Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 833-837
Received: 24-05-2018
Accepted: 29-06-2018

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Advances in agronomical manipulation on Indian mustard (*Brassica juncea* Cezern and Coss.): An review

Nikhil Raghuvanshi and Vikash Kumar

Abstract
Crop production largely depends on cultivation of high yielding varieties and need based application of nutrients. Nitrogen (N) is the most important nutrient, and being a constituent of protoplasm and protein, it is involved in several metabolic processes that strongly influence growth, productivity, yield and quality of mustard. Varieties may differ in their response to applied N. These may differ in their ability to absorb nitrogen from soil (uptake efficiency) and/or in their efficiency to utilize absorbed N for dry matter production (utilization efficiency). Nitrogen efficient cultivars may yield better under conditions of limited N supply or require lower amount of N for given yield than N inefficient varieties. This review provides an overview of the nitrogen management and adoption of varieties is differ in different agro-climatic.

Keywords: nitrogen, varieties, mustard, growth, yield, quality

Introduction
Brassica juncea (L.) Czern & Coss., also known by the name of Indian mustard, belongs to the plant family *Brassiceae* (*Cruciferae*) or the mustard family. Research on oilseed was initiated under the aegis of the erstwhile Indian Central Oilseed Committee. After its dissolution in 1967, research on rapeseed and mustard was more systematically organized by the Indian Council of Agricultural Research under the "All India Coordinated Research Project for Improvement of Oilseeds". The Directorate of Oilseed Research after converting the erstwhile coordination unit of AICRPO was established in 1977.
The mustard crop is widely grown in India under rain fed as well as assured irrigation condition but its productivity is low because of inadequate supply of nitrogen. Among primary and secondary nutrients, nitrogen is deficient in soils of India. Nitrogen and varieties not only affect the growth and yield of mustard but also improve the quality of seed in terms of oil and other nutrients fatty acids content which are essential in human and animal diets. The literature relevant to present study entitled "Advances in agronomical manipulation on indian mustard (*Brassica juncea* Cezern and Coss.) - An Review" is contained in this review article under the following heads:-

Effect of nitrogen on growth and yield attributes of mustard
The importance of nitrogen fertilizer to achieve the higher production potential in mustard is well recognized. Nitrogen is an important metabolic element for growth and development of plants. It is considered essential for metabolic activities and transformation of energy and essential for metabolism of protein and other biochemical product such as nucleic acid, chlorophyll and protoplasm. It is, thus the basic constituent of plant life. Its application favours cell division, cell elongation, growth and development of all the living plant tissues. It increases size and number of leaves, number of branches and shoot height and fruit development.
Kumar *et al.* (2001) [15] observed the significant increase in plant height, branches plant^{-1}, siliquae plant^{-1}, seed siliqua^{-1}, 1000 seed weight, harvest index, seed yield and stover yield with increasing doses of nitrogen upto 120 kg N ha^{-1} in Indian mustard (*Brassica juncea* L.), same results reported by Premi and Kumar (2004) [39, 18]
Singh and Meena (2004b) [20] reported the effect of N on plant height, primary and secondary branches and dry matter accumulation of Indian mustard. Nitrogen at 80 kg ha^{-1}+ S at 60 kg ha^{-1} significantly increased the above over the 40, 60 kg N ha^{-1} and 20, 40 kg S ha^{-1}.
Sah *et al.* (2006) [20] reported that the plant and primary branches plant^{-1} increased significantly up to 80 kg N ha^{-1}, while secondary branches and dry matter plant^{-1} increased up to 120 kg ha^{-1}.

Dongarkar *et al.* (2005) [5] reported that various doses of sulphur (0, 20, 40 kg ha^{-1}) and nitrogen (0, 25, 50, 75 kg ha^{-1}) significantly influenced the growth of mustard. Plant height, number of branches, dry matter production were found significantly more with 75 kg N and 25 kg S ha^{-1} over rest of the doses.

Reager *et al.* (2006) [19] observed that increasing levels of nitrogen from 40 to 100 kg ha^{-1} significantly enhanced siliquae plant^{-1}, seeds silqua^{-1}, silqua length, test weight and seed yield of Indian mustard. However, significant increase in stover and biological yield was recorded upto 120 kg N ha^{-1}.

Kumar *et al.* (2007) [14] reported that number of branches plant^{-1}, number of leaves plant^{-1} and dry matter accumulation increased significantly with the increasing levels of N up to 120 kg ha^{-1}. Crop maturity was delayed for 5 days with the application of 0 to 120 kg N ha^{-1}.

Sharma *et al.* (2007) [23] obtained significant increase in plant height, plant growth and dry matter accumulation under 80 kg N ha^{-1} over the 0 and 30 kg N ha^{-1}.

Keivanrad and Zandi (2012) [6] observed that all growth and yield parameters of mustard plant were significantly affected by nitrogen fertilization except for harvest index (HI). 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} in plots with 80 plant m^{-2}.

Rimi *et al.* (2015) reported the Nitrogen significantly increased number of siliquae plant-1, thousand seed weight and oil content percent up to 120 kg N/ha but the highest dose 180 kg N/ha failed to produce better results as other doses.

Pattam *et al.* (2017) [37] reported that the increase in nitrogen dose increased the plant height and dry matter accumulation, seed yield, biological yield up to 100 kg N/ha during both the years. However, the biological yield of Indian mustard was statistically at par with highest dose of 100 kg N ha^{-1} with 80 kg N ha^{-1}.

Effect of nitrogen levels on yield of mustard

Kumar *et al.* (2001b) [15] reported that the seed yield and oil yields of *Brassica* spp. increased significantly with each successive increase in nitrogen level up to 100 kg ha^{-1} maximum seed yield was reported as 17.0 q ha^{-1}.

Rana (2001) [40] eported that mustard response significantly to 80 kg N ha^{-1} under rain fed conditions and up to 120 kg N ha^{-1} under irrigated conditions.

Kumar *et al.* (2002) [13] reported significant increase in seed yield with nitrogen application up to 100 kg N ha^{-1}. The increase in seed yield with 75, 100 and 125 kg N ha^{-1} was 70.0, 86.5 and 95.70 kg seed yield ha^{-1}, respectively over the control. Singh and Singh (2005) [33] studied the effect of different levels of nitrogen (0, 40, 80 and 120 kg ha^{-1}) and sulphur (0, 20, 40, and 60 kg ha^{-1}) on yield of mustard crop. The seed yield of Indian mustard significantly increased with increasing levels of applied N and S, Nitrogen application increased the mean seed yield by 36.2 % from the control.

Singh and Sinsinwar (2006) [34] conducted an experiment on the yield under various levels on inorganic N (0, 40 & 80 kg ha^{-1}). The 1000-seed weight, seed and straw yield increased significantly with the application of nitrogen up to 80 kg ha^{-1}.

De *et al.* (2007) reported that nitrogen up to 120 kg N ha^{-1} increased the yield compo- nent of Indian mustard significantly over 0, 40, 60 kg N ha^{-1} and at par with the 80 kg N ha^{-1}.

Keivanrad and Zandi (2014) [7] reported that the 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} in plots.

Singh and Verma (2007) [29] observed the effect of nitrogen levels of Indian mustard. Seed yield (16.4 q ha^{-1}) significantly increased with N application up to 120 kg ha^{-1}. The increase in seed yield at 120 kg N ha^{-1} over 80, 40 and 0 kg ha^{-1} was 3.8, 29.2 and 117.6 %, respectively.

Tomar and Singh (2007) [29] conducted an experiment on mustard to determine the effect of nitrogen levels (0, 40, 80 and 120 kg N ha^{-1}). They reported that yield and yield attributes increased significantly up to 80 kg N ha^{-1}, while stover yield increased up to 120 kg N ha^{-1} over rest of the nitrogen levels.

Keerthi *et al.* (2017) [9] Reported that the increased doses of nitrogen application also increased the growth parameters and yield attributes significantly. Nitrogen appli-cation responded seed and biological yields significantly up to 100 kg N/ha.

Parminder and Sidhu (2004) [36] reported significant increase in seed yield with increasing levels of nitrogen up to 100 kg N ha^{-1} beyond which difference were not significant. Maximum yield was observed with 150 kg N ha^{-1}.

Singh *et al.*(2008) [32] observed that seed yield (1.98 t ha^{-1}) of mustard increased signify-cantly up to 120 kg N ha^{-1} over the 40 and 80 kg N ha^{-1}.

Effect of nitrogen levels and mustard varieties on quality of mustard

Meena and Sumeriya (2003) [31] reported that maximum oil content was found 37.04 per cent at 60 kg N ha^{-1} and maximum protein content was found 21.57 per cent at 90 kg N ha^{-1}.

Singh and Meena (2003) [31] results showed that 40 kg N gave the highest oil content (39.61 and 39.48 %) N at 80 kg ha^{-1} gave the highest oil yield (774.0 kg ha^{-1}, respectively). N at 100 kg ha^{-1} gave the highest protein content (20.60 %) and protein yield (369.0 kg ha^{-1}), respectively.

Keerthi *et al.* (2017) [9] reported that the maximum total N (82.4 and 79.3 kg/h Keerthia) uptake was recorded with the application of 100 kg N/ha during 2013-14 and 2014-15, respectively and decreased with decreasing dose of nitrogen.

Singh *et al.* (2002) [11, 22, 28, 32] reported that the highest net returns (Rs.14725 hs^{-1}) was observed with the application of 150kg N and 40 kg S ha^{-1} respectively.

Singh and Prasad (2003) [25] reported the effect of nitrogen rates (60,120 and 180 kg ha^{-1}) on economics of mustard and observed that net profit of mustard (Rs. 12,975 ha^{-1}) and highest cost – benefit ratio (0.89) was obtained with 180 kg N ha^{-1}. Tripathi and Tripathi (2003) reported that the net returns were maximum (Rs. 19,901 ha^{-1}) at 160 kg N ha^{-1} because seed yield was maximum at this N rate. The benefit cost ratio increased upto 160 kg N ha^{-1} with a maximum of Rs. 2.09 earned per rupee investment.

Singh and Meena (2004a) [20] reported that application of Nitrogen at 80 kg ha^{-1} resulted in highest net income and benefit cost ratio of Rs. 15799/ha and 2.69, respectively during the first year and Rs. 18193/ha and 2.87 during the second year. Kumar *et al.* (2011) [16] observed that recovery was maximum at 60 kg N ha^{-1} and 15 kg S ha^{-1}, and it declined with further increases in the levels of nitrogen and sulphur, Optimum economic dose of nitrogen was 39.5 - 46.3 kg ha^{-1} and 24.5 kg S ha^{-1}. Maximum net returns and benefit - cost ratio were observed with the application of 80 kg N and 45 kg S ha^{-1}, respectively. Kumawat *et al.* (2013) reported that the results of the FLDs conducted on varietal evaluation revealed that variety GM-3 produced maximum net return of

Rs. 35354/ha among the eight varieties tested. Fertilizer management + variety GM-3 recorded considerably higher net return (Rs. 37961/ha).

Singh *et al.* (2017) [45] reported that highest oil content% and economic return was computed under25th October sowing, with Coral-437 variety.25th October sowing with Coral-437 variety proved that the most qualitative and economically feasible for cultivation of Indian mustard

Effect of nitrogen levels on quality of mustard

Bhari *et al.* (2000) [1], Singh *et al.* (1998) [35], and Sharawat *et al.* (2002) reported that the application of 120 kg N resulted significant increase in protein and oil content of Indian mustard.

Charak *et al*. (2006) [2] reported significant decrease in oil content with the increasing levels of nitrogen up to 90 kg N ha^{-1}, over the 0, 30 and 60 kg N ha^{-1}.

Singh *et al.* (2008) [32] reported that the nitrogen at 120 kg ha^{-1}, produced highest oil yield, protein content, protein yield and nutrient uptake of mustard which was significantly superior over the 40 and 80 kg N ha^{-1} but oil content did not differ significantly at 40, 80 and 120 kg N ha^{-1}.

Kumar and Kumar (2008) [32] reported the results indicated that 50 % flowering and 50 % podding started significantly earlier in the plots fertilized with nitrogen compared to control treatment but the days to maturity were not affected by fertilization. The grain growth duration was significantly longer by 9 days for fertilized plots compared to control.

Effect of varieties on mustard

Kumar *et al.* (2001) [15] reported from faizabad that Narndra rai -1 and varuna reported higher plant height, branches plant-1, siliquae plant-1, seed siliqua-1, 1000 seed weight and harvest index and resulted significantly higher seed and stover yield, oil and protein content than vardan.

Shukla *et al.* (2001) reported that NDYS-5 recorded the highest values for plant height (153.3), number of siliquae plant-1 (119.4), 1000 seed weight (3.6 g) and seed yield (1409 q ha-1) among the cultivars YST-151, PYS-842, NDYS-5, NDYS-17 AND ROUDYS-89-115.

Keivanrad and Zandi (2014) [7] reported that the maximum oil content (43.97%) Nitrogen application level of 50 kg/ha. Results suggest that in semi-arid region of Takestan, researchers must direct their selection treatments to increase oil quality of Indian mustard.

Shukla *et. al.* (2002) [24] reported that NDYS-5 recorded the highest values for the plant height (153.3 cm), number of siliquae $plant^{-1}$ (119.4) and seed yield (14.9 q ha^{-1}), among the cultivars YST-515, PYS-842, NDYS-5 NDYS-17 and RAUDYS-89-115.

Singh *et al.* (2002) [11, 22, 28, 32] [reported that cultivars NDYS-921 registered the highest values of growth, yield attributes and yield (14.00 q ha-1) of seed and 53.18 q ha-1 of stover, among the cultivars Bio-YS-1, YST-151, NDYS-921 and Varuna gave greater plant height, number of branches plant-1, seed siliqua-1, siliqua plant-1, test weight, harvest index, seed and stover yield, oil protein content than Vardan.

Datta *et al.* (2012) [3] observed that variety Ragini recorded a significant higher seed yield along with other growth, yield and morphophysiological factors, which was found to be superior to other varieties under old alluvial soil.

Thakur, k.s. (1999) [41] found that cultivars RCC-4 and Varuna were statistically similar in terms of yield attributes, however, RCC-4 ~(1085 kg ha^{-1}) compared to varuna (918 kg ha^{-1}).

Prakash and singh (2002) [11, 22, 28, 32] reported that the variety of pussabhar recorded the highest seed yield, Protien and oil content, number of branches plant-1, where asrohini registered the highest number of leaves plant-1.

Sahito *et. al.* (2014) [21] reported that variety S-9 proved superior with 216.50 cm plant height, 10.84 branches $plant^{-1}$, 581.11 pod $plant^{-1}$, 19.60 q ha^{-1} seed yield over other early maturing varieties of mustard.

Verma *et al.* (2014) [16] reported that all the parameters of the growth and yield attributes and yield of the crop was maximum under NDYR-8 which was significantly superior to Maya and NDR-8501.

Yadav *et al*. (2017) [19] reported that the growth characters, seed yield and stover yields of mustard crop were significantly higher with Narendra Rai-8501 as compared to Varuna and Rohini.

Helal *et al*. (2016) [6] reported that the variety Improved Tori, BARI Sharisa-8, BARI Sharisa-14 and BARI Sharisa-15 produced the highest seed yield and took minimum days to mature and their growth parameters were also highly significant and positive correlation was observed in seed yield with siliqua/plant, straw yield, biological yield, 1000 seed weight and harvest index. So, Improved Tori, BARI Sarisha-8, BARI Sarisha-14 and BARI Sarisha-15 are suitable for cultivation in north-east region (Sylhet) of Bangladesh.

Table 1: Effect of nitrogen under different condition

Area	Dose of N (kg ha^{-1})	Reference
Irrigated	120	Rana (2001),Kumar *et al.* (2007)
Rainfed	80	Rana (2001),Kumar *et al.* (2007)
Timely	120	Singh *et al.(*2008)
Late	100	Pattam *et al.* (2017)
Hybrid variety	125	AICRP-RM, 2008

Conclusion

Nitrogen is the most responsive nutrient for rapeseed-mustard. Two major factors that determine the quantum of yield response are the nutrients and varieties along with environment. The nitrogen requirement of the crop also depends on the soil type and organic matter content. Improved varieties of mustard have been reported to respond nitrogen application 80 to 150 kg N ha^{-1} based on time of sowing, variety, soil type, water availability etc. Consequent upon the release of improved cultivars, a significant change has occurred in plant type and fertilizer use efficiency as compared to traditional varieties.

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