Chemical Science Review and Letters ISSN 2278-6783

Research Article

Effect of Sowing Time and Nitrogen on Growth, Yield and Nutrient Uptake by Indian Mustard (*Brassica Juncea* L.) Under Western Haryana

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Abstract

A field experiment was conducted during *rabi* seasons of 2013-15 at Hisar to find out the response of Indian mustard to four dates of sowing (Oct 15^{th}& 25^{th} and Nov 5^{th}& 15^{th}) and five nitrogen levels (0, 40, 60, 80 and 100 kg N/ha). Among the times of sowing, Oct 15 being at par with Oct 25 gave significantly higher seed yield, stover yield and nitrogen uptake probably due to higher growth and yield attributes. Application of 100 kg N/ha significantly improved the seed yield, stover yield and nitrogen uptake. Agronomic efficiency, apparent recovery and nutrient use efficiency was maximum at Oct 15 sown crop and among the nitrogen doses agronomic and nutrient use efficiency was highest with 40 kg N/ha whereas apparent recovery was highest with 60 kg N/ha. Optimum economic dose of nitrogen for Oct 15^{th}& 25^{th}, Nov 5^{th}& 15^{th} were 119.8, 116.8, 110.6 and 101.8 kg/ha respectively.

Keywords: Indian mustard, Nitrogen, nutrient uptake, Sowing time and Yield

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Introduction

Rapeseed-mustard (*Brassica spp*.) is a major group of oilseed crops of the world with second largest acreage in India after China. Rapeseed-mustard contributed 24.5 % in total oilseed production in the country. Indian mustard is preferred due to its high yield potential and oil content. Indian mustard has multiple uses as a spice or condiment in preparation, seasoning and stuffing of several foods and pickles in India. Yield potential of this crop can be explored by the use of agronomic-techniques. Among them, time of sowing is an important non monetary input. Variation in the sowing date, day length and temperature interact to influence growth, yield and quality of a crop. The optimum time of sowing can provide congenial conditions to have maximum light interception, best utilization of moisture and nutrients from early growth stage to seed filling stage. Sowing time is very important for mustard production [9]. It is responsive to plant nutrient, especially nitrogen. Nitrogen is considered to be the most important nutrient for the crop to activate the metabolic activity and transformation of energy, chlorophyll and protein synthesis. Nitrogen also affects uptake of other essential nutrients and it helps in the better partitioning of photosynthates to reproductive parts which increased the seed: stover ratio [7]. Optimum sowing time and nutrient management are important factor for improving crop productivity. Yet there is a lack of sufficient research information pertaining to the effect of sowing time and nitrogen on yield and economics of mustard in western Haryana. This calls for a need to generate more information on the performance of Indian mustard to different sowing time and nitrogen level under western Haryana.

Materials and Methods

A field experiment was conducted during *rabi* seasons of 2013 and 2014 at the Agronomy Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. The soil of the field was sandy loam in texture, having 0.57% of organic carbon Ec_2 of 0.185 and pH_2 of 8.73. It was low in available N 154.5 kg /ha, medium in available P_2O_5 23.25 kg/ha and rich in available K_2O 304.8 kg/ha. The experiment consisting of four dates of sowing *viz*. October 15, October 25, November 5 and November 15 in main plots and five nitrogen levels *viz*. Control *i.e*. 0 kg N/ha, 40 kg N/ha, 60 kg N/ha, 80 kg N/ha and 100 kg N/ha in sub plots was laid out in split plot design with three replications. Quality seeds of Indian mustard 'RH-749' was directly sown with the help of seed drill in rows 30 cm apart at the rate of 5 kg/ha. Crop was sown in different dates of sowing in main plot. The doses of nitrogen were applied in the form of urea. Fertilizer, viz. Phosphorous @50 kg/ha through single super phosphate along with half dose of nitrogen as per treatment through urea were applied at the time of sowing. Remaining nitrogen was top dressed after the first irrigation during both the seasons. Two irrigations were given to the crop each at day 30 and siliqua-formation stage. All the recommended cultural practices were followed as per recommendation. Harvesting was done when more than 85% of siliquae turned brownish. Observations recorded were plant height, leaf area duration at 120DAS, branches/plant, yield attributes, seed yield, and economics at harvest. Organic carbon, available N, available P and available K content in soil was determined as per standard procedures. N content in seed and straw at harvest was determined. For analysis of N oven dried plant material (seed and straw at harvest) from each plot were grinded separately with grinder. The methods for analysis were Nesslers reagent method [4] for nitrogen in seed and straw, uptake of these nutrients was calculated as kilogram per hectare by multiplying the contents with seed and straw yields in different treatments respectively. Agronomic efficiency, apparent recovery and nutrient use efficiency was calculated as per [1].

The response of mustard yield to nitrogen was studied as per procedure explained by [2]. Quadratic response to nitrogen application was observed and the following quadratic model was used to compute the optimum dose of nitrogen:

$$Y=a+bx+cx^2$$

Y= seed yield of mustard (kg/ha) for a given level of x, X= unit of nitrogen (kg/ha), a, b and c are parameters of the model.

To work out the Physical Optimum Nitrogen rate (PONR), the equation below was used:

$$\text{PONR} = \frac{b}{2c}$$

The Economic Optimum Nitrogen Rate (EONR) was computed with the help of following equation:

$$\text{EONR} = \frac{1}{-2c}\left(\frac{q}{p} - b\right)$$

Q= price of N per unit, P= price of per kg yield of mustard.

The economics was calculated by considering the sales prices of mustard and cost of cultivation during 2013 and 2014, respectively. Data collected on various parameters of crop were subjected to statistical analysis to draw valid conclusion.

Results and Discussions

Growth and yield attributes

Successive delay in sowing and increase in nitrogen levels significantly affect the growth and yield attributes (**Table 1**). Among the times of sowing, crop sown on Oct 15 recorded the tallest plant with maximum leaf area duration, branches/plant, number of siliquae on main shoot, siliqua bearing length, siliquae per plant and test weight which were significantly higher over delay in sowing. There was7.9, 25.6, 30.2, 12.9, 12.5, 32.7 and 11.3 % decrease in plant height, leaf area duration, branches/plant, number of siliquae on main shoot, siliqua bearing length, siliquae per plant and test weight were recorded in November 15 over early sown crop on October 15, respectively. This might be earlier sown crop (Oct 15 and 25) faced favorable soil moisture condition and relatively warmer temperature during vegetative phase and conducive temperature during 50% flowering and pod formation stage and might be maintained better plant relations like leaf water potential (LWP) and higher turgor potential which led to higher rate of photosynthesis due to more opening of stomata for longer period of time. This has also increased for faster cell division and enlargement, which leds to higher growth and yield attributes [3]. All the growth and yield attributes of Indian mustard increased significantly with increasing levels of nitrogen up to 100 kg N/ha. However, it remained at par with 80 kg N/ha for growth and yield attributes in both the years were non significant. However the increase in plant height, leaf area duration, branches/plant, number of siliquae on main shoot, siliqua bearing length, siliqua per plant and test weight under 100 kg N/ha by 7.1, 41.9, 64.5,22.2, 13.6, 53.9 and 22.4 % over the control, respectively. This might be due to the nitrogen being the basic constituent of chlorophyll, protein and cellulose required for the process of photosynthesis and tissue formation for proper growth and thereby increasing the yield attributes. These results are in line with those of [5].

Table 1 Effect of time of sowing and nitrogen on growth, yield attributes and yields of Indian mustard (Pooled data of 2 years)

Treat ments	Plant height (cm)	Leaf area duration (LAD)at 120 DAS	Branches/ plant	No. of siliquae on main shoot	Siliqua bearing Length (cm)	No. of siliquae/ plant	Test weight (g)	Seed yield (tonnes/ ha)	Stover yield (tonnes/ ha)	Harvest index (%)
Time of sowing										
Oct 15	226.7	118	17.7	49.9	74.25	363.1	6.7	2635	9193	21.9
Oct 25	222.3	114	16.4	47.7	72.8	340.5	6.3	2445	8603	21.8
Nov 5	218.2	97.4	15.7	46.15	67.1	323.9	6.1	1992	7319	20.3
Nov 15	208.6	87.8	12.35	43.45	64.95	278.8	5.5	1599	6007	19.6
CD(P=0.05)	1.93	3.83	2.65	1.75	2.35	27.8	0.29	211	698	NS
Nitrogen levels (kg/ha)										
0 kg N/ha	211.3	85.7	11.25	41.25	64.15	232.5	5.5	1229	6594	15.25
40 kg N/ha	212.7	93.9	14.55	45.85	69.45	327.8	5.9	2029	7153	21.59
60 kg N/ha	219.9	104.6	15.9	47.5	70.35	344.6	6.2	2377	8027	22.25
80 kg N/ha	224.1	115.2	17.45	49	71.95	358.2	6.4	2560	8465	22.66
100 kg N/ha	226.7	121.8	18.5	50.45	72.9	369.8	6.7	2645	8663	22.82
CD(P=0.05)	1.82	6.5	3.6	1.95	2.15	18.7	0.18	67	432	NS

Seed and stover yield

Seed yield and straw yield decreased progressively with delay in sowing in both the years. However, the difference between 15 and 25 Oct sowings were at par for seed yield in both the years. The delay in sowing from Oct 15 to 25, Oct 15 to Nov 5, Oct 15 to Nov 15 decreased the seed yield of mustard by about 7.21, 24.4 and 39.3 during both the years. This might be due to decrease in stover yield by 6.4 20.4 and 34.7 during both the years. The early sown crop, Oct 15 increased the plant growth in terms of plant height along with increased number of siliquae per plant (Table1) which resulted in more yields. Early (Oct 15 and 25) sown crop received the optimum environment conditions required for better crop growth. The significant positive association between seed yield with plant height (r=0.88) and leaf area duration (r=0.93) and no. of siliqua per plant (0.94). Application of 100 kg N/ha recorded significantly higher seed and stover yield, but stover yield was at par with 80 kg N/ha during both the years. The significantly higher seed yield (115.2 %) and stover yield (31.3 %) along with the harvest index (49.63 %) in 100 kg N/ha over control were because of more availability of nutrients for their growth and development of better yield attributes and yield. The poor nutrition in control affected the seed yield more than biological yield which ultimately resulted in significant reduction in harvest index. This decline in response of nitrogen at higher doses may be explained with the well established Mitscherlich equation. Similar trend have been reported by [8].

The interaction between time of sowing and nitrogen was significant on seed yield of mustard (**Table 2**). Increase in the level of nitrogen doses increased seed yield significantly up to 80 kg N/ha under all the dates of sowing. But, crop sown on Nov 15 increase in seed yield was observed significantly up to 60 kg N/ha. The decrease in seed yield with delay in sowing at all the nitrogen levels were significant, except the seed yield difference between crop sown on Oct 15 and 25 sown crop was non significant at 0, 40 and 80 kg N/ha. The favorable environment conditions in early sown crop combined with higher dose of nitrogen 100 kg N/ha increases the growth and yield.

Table 2 Interaction between time of sowing and nitrogen levels on seed yield (tonnes/ha) of Indian mustard (2013-14)

Treatments	0 kg N/ha	40 kg N/ha	60 kg N/ha	80 kg N/ha	100 kg N/ha	Mean
Oct 15	1.54	2.49	2.93	3.15	3.30	2.68
Oct 25	1.43	2.33	2.73	2.94	3.05	2.50
Nov 5	1.23	1.90	2.22	2.39	2.42	2.03
Nov 15	9.00	1.55	1.76	1.90	1.95	1.61
Mean	1.28	2.07	2.41	2.60	2.68	
C.D. of nitrogen levels at same level of time of sowing (P=0.05)	0.16					
C.D. of time of sowing at same level of nitrogen levels (P=0.05)	0.25					

The response of mustard to dates of sowing and nitrogen levels was quadratic (pooled of two years). Physical optimum dose for October 15, October 25, November 5 and November 15 sown crops were 121.4, 118.4,112.5 and 103.7 kg N/ha with yield of 3319, 3053, 2428 and 1949 kg/ha, respectively. Whereas, economic optimum dose were 119.8, 116.8, 110.6 and 101.8 kg N/ha with yield of 3318, 3053, 2428 and 1948 kg/ha, respectively (**Table 3** and **Figure 1**).The regression equation predicted linear decrease in the seed yield with a unit delay in sowing.

Table 3 Regression equations, Regression coefficients (R^2), economic optimum dose (EOD) of nitrogen and seed yield (kg/ha) for different dates of sowing (Pooled data of 2 years)

Dates of sowing	**POD (kg/ha)**	**Grain yield (kg/ha)**	**EOD (kg/ha)**	**Grain yield (kg/ha)**	**Actual (Pooled)**
Oct 15	121.4	3319	119.8	3318	2635
Oct 25	118.4	3053	116.8	3053	2445
Nov 5	112.6	2428	110.6	2428	1992
Nov15	103.7	1949	101.8	1948	1599

POD=Physical optimum dose of nitrogen is the nitrogen rate that will produce maximum grain yield regardless of cost. EOD= Economic optimum dose of nitrogen rate that will result in maximum financial return to nitrogen. It is usually less than the POD.

Figure 1 Crop at different phenological stages (vegetative and flowering stage) due to staggered sowing dates

Figure 2 Indian mustard crop at full blooming stage and at physiological maturity

Nutrient uptake and nutrient use efficiency

The maximum uptake of nitrogen was recorded with Oct 15 sown crop (82.9 kg/ha) and 100 kg N/ha (80.9 kg /ha) compared to other treatments (**Table 4**).The uptake of nitrogen was higher with Oct 15 sown crop was 68.5 % over Nov 15 sowing. Application of 100 kg N/ha resulted in significant increased in nitrogen uptake. The uptake of nitrogen were higher under 100 kg N/ha by 78.6 % over the control. The higher uptake of Nitrogen under higher dose of N was because of more availability of these nutrients, which encouraged the crop growth and finally higher seed yields (Table 1). The nutrient status of plant tissue being the genetic character was affected less by the environment but, higher growth require higher uptake. Similar results have been reported by [6].Maximum agronomic efficiency, apparent recovery and nutrient use efficiency was observed with crop sown on October 15 with 40 kg N/ha except for apparent recovery where it was highest with 60 kg N/ha during both the years. Further delay in sowing and increased in the level of nitrogen the sharp decline was observed for agronomic efficiency, apparent recovery and nutrient use efficiency.

Table 4 Effect of time of sowing and nitrogen on nutrient uptake and nutrient use efficiency

Treatments	Nitrogen uptake (kg/ha)	Agronomic efficiency (kg/kg)	Apparent recovery (%)	Nutrient use efficiency (kg/kg)
Time of sowing				
Oct 15	82.9	21.3	48.5	45.1
Oct 25	75.4	19.8	44.9	41.9
Nov 5	61.8	15.0	37.5	34.0
Nov 15	49.2	13.9	28.2	27.7
CD (P=0.05)	3.4	3.0	10.4	3.4
Nitrogen levels (kg/ha)				
0 kg N/ha	45.3			
40 kg N/ha	61.5	20.0	40.5	50.7
60 kg N/ha	71.5	19.1	43.6	39.6
80 kg N/ha	77.5	16.6	40.2	32.0
100 kg N/ha	80.9	14.1	34.8	26.4
CD (P=0.05)	2.5	1.3	3.9	1.2

Table 5 Effect of time of sowing and nitrogen levels on economics of Indian mustard (Pooled data of 2 years)

Treatments	Cost of cultivation (₹/ha)	Net Profit (₹/ha)	B:C Ratio
D_1N_0	52300	-3507.6	0.94
D_1N_1	52775	25051.85	1.46
D_1N_2	53005	38854	1.71
D_1N_3	53253	44662.15	1.81
D_1N_4	53475	49029.85	1.89
D_2N_0	52280	-6332.65	0.88
D_2N_1	52755	20470.95	1.38
D_2N_2	52985	32480.85	1.6
D_2N_3	53233	38716.45	1.71
D_3N_4	53455	41872.4	1.76
D_3N_0	53505	-13696	0.75
D_3N_1	53980	6463.46	1.12
D_3N_2	54210	15813.45	1.28
D_3N_3	54458	20856.3	1.37
D_3N_4	54680	21702.65	1.39
D_4N_0	51075	-20407.5	0.61
D_4N_1	51573	-442.963	0.99
D_4N_2	51780	6028.45	1.11
D_4N_3	52028	10217.55	1.19
D_4N_4	52250	11291.1	1.21

* D_1: October 15, D_2: October 25, D_3: November 5, D_4: November 15, N_o: Control, N_1:40 kg N/ha, N_2: 60 kg N/ha, N_3: 80 Kg N/ha, N_4: 100 Kg N/ha.

Economics

The economics of Indian mustard affected by combination of dates of sowing and nitrogen levels is given in (**Table 5**). The cost of cultivation of Indian mustard is highest at Nov 5, followed by Oct 15, and 25 and lowest cost of cultivation was observed in Nov 15 sown crops. The cost of cultivation increased with increase in dose of nitrogen during both years of experimentation. Among the different combinations of dates of sowing and nitrogen levels, the cost of cultivation was highest at (D_3N_4) and it was lowest at (D_4N_0). The net profit and B:C ratio decreased with delay in sowing, but it increased with increase in nitrogen doses. Maximum net profit (₹57445) and B: C ratio (1.89) was recorded in D_1N_4 and it was lowest in D_4N_0 with a loss of ₹ 20407.5and 0.61during both the years.

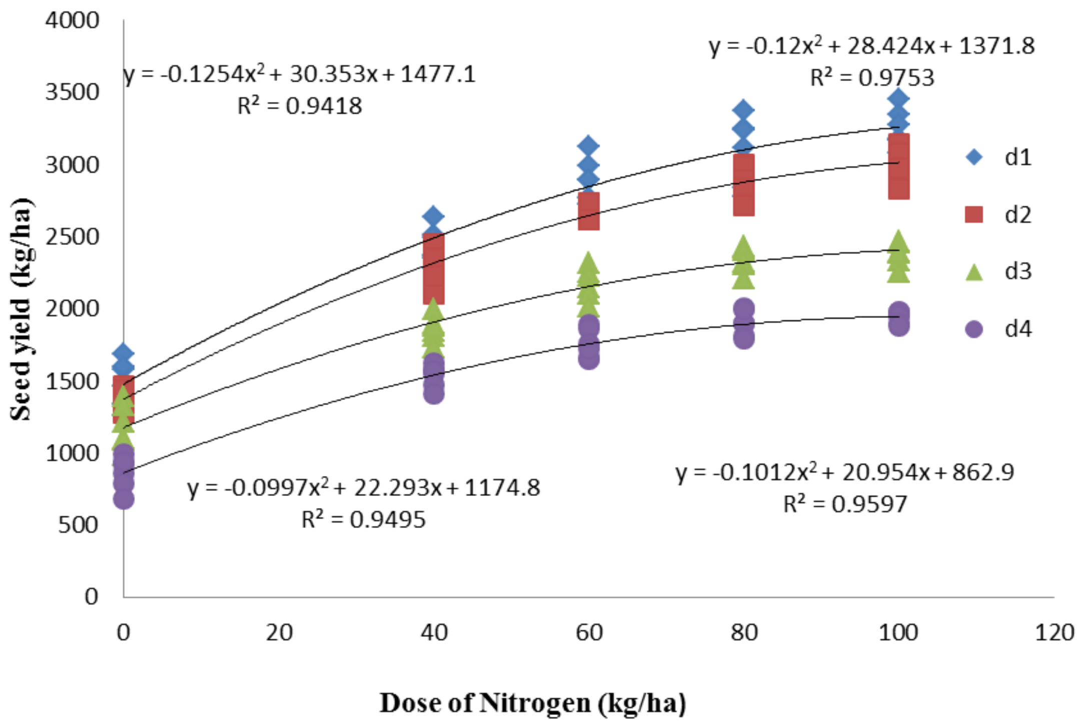

Figure 3 Economic optimum dose of nitrogen for different dates of sowing

Conclusion

Based on the results of two year study (2013 and 2014) it can be concluded that crop sown on October 15 with 100 kg N/ha performed significantly better growth, yield attributes and yield. Among the nitrogen doses, growth, yield attributes and yield were increased significantly with increased dose of nitrogen. The economic optimum dose for Indian mustard computed for October 15th, October 25th, November 5th and November 15th sown crops were 119.8, 116.8, 110.6 and 101.8 kg N/ha, respectively. Maximum net profit (Rs.50566 and Rs.47493) and BC ratio (1.94 and 1.82) was recorded with October 15 with 100 kg N/ha sown crop (D_1N_4) during 2013-14 and 2014-15, respectively, under western Haryana.

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Publication History
Received 10th Dec 2017
Revised 18th Dec 2017
Accepted 19th Dec 2017
Online 30th Dec 2017