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Effect of nitrogen and phosphorus on growth parameter and yield of canola (*Brassica napus* L.)

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Abstract
A study was carried out during *rabi* 2015-16 at Research Farm Dhablan, Khalsa College, Patiala, Punjab. Plant height increased linearly with successive increment in nitrogen levels at all the crop growth stages. Highest seeds per siliqua were also obtained in 70 kg N ha^{-1}, whereas test weight was maximum with 100 kg N ha^{-1}. Seed yield of 22.71 q ha^{-1} was obtained with the application of 100 kg N ha^{-1}, which was at par with 130 kg N ha^{-1} but significantly higher than 70 kg N ha^{-1}.

Keywords: Nitrogen, phosphorus, *Brassica Napus* L.

Introduction

Oilseed crops from the second major group among agriculture crops after cereals in the country. Oilseed sector occupies an important position in agricultural economy. In India, oilseed crops are grown on an area of 28.52 million ha with production of 32.88 million tones and productivity of 1153 kg ha^{-1}.The share of oilseed crops is 14.61 per cent out of the total cropped area of 195.2 million ha (Anonymous 2015a) [1]. Rapeseed-mustard is the third important group of oilseed crops in the world after soybean and palm oil in the world rapeseed-mustard is grown on an area 37.07 million ha with production of 73.27 million tones and productivity of 1976 kg ha^{-1} India is the third largest producer of rapeseed –mustard in the world after china and Canada, contributes 17.15 per cent and 10.95 per cent in the world acreage and production, respectively (Anonymous 2015 b) [2] rapeseed-mustard is the second most important oilseed crop after groundnut sharing 27.8 percent in India's oilseed industry. In India rapeseed-mustard were grown on an area of 6.36 million ha with a production of 8.03 million tones and productivity of 1262 kg ha^{-1}. The productivity of rapeseed-mustard in India is still below the world average (1976 kg ha^{-1}) (Anonymous 2015 c) [4]. Rajasthan, Madhya Pradesh, Uttar Pradesh Haryana and Gujarat impart more than 86 percent of total rapeseed-mustard cropped area. In Punjab rapeseed and mustard were grown on 32 thousand hectares with a production of 41.8 thousand tones and productivity of 1306 kg ha^{-1} (Anonymous 2015 d).

Assuming an average oil recovery of 30 per cent from major oilseeds, the country needs to produce at least 66 million tons of oilseed by 2020. The current annual production of edible oilseeds in the country fulfils only about 50 per cent of the domestic requirement and the deficit is bridged through massive imports costing huge amount of foreign exchange. With increasing population and improving purchasing power of people, the demand of edible oil in the country is increasing at the rate of 4-6 per cent per annum (Rao 2009). To overcome this chronic shortage, efforts are needed to increase productivity and production of edible oils in the country on sustainable basis. This indicates that country needs almost double the oilseeds production which will indeed be a big challenge, requiring efforts much beyond which are being pursued until now. The low productivity of these crops under Indian sub-continent is in fact due to their cultivation on low fertility soils with poor management practices.

Rapeseed and mustard comprise four sub-species namely *Brassica campestris* (var. toria, yellow sarson and brown sarson), *Brassica juncea* L. (Indian mustard), *Brassica napus* L. (*gobhi sarson* and canola) and *Brassica carinata* A. Br. (African sarson) besides *Eruca sativa* (Taramira). Among these crops, canola varieties are internationally accepted for higher yield potential. For diversification of agriculture in Punjab, these crops can play an important role. *Brassica napus* is an amphiploid between *Brassica Campestris* and *Brassica oleracea* and popularly known as *gobhi sarson*. It is an emerging oilseed crop having limited area of cultivation confined to Haryana, Punjab and Himachal Pradesh. Because of photo-sensitivity and thermo-sensitivity, this crop is slow growing at the initial stage and as a result it evades the frost. It has wider adaptability, higher oil content and better nutriti.

It is grown for biological control, erosion control, ground cover, mulch and biomass production. It is also used as coffee substitute, hay, pasture and grain purposes. It is used in cosmetics, fibers, paper, animal bedding, pillow filling and thatching. *Brassica* based intercropping systems assume great significance to generate more income per unit area per unit time under specific set of conditions.

Presently, *gobhi sarson* is grown as sole crop in Punjab. It is imperative to reduce its cost of production and increase the system productivity. *Gobhi sarson* is a long duration crop takes 150-170 days for maturity.

Among the nutrients the role of nitrogen and phosphorus is well established these two nutrients play an important role in crop nutrition nitrogen promotes vegetative growth, photosynthesis and is an important constituent of protein .phosphorus is known to have direct relation with proliferous root system , seed formation and play key role in energy transformation cycle. Gobhi sarson responds to nitrogen and phosphorus 150 kg ha^{-1} and 45 kg ha^{-1} respectively, on loamy sand soil of Punjab (Singh 1989; anonymous 1997-98) [15, 3].

Material and Methods

A field experiment was conducted during rabi season (2015-16) at student's research farm Dhablan, Department of Agriculture, GSSDGS Khalsa College, Patiala to study the Effect of nitrogen and phosphorus on growth parameter and yield of canola (*Brassica Napus* L). The experiment was laid out in Randomized Block Design with three levels of nitrogen (N_{70} - 70 kg N ha^{-1} , N_{100} -100 kg N ha^{-1} N_{130} - 130 kg N ha^{-1}) and three levels of phosphorus (P_{20} -20 kg P_2O_5 ha^{-1} , P_{30} - 30 kg $P_2O_5ha^{-1}$, P_{40} - 40 kg P_2O_5/ ha^{-1}) with four replication. After a pre-sowing irrigation, a fine seed bed was prepared by ploughed the field three times with tractor drawn cultivator followed by two planking. The variety (GSC-6) is recommended for cultivation in the state of timely sowing under irrigated condition. The crop was sown on October 27, 2015 by Pora method in rows 45 cm apart. The plant to plant distance was about 10 cm maintained at the time of thinning. This is short saturated and early maturing variety recommended for throughout the state. It has lustrous bold seeds (4.1 gm/ 1000 seeds). Its average yield is 6.07 quintals per acre with oil content of 39.1 percent. It matures in 147 days.

Half dose of nitrogen in form of urea and whole of phosphorus as single super phosphate was applied as per treatment at the time of sowing. Remaining half of the nitrogen dose was applied after first irrigation. To control weeds, crop was given two hand weeding at 25 and 45 days after sowing respectively. In addition to pre-sowing irrigation, three more irrigations were given during growth period of crop. To protect the crop from alternaria blight and attack of hairy caterpillar, three sprays of Indofil M 45 @ 625 g ha^{-1} and one spray of Thiodan 35 EC @1250 ml ha^{-1} were applied respectively.

The seedling emergence count was recorded from one meter row length from each plot at twelve days after sowing. Number of plants per meter row length were counted from each plot at two sites and then averaged out for one meter row length. Five plants were selected randomly from each plot and tagged. Periodic plant height was measured from ground to tip of main shoot. This stage was recorded when five plants selected plants from each plot had borne one or more flowers. The numbers of primary and secondary branches were recorded from five plants already tagged one week before harvesting. Number of siliquae per plant was recorded from five plants already tagged one week before harvesting. Hundred siliquae were plucked at random from each plot to record number of seeds per siliqua. The maturity of the crop was determined when 85 per cent of siliquae changed colour from green to pale greenish and days taken to attain this stage were counted. Number of plants per meter row length was counted at two sites and then averaged for one meter row length. One thousand seeds were taken from each plot for obtaining test weight (g). The crop was harvested on March 27**,** 2016. The harvested crop was tied in well labeled bundles and kept for sun drying. Threshing was done manually with sticks after sun drying and the seed yield was recorded from each plot. The entire produce from net plot was threshed, weighed and expressed as quintal per hectare. It was worked out by deducting the seed yield from total bundle weight from each plot. Harvest Index (HI) was calculated as

Results and Discussion

Data were obtained under the field experiment under irrigated condition of Punjab" results are presented and discussed under the following heads:

Growth characters

Emergence of crop is critical for good stand establishment. Canola seedlings started emerging 7-10 days after sowings. The effect of different nitrogen and phosphorus treatments on the emergence count was not significant (Table 1). Nitrogen and phosphorus levels and nitrogen and phosphorus interaction did not exhibit any significant effect on plant stand after thinning and at harvest. Plant height is a good index of relative growth rate of crop and is an important morphological character related with vegetative growth. To assess the effect of nitrogen and phosphorus, the data on plant height was recorded periodically at 45, 90, 135 days after sowing and at harvest (Table 1). The data indicated that plant height recorded at all the growth stages of the crop and at harvest increased consistently with successive increments of nitrogen levels upto 130 kg N ha^{-1}. At 45 DAS, the plant height recorded with 130 kg N ha^{-1} was significantly higher than all other nitrogen levels. During the rest of the crop growth stages i.e. 90, 135 DAS and at harvest, plant height recorded with 130 kg N ha^{-1} was significantly higher than 70 and 100 kg N ha^{-1}, whereas treatments 70 kg N ha^{-1} and 100 kg N ha^{-1} was at par with each other. The plant height at 100 kg N ha^{-1} and 130 kg N ha^{-1} also did not differ significantly at all the crop growth stages. The increase in plant height due to nitrogen application may be ascribed to its role in cell elongation and cell multiplication in plant structure. Singh (1989) [15] and Sardana (1990) [13] also reported significant increase in plant height of gobhi sarson with increasing levels of nitrogen. The phosphorus application to Canola *Brassica napus* did not influence the plant height significantly at all the crop growth stages. Nitrogen and phosphorus interaction was also found to be non-significant (Table 1).

Flowering time and Maturity time

Flower opening, the beginning of the reproductive phase of crop is governed by its genetic makeup and certain ecological factors like temperature and photoperiod. However, application of fertilizers also influence flowering. A perusal of data in Table indicated that decrease in flowering time with increasing nitrogen levels. Crop supplied with 130 kg N ha^{-1} took minimum number of days for 50% flowering (77.2) as compared to 70 kg N ha^{-1} (78.2) as nitrogen nutrient may favors early completion of vegetative phase or higher dose might have resulted in rapid channelization of assimilates to sink. Similar results were reported by Cordeiro *et al.* (1993) [8] in *Brassica napus.* However, phosphorus and nitrogen interaction were found to be non-significant (Table 1). The change in siliquae colour from green to pale green indicates maturity. The data on maturity time is presented in Table 1 days taken to maturity increase with increasing nitrogen levels upto 130 kg N ha^{-1}. Higher nitrogen dose increase leaf area, leaf succulencey and chlorophyll content in leaves. Nitrogen being part of chlorophyll, delay leaf senescence and hence maturity. Crop supplied with 130 kg N ha^{-1} took more days (154.0) to maturity, which is at par with 100 kg N ha^{-1} (153.0) but significantly higher than 70 kg N ha^{-1} (152.6). It was observed that increase in nitrogen dose from 70 to 100 kg N ha^{-1} did not delay the maturity of Canola *gobhi sarson* significantly. Saini and Sidhu (1998) also reported delay in maturity time of *Brassica napus* L. with increasing nitrogen levels from 70 to 130 kg N ha^{-1}. Application of Phosphorus showed non-significant effect on flowering & maturity time. Phosphorus and its interaction effect with nitrogen didn't influence the flowering & maturity time significantly (Table 1).

Table 1: Emergence count, plant stand, plant height, flowering time and maturity of Canola *B. napus* under different nitrogen and phosphorus levels

Treatment	Emergence count per meter row length	Plant stand per meter row length		Plant height (cm) Days after sowing				Number of days	
		After thinning	At harvest	45	90	135	At harvest	50% flowering	Maturity
Nitrogen (kg N ha^{-1})									
70	40.25	11.08	11.08	12.44	117.4	143.2	143.7	78.2	152.6
100	40.92	11.25	11.20	13.85	120.4	147.4	147.7	78.1	153.0
130	40.17	10.83	10.50	15.08	123.6	149.2	150.5	77.2	154.0
C.D. (P=0.05)	NS	NS	NS	1.45	5.4	5.5	5.5	1.5	1.2
Phosphorus (kg $P_2O_5ha^{-1}$)									
20	40.38	10.88	10.80	12.03	115.5	139.7	140.4	79.9	152.4
30	41.19	11.06	11.00	12.42	115.7	141.6	142.5	79.0	152.2
40	40.63	11.50	11.30	12.62	116.1	142.7	143.1	79.1	152.5
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Interactions were found to be non-significant.

Number of siliquae bearing branches

The number of siliquae bearing primary and secondary branches per plant recorded at the time of harvest (Table 2) increased consistently with successive increment of nitrogen levels upto 130 kg N ha^{-1}, but significant response was observed upto 100 kg N ha^{-1}. Nitrogen applications breaks the lateral bud dormancy and encourage branching thus proved beneficial for crop plant. Application of 130 kg N ha^{-1}&100 kg N ha^{-}1 were found statistically at par with each other for number of siliquae bearing primary branches per plant. Likewise, similar trend was observed for number of secondary branches per plant. Sardana (1990) [13] and Singh (1995) [16] also reported significant increase in primary and secondary branches per plant of *gobhi* sarson with successive increment of nitrogen levels. The number of siliquae bearing primary and secondary branches increased significantly upto 30 kg P_2O_5 ha^{-1}.Application of 40 kg P_2O_5 ha^{-1}had no beneficial effect on branching of Canola and was statistically at par with application of 30 kg P_2O_5 ha^{-1}. These results are in accordance with the findings of Mankotia and Sharma (1997) [11] who observed significant increase in branches per plant of *gobhi sarson* with increasing phosphorus rates from 17.5 to 30 kg $P_20_5ha^{-1}$. The interaction effect of nitrogen and phosphorus also failed to show any significant influence on number of primary and secondary branches per plant (Table 2).

Number of siliquae per plant and number of seeds per siliqua

Siliquae, which represent the seed bearing capacity are considered the primary determinants of yield in rapeseed and mustard. Perusals of data in Table 2 revealed that the number of siliquae per plant was significant upto 100 kg N ha^{-1}. The increase in nitrogen level from 100 to 130 kg N ha^{-1} did not show any beneficial effect on number of siliquae per plant and were statistically at par with each other (Table 2). This increase may be attributed to the fact that increasing nitrogen levels promotes vigorous vegetative growth leading to better canopy architecture on which more siliquae can develop and also facilitates adequate supply of photosynthates for more siliquae formation. Increases in number of siliquae per plant with increasing level of nitrogen corroborate the results of Singh (1989) [15] and Choudhary *et al.* (1990) [7]. Although increasing trend in number of siliquae per plant was observed with phosphorus application but improvement was not significant. Interaction of nitrogen and phosphorus in affecting the number of siliquae per plant were also non-significant (Table 2).

Number of seeds per siliqua is also major yield contributing character. Nitrogen being constituent of protein and nucleic acid play an important role in seed development and had favorable effect on number of seeds per siliqua (Table 2). Data revealed that number of seeds per siliqua increased significantly higher with application of 100 kg N ha^{-1} over 70 kg N ha^{-1}.The maximum number of seeds per siliqua (22.7) were registered with application of 100 kg N ha^{-1} followed by 130 and 70 kg N ha^{-1} (22.6 and 21.3) respectively and all these three were at par with each other. These results are in line with that reported by Sardana (1990) [13] and Singh (1989) [15]. Phosphorus application to crop did not improve the number of seeds per siliqua significantly. Maximum number of seeds per siliqua (21.8) were registered with 40 kg $P_2O_5ha^{-1}$followed by 30 kg $P_2O_5ha^{-1}$. Interaction effect of nitrogen and phosphorus in affecting the number of seeds per siliqua was also non-significant (Table 2).

Table 2: Number of siliquae bearing branches, Number of Siliquae per plant, seeds per siliqua and test weight of Canola *B. napus* under different nitrogen and phosphorus levels

Treatment	Number of siliquae bearing branches per plant		Siliquae per plant	Seeds per siliqua	Test weight. (g) (1000 seed weight)
	Primary	Secondary			
Nitrogen (kg N ha^{-1})					
70	4.5	9.9	341	21.3	3.41
100	5.4	12.4	397	22.7	3.47
130	5.6	13.3	409	22.6	3.56
C.D. (P=0.05)	0.3	1.1	29	1.7	0.14
Phosphorus (kg $P_2O_5ha^{-1}$)					
20	4.5	9.8	337	21.2	3.39
30	4.9	11.2	348	21.5	3.43
40	4.9	11.5	359	21.8	3.47
C.D. (P=0.05)	0.3	0.9	NS	NS	NS

Interactions were found to be non-significant

Test weight

Thousand seed weight is a parameter through which the development of seed can be judged. Test weight of Canola *B. napus* increased with increase in nitrogen dose upto 130 kg N ha^{-1} (Table 2) Maximum test weight (3.56 g) was observed with 130 kg N ha^{-1}which is at par with test weight at 100 kg N ha^{-1}(3.47 g) but significantly higher than 100 kg N ha^{-1}(3.41 g). The increase in nitrogen dose from 70 to 100 kg N ha^{-1} did not improve seed weight significantly. Nitrogen application enhanced growth attributes that diverted photosynthates to reproductive organs for formation of seeds of higher seed weight. Singh (1989) [15] reported significant increase in thousand seed weight of *gobhi sarson* upto 130 kg N ha^{-1}at Ludhiana. Phosphorus and interaction effect of nitrogen and phosphorus in affecting the test weight of Canola seeds were found to be non-significant. Interactions were found to be non-significant (Table 2).

Seed yield

Seed yield is the net resultant of various agronomic inputs influencing growth and yield attributing characters during life cycle of crop. It is most important character regarding economic value of crop and for comparing efficiency of different treatments (Table 3). It is apparent from data that the seed yield increase with each successive increment in the nitrogen levels upto 130 kg N ha^{-1}. However, seed yield of 22.71 q ha^{-1} was obtained with application of 100 kg N ha^{-1}which was significantly higher than 70 kg N ha^{-1} but at par with 130 kg Nha^{-1}. In case of application of phosphorus seed yield was slightly increased but it had not any significant effect on seed yield. It was noticed that significantly higher numbers in primary branches, secondary branches, siliquae per plant, seeds per siliqua and thousand seed weight, with application of 130 kg N ha^{-1} over lower doses, which mainly accounted for increased seed yield of Canola. Nitrogen fertilizer promotes all the growth, yield contributing characters and ultimately seed yield of *gobhi sarson* (Bal 1993) [5]. Brar *et al*. (1998) [6], Gupta and Saini (1988) [10] and Gill and Narang (1991) [9] also reported increase in seed yield of *gobhi sarson* with increasing levels of nitrogen.

Seed yield of Canola *gobhi sarson* showed increasing trends with the application of phosphorus, but the differences were non-significant because of high initial phosphorus status of soil. Seed yields of 20.15, 20.61 and 20.65' q ha^{-1} were obtained with application of 20, 30 and 40 kg $P_2O_5ha^{-1}$respectively. Nitrogen and phosphorus interaction also proved non-significant with respect to seed yield but combine application of 130 kg N ha^{-1} + 40 kg $P_2O_5ha^{-1}$ gives maximum seed yield of 22.96 q ha^{-1} (Table 3).

Straw yield

Straw yield, a measure of vegetative growth was recorded under different treatments (Table 3). The data revealed that straw yield of Canola (*B. napus*) increased with nitrogen application. Maximum straw yield was obtained with 130 kg N ha^{-1}which was significantly higher than all other lower doses.70 and 100 kg N ha^{-1}were statistically at par with each other. Straw yield was recorded 73.05 q ha^{-1}, followed by 66.67 and 64.85 q ha^{-1} with application of N @130, 100, 70 kg ha^{-1}. Increase in straw yield with nitrogen application may be attributed to favorable effect of nitrogen on plant height and number of primary and secondary branches per plant. Increased straw yield of *gobhi sarson* with nitrogen application has been reported by Singh (1997) [14]. Similarly successive increment in nitrogen levels upto 200 kg N ha^{-1}led to significant increase in straw yield of *gobhi sarson* (Bal 1993) [5]. However, different levels of phosphorus and interaction of nitrogen and phosphorus was found to be statistically non-significant.

Harvest Index

Harvest index of Canola *B. napus* increased upto 100 kg N ha^{-1}. Maximum harvest index of (24.13%) was recorded with the application of 100 kg N ha^{-1} which was significantly higher than harvest index at 130 kg N ha^{-1} (22.67%) but was at par with 70 kg N ha^{-1} (23.23%) (Table3). The decrease in harvest index with application of 130 kg N ha^{-1}might be due to more increase in vegetative growth as compare to increase in seed yield. Bal (1993) [5] also reported as same as above. However different levels of phosphorus had not any significant effect on straw yield. Like other parameters, phosphorus and its interaction with nitrogen in affecting harvest index was statistically non-significant (Table 3).

Table 3: Seed yield, straw yield and harvest index of Canola B. *napus* under different nitrogen and phosphorus levels

Treatment	Seed yield (q ha^{-1})				Straw yield (q ha^{-1})				Harvest Index (%)			
	Nitrogen (kg N ha^{-1})				Nitrogen (kg N ha^{-1})				Nitrogen (kg N ha^{-1})			
	70	100	130	Mean	70	100	130	Mean	70	100	130	Mean
20	20.78	22.46	22.36	20.15	65.30	63.23	69.21	61.75	22.82	24.88	23.20	23.14
30	21.19	22.85	22.94	20.61	67.53	70.33	75.45	65.75	22.69	23.30	22.33	22.61

40	21.29	22.82	22.96	20.66	61.73	66.45	74.50	63.48	24.19	24.21	22.48	23.14
Mean	21.09	22.71	22.75	-	64.85	66.67	73.05	-	23.23	24.13	22.67	-
C.D. (P=0.05)												
N	0.87				4.36				1.16			
P	NS				NS				NS			
N x P	NS				NS				NS			

Conclusion

Plant height increased linearly with successive increment in nitrogen levels at all the crop growth stages. At 45, 90, 135 DAS and at harvest plant height with 130 kg N $ha^{-1}$was significantly higher than 70 kg N ha^{-1} but at par with 130 kg N ha^{-1}. Flowering time (50% flowering) occurred earlier with nitrogen application whereas maturity was delayed with increasing nitrogen levels up to130 kg.N ha^{-1}. Yield contributing characters like number of primary and secondary branches, siliquae per plant increased significantly up to 100kg N ha^{-1}. Highest seeds per siliqua were also obtained in 70 kg N ha^{-1}, whereas test weight was maximum with 130 kg N ha^{-1}. Seed yield of 22.71 q ha^{-1} was obtained with the application of 100 kg N ha^{-1}, which was at par with 130 kg N ha^{-1} but significantly higher than 70 kg N ha^{-1}. However, straw yield was significantly higher with 130 kg N ha^{-1}. Maximum harvest index value was registered with 100 kg N ha^{-1}.

Growth and yield contributing characters of Canola *B. napus* remained unaffected with phosphorus application except siliquae bearing branches which increased significantly upto 30 kg P_2O_5 ha^{-1}. Therefore, siliquae bearing branches, siliquae per plant, seeds per siliqua and thousand seed weight were main parameters which contribute towards increased seed yield.

Hence, it is concluded that maximum yield of Canola *B, napus* was obtained with application of 130 kg N ha^{-1}on clayey soil, low in available nitrogen status. However, the optimum economic dose of nitrogen was 100 kg N ha^{-1}as both the treatments were at par. Phosphorus did not show any positive influence on seed yield due to the high initial phosphorus status of the soil.

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