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Plant attributes and yield variability due to N in Indian mustard genotypes

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Abstract

A field experiment consisting of two N levels (100 % and 50 % RDF) in main plots, and twenty-two genotypes in sub plots was conducted at ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan during *rabi* 2016-17 under factorial randomized block design to find the N efficient genotypes, and replicated thrice. The results revealed that recommended levels of N (100% RDF, 80 kg N ha^{-1}) recorded maximum growth and yield parameters, and test weight (6.4 g), seed yield (2666 kg ha^{-1}), stover yield (6550 kg ha^{-1}), harvest index (28.9 %), over 50 % N. The highest stem girth, primary and secondary branches and main shoot length at harvest were found in RH 1215, RH 1118 and RH 1223, respectively. In the yield attributes, the number of siliquae on main shoot, number of seeds siliqua^{-1}, highest seed weight siliqua^{-1} were found in RH 1215, RH 749 and RH 1441, respectively. The NRCDR 02 recorded the highest biological yield (10728 kg ha^{-1}) and stover yield (8366 kg ha^{-1}), whereas, RH 749 recorded the highest seed yield (2985 kg ha^{-1}) both under normal and limited N supply. The maximum harvest index (31.8 %) and test weight (7.6 g) was recorded in NRCHB 101 and RH 555, respectively. Thus, the varieties DRMRIJ 31 and RH 1215 found efficient both under normal N (100% N) and deficit N supply (50% N).

Keywords: *Genotypes, Indian mustard, nitrogen levels, yield attributes, yield*

Introduction

The oilseeds sector is being a vibrant and dynamic in the world agriculture and growing at a pace of 4.1 % per annum in production in the last three decades. India is the fifth largest vegetable oil economy in the world accounting 7.4 % world's oilseeds, 5.8 % oils and 6.1 % oil meal production, and accounts 9.3 % of world's edible oil consumption (Jat *et al.,* 2019). Oilseeds are the second most important agricultural economy in India next to cereals. Rapeseed and mustard are an important oilseed crop of family cruciferae and occupies a prominent place among oilseed crops. Despite being the largest cultivator of oilseeds in the world, India imports about 50 % of the domestic oil requirements and become the biggest importer of vegetable oils with 11.2 % share in total world import worth of about Rs. 68000 crores in 2016-17.

The major constraint limiting production of mustard is poor fertility status of soil. The soils of mustard growing regions are mostly deficient in soil nitrogen content (<120 kg N ha^{-1}) throughout the country. Nitrogen is a most limiting nutrient to crop production and it's use is increasing over the years because most of the Indian soils are deficient in available nitrogen (Sahota and Saini, 1998). In loamy sand texture of soil, leaching of plant nutrients especially of nitrogen under irrigated farming is another causative factor for low nitrogen content of soil. Results of the experiments conducted in various parts of the country indicates that mustard crop responded appreciably to nitrogen fertilization. High rates of N fertilizers are usually applied to this crop in order to obtain maximum seed yield because of its low harvest index (Schjoerring *et al*., 1995) due to low (33 %) nitrogen use efficiency (NUE) at agricultural fields (Abrol *et al*., 1999; Zhu and Chen, 2002). Many approaches such as optimal time, rate, and methods of application for matching N supply with crop demand; the use of specially formulated forms of fertilizer, including those with urease and nitrification inhibitors; the integrated use of fertilizer, manures, and/or crop residues; and optimizing irrigation management have been suggested for increasing NUE (Abrol *et al*., 1999; Abdin *et al*., 2004 and Raghuram *et al*., 2006). But their adoption at the farm level has been limited for various reasons in developing countries. There are good opportunities for improving NUE by the identification of genotypes, which can grow and yield well under low N conditions *i.e.* N-efficient genotypes. Information about the nitrogen economy of oilseed Brassica species is meagre as most of our studies have concentrated on the NUE of cereals crops. The present investigation provides information about the effects of N on agro-physiological traits, yield contributing traits to find out the genotypes that can produce as optimum seed yield under limited N supply, and help in reducing the nitrogen load in the environment.

Materials and Methods

The experiment was conducted at research farm of the ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur located at 77°3' E longitude, 27°15' N latitude and at an altitude of 178.37 meter above mean sea level. The region falls under Agro climatic Zone III B (Flood prone eastern plain) with sub-tropical and semi-arid climate. The climate of this zone is typically semi-arid, characterized with wide range of temperature between summer and winter. High temperature with high wind velocity during summers and low temperature during winters are the characteristic features of climatic condition. The average rainfall of the locality is around 650 mm of which 85 % is contributed by SW monsoon during July to September. The mean weekly maximum and minimum temperature during the crop growing season of mustard fluctuated between 20.8 to 40.9°C and 7.0 to 25.1°C. The mean daily evaporation from 'USWB class A' pan evaporimeter ranged from 1.0 to 9.7 mm per day. The average relative humidity fluctuated between 20.4 to 57.8 percent at noon. The bright sunshine hours varied from 5.9 in January to 10.3 in April. The soil pH and EC of the experimental area were 8.3 and 1.3 dS m^{-1}, respectively. The soil before the experiment was poor in organic carbon (2.4 g kg^{-1}) and available N (126.3 kg ha^{-1}), while moderate in 0.5N $NaHCO_3$ extractable P (17.2 kg ha^{-1}) and 1.0N NH_4OAc exchangeable K (149.3 kg ha^{-1}). The bulk density was 1.52 Mg m^{-3}. The treatments comprising two levels of nitrogen (N) and 22 genotypes Indian mustard making forty-four treatment combination, were laid out in factorial randomized block design and randomly allocated using random number Table (Fisher, 1950) and replicated three times. Nitrogen (80 kg N ha^{-1}) was applied through urea (46 % N) as per the treatment. The half dose of N was drilled in furrows at 8-10 cm depth before sowing and another half dose was top dressed at first irrigation.

The crop was sown by 'mustard seeder' in the rows at 45 cm apart along with fertilizer application using 4 kg seed ha^{-1}. The crop was harvested from net plot area (4 × 8.7 m, 8 rows) from each plot. The harvested material of each plot was tied up in bundles and tagged. The five plants were selected randomly from each plot and tagged. Height of individual plant at harvest from base of the plant to top the main shoot were recorded by a meter scale and average was computed. Plants from one-meter row length at harvest were dried in air for some time and finally in an electric oven at 70°C till constant weight and dry weight averaged. Number of primary and secondary branches was counted at harvest from the same five tagged plants (used for plant height) and average was worked out. At harvest, total number of siliquae of five tagged plants was counted and average was calculated. Number of seeds per siliqua was recorded at harvest by counting the number of seeds of randomly selected siliqua from tagged five plants and average was taken. One thousand seeds were counted from each sample drown from the finally winnowed and cleaned produce of each plot and their weight was recorded. The total biomass harvested from each plot was threshed and cleaned. The seeds so obtained were weighed and then converted in to kg ha^{-1}. Stover yield was calculated by deducting the seed yield (kg ha^{-1}) from the biological yield (kg ha^{-1}). The ratio of economic yield (seed yield) to biological yield worked out to estimate harvest index and expressed as percentage (Singh and Stoskopf, 1971). To test the significance of variance in the data obtained for various character, the analysis of various technique (Fisher, 1950) for 'Factorial Randomized Block Design' was adopted. Significance of difference among the treatment effects was tested through 'F' test and critical difference (CD) was calculated, wherever, the results were found significant.

Results and Discussion

Growth attributes

Application of 100 % N recorded highest plant height (212 cm) increased by 14.4 % over application of 50 % N at harvest. Among the genotypes, RH 1140 recorded highest plant height 225 cm at harvest followed by RH 601 and RH 1223. Application of 100 % N recorded highest dry matter 94 g $plant^{-1}$ at harvest increased by 42.4 % higher over application of 50 % N at 120 DAS. Among the genotypes, RH 749 at 120 DAS recorded highest dry matter Application of 100 % N recorded highest stem girth of 6.7 cm at harvest. Application of 100% increased stem girth by 81.1 % over application of 50 % N. Among the genotypes, RH 1215 followed by RH 555 recorded highest stem girth of 5.9 and 5.8 cm, respectively. Application of 100 % N recorded highest primary branch of 12 $plant^{-1}$ at harvest which was 135.3 % higher over 50 % N, respectively. Among the genotypes RH 1118 at harvest recorded the highest primary branches. Application of 100 % N recorded highest secondary branches 29.4 $plant^{-1}$ at harvest which was 180 % higher over 50 % N, respectively. Among the genotypes RH 1140 (29.9 $plant^{-1}$) and RH 1118 (24.3 $plant^{-1}$) at harvest recorded the highest secondary branches (Table 1). Significantly higher plant height, dry matters accumulation and number of primary and secondary branches per plant recorded at all the growth stages of plant as a result of N application may be attributed to better nutritional environment in the root zone as well as the plant system. It is obvious that N is the most indefensible of all mineral nutrients for growth and development of all the plants as it is the basis of fundamental constitute of all living matter. It plays an important role in plant metabolism by virtue of being an essential constituent of diverse types of metabolically active compounds, like amino acid, portions, nucleotides, prophyrins, flavins, and phyrimidine nucleotides, enzymes, co-enzymes and alkaloids. The biological role of nitrogen as an essential constituent of chlorophyll in harvesting solar energy and accelerated the photosynthetic rate and ultimately increased supply of carbohydrate to plant which results in to the increased dry matters per unit area, plant height and number of primary and secondary braches per plant. Jat (1979), Bhati and Rathore (1982), Chauhan *et al*. (1994), Kumar and Kumar (2011) and Banerjee *et al.* (2012) have also reported the similar findings. The genotypes significantly differed in growth parameters. Among the genotypes, RH 1140 recorded highest plant height, whereas, RH 749 recorded highest dry matter. The highest stem girth, primary and secondary branches and main shoot length at harvest were found in RH 1215, RH 1118 and RH 1223, respectively. Plants with high N use efficiency taken up N efficiently from the soil and recorded higher plant height, dry matter accumulation, chlorophyll content and leaf area index. The genotypes with such traits are highly desirable because these can be grown with limited N supply for environment friendly farming systems. Similar results were also reported by Saud *et al*. (2016), Ahmad *et al*. (2008) and Patil *et al*. (1996).

Table 1: Effect of N levels and genotypes on growth attributes of Indian mustard at harvest

Treatment	Plant height (cm)	dry matter accumulation (g plant^{-1}) at 20 DAS	Primary branches plant^{-1}	Secondary branches plant^{-1}	Stem girth (cm) at 120 DAS
Nitrogen					
100 % N	212	94	12.0	29.4	6.7
50 % N	186	66	5.1	10.5	3.7
SEm±	2.0	1	0.1	0.3	0.1
CD at 5%	5.6	2	0.4	0.9	0.9
Genotypes					
RH 555	194	74	6.9	17.4	5.8
RH 1222-28	206	62	7.2	18.8	5.6
RH 1301	202	84	7.8	19.9	5.1
RH 749	206	148	8.2	20.2	5.5
DRMRIJ 31	183	101	9.4	20.2	4.7
RH 1215	199	88	8.7	19.6	5.9
NRCHB 101	211	99	9.7	20.3	4.6
RH 1210	200	82	9.2	18.2	5.2
RH 1053	205	68	8.7	19.0	5.4
RH 1223	214	79	8.5	21.7	5.4
NRCDR 02	211	66	7.6	18.8	5.1
RH 601	222	76	7.8	17.4	5.4
RH 1140	225	80	11.5	29.9	5.6
RH 1118	193	89	10.4	24.3	5.2
RH 345	192	69	8.3	19.8	4.8
RH 1441	204	70	7.6	24.0	5.3
RH 1060	192	76	7.9	16.7	5.4
RH 1117	188	84	7.6	16.0	5.2
RH 1019	194	76	7.3	19.0	5.1
RH 1134	200	79	7.0	14.2	5.7
RH 1138	181	81	8.7	22.2	4.4
RH 1172	190	92	7.7	21.5	4.6
SEm±	6.6	2	0.4	1.1	0.2
CD (p=0.05)	18.6	7	1.2	3.0	0.5
CV (%)	8.1	7	12.7	13.3	8.2

Yield attributes

Application of 100 % N recorded highest main shoot length of 78 cm at harvest which was 23.9 % higher over 50 % N. Among the genotypes RH 1223 recorded the highest main shoot length (79 cm) followed by DRMRIJ 31 and RH 1140 (74 cm). Application of 100 % N recorded highest number of siliqua of 51 plant^{-1} at harvest which was 31.4 % higher over 50 % N. Among the genotypes, RH 749 recorded the highest number of siliqua on main shoot (51 plant^{-1}) followed by RH 1301 (51 plant^{-1}) and RH 1138 (49 plant^{-1}). Application of 100 % N recorded highest number of seeds siliqua^{-1} of 16 which was 3.9 % higher over 50 % N. Among the genotypes, RH 1215 recorded the highest number of seeds siliqua^{-1} (17.8) followed by DRMRIJ 31 (17.7) and RH 747 (7.5). Application of 100% N recorded highest seeds weight (5.4 g siliqua^{-1}) and siliqua wall weight (4.9 g siliqua^{-1}) which were 42.1 and 44.1% higher over 50% N. However, application of N did not improve seed: siliqua wall ratio (1.1). Among the genotypes, RH 1441 recorded the highest seeds weight siliqua^{-1} (6.1 g siliqua^{-1}) followed by RH 555 and RH 1222-28 (5.9 g siliqua^{-1}). The seed: siliqua wall ratio was recorded in NRCHB 101 (1.4) followed by RH 1222-28, RH 749 and DRMRIJ 31 (1.3) (Table 2). Application of N significantly increased that number of sillquae per plant, seeds per siliqua and test weight. An adequate supply to nitrogen early in the life of a plant is considered important in promoting rapid vegetable growth and branching, thereby increasing the sink size

Table 2: Effect of N levels and genotypes on yield attributes of Indian mustard

Treatment	Main shoot length (cm)	Number of siliquae on main shoot	Number of seeds per siliqua	Seed weight siliqua^{-1} (g)	Siliqua wall weight siliqua^{-1}(g)	Seed: Siliqua wall ratio
Nitrogen						
100% N	78	51	16.0	5.4	4.9	1.1
50% N	63	39	15.4	3.8	3.4	1.1
SEm±	0.7	0.6	0.2	0.1	0.0	-
CD at 5%	2.1	1.6	0.5	0.1	0.1	-
Genotypes						
RH 555	73	42	15.0	5.9	5.1	1.2
RH 1222-28	71	45	15.5	5.9	4.7	1.3
RH 1301	69	51	15.1	3.8	3.6	1.1
RH 749	64	51	17.5	5.6	4.4	1.3
DRMRIJ 31	74	48	17.7	5.1	3.9	1.3
RH 1215	66	42	17.8	4.7	4.2	1.1
NRCHB 101	68	42	17.0	4.6	3.3	1.4
RH 1210	74	45	15.3	4.3	3.9	1.1
RH 1053	67	41	16.1	3.9	4.0	1.0
RH 1223	79	46	17.4	5.0	4.6	1.1
NRCDR 02	71	44	16.3	4.1	3.7	1.1
RH 601	70	47	15.6	3.9	3.3	1.2
RH 1140	74	40	16.6	4.9	5.1	0.9
RH 1118	74	49	13.4	4.6	4.9	0.9
RH 345	72	48	14.5	2.5	2.4	1.1
RH 1441	72	47	15.5	6.1	5.8	1.1
RH 1060	68	42	15.4	5.6	4.7	1.2
RH 1117	72	45	15.9	5.4	4.9	1.1
RH 1019	68	44	15.5	4.8	4.5	1.1
RH 1134	70	44	15.4	5.5	5.3	1.1
RH 1138	68	49	14.3	2.6	2.1	1.2
RH 1172	69	46	15.6	3.0	2.6	1.2
SEm±	2.4	1.9	0.6	0.2	0.1	-
CD (p=0.05)	6.8	5.3	1.8	0.5	0.3	-
CV (%)	8.4	10.1	9.9	8.8	7.2	-

in terms of flowering seed setting. Thus, nitrogen fertilization stimulated seed setting and increased the number of silique per plant and test weight significantly. Thus, improved overall growth and profuse branching due to nitrogen coupled with increased net photosynthesis on one hand and greater mobilization of photosynthates towards sink significantly. Similar results have also been reported by Ghatak *et al*. (1992); Singh *et al*. (1985); Arthamwar *et al*. (1996). Among the genotypes, RH 749 recorded the highest number of siliqua on main shoot, RH 1215 recorded the highest number of seeds siliqua^{-1}, RH 1441 recorded the highest seed weight siliqua^{-1}.

Yield, harvest index and test weight

Application of 100 % N recorded highest biological yield (9260 kg ha^{-1}) which was 31.6 % higher over 50 % N. Among the genotypes, NRCDR 02 recorded the highest biological yield (10728 kg ha^{-1}) followed by RH 1210 (10321 kg ha^{-1}) and RH 749 (10083 kg ha^{-1}). Application of 100% N recorded highest seed yield (2666 kg ha^{-1}) which was 61.7 % higher over 50 % N. Among the genotypes, RH 749 recorded the highest seed yield (2985 kg ha^{-1}) followed by DRMRIJ 31 (2868 kg ha^{-1}) and RH 1215 (2754 kg ha^{-1}). Application of 100% N recorded highest stover yield (6595 kg ha^{-1}) which was 22.5 % higher over 50 % N. Among the genotypes, NRCDR 02 recorded the highest stover yield (8366 kg ha^{-1}) followed by RH 1210 (7895 kg ha^{-1}) and RH 1223 (7777 kg ha^{-1}). Application of 100 % N recorded highest harvest index (28.9 %) which was 20.9 % higher over 50 % N. Among the genotypes, NRCHB 101 recorded the highest harvest index (31.8 %) followed by DRMRIJ 31 (30.2) and RH 1222-28 (29.8). Application of 100 % N recorded highest (6.4 g) which was 4.9 % higher over 50 % N. Among the genotypes, RH 555 recorded the highest

Table 3: Effect of N levels and genotypes on yield, harvest index and test weight of Indian mustard.

Treatment	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Test weight (g)
Nitrogen					
100% N	9260	2666	6595	28.9	6.4
50% N	7034	1649	5385	23.9	6.1
SEm±	131	34	109	0.3	0.1
CD at 5%	370	95	306	1.0	0.3
Genotypes					
RH 555	6924	1879	5045	26.4	7.6
RH 1222-28	7462	2239	5223	29.8	7.0
RH 1301	8407	2133	6275	25.4	6.5
RH 749	10083	2985	7098	29.4	6.5
DRMRIJ 31	9569	2868	6702	30.2	7.2
RH 1215	10069	2753	7316	27.3	5.6
NRCHB 101	8229	2599	5630	31.8	6.5
RH 1210	10321	2427	7895	23.6	7.1
RH 1053	9446	2502	6945	26.4	6.4
RH 1223	9921	2143	7777	21.0	6.4
NRCDR 02	10728	2361	8366	22.0	6.2
RH 601	9239	2678	6561	29.1	6.3
RH 1140	8910	2071	6839	22.6	6.4
RH 1118	9206	2111	7095	22.0	7.5
RH 345	6892	1876	5016	26.8	5.0
RH 1441	5758	1697	4062	29.7	6.6
RH 1060	6609	1785	4824	27.2	5.7
RH 1117	6511	1825	4686	27.3	5.8
RH 1019	5408	1472	3936	26.6	6.0
RH 1134	5447	1360	4088	24.3	7.1
RH 1138	7889	2086	5802	26.1	4.3
RH 1172	6208	1614	4594	25.6	4.2
SEm±	436	112	360	1.1	0.3
CD (p=0.05)	1227	314	1014	3.2	0.9
CV (%)	13	13	15	10.5	12.8

test weight (7.6 g) followed by RH 1118 (7.5) and DRMRIJ 31 (7.2 g) (Table 3).

A significantly increase in both seed and stover yield was recorded with the application of 100 % N. Conversely deficiency of N in the experimental field as seen from Table 3.2 affected the crop growth, number of siliquae per plant, seeds per siliqua and test weight adversely under limited N supply. The seed yield, being a function primarily of the cumulative effect of these parameters, increased significantly with the application of N. Similar results have also been obtained by Chainara and Damor (1982), Khanpara *et al*. (1993), Gupta (1995), Zheljazkov *et al.* (2012) and Vineet *et al.* (2016). The genotypes, NRCDR 02 recorded the highest biological yield and stover yield, whereas, RH 749 recorded the highest seed yield both under normal and limited N supply. The maximum harvest index and test weight was recorded in NRCHB 101 and RH 555, respectively. The genotypes which accumulated higher N contents than genotypes with low N use under limited N conditions have more N use efficiency. High N use is essential for optimum seed yield, because these genotypes utilize absorbed N very efficiently.

Conclusion

The application of 100 % N significantly increased plant growth and yield parameters and yield. The genotypes varied in the growth pattern and yield and quality. RH 749 recorded highest dry matter and siliqua weight plant^{-1}, seed yield. The stem girth, primary and secondary branches and main shoot length were highest in RH 1215, RH 1118 and RH 1223, respectively at harvest. The maximum yield attributes were found in RH 1215, whereas biological yield and stover yield were found maximum in NRCDR 02. The maximum harvest index and test weight was recorded in NRCHB 101 and RH 555, respectively. Thus, under normal N supply (100 % N), var. RH 749 followed by DRMRIJ 31 and RH 1215 is recommended for cultivation in the region. However, under limited N supply (50% N), DRMRIJ 31 followed by RH 1215 and RH 601 is recommended for cultivation in rainfed conditions of Bharatpur region.

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