisher and Yates, 1963). In case of significant interaction, it has been explained by the corresponding two - way table of both the treatment means to locate the best treatment combination.

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3. RESULTS AND DISCUSSION

Effect of nitrogen level

Nitrogen fertilization contributed to a greater extent in influencing the seed yield of Indian mustard on account of its pronounced effect on the growth and yield attributes at various stages of the crop growth. The various growth parameters including plant height, dry matter accumulation, number of leaves, leaf area, index and number of branches plant⁻¹ were increased significantly with increase in the dose of nitrogen and the effect was more pronounced at the higher rates of nitrogen application. The maximum plant height, dry matter accumulation, number of branches was observed with 160 kg N ha⁻¹ while shortest plants were noted under control plots all the stage of crop growth. It may be due the mineral nitrogen and the carbohydrates synthesized in the green part of the plant are metabolized in to amino-acid and family of the protein which allowed the plants to grow faster. Thus the plant height significantly increased with increasing levels of nitrogen. There was a significant difference in number of branches plant⁻¹ and leaf are index with increasing levels of nitrogen from 0 to 160 kg ha⁻¹. Adequate supply of nitrogen favoured the nitrogen content and nutrient utilization towards protein which favoured vertical (plant height) and lateral (branching) growth of the plant and ultimately increased in growth of plants with successive increments in the branches of nitrogen are in agreement with (Kachroo and Kumar, 1999) and (Dongarkare *et al.*, 2005). The dry matter accumulation plant⁻¹ showed increasing trend with age of crop and the highest growth rate was noticed between 30-60 days stage. The dry matter accumulation plant⁻¹ increase significantly with increase in dose of nitrogen upto 160 kg N ha⁻¹ at all stages of crop growth. Increase in plant height, leaf area index and branches plant⁻¹ were the major reason for higher dry matter accumulation with nitrogen application. Similar results have also been reported by Bhari *et al.* (2000), Keivanrad and Zandi (2012) and Premi and Kumar (2004). Fifty percent flowering as well as maturity was delayed at higher levels of nitrogen. The possible reasons behind the fact may be that the nitrogen application delayed the senescence of leaves, which in turn remained engaged in the production of photosynthates for relatively longer period leading to delayed flowering and maturity with increasing dose of nitrogen. Nitrogen fertilization enhanced the stover yield with increase in the dose of nitrogen up to 160 kg N ha⁻¹. This might be due to the fact that nitrogen application increased all the growth contributing characters viz. plant height, branches plant⁻¹ and leaf area which enhanced the Stover production. The beneficial effect of nitrogen fertilization on stover yield of mustard has also been reported by Singh and Singh (1998), Kumar *et al.* (2001), Bhari *et al.* (2000), Singh and Meena (2004) and Sah *et al.* (2006). There was significant increase in seed yield with every increasing dose of nitrogen up to 120 kg N ha⁻¹. The highest yield of 16.88 q ha⁻¹ was recorded with 120 kg N ha⁻¹ which remained at par with 160 kg N ha⁻¹ (16.44 q ha⁻¹). The increase seed yield was associated with increase in all yield contributing characters viz. siliquae plant⁻¹, length of siliqua, seed siliqua⁻¹, and test weight. Adequate supply of nitrogen facilitated better growth and development of crop plant, enhanced nutrient content and resulted significant increase in yield attributes. Similar results have also been reported by, (Singh *et al.*, 2008) and (Parmindar and Sandhu, 2004), (Keerthi *et al.*, 2017). Nitrogen application resulted in significant increase in protein yield and nitrogen uptake by seed & stover (kg ha⁻¹) with progressive increase in the dose of nitrogen. The higher protein yield of (402.53 kg ha⁻¹) was obtained with 160 kg N ha⁻¹ which remained at par with 120 kg N ha⁻¹ (399.50 kg ha⁻¹). The increase in protein content was mainly due to the increase in nitrogen uptake by the crop. It may be stated that due to higher availability of nitrogen in plants, the synthesized carbohydrates may be converted more rapidly in to proteins which in turn enhanced the protein content of seed. Kachroo and Kumar (1999), Kumar *et al.* (2001) and singh (2002) have also been reported the increase in protein content with increasing doses of nitrogen.

Effect of varieties

Difference among varieties contributed to a great extent in influencing the seed yield of Indian mustard on account of its effect on the growth and attributes of the plant at various stages. The various growth and yield parameters affected significantly, due to various mustard varieties. The variety NDR-8501 attained the maximum plant height as compared to other varieties at all the stages of crop growth. While minimum plant height was recorded with Maya at all stage of crop growth. Dry matter accumulation plant⁻¹ was also higher in NDR-8501 at all stages of crop growth. The probable reason reason may be attributed to genetic characteristics of NDR-8501 which has higher capacity to utilize photosynthates more efficiently for rapid formation of leaves, branches and ultimately the dry matter production. The number of days taken to 50 per cent flowering and maturity was higher in

NDR-8501 and minimum with Maya. Higher days taken to flowering and maturity by NDR-8501 are being mainly a genetic character, which is performed according to varietal characteristics. The seed yield of mustard depends mainly on the number of siliquae plant⁻¹ length of siliqua. Number of seed siliqua⁻¹, 1000-seed weight as these characters have high degree of positive correlation with seed yield. Variety NDR-8501 has higher values of all the above mentioned yield contributing characters. It may be the main reason for better yield of NDR-8501, which was significantly higher over other varieties similar results also have been reported by Verma *et al.* (2014) and Yadav *et al.* (2017). Variety NDR-8501 recorded highest protein yield (322.76 kg ha⁻¹) and uptake by seed and stover 51.70, 12.20 kg ha⁻¹, respectively, followed by Vardan and Maya, which may be due to little variation in genetic characters of the varieties. Interaction effect between nitrogen levels and varieties was found to be non-significant for all the growth and yield contributing characters except seed yield and stover yield. Where the treatment combination N₃V₂ (120 kg N and NDR-8501) produced significant higher yield 18.50 q ha⁻¹ over other combinations.

Table 2: Interaction effect between nitrogen levels and varieties on seed yield

Treatment	V ₁	V ₂	V ₃	Average
0	9.50	10.90	9.33	9.91
40	11.53	12.19	10.37	11.36
80	14.03	14.16	12.90	13.70
120	16.26	16.93	16.07	16.44
160	16.33	17.10	15.87	16.41
Average	13.53	14.25	12.91	
SEm+	0.71			
CD (P=0.05)	2.07			

Comment [F16]: Indicate the significant differences among the varieties V₁, V₂ and V₃ inline to the treatments. State LSD value and use letters to show significant differences.

Table 3: Interaction effect between nitrogen levels and varieties on stover yield

Treatment	V ₁	V ₂	V ₃	Average
0	42.9	45.83	42.00	43.57
40	45.13	54.90	46.10	48.7
80	52.27	61.39	49.23	54.25
120	57.27	63.16	57.00	59.14
160	58.00	63.53	59.85	60.46
Average	51.11	56.53	50.84	
SEm+	2.39			
CD (P=0.05)	6.91			

Comment [F17]: Refer to comment 16 above.

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Table 4: Effect of nitrogen levels on growth and yield of mustard (*Brassica juncea* Cuzern and Coss.) varieties under late sown condition.

Comment [F18]: Display the results in a clear table.

Treatment	Plant height (cm)	Leaf area index (90 DAS)	Number of branches	Dry matter accumulation (g plant ⁻¹)	Days taken to 50 % flowering	Days taken to 50 % flowering
Nitrogen Levels (kg ha ⁻¹)						
0	146.0	2.74	10.93	62.98	51.60	111.55
40	156.0	3.70	13.20	68.21	52.14	112.70
80	164.8	4.30	15.42	72.56	53.20	115.00
120	175.5	4.95	20.03	78.76	54.80	118.45
160	180.0	4.99	21.21	81.28	54.26	117.30
SEm±	2.86	0.16	0.74	1.34		
CD	8.03	0.47	2.15	3.89		
Varieties						
Vardan	162.6	4.04	15.92	71.26	53.33	115.28
NDR-8501	169.6	4.56	17.96	77.01	53.86	116.42
Maya	161.2	3.80	14.59	70.01	51.22	110.71
SEm±	2.22	0.13	0.57	1.04		
CD	6.43	0.36	1.66	3.02		

Means of the same parameter in a column followed by the same letter are not significantly different at P = 0.05 according to Fishers Protected LSD test

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Table 5. Effect of nitrogen levels on quality and nitrogen uptake efficiency of mustard (*Brassica juncea*Curzen and Cross.) varieties under late sown condition.

Comment [F19]: Adjust the tables.

Treatment	Protein yield (kg ha ⁻¹)	Nitrogen uptake (kg ha ⁻¹)			Nitrogen uptake Efficiency (%)		
		Seed	stover	Total	Seed	Stover	Total
Nitrogen Levels (kg ha ⁻¹)							
0	189.57	25.78	4.95	30.74	-	-	-
40	245.37	33.00	7.10	40.07	18.00	5.36	23.37
80	314.40	44.60	10.13	54.72	25.52	6.47	30.00
120	399.50	59.85	14.90	74.49	28.40	8.29	36.70
160	402.5	63.24	16.24	79.49	23.42	7.05	30.47
SEm±	6.21	2.52	1.04	2.78			
CD (P=0.05)	18.68	8.17	3.38	9.05			
Varieties							
Vardan	300.5	42.81	10.25	53.02	22.53	7.14	29.67
NDRI-8501	322.7	51.70	12.20	63.90	23.10	6.75	29.85
Maya	272.5	41.38	09.62	50.95	24.35	6.40	30.75
SEm±	3.44	1.12	0.31	1.15			
CD (P=0.05)	11.22	3.31	0.91	3.39			

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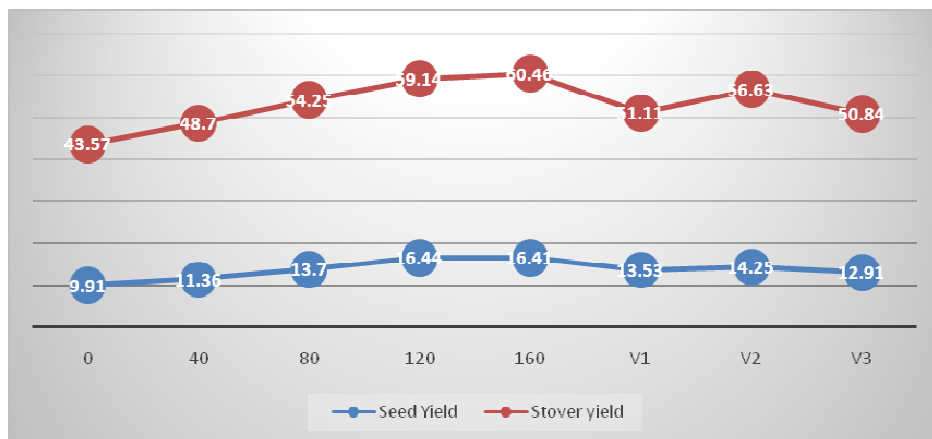


Fig. Interaction effect between nitrogen levels and varieties on seed and stover yield

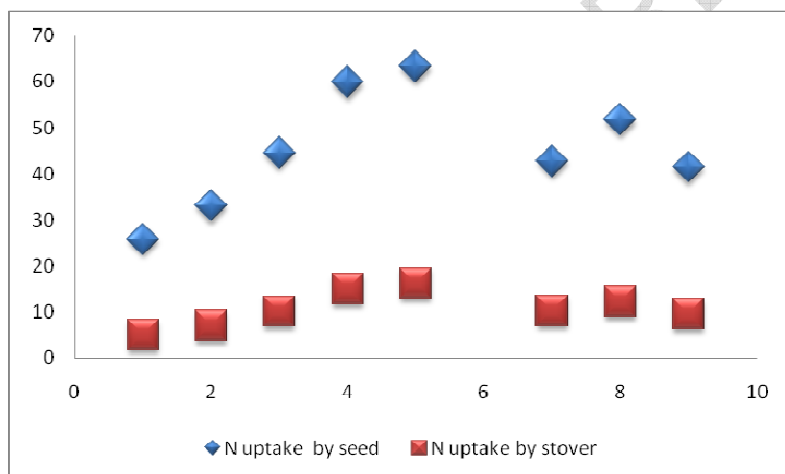


Fig. Effect of nitrogen levels on uptake of mustard seed and stover

4. CONCLUSION

Nitrogen level of 120 kg/ha can be considered as suitable dose for higher yield of mustard. Among mustard varieties, NDR-8501 performed most promising followed by Vardan and Maya in terms of growth and yield and can be recommended for the cultivation in eastern UP. A combination of mustard variety NDR-8501 along with 120 kg N ha⁻¹ recorded significantly higher growing yield of mustard seed in over rest of the treatments.

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