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Selection parameter analysis in Indian mustard (*Brassica juncea*) germplasm under normal sown condition

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Abstract
The maximum value of heritability and genetic advance were found for days to 50% flowering, length of main raceme and 1000-seed weight. Grain yield showed highly significant and positive association with harvest index, while negative and highly significant association with number of secondary branches per plant at both genotypic and phenotypic level. Number of primary branches per plant, number of secondary branches per plant, oil content and 1000-seed weight had positive direct effects whereas; days to 50% flowering, plant height, days to maturity and seed yield per plant had negative direct effect on seed yield.

Keywords: Parameter, Indian mustard, *Brassica juncea*

Introduction
Historically the brassicas are one of the earliest domesticated crop plants by man. Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis* Jacq.) oil. Among the seven edible oilseed (groundnut, rapeseed-mustard, sesame, linseed, sunflower, safflower and niger) cultivated in India, rapeseed-mustard (*Brassica spp*.) contributes 28.6% in the total production of oilseeds. The edible oil industry is one of the most vibrant sectors of the Indian agriculture economy. The county ranks first in the world in the production of castor, safflower, sesame and niger; second in groundnut; third in rapeseed-mustard and linseed and fourth in soybean. Indian mustard [*Brassica juncea* (L.) Czern & Coss], which is cultivated under the genus *Brassica* is cultivated all over India and it is throughout the world belongs to family Cruciferae (Brassicaceae). It has 38 to 42 % oil and 24% protein.

Materials & Methods
The present experiment was conducted using 25 diverse origin genotypes/ varieties/ lines/ hybrids of Indian mustard (*Brassica campestris* L. Czern & Coss). Materials were tested in randomized block design with two replications at Nawabganj, Research farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during *Rabi* 2016-18. The materials used in the study comprised of 25 germplasm namely; DRMRIJ-31, Basanti, LAHAR, Pusa Bahar, NRH-101, NRC-DR-2, Mutant Varuna, Selection 2016/10, Selection ns/4, Pusa Bold, B-85, Vardan, KR-5610, Ashirvadh, Nav Gold, Pusa Barani, Pusa Jai Kisan, Kranti, Vaibhav, RH-30, Urvashi, Maya, Agarani, NDR-8501 and RLM-198 of Indian mustard. The experiment was laid out in Randomized Block Design with three replications. These lines were grown in single row plot of 5 meter length. The spacing between row to row and plant to plant was 45 cm and 15 cm, respectively maintained by thinning. Recommended agronomic practices were adopted to raise a good crop. Five competitive plants from each plot were randomly selected for recording observations for all the quantitative characters except days to flowering and days to maturity which were recorded on the plot basis. Observations were recorded on thirteen character namely, days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, length of main raceme, number of siliquae per plant, number of seeds per siliqua, 1000-seed weight (g), biological yield per plant (g), harvest index (%), oil content (%) and seed yield per plant (g). Correlation coefficients was calculate as per formula suggested by (Aljibouri *et al.*, 1958) [3]. Path-coefficient was calculate as per formula suggested by (Dewey and Lu, 1959) [5]. Oil content was estimated by using Near Infra-Red Analyzer (NIR) at Directorate of rapeseed-mustard, Bharatpur (Rajasthan).

Results & Discussion

The results of heritability and genetic advance are shown in table-1. The highest magnitude was obtained for the characters viz., days to 50% flowering (77.59%), length of main raceme (77.39%), 1000-seed weight (76.44%), plant height (75.67%), days to maturity (75.23%), number of secondary branches per plant (73.63%), number of siliquae per plant (71.64%), harvest index (70.63%), oil content (70.02%), biological yield per plant (69.09%), seed yield per plant (69.01%), number of primary branches per plant (68.98%), number of seeds per siliqua (67.60%). The high genetic advance in per cent were recorded for number of siliquae per plant (31.39%), medium for plant height (24.03%), length of main raceme (19.07%), days to 50% flowering (16.94%), days to maturity (13.01%) and low for number of secondary branches per plant (5.27%), harvest index (2.10%), biological yield per plant (1.58%), oil content (1.18%), 1000-seed weight (1.17%),seed yield per plant (0.96%), primary branches per plant (0.82%), number of seeds per siliqua (0.71%). Similar results were also observed by Khulbe *et al.* (2000) [8], Khan *et al.* (2006) [7], Acharya *et al.* (2008) [1], Gangwar *et al.* (2009) [6], Singh *et al.* (2013) and Akabari *et al.* (2015) [2].

The results of correlation studies are shown in table-2. At genotypic level seed yield per plant showed highly significant and positive association with harvest index (0.8736), number of seeds per siliqua (0.7347) and biological yield per plant (0.5384) and highly significant and negative correlation with oil content (-0.3521), number of secondary branches per plant (-0.2820), and days to maturity (-0.2003), while significant and positive correlation with number of number of primary branches per plant (0.1254) and negative correlation with plant height (-0.1409).

At phenotypic level seed yield per plant showed highly significant and positive association with harvest index (0.8736) while negative and significant correlation with number of secondary branches per plant (-0.1437) and number of siliquae per plant (-0.1147). Path coefficient analysis revealed that number of primary branches per plant, number of secondary branches per plant, oil content and 1000-seed weight had positive direct effects whereas; days to 50% flowering, plant height, days to maturity and seed yield per plant had negative direct effect on seed yield. These findings were also similar to Singh *et al.* (2003), Singh *et al.* (2003), Kumar *et al.* (2006) [9], Ramanjaneyulu *et al.* (2007) [14], Maurya *et al.* (2013) [12] and Singh *et al.* (2013).

The results of direct and indirect effects are shown in table-3. Path coefficient analysis revealed that number of primary branches per plant, number of secondary branches per plant, oil content and 1000-seed weight had positive direct effects whereas; days to 50% flowering, plant height, days to maturity and seed yield per plant had negative direct effect on seed yield. Similar findings were also observed by Tusar *et al.* (2006) [18], Yadav *et al.* (2011) [19], Ray *et al.* (2014) [15], Sweta *et al.* (2014) [16] and Tahir *et al.* (2014) [17].

Table 1: Heritability, genetic advance per-cent of mean for 13 characters in Indian mustard (*Brassica juncea* L. Czern & Coss).

Character	Heritability (%)	Genetic advance	Genetic advance% over mean
Days to 50% flowering	77.59	16.946	22.484
Days to maturity	75.23	13.013	10.161
Plant height (cm)	75.67	24.034	14.270
No. of primary branches/plant	68.98	0.821	10.446
No. of secondary branches/Plant	73.63	5.279	29.418
Length of main Raceme (cm)	77.39	19.074	35.498
No. of siliquae/ plant	71.64	31.398	9.899
No. of seeds/ siliqua	67.60	0.711	5.391
1000-seed Weight (g)	76.44	1.177	33.535
Biological yield / plant (g)	69.09	1.588	3.063
Harvest index (g)	70.63	2.108	9.270
Oil content (%)	70.02	1.185	3.036
Seed yield/plant (g)	69.01	0.966	8.190

Table 2: Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficient between different character combinations in Indian mustard.

Character	Days 50% flowering	Days to maturity	Plant height (cm)	No. of primary branch/plant	No. of Secondary branch/plant	Length of main raceme (cm)	No. of siliquae/ plant	No. of seeds / siliqua	1000-seed Weight (g)	Biological Yield / plant (g)	Harvest index (%)	Oil Content (%)	Seed yield/ plant (g)
Days 50% flowering	1.0000	0.8125**	0.8931**	0.4124**	0.5586**	0.0161	0.0597	0.1483**	-0.2007**	0.0999	-0.1507**	0.0143	-0.1078
Days to maturity	0.6820**	1.0000	0.6678**	0.4451**	0.2708**	-0.0673	-0.5147**	0.3354**	-0.3236*	0.0079	-0.1773**	0.1785**	-0.2003**
Plant height (cm)	0.7657**	0.5584**	1.0000	0.4426**	0.6520**	-0.0870	0.0374	0.3402**	-0.2794**	0.0014	-0.1095	-0.1526**	-0.1409*
No. of primary branch/plant	0.1918**	0.2460*	0.2135**	1.0000	0.5882**	0.1892**	0.0887	0.8053**	-0.4165**	0.4870**	-0.0295	-0.3992**	0.1254*
No. of secondary branch/plant	0.4260**	0.2460*	0.4432**	0.3722**	1.0000	0.2086**	0.2490**	0.3467**	-0.1694**	0.1216**	-0.3404**	-0.2404**	-0.2820**
Length of main raceme (cm)	0.0150	-0.0469	-0.0534	0.1040	0.1494**	1.0000	0.3355**	0.0165	0.0844	0.1199**	-0.0581	-0.0820	0.0076
No. of siliquae/plant	0.0356	-0.2347*	0.1062	0.1010	0.2301**	0.2268**	1.0000	-0.4987**	0.0871	0.0211	-0.1310*	-0.0467	-0.0716
No. of seeds/siliqua	0.0568	0.1066	0.0696	0.3290**	0.0237	-0.0097	0.0056	1.0000	0.0189	0.4510**	0.5374**	-0.3107**	0.7347**
1000-seed Weight (g)	-0.1888**	-0.2420*	-0.2122**	-0.1315*	-0.1442*	0.0941	0.0635	0.0137*	1.0000	0.0883	0.0148	-0.1658**	0.0254
Biological Yield/plant (g)	0.0272	0.0800	0.1012	0.0820	-0.0445	0.782**	0.0374	0.0910	0.0751	1.0000	0.1927**	-0.0857	0.5384**
Harvest Index (%)	-0.0901	-0.0406	-0.0216	-0.0480	-0.1404*	-0.0479	-0.1237*	-0.0345	-0.0564	0.1836**	1.0000	-0.0857	1.0176**
Oil Content (%)	-0.0683	-0.0068	-0.1240*	0.0017	-0.1927**	-0.0526	-0.1351*	0.0525	-0.0536	-0.2389*	-0.0200	1.0000	-0.3521**
Seed yield/plant (g)	-0.0750	0.0187	0.0520	-0.0108	-0.1437*	-0.0002	-0.1147*	-0.0336	0.0204	0.5312**	0.8736**	-0.1032	1.0000

* Significance at 5% level of significance, ** Significance at 1% level of significance

Table 3: Direct and indirect effects of different characters on seed yield per plant in Indian mustard.

Character	Days 50% flowering	Days to maturity	Plant height (cm)	No. of primary branch / plant	No. of secondary branch / plant	Length of main raceme (cm)	No. of siliquae / plant	No. of seeds / siliqua	1000-seed Weight (g)	Biological Yield/ plant (g)	Harvest index (%)	Oil Content (%)
Days 50% flowering	-0.3336	-0.2710	-0.2979	-0.1375	-0.1863	-0.0054	-0.0199	-0.0495	0.0669	-0.0333	0.0503	-0.0048
Days to maturity	0.2297	0.2827	0.1888	0.1258	0.0765	-0.0190	-0.1455	0.0948	-0.0915	0.0022	-0.0501	0.0505
Plant height (cm)	0.0311	0.0232	0.0348	0.0154	0.0227	-0.0030	0.0013	0.0118	-0.0097	0.0000	-0.0038	-0.0053
No. of primary branch / plant	0.0577	0.0623	0.0619	0.1399	0.0823	0.0265	0.0124	0.1127	-0.0583	0.0681	-0.0041	-0.0559
No. of secondary branch / plant	0.1093	0.0530	0.1276	0.1151	0.1956	0.0408	0.0487	0.0678	-0.0331	0.0238	-0.0666	-0.0470
Length of main raceme (cm)	-0.0004	0.0016	0.0021	-0.0046	-0.0050	-0.0241	-0.0081	-0.0004	-0.0020	-0.0029	0.0014	0.0020
No. of siliquae/ plant	0.0019	-0.0165	0.0012	0.0028	0.0080	0.0107	0.0320	-0.0160	0.0028	0.0007	-0.0042	-0.0015
No. of seeds / siliqua	-0.0430	-0.0973	-0.0987	-0.2336	-0.1006	-0.0048	0.1447	-0.2901	-0.0055	-0.1308	-0.1559	0.0901
1000-seed Weight (g)	-0.0218	-0.0351	-0.0303	-0.0452	-0.0184	0.0092	0.0095	0.0021	0.1085	0.0090	0.0016	-0.0180
Biological Yield / plant (g)	0.0384	0.0030	0.0005	0.1871	0.0467	0.0461	0.0081	0.1733	0.0320	0.3842	0.0740	-0.2743
Harvest index (%)	-0.1773	-0.2085	-0.1288	-0.0347	-0.4004	-0.0683	-0.1541	0.6320	0.0175	0.2266	1.1761	-0.1008
Oil Content (%)	0.0002	0.0023	-0.0020	-0.0051	-0.0031	-0.0011	-0.0006	-0.0040	-0.0021	-0.0092	-0.0011	0.0129
Seed yield / plant (g)	-0.1078	-0.2003	-0.1409	0.1254	-0.2820	0.0076	-0.0716	0.7347	0.0254	0.5384	1.0176	-0.3521

R Square = 1.1231, Residual Effect =SQT (1.1231)

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