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Yield attributes, yield and quality of Indian mustard (*Brassica juncea* L.) as influenced by dates of sowing and nitrogen levels in Western Haryana

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Abstract
A field experiment was conducted during the winter (r*abi*) season of 2013-14 and 2014-15 at Hisar, Haryana in a split plot design having four dates in the main plot and five nitrogen levels in the sub plots with three replications, to find out the effect of planting dates and nitrogen level on yield attributes and yield of Indian mustard (*Brassica juncea*). Growth characters, yield attributes, yields and qualities were found to be more with 15 October sowing compared to 30 October, 5 November and 15 November sowing dates. Growth characters, yield attributes, yields and qualities increased significantly with successive increase in nitrogen up to 100 kg N/ha. Integration of 100 kg N/ha with 15 October sowing, gave highest amount of seed yield than rest of the combinations of nitrogen levels and sowing dates during both the years.

Keywords: Sowing date, nitrogen levels, yield attributes, yield and Indian mustard

Introduction
Indian mustard is preferred due to its high yield potential and oil content. 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 (Mondal *et al*., 1999) [5]. Major plant nutrients also a play a key role in increasing productivity. Among them, nitrogen is major essential nutrient required for obtaining good yields. 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 (Singh and Meena 2004) [7]. Hence the present investigation was carried out and the results were reported in this paper.

Materials and Methods
A field experiment was conducted during winter (*rabi*) seasons of 2013-14 and 2014-15 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 on growth (plant height, leaf area index 90 DAS, dry matter accumulation per plant and primary and secondary branches/plant), yield attributes (siliquae/plant, siliqua length, seeds/ siliqua seed yield/plant and test weight), yields (seed, biological, stover, oil and protein yields) and qualities (oil and protein content) were recorded.

Results and Discussions

Growth attributes

Sowing date significantly influenced the growth characters, yield attributes, yield and qualities of Indian mustard (Tables 1, 2, 3). The crop has sown on 15 October produced significantly higher growth characters viz. plant height, dry matter accumulation per plant, primary and secondary branches/plant compare to 25 October, 5 November and 15 November. However, leaf area index at 90 DAS under October 15 was statistically on par with 25 October. Earlier sown crop (October 15 and 25) faced favourable soil moisture condition and relatively warmer temperature during vegetative phase and conducive temperature during 50% flowering and pod formation stage, while later sown crop (November 5 and 15) faced low temperature at the time of emergence as well as at 50% flowering stage. The early sown crop (October 15 and 25) 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 rate. Kumar *et al*., (2013) [2], and Uzun *et al.*, (2009) [10] also reported similar findings.

The plant height, dry matter per plant, primary branches/plant and secondary branches/plant increased significantly with increase in nitrogen dose from 0 to 100 kg N/ha (Table 1). Minimum plant height, dry matter per plant, primary branches/plant and secondary branches/plant, were recorded at control (0 kg N/ha) and maximum at 100 kg N/ha. The LAI 90 DAS increased with an increase in the level of N doses from control to 100 kg N/ha, however the increase in LAI at 40 kg N/ha was statistically on par with control, thereafter shows significant improvement up to 60 kg N/ha. The maximum LAI was recorded at 100 kg N/ha which was statistically on par with 80 kg N/ha during both the years of study. The plant height, dry matter per plant, primary and secondary branches per plant was significantly lower in control than higher doses of nitrogen. Poor growth in these treatments may be due to low availability of plant nutrient which are necessary for the normal growth. Nitrogen being the basic constituent of chlorophyll, protein and cellulose required for the process of photosynthesis and tissue formation for proper growth. Maereka *et al*., (2007) [3] and Singh *et al*., (2003) [8]

Yield attributes and yield

The yield attributes siliqua/plant, siliqua length, seed yield/ plant, seed yield, and stover yield decreased significantly with the crop sown on after 25 October in both the years However, 15 and 25 October sowings were at par (Table 2). Maximum number of Seeds/siliqua was recorded with 15 October which was superior to 5 and 15 November. Test weight, oil yield, protein yield and biological yield decreased significantly with delay in sowing from 15 October to 15 November (Table 3). Harvest index could not cross the limit of significance. The stronger source is required for the stronger sink. The higher biological yield was found significantly associated with higher seed yield of mustard (r=0.96).This clearly shows the biological yield increased by any input or management practice will automatically increase the seed yield of mustard. The seed yield of mustard can also be estimated through biological yield with the regression equation (Fig 1, Seed yield = -851.5+0.303 biological yield, r^2= 0.92). Similarly, Stover yield being the constituent of biological yield have very high association (r=0.89). This fact can further be corroborated by the regression line drawn between stover yield and biological yield (Fig. 2, biological yield = -536.1+1.444 straw yield, r^2=0.79). Early (October 15 and 25) sown crop received the optimum environment conditions required for better crop growth in terms of plant height and dry matter accumulation. The significantly positive association between biological yield with growth parameters namely plant height (r= 0.95) and dry weight (r=0.96).

Nitrogen application had significant effects on yield attributes and yield. Yield attributes viz. siliquae/plant, siliqua length, seeds/ siliqua and seed yield/ plant were significantly increased with increasing level of N upto 40 kg N/ha (Table 2), which remained at par with 60, 80 and 100 kg N/ha. Maximum test weight was recorded with 100 kg N/ha which was superior to 40 and 0 kg N/ha. Seed yield, oil yield and protein yield increased significantly with increase in doses of nitrogen from 0 to 100 kg N/ha, whereas biological and stover yield increased significantly upto 80 kg N/ha, which remained at par with 100 kg N/ha. While nitrogen had no significant effect on harvest index (Table 2). The significantly higher seed yield (115 %), stover yield (31.3 %) and biological yield (44.54 %) 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. Harvest index is the parameter which dependent on seed yield (r= 0.83) and biological yield (r=0.66). This shows that harvest index was more associated with seed yield than biological yield. The harvest index can also be computed from the seed yield with regression equation (SY= -1792+185.2HI, r^2=0.70, Fig, 3). This decline in response of nitrogen at higher doses may be explained with the well-established Mitscharlich equation. Singh *et al*., (2014) [9] and Keivendra *et al*., (2012) was also reported similar findings.

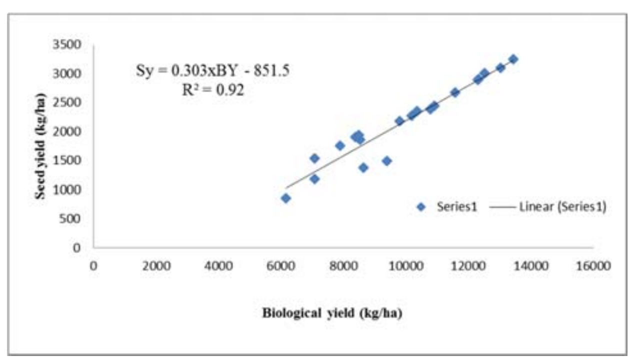

Fig. 1: Regression line showing the relationship of biological yield (kg/ha) with seed yield (kg/ha).

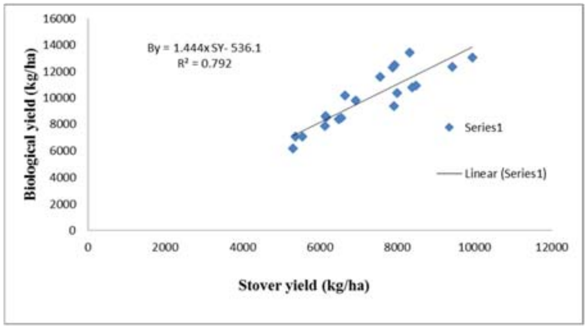

Fig 2: Regression line showing the relationship of Stover yield (kg/ha) with biological yield (kg/ha)

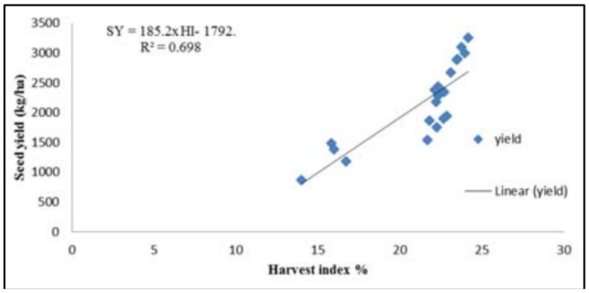

Fig. 3: Regression line showing the relationship of Harvest index (%) with Seed yield (kg/ha)

Quality attributes

Quality analysis of Indian mustard (Table 3) revealed that sowing on 15 October gave the highest oil content and protein content against the minimum oil content and protein content, recorded with 15 November. However, reverse trend was followed with different doses of nitrogen levels in case of oil content. The maximum value of oil content was recorded with 0 kg N/ha (40.2 %), which was significant with 40 kg N/ha (39.6), and there was no significant increase in oil content with increase in nitrogen doses. Whereas, protein content increased significantly with increase in doses of nitrogen. The significant increase in oil content, protein content in early sown crop was due to increased nitrogen content in seed. The increased nitrogen doses increased the protein content of mustard by significant decrease in oil content in nitrogen applied treatment over control. Presence of N compounds in seed oil complicates the procedure of oil extraction and increases the amount of undesirable materials like glucosinolates. The results are in conformity with Mirzashahi *et al.*, (2000). With increasing nitrogen doses, there was significant increase in protein content in seeds. Nitrogen is a basic constituent of protein and with the increase in rate of nitrogen application. The nitrogen availability increased which resulted in increased protein content in seeds. The positive correlation between protein content and fertilizer rates were also reported by Shukla and Kumar (1992

Table 1: Growth characters of Indian mustard as influenced by sowing date and nitrogen (pooled data of 2 years)

Treatment	Plant height (cm)	Leaf-area index 90DAS	Dry matter/plant (g)	Primary branches/plant	Secondary branches/plant
Sowing date					
15 October	226.7	4.46	145.0	7.46	10.21
25 October	222.3	4.27	131.2	7.02	9.45
5 November	218.2	3.69	122.6	6.52	9.21
15 November	208.6	3.25	111.8	6.09	6.28
SEm±	0.55	0.06	0.4	0.09	0.19
CD (P=0.05)	1.93	0.22	1.4	0.30	0.65
Nitrogen levels (kg/ha)					
0	211.3	3.03	114.6	5.60	5.64
40	212.7	3.36	123.2	6.46	8.11
60	219.9	3.92	129.5	6.91	9.02
80	224.1	4.51	133.1	7.25	10.25
100	226.7	4.78	137.9	7.63	10.91
SEm±	0.63	0.l5	0.4	0.08	0.11
CD (P=0.05)	1.82	0.43	1.1	0.23	0.31

Table 2: Yield attributes and yield of Indian mustard as influenced by sowing date and nitrogen (pooled data of 2 years)

Treatment	Siliquae/plant	Siliqua length (cm)	Seeds/siliqua	Seed yield/ plant (g)	Test weight (g)	Seed yield (kg/ha)	Biological yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
Sowing date									
15 October	363.1	5.99	12.9	21.7	6.7	2635	11828	9193	21.9
25 October	340.5	5.95	12.5	19.8	6.3	2445	11049	8603	21.8
5 November	323.9	5.76	12.4	17.9	6.1	1992	9311	7319	20.3
15 November	278.8	5.83	12.1	14.9	5.5	1599	7606	6007	19.6
SEm±	7.9	0.03	0.14	0.11	0.08	59.9	181	198	0.77
CD (P=0.05)	27.8	0.13	0.49	0.40	0.29	211	640	698	NS
Nitrogen levels (kg/ha)									
0	232.5	5.55	11.7	14.3	5.5	1229	7823	6594	15.25
40	327.8	5.81	12.2	17.9	5.9	2029	9182	7153	21.59
60	344.6	5.93	12.5	19.3	6.2	2377	10404	8027	22.25
80	358.2	5.96	12.8	20.3	6.4	2560	11025	8465	22.66
100	369.8	6.18	13.1	21.2	6.7	2645	11308	8663	22.82
SEm±	6.5	0.08	0.13	0.15	0.18	23.1	154	149	1.72
CD (P=0.05)	18.7	0.23	0.37	0.43	0.51	67.0	446	432	NS

Table 3: Oil content, protein content, oil yield and protein yield as influenced by sowing date and nitrogen (pooled data of 2 years)

Treatment	Oil content (%)	Protein content (%)	Oil yield (kg/ha)	Protein yield (kg/ha)
Sowing date				
15 October	40.0	8.77	1052	233
25 October	39.0	8.62	949	212
5 November	38.9	8.46	773	170
15 November	38.7	8.27	616	133
SEm±	0.2	0.01	26.5	5.04
CD (P=0.05)	0.8	0.04	93	18
Nitrogen levels (kg/ha)				
0	40.2	8.09	494	100
40	39.6	8.52	805	173
60	39.1	8.60	931	205
80	38.6	8.67	990	223
100	38.4	8.78	1018	233
SEm±	0.18	0.02	8.6	2.03
CD (P=0.05)	0.53	0.06	25	5.9

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