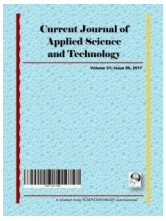

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Effect of Nitrogen Levels on Mustard (*Brassica juncea* (L.) Cuzern and Coss.) Varieties under Late Sown Condition

Nikhil Raghuvanshi[1*], Vikash Kumar[2] and Jai Dev[3]

[1]Department of Agronomy, Narendra Deva University of Agriculture and Technology, Kumargaj, Faizabad, Uttar Pradesh, India.
[2]Department of Agronomy, Banaras Hindu University, Varanasi, Uttar Pradesh, India.
[3]Narendra Deva University of Agriculture and Technology, Kumargaj, Faizabad, Uttar Pradesh, India.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To Study on the Effect of nitrogen levels on growth and yield of mustard (*Brassica juncea* Curzen and Cross.) varieties under late sown condition
Study Design: The Field experiment was laid out in a Factorial randomized block design used in this study.
Place and Duration of Study: The study was carried out between November 2015 and March 2016 at the Agronomy Research Station, Narendra Deva University of Agriculture and Technology, Faizabad (Uttar Pradesh) at 26.47˚ N latitude, 82.12° E longitude and an altitude of about 113 metres above the mean sea level.
Methodology: Testing the experiment near alkaline in pH, low EC, low Organic carban and available N, medium in available P and medium available K. Growth parameter observed at 30,60,90, and at harvest stage and the following parameters were determined: plant height (cm), number of seeds branches, LAI and reported as dry matter in g plant^{-1}. The seed yield was measured by harvesting net plot area of each plot at crop full maturity (physiological maturity).

**Corresponding author: E-mail: agronikhil@gmail.com;*

Results: The current study showed that the all growth parameter like, Plant height, Dry matter accumulation, number of branches, LAI and stover yield significantly 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.

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 Uttar Pradesh. 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.

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 [1]. In the Eastern Uttar Pradesh, especially in the lowland areas, farmers grow the rice which is generally harvested in the last week of October and sometimes first week of November. Many times, farmers 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 shows a significant increase in yield [2]. Nitrogen is the most responsive nutrient for rapeseed-mustard [3]. Here are no uniform recommendations by the Agronomists regarding N fertilizer levels for a given unit area Kumar et al. [4] recommended 120 kg N ha^{-1} while Singh et al. [3] and Singh and Verma [5] reported 120 N kg ha^{-1} for best yield of Indian mustard; and Keerthi et al. [6] 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 [7]. 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. [8] 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 [1] and hence there is need to study the potential of N and varieties increasing yield under India conditions.

2. MATERIALS 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 42 km away from Faizabad city on Faizabad- Raebareily 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 November and March, respectively. Daily mean sunshine hours ranged from 2.7 hours in 3_{rd} 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).

2.1 Experimental Details of the Research Field

The cropping sequence of the experimental field for the preceding 5 years was rice, black gram and sorghum followed by mustard, chickpea wheat. The experiment was laid out in Randomized Block Design (RBD), keeping the five nitrogen levels viz. 0, 40, 80, 120 and 160 kg ha^{-1} were laid out with three varieties viz. Vardan, NDRI - 8501 and Maya respectively, with thee 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 the source of nitrogen, phosphorus and potassium. The full dose of phosphorus and potassium and half dose of nitrogen were 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 Days after sowing (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.

2.2 Description of Varieties under Investigation

Of the three varieties studied in the experiment, one was national check (NDR- 8501). NDR-8501 mature in 125 days. It is suitable for growing in irrigated area of Uttar Pradesh and Madhya Pradesh. Plants of this variety grow to a height of 160-175 cm and produced an average Seed per siliqua is 15.7. Seed contain 39.5 percent oil with 25-30 qha^{-1}productivity. Mainly this variety is suitable for cultivation in salt tolerance capacity and rest of the two was is state check (Vardan) it matures in 120-125 days. Vardan is resistance to alternaria blight and white rust. It is suitable for growing in irrigation

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

S. no.	Particulars	Values before experiment	Values after experiment
(I)	Sand (%)	25.0	25.20
(II)	Silt (%)	49.50	49.40
(III)	Clay (%)	25.50	25.40
(IV)	Textural class	Silt loam	Silt loam
(I)	pH (1:1.25 soil : water)	8.2	8.3
(II)	Organic carbon (%)	0.32	0.31
(III)	EC dSm^{-1} at 25 °C	0.24	0.26
(IV)	Available N ($kgha^{-1}$)	136.5	132.8
(V)	Available P_2O_5 (kg ha^{-1})	14.5	13.2
(VI)	Available K_2O ($kgha^{-1}$)	248.5	225.8
(VIII)	Available Zn (ppm)	0.54	0.52

condition of Uttar Pradesh and Madhya Pradesh. This variety does well late planting too also this variety do's better for intercropping with wheat. Seeds contain 40 percent oil. It is yield potential is 25-28 q ha^{-1} and Maya was derived from the cross between Vardan × KRV 11.This can be adopted in Madhya Pradesh, Uttar Pradesh and South Rajasthan Plants, mature in 130-135 days with average yield 22-25 qha^{-1} suitable for especially late sown. Maya is well suitable for the area prone to white rust attack due to its resistance capacity.

2.3 Estimation of Traits

At 30, 60 90 DAS and at harvest, five plants were selected randomly from each plot and tagged than average the value of all plants recorded 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 at harvest. 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 has 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:

Leaf area index = leaf area / ground area

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

2.4 Data Collection and Measurements

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

Protein yield (kg ha^{-1}): The protein yield was calculated from protein concentration (%) × grain yield (kg ha^{-1}).

Nitrogen Uptake (kg ha^{-1}): The nutrient uptake was calculated as seed/ stover yield (kg ha^{-1}) × nitrogen content (%).

Nitrogen Uptake efficiency:

N-uptake efficiency (%) = N-recovery/N-application × 100

Where N-recovery= total N-uptake ($kgha^{-1}$) - control N-uptake (kg ha^{-1}).

3. RESULTS AND DISCUSSION

3.1 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 into 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 [9] and [10]. 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 up to 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. [11], Keivanrad and Zandi [12] and Premi and Kumar [13]. 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 the 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 [14], Kumar et al. [15], Bhari et al. [11], Singh and Meena [16] and Sah et al. [17]. There was a 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 an 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 in a significant increase in yield attributes. Similar results have also been reported by, (Singh et al. [18] and Parminder and Sindhu [19], Keerthi et al. [6]).

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 into proteins which in turn enhanced the protein content of seed. Kachroo and Kumar [9], Kumar et al. [7] and Singh [20] have also been reported the increase in protein content with increasing doses of nitrogen.

3.2 Effect of Varieties

The 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 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. [21] and Yadav et al. [22]. 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 expect seed yield and stover yield. Where the treatment combination N_3V_2 (120 kg N and NDR-8501) produced significant higher yield 18.50 q ha^{-1} over other combinations.

Table 2. Effect of nitrogen levels on growth and yield of mustard (*Brassica juncea* Cuzern and Coss.) varieties under late sown condition

Treatment	Plant height (cm)	Leaf area index at (90 DAS)	Number of branches plant^{-1}	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

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

Treatment	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})
Nitrogen levels (kg ha^{-1})		
0	9.91	43.57
40	11.36	48.7
80	13.70	54.25
120	16.44	59.14
160	16.41	60.46
Varieties		
Vardan	13.53	51.11
NDR-8501	14.25	56.53
Maya	12.91	50.84
SEm±	0.71	2.39
CD	2.07	6.91

Table 4. Effect of nitrogen levels on quality and nitrogen uptake efficiency of mustard (*Brassica juncea* Curzen and Cross.) varieties under late sown condition

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			

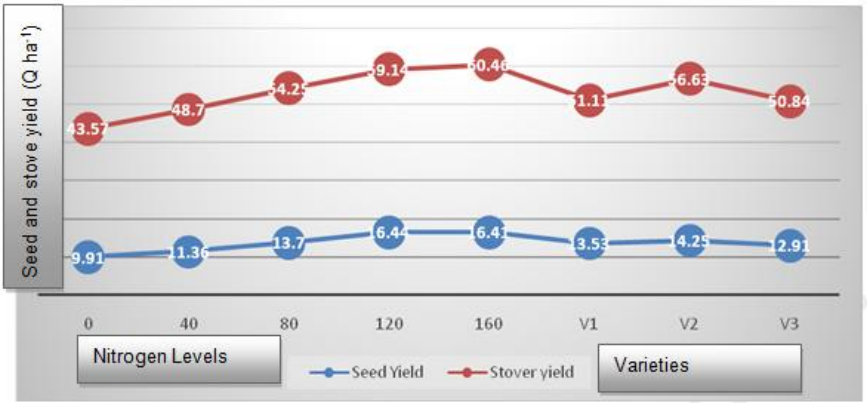

Fig. 1. Interaction effect between nitrogen levels and varieties on seed and Stover yield

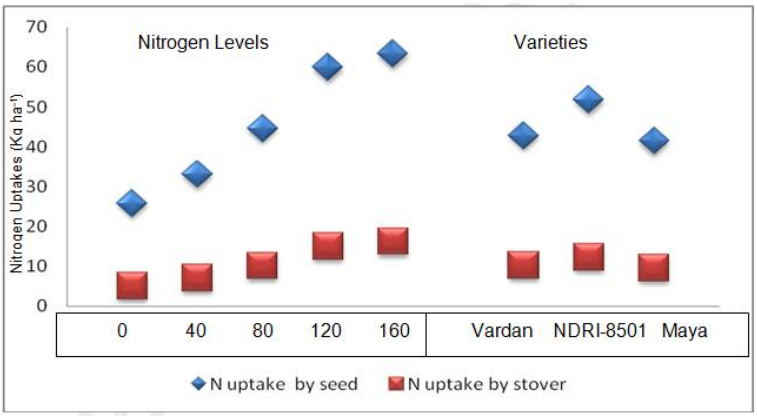

Fig. 2. Effect of nitrogen levels on nitrogen uptake (kg ha^{-1}) of mustard seed and Stover

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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