Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(5): 2360-2363
Received: 10-07-2019
Accepted: 12-08-2019

Swetalina Mohapatra
Assistant Professor, Department of Agronomy, CUTM, Paralakhemundi, Odisha, India

Manoranjan Satapathy
Professor, Department of Agronomy, OUAT, Bhubaneswar, Odisha, India

P Pati
Senior Agronomist, AICRP on Rapeseed and Mustard, OUAT, Bhubaneswar, Odisha, India

TR Sahoo
Scientist (Agronomy), Krishi Vigyan Kendra, Kendrapara, Odisha, India

Corresponding Author:
Swetalina Mohapatra
Assistant Professor, Department of Agronomy, CUTM, Paralakhemundi, Odisha, Odisha, India

Growth, yield attributes and yield performance of Indian mustard (*Brassica juncea* L.) under graded levels of fertilizer

Swetalina Mohapatra, Manoranjan Satapathy, P Pati and TR Sahoo

Abstract
The present study was carried out with the objectives to study the growth characters of the variety under different fertility levels and yield performance of the Indian mustard variety NRCHB-101 under graded doses of fertilizer. The field experiment was conducted during 2016-17 at the Agronomy Main Research Station, OUAT, Bhubaneswar laid out in a Factorial Randomized Block Design with three replications and twelve treatments. At harvest, highest plant height and highest number of secondary branches was observed at P_2 (40 kg ha^{-1}) whereas highest number of primary branches were observed at N_3 (120 kg ha^{-1}). Numerically higher LAI was noticed at N_2 (80 kg ha^{-1}). The dose of 100kg N ha^{-1} produced maximum amount of seed and the dose of 80kg N ha^{-1} produced maximum stover. As regards P application, 40 kg P ha^{-1} had the highest yield of seed and stover. Highest seed yield and stover yield were obtained from 30 kg K ha^{-1}. The increasing doses of nutrients have a positive effect on the seed yield and stover yield. The harvest index also increased significantly with increased doses of nitrogen application.

Keywords: Indian mustard, graded doses, NRCHB-101, nitrogen, phosphorus, potassium

Introduction
Role of oilseeds in Indian agriculture needs hardly any emphasis. Oilseeds constitute an important group of crops next to cereals. India is a premier oilseed growing country. India is the fourth largest oilseed economy in the world. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6 per cent of the total area. Presently, rapeseed-mustard is the third most important oilseed crop in India after groundnut and soybean. India is one of the largest producer, consumer and importer of oilseeds in the world. Out of nine major oilseeds grown in India, Indian mustard (*Brassica juncea*) is an important winter season *Rabi* crop. The gap between production and demand of rapeseed-mustard is progressively widening and therefore, the production is to be increased for self sufficiency.

Indian mustard requires relatively larger amount of nutrients for realization of higher yield potential. Moreover, with increase in irrigated area and introduction of high yielding varieties, it becomes imperative to work out the response of Indian mustard to nitrogen, phosphorus and potassium in Odisha condition. The mustard growing areas in India are experiencing the vast diversity in the agro climatic conditions and different species of rapeseed-mustard are grown in some or other part of the country. Under marginal resource situation, cultivation of rapeseed-mustard becomes less remunerative to the farmers. This results in a big gap between requirement and production of mustard in India.

Therefore site-specific nutrient management through soil-test recommendation based should be adopted to improve upon the existing yield levels obtained at farmers field. Effective management of natural resources, integrated approach to plant-water, nutrient and pest management and extension of rapeseed-mustard cultivation to newer areas under different cropping systems will play a key role in further increasing and stabilizing the productivity and production of rapeseed-mustard.

With this backdrop, the present paper on Indian mustard high yielding variety NRCHB-101 entitled "Growth, yield attributes and yield performance of Indian mustard (*Brassica juncea* L.) under graded levels of fertilizer" has been presented with the objectives to study the growth characters of the variety under different fertility levels and yield performance of the variety under graded doses of fertilizer.

Materials and Methods
The field experiment was conducted during *Rabi* 2016-17 at the Agronomy Main Research Station, Odisha University of Agriculture and Technology, Bhubaneswar ($20^0$26'N, $85^0$81'E, 25.9m above MSL), Odisha.

The soil of the experimental sandy loam acidic (pH-5.4) medium in organic carbon (0.628%) and available nitrogen (1673.3kg/ha), phosphorus (64.5kg/ha) and potassium (123.4 kg/ha). The experiment was laid out in a factorial randomized block design with three replications. Twelve treatment combinations comprising 3 nitrogen levels (80, 100, 120 kg N/ha), two (20, 40 kg P_20_5/ha) and two potassium levels (0, 30 kg K_2O/ha) were tested in the experiment. Indian mustard variety 'NRCHB-101' was sown 30 cm row distance. Thinning was done as 15 DAS to maintain plant to plant distance of 10 cm. All the recommended agronomic practices are done throughout the crop season. The crop was sown on 20th November and harvesting was done manually during last week of February. Growth, yield attributes, yield and oil content (%) were recorded and analysed as per standard statistical procedures.

Results and Discussion

Growth parameters of Indian mustard at harvest: Plant height, number of branches, LAI and dry matter accumulation

Plant height, number of primary and secondary branches, leaf area index (LAI) and dry matter accumulation of Indian mustard variety NRCHB-101 at harvest has been presented in Table 1.

At harvest the heights of the plants were at par with each other at different levels of N and K, among which numerically highest was at N_3 (120 kg ha^{-1}). But there was significant difference in the heights at P levels. Highest plant height was observed at P_2 (40 kg ha^{-1}). At harvest time the plant were 5.6% taller at 40 kg P ha^{-1} than those at lower level of P (20 kg ha^{-1}). But in case of K the increase in height was non-significant. Higher doses of P and K increases plant height has also been reported by Kumar and Yadav (2007) [7] and Cheema *et al*. (2012) [4].

At harvest highest number of primary branches were observed at N_3 (120 kg ha^{-1}) and the number of primary branches was found to be significant at N and P levels but were at par with each other at K levels. With increasing levels of N, P and K, the number of primary branches increased. At harvest the number of primary branches was 3.65% more at higher p level (40 kg ha^{-1}) than the lower level, and 2.16% more at higher K level (30 kg ha^{-1}) than the lower K level.

The highest number of secondary branches at harvest was observed P_2 (40 kg ha^{-1}) *i.e.*, 8.24 and the number of secondary branches were found to be significant at N, P and K levels. In case of secondary branches also the number increased with increase in N, P and K levels. The positive effects of higher dose of N might be attributed to their direct role in formation of protoplasm and chlorophyll molecule in the leaf cells resulting in increased photosynthetically active leaf area.

Numerically higher LAI was noticed at N_2 (80 kg ha^{-1}), N_3 (120 kg ha^{-1}) and N_3 (80 kg ha^{-1}) with value of 1.79, 1.75 and 1.72, respectively. At harvest, highest dry matter accumulation was found at N_3 (120 kg ha^{-1}) 39.43 g $plant^{-1}$ followed by K_2 (30 kg ha^{-1}) 39.12 g $plant^{-1}$ and N_2 (100 kg ha^{-1}) 38.77 g $plant^{-1}$. The LAI increased at higher levels of P and K. At harvest the LAI was 2.11% more at higher p level (40 kg ha^{-1}) than the lower level, and 2.45% more at higher K level (30 kg ha^{-1}) than the lower K level. Similar results have been reported by Mandal and Sinha (2001) [9].

At the time of harvest, higher levels of P (40 kg ha^{-1}) and K (30 kg ha^{-1}) produced 38.04 and 39.12 g dry matter per plant. The increase in dry matter accumulation was found to be significant with different levels of P and K.

Table 1: Plant height, number of branches, leaf area index (LAI) and dry matter accumulation in Indian mustard NRCHB-101 at harvest

Treatment	Plant height at harvest (cm)	No. of primary branches $plant^{-1}$ at harvest	No. of secondary branches $plant^{-1}$ at harvest	LAI at harvest	Dry matter accumulation at harvest (g $plant^{-1}$)
N-levels (kg ha^{-1})					
80	147.12	4.90	6.70	1.72	36.17
100	147.77	5.31	7.22	1.79	38.77
120	149.12	6.21	8.01	1.75	39.43
SE(m)±	2.36	0.38	0.65	0.03	0.67
CD(P=0.05)	NS	0.79	1.71	NS	NS
P_2O_5 levels (kg ha^{-1})					
20	142.56	5.11	6.12	1.62	37.98
40	150.12	6.02	8.24	1.69	38.04
SE(m)±	2.13	0.28	0.44	0.02	0.54
CD(P=0.05)	4.71	0.70	1.23	NS	NS
K_2O levels (kg ha^{-1})					
0	148.42	5.10	6.46	1.71	38.45
30	148.29	5.67	7.91	1.69	39.12
SE(m)±	1.66	0.29	0.48	0.02	0.61
CD(P=0.05)	NS	NS	1.17	NS	NS

Yield attributing characters and yield of Indian mustard

The data on mean value of different yield attributing characters *viz*., number of silique per plant, siliqua length, number of seed per siliqua and test weight of seeds and data on the yields of seed and stover and harvest index as influenced by different levels of nitrogen, phosphorus and potassium have been presented in Table 2.

As depicted in the table, the number of silique per plant was highest at N_3 (120 kg ha^{-1}), P_2 (40 kg ha^{-1}) and K_2 (30 kg ha^{-1}) levels (13). However, the number of silique was at par with each other at different N levels but, was found to be significant at P and K levels. The length of siliqua was highest at P_2 (40 kg ha^{-1}) level *i.e*., 5.13 cm followed by N_2 (100 kg ha^{-1}) and N_3 (120 kg ha^{-1}) *i.e*., 4.88 cm. The average number of seeds per siliqua was estimated highest at N_3 (120 kg ha^{-1}) level *i.e*., 13.20 followed by P_2 (40 kg ha^{-1}) level *i.e*., 12.93. The average number of seeds per siliqua was found to be non-significant with different N, P and K levels. The maximum test weight was observed at N_3 (120 kg ha^{-1}) level *i.e*., 4.82 g followed by P_2 (40 kg ha^{-1}) level *i.e*., 4.62 g. The test weights were found to be non-significant in all the nutrient application levels. The number of silique per plant was highest at N_3 (120 kg ha^{-1}) which was 3.16% and 2.87% over those at lower levels, however, the number of silique was at par with each other at different N levels. Similarly, the other yield attributing characters viz., siliqua length, number of seed per siliqua and test weight of seeds (1000-seed weight) were also found to be the highest at N_3 (120 kg ha^{-1}).

Among various nitrogen levels, there was no significant difference between the yields. However, numerically higher seed yield (1272.25Kg) was found at N_2 *i.e.,* 100 Kg/ha. After that, as dose of N increased, yield decreased. Among P levels, significantly higher seed yield (1378.16 Kg) was found at 40 kg P_2O_5 ha^{-1}. Similar kind of result was also found in K level where significantly higher seed yield (1344.50 kg) was found at 30 kg K_2O ha^{-1}. In both P and K, yield increased as the levels of P and K increased. Yield of mustard increased with increase in N level was reported by Mozaffari *et al.* (2012) [10]. This established the significance of N in the metabolic activities of the oilseeds.

There was no significant difference between the stover yields among various nitrogen levels. However, numerically higher yield (1867.30Kg) was found at N_1 *i.e.,* 80 Kg/ha which was at par with N_3 i.*e.,* 120 Kg/ha. But, at different P levels, there was significant difference in stover yield. Significantly higher stover yield (1980.20 Kg) was found at 40 kg P_2O_5 ha^{-1}. Stover yield increased as the levels of P increased. The stover yield decreased with increasing K level, and significantly higher stover yield (1922.00 kg) was found at 0 kg K_2O ha^{-1}.

There was significant difference between the harvest indices among various nitrogen levels. Higher HI (41.20%) was found at 120 Kg N ha^{-1}. HI increased with increasing levels of N. But, HIs was found to be at par with each other at different levels of P and K. However, numerically higher HI of 41.03% was witnessed at 40 kg P_2O_5 ha^{-1} and 40.29% at 30 kg K_2O ha^{-1}. HI increased as the levels of P_2O_5 and K_2O increased. The HI increased significantly with increased doses of N application. This was because of the corresponding higher increase in seed and stover yield. Increased HI with increasing levels of nutrients has been reported by Bohra *et al.* (2002) [3].

Among nitrogen levels, there was significant difference between the oil content of Indian Mustard. 120 Kg N /ha registered highest oil content of 37.78%. A direct relationship was observed between levels of nitrogen and oil content. Significantly higher oil content (37.12%) was found at 40 kg P_20_5 /ha. However the oil content at different levels of K_2O was at par with each other being the highest oil content (36.95%) at 30 kg K_2O level. In both P and K, yield increases as the levels of P and K increase. The increase in oil content is favoured by P application due to less formation of lecithin, a form of phospholipids. However, the oil content at different levels of K was at par with each other where, numerically highest oil content (36.95 per cent) was found at 30 kg K_2O ha^{-1}. These results corroborated with the findings of Khan *et al.* (2004), Lone *et al.* (2010) and Mozaffari *et al.* (2012) [10]. The increased oil yield was attributed to increase in seed yield which confirm the findings of Dabi *et al.* (2015) [5].

Table 2: Yield attributing characters, yield and oil content (%) of Indian mustard under different levels of nitrogen, phosphorus and potassium

Treatment	No of silique /plant	Length of siliqua (cm)	No of seeds /siliqua	Test weight (g)	Seed Yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Oil content (%)
N-levels (kg ha^{-1})								
80	12.00	4.90	12.42	4.28	1249.17	1867.3	40.08	35.68
100	13.00	4.98	12.59	4.47	1272.25	1815.5	41.20	37.11
120	13.00	4.98	12.93	4.82	1268.01	1867.2	40.44	37.78
SE(m)±	0.33	0.08	0.33	0.13	30.02	47.98	2.02	1.57
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
P_2O_5 levels (kg ha^{-1})								
20	12.00	4.78	12.09	4.43	1148.13	1719.8	40.03	36.59
40	13.00	5.13	13.20	4.62	1378.16	1980.2	41.03	37.12
SE(m)±	0.27	0.07	0.33	0.11	24.51	39.17	2.45	1.28
CD(P=0.05)	0.66	0.16	0.81	NS	59.62	95.27	NS	NS
K_2O levels (kg ha^{-1})								
0	12.00	4.87	12.41	4.48	1181.71	1778.0	39.92	36.76
30	13.00	5.03	12.89	4.57	1344.57	1992.0	40.29	36.95
SE(m)±	0.27	0.07	0.27	0.11	24.51	39.17	2.64	1.28
CD((P=0.05)	0.66	0.16	NS	NS	59.27	94.72	NS	NS

Conclusion

It may be concluded that on the basis of the findings obtained that, N, P and K were necessary to improve the seed as well as oil yield of mustard when the soil is at sub-optimal level of availability of these nutrients. The dose of 100kg N ha^{-1} produced maximum amount of seed and the dose of 80kg N ha^{-1} produced maximum stover. As regards P application, 40 kg P ha^{-1} had the highest yield of seed and stover. Highest seed yield and stover yield were obtained from 30 kg K ha^{-1}. These levels of nutrients put up maximum vegetative and reproductive growths that were reflected equally on yields.

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