Indian Journal of Agronomy **62** (3): 374–377 (September 2017)

Research Communication

Variability in Indian mustard (*Brassica juncea*) genotypes in response to applied phosphorus

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Received : July 2016; Revised accepted : April 2017

ABSTRACT

A field study was conducted during the winter season (*rabi*) 2012–13 at Ludhiana, Punjab, to identify the phosphorus-efficient genotypes of Indian mustard [*Brassica juncea* (L.) *Czernj. & Cosson*]. Application of 15 kg/ha of P_2O_5 increased the seed yield by 6.8% and stover yield by 8.5% over the control, whereas the increase with 30 kg/ha of P_2O_5 over 15 kg/ha of P_2O_5 was non-significant. The increase in oil content and P uptake at maturity with successive dose of phosphorus was also significant. Among genotypes, 'NRCHB 101' with the highest seed (1.91 t/ha) and stover (7.29 t/ha) yields outyielded all the other tested genotypes by significant margin of 6.7–30.8% for seed yield and 9.0–30.9% for stover yield. Genotype 'NRCDR 2' registered significantly higher oil content (40.2%), while 'NRCHB 101' registered significantly higher total phosphorus uptake at maturity (21.52 kg/ha). Interactions between doses of phosphorus and genotypes for all the parameters were found non-significant.

Key words: Genotypes, Indian mustard, Oil content, Phosphorus uptake, Yield

Indian mustard with a share of about 80% in area and production in the country is the most important *Brassica* species among different rapeseed-mustard crops. Rapeseed–mustard group of crops have relatively high phosphorus(P) requirement. Phosphorus deficiency in crop fields has been observed worldwide (Vance *et al.,* 2003) including India (Muralidharudu *et al*., 2011). Low temperature during the winter season and inadequate moisture under conserved moisture or limited irrigation conditions in the semi-arid region of the country reduce solubilization of fixed forms of P and its uptake by the plants. High P fixation and low P uptake rate make it imperative to evaluate P-efficient germplasm for developing P-efficient cultivars (Fageria *et al.,* 2008) so as to reduce P fertilizer requirements and sustain productivity on low P soils. Genetic improvement of P-nutrition traits in crops is considered to be more economical and sustainable than application of P fertilizers. The aim of the present investigation was to study the variability in Indian mustard genotypes of different genetic background for growth, yield attributes, yields and use efficiency in response to phosphorus application rates so as to identify the P-efficient genotypes.

The field experiment was conducted at the research farm of Oilseeds Section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana during the winter (*rabi*) 2012–13. The soil was loamy sand, free from salts (EC 0.10 dS/m), neutral in reaction (*p*H 7.8) with low organic carbon content (0.37%), low in available nitrogen (245 kg/ha), low in Olsen's available phosphorus (11.7 kg/ha) and rich in NH_4OAc-extractable potassium (165 kg/ha) in the 0–15 cm soil depth. Treatments comprising 3 doses of phosphorus (0, 15 and 30 kg P_2O_5/ha) in the mainplots and 14 genotypes of Indian mustard ('RLC 1', 'PBR 210', 'PBR 91', 'RLM 619', 'RL 1359', 'PBR 357', 'ELM 123', 'NRCDR 2', 'NRCHB 101', 'Pusa Bold', 'Varuna', 'MLM 19', 'NPJ 79', and 'PLM 2') in the subplots were replicated thrice. The gross and net plot size were 18.0 m^2 (3.0 m × 6.0 m) and 9.0 m^2 (1.8 m × 5.0 m) respectively. The test genotypes were sown on 5 November 2012 and harvested on 8 April 2013.

Phosphorus as per treatments was applied through single superphosphate at the time of sowing. Nitrogen @ 50 kg/ha as urea and potassium @ 15 kg/ha as muriate of potash were also applied at sowing. Another dose of 50

Based on a part of M.Sc. (Agriculture) Thesis of the first author, submitted to Punjab Agricultural University, Ludhiana, Punjab (Unpublished)

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kg/ha of N as urea was top-dressed after the first irrigation. The row spacing was kept as 30 cm and plant-to-plant spacing of 12–15 cm was maintained at 3 weeks after sowing. Data were recorded on plant height from 10 random plants, branching and number of siliquae/ plant from 5 random plants at physiological maturity, number of seeds/ siliqua from 25 random selected siliquae/plant, 1,000-seed weight from a representative sample of seeds after threshing. The biomass, seed and stover yields from 6 inner rows were recorded. For dry-matter accumulation, plants were cut at the base in the 0.5 m row length from second outermost row in each plot, were dried first under shade and later in oven at 65 ± 2^{c}C till constant weight. Phosphorus content in seed and stover was determined by Vanado-molybdo-phosphoric yellow colour method. The uptake of phosphorus by seed and stover at harvesting was worked out by multiplying per cent phosphorus content in seed and stover with respective yields.

Application of 15 kg/ha of P_2O_5 resulted in significant increase (9.3%) in DMA over without its application, whereas application of 30 kg/ha of P_2O_5 significantly increased the plant height (2.0%) and DMA (4.9%) over 15 kg/ha of P_2O_5 (Table 1). Number of siliquae/plant, seeds/ siliqua and seed weight are the major yield-forming traits in rapeseed–mustard. Phosphorus application up to 30 kg/ ha of P_2O_5 increased the total number of siliquae/plant by 8.2% and 16.3% over application of 15 kg/ha of P_2O_5 and without its application respectively. Application of 15 kg/ ha of P_2O_5 increased number of seeds/siliqua by 5.7% and 1,000-seed weight by 1.7% over the control, whereas application 30 kg/ha of P_2O_5 increased seeds/siliqua by 4.5% and 1,000-seed weight by 6.7%t over 15 kg/ha of P_2O_5.

Application of 30 kg/ha of P_2O_5 increased the seed yield (1.77 t/ha) by 9.9% and 2.9% and stover yield (6.58 t/ha) by 15.2% and 4.9% over the control and 15 kg/ha of P_2O_5, respectively, whereas application of 15 kg/ha of P_2O_5 significantly increased the seed yield (1.72 t/ha) by 6.8% and stover yield (6.27 t/ha) by 8.5% over the control. Higher seed and stover yields with successive higher doses of phosphorus could be attributed to the improvement in vegetative growth (height and DMA) and yield-forming traits (siliquae/plant, seeds/siliqua and 1,000-seed weight). Similar positive and significant relationships have been reported between seed yield with DMA (Mir *et al.*,

Table 1. Growth, yield attributes, yields, oil content, phosphorus uptake, agronomic efficiency and physiological efficiency of Indian mustard as influenced by doses of phosphorus and genotypes

Treatment	Plant height (cm) at maturity	Dry-matter (t/ha) at maturity	Primary branches	Siliquae/ plant	Seeds/ siliqua	1,000-seed weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Oil (%)	Total phosphorus uptake (kg/ha)	AE (kg seed/ kg P_2O_5)	PE (kg seed/ kg P uptake)
Phosphorus (kg P_2O_5/ha)												
0	162.9	7.26	4.2	214	10.6	4.61	1.61	5.71	38.9	13.1	-	-
15	165.5	7.93	4.4	230	11.2	4.69	1.72	6.27	39.1	16.9	7.7	80
30	168.8	8.32	4.7	249	11.7	4.92	1.77	6.58	39.3	19.4	5.3	72
SEm±	1.09	0.14	-	5.04	0.04	0.06	0.02	0.12	0.04	0.52	-	-
CD (P=0.05)	2.8	0.38	NS	14	0.1	0.17	0.07	0.34	0.1	1.45	-	-
Genotypes												
'RLC 1'	167.8	7.53	4.0	240	11.1	4.55	1.73	6.08	37.7	18.1	5.0	59
'PBR 210'	166.0	8.23	4.7	221	11.4	4.57	1.77	6.46	39.1	15.9	8.6	76
'PBR 91'	168.3	7.23	4.6	240	11.3	4.84	1.66	5.57	39.7	15.3	9.3	82
'RLM 619'	161.8	7.97	4.0	245	10.7	4.70	1.74	6.23	39.6	17.7	6.6	67
'RL 1359'	160.1	7.88	4.1	217	10.7	4.72	1.74	6.14	39.6	15.9	4.7	60
'PBR 357'	165.6	8.11	4.6	211	10.4	5.56	1.72	6.39	39.1	15.9	7.3	73
'ELM 123'	162.2	7.29	4.4	249	11.1	4.17	1.69	5.59	37.5	15.7	6.2	65
'NRCDR 2'	168.4	7.59	4.7	207	11.0	5.08	1.65	6.04	40.2	16.5	6.2	93
'NRCHB 101'	166.6	9.19	4.8	252	12.8	4.62	1.91	7.29	39.6	21.5	5.3	61
'Pusa Bold'	162.4	7.77	4.4	236	10.4	5.61	1.79	5.99	39.5	17.4	9.4	96
'Varuna'	160.2	7.06	4.7	251	11.6	5.36	1.66	5.68	39.2	15.4	9.3	75
'MLM 19'	168.7	7.59	4.5	221	10.8	4.52	1.53	6.06	38.5	13.9	5.2	95
'NPJ 79'	170.4	7.86	4.0	217	12.3	3.85	1.46	6.40	39.6	14.7	5.0	70
'PLM 2'	171.6	8.40	4.6	233	10.8	4.25	1.71	6.69	39.0	17.1	3.5	95
SEm±	1.85	0.31	0.25	15.5	0.15	0.13	0.05	0.28	0.20	0.56	-	-
CD (P=0.05)	3.70	0.61	0.50	31	0.30	0.27	0.11	0.56	0.40	1.55	-	-

AE, Agronomic efficiency (kg seed/kg P_2O_5); PE, physiological efficiency (kg seed/kg P uptake)

2010), siliquae/plant, seeds/siliqua (Mir *et al.,* 2010) and 1,000-seed weight (Kumar and Yadav, 2007).

The oil content increased consistently and significantly with each increasing dose of phosphorus up to 30 kg/ha of P_2O_5. Apart from direct role of phosphorus in synthesis of phospholipids, higher dose of phosphorus also supplied more amount of sulphur which is involved in oil synthesis, from single superphosphate used as source of P. Application of 30 kg/ha of P_2O_5 resulted in significantly higher (14.2%) total (seed + stover) P uptake than that of 15 kg/ha of P_2O_5 which in turn resulted in significantly higher total P uptake (28.9%) than the control (13.18 kg/ha). Reddy and Sinha (1988) reported significant increase in phosphorus uptake in Indian mustard up to 30 kg/ha of P_2O_5.

Agronomic efficiency (increase in seed yield (kg/ha) per unit of applied phosphorus) and physiological efficiency (increase in seed yield/unit increase in phosphorus uptake with P application in comparison to without application of phosphorus) with application of 15 kg/ha of P_2O_5 were higher than 30 kg/ha of P_2O_5. At lower dose of phosphorus application, its amount available to plants was low and there might have been more competition between plants in comparison to higher dose where due to sufficiency of the nutrient, its utilization decreased.

Genotypes 'PLM 2', 'NPJ 79', 'MLM 19', 'NRCDR 2' and 'PBR 91' attained statistically similar (168.3–171.6 cm) and significantly more plant height than 'RL 1359', 'Pusa Bold', 'RLM 619', 'ELM 123' and 'Varuna' (160.1 cm–162.4 cm). The DMA by 'NRCHB 101' (9.19 t/ha) was significantly higher than all other test genotypes (7.06–7.59 t/ha). Genotype NRCHB 101 also produced the highest (4.8) and significantly more primary branches/plant than 'RLC 1', 'RLM 619', 'RL 1359' and 'NPJ 79'. Genotype 'NRCHB 101' also produced significantly more siliquae/plant (252) than 'PBR 357', 'NRCDR 2', 'RL 1359' and 'NPJ 79'. Genotype 'NRCDR 2' (207) produced significantly lower siliquae/plant than 'RLC 1', 'PBR 91', 'RLM 619', 'ELM 123', 'Varuna' and 'NRCHB 101'. Seeds/siliqua produced by 'NRCHB 101' (12.8) were also significantly higher than rest of the test genotypes. Pusa Bold produced the highest 1,000-seed weight (5.61 g) which was at par with 'PBR 357' (5.56 g) and 'Varuna' (5.36 g) and significantly higher than rest of genotypes, whereas 'NPJ 79' (3.85 g) produced significantly lower 1,000-seed weight than all the test genotypes. Significant variations in cultivars of Indian mustard were reported by Rana and Pachauri (2001) for number of siliquae, number of seeds/siliqua and 1,000-seed weight, by Gurjar and Chauhan (1997) for number of branches/plant and number of seeds/siliqua, and by Singh *et al.* (2002) for 1,000-seed weight.

Genotype 'NRCHB 101' gave the highest seed yield (1.91 t/ha) and stover yield (7.29 t/ha) and significantly outyielded all the other tested genotypes by margin of 6.7%–30.8% for seed yield and 9.0%–30.9% for stover yield. Genotype 'NPJ 79' gave the lowest seed yield (1.46 t/ha) and 'PBR 91' (5.57 t/ha) the lowest stover yield. The highest seed yield given by 'NRCHB 101' may be ascribed to its highest dry-matter, siliquae/plant and seeds/siliqua. Rana and Pachauri, (2001); Kumar and Yadav, (2007) reported similar differences among Indian mustard cultivars for seed and stover yields Interactions between doses of phosphorus and genotypes for different growth and yield attributes, seed and stover yields were non-significant.

Genotype 'NRCDR 2' registered significantly higher oil content (40.2%) than the remaining genotypes. Genotype 'NRCHB 101' exhibited significantly higher total (seed + straw) phosphorus uptake (21.52 kg/ha) than rest of the genotypes. Such an increase in phosphorus uptake in 'NRCHB 101' ranged from 3.4 kg/ha over 'RLC 1' to 7.62 kg/ha over 'MLM 19'. Observed differences in P uptake were mainly due to similar differences in yields of different genotypes. Genotype 'NRCHB 101' also attained highest P content in seed (0.67%) and stover (0.12%). 'Pusa Bold' Indian mustard attained the highest agronomic efficiency (9.4) closely followed by 'Varuna' and 'PBR 91' (9.3) genotypes and, physiological efficiency (96) followed by 'MLM 19' and 'PLM 2' (95). These differences may be due to genotypic differences in P utilization and exudation of organic acids in rhizosphere which facilitate solubilization of fixed forms of P (Zhang *et al.,* 2009).

Thus application of P_2O_5 up to 30 kg/ha significantly increased the DMA at maturity, number of siliquae/plant, seeds/siliqua and 1,000-seed weight. Seed and stover yields though increased up to 30 kg/ha of P_2O_5 but significantly up to 15 kg/ha of P_2O_5. Among the genotypes, 'NRCHB 101' with the highest seed yield (1.91 t/ha), stover (7.29 t/ha) yield and total P uptake (21.52 kg/ha) outyielded all the other tested genotypes by significant margin for seed yield (6.7-30.8%), stover yield (9.0–30.9%) and total P uptake (18.8–46.1%) due to highest dry DMA at maturity, primary branches/plant, number of siliquae/plant and seeds/siliqua. Seed yield given by 'NPJ 79' (1.46 t/ha) was significantly lower than rest of the genotypes except 'MLM 19' (1.53 t/ha). Cultivar 'PBR 91' (5.57 t/ha) produced the lowest stover yield. Genotype 'NRCDR 2' registered significantly higher oil content (40.2%) than the remaining genotypes of Indian mustard.

REFERENCES

Fageria, N.K., Baligar, V.C., and Li, Y.C. 2008. The role of nutrient efficient plants in improving crop yields in the twenty-first century. *Journal of Plant Nutrition* **31**(6): 1,121–1,157.

Gurjar, B.S. and Chauhan, D.V.S. 1997. Yield attributes and seed yield of Indian mustard (*Brassica juncea*) as influenced by varieties, fertility levels and spacing in Harsi command area. *Indian Journal of Agronomy* **42**(2): 142–144.

Kumar, H. and Yadav, D.S. 2007. Effect of phosphorus and sulphur levels on growth, yield and quality of Indian mustard (*Brassica juncea*) cultivars. *Indian Journal of Agronomy* **52**(2): 154–157.

Mir, M.R., Mobin, M., Khan, N.A., Bhat, N.A., Lone, N.A., Bhat, K.A., Razvi, S.M., Wani, S.A., Wani, N., Akhter, S., Rashid, S., Masoodi, N.H. and Payne, W.A. 2010. Effect of fertilizers on yield characteristics of mustard [*Brassica juncea* (L.) Czern & Coss]. *Journal of Physiology* **2**(10): 20–24.

Muralidharudu, Y., Sammi Reddy, K., Mandal, B.N., Subba Rao, A., Singh, K.N. and Sonekar, S., 2011. *GIS Based Soil Fertility Maps of Different States of India.* AICRP-STCR, IISS, Bhopal, pp. 224.

Rana, D.S. and Pachauri, D.K. 2001. Sensitivity of zero erucic acid genotypes of oleiferous *Brassica* to plant population and planting geometry. *Indian Journal of Agronomy* **46**(4): 736–740.

Reddy, B.N. and Sinha, M.N. 1988. Yield and phosphorus utilization of mustard as influenced by phosphorus at various levels of N and moisture regimes. *Fertiliser News* **33**(2): 31–37.

Singh, R, Rao, V.U.M., Singh, D. and Surakant. 2002. Effect of sowing date and plant density on pheonological behaviour, yield and its attributes in oilseed *Brassica*. *Journal of Oilseeds Research* **19**(1): 119–121.

Vance, C.P., Uhde-Stone, C. and Allan, D.L. 2003. Phosphorus acquisition and use: Critical adaptations by plants for screening a non-renewable resources. *New Phytologist* **157**: 423–447.

Zhang, H., Huang, Y., Ye, X., Shi, L. and Xu, F. 2009. Genotypic differences in phosphorus acquisition and the rhizosphere properties of *Brassica napus* in response to low phosphorus stress. *Plant and Soil* **320**(1): 91–102.