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Correlation studies for drought tolerance in Indian mustard (*Brassica juncea*) under different water regimes

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ABSTRACT

Indian mustard (*Brassica juncea* (L.) Czern & Coss) is the major oilseed crop of India ranking first both in acreage and production of rapeseed and mustard in Asia. Among abiotic stresses, drought condition may cause the most fatal economic losses in agriculture due to their wide range occurrence. Present investigation was undertaken with the objective to study RB 50 × Kranti $F_{2:3}$ population under irrigated and drought environments for phenotypic and genetic variability, broad-sense heritability, and interrelationships among agronomic and seed quality traits to select Indian mustard genotypes for drought tolerance in research area of oilseed section. The study was carried out at CCS Haryana Agricultural University, Hisar during *rabi* 2014-15. Higher mean values for agronomic traits were observed under irrigated than drought environment. Phenotypic correlation coefficient analysis of $F_{2:3}$ populations under irrigated conditions was calculated to assess the association between various traits. Fifty three promising plants with higher seed yield as well as better physiological traits having greater drought tolerance were selected, which may be useful material for further studies and cultivar development for drought tolerance.

Key words: Drought, Electrolyte leakage, Heritability and genetic advance, Phenotypic correlations

Brassica oilseed, an important source of vegetable oil, occupy third place among the various oilseed crops due to its great economic and nutritional importance. Oilseed *Brassica* is sensitive to drought stress. *Brassica juncea* (L.) Czern & Coss (Indian mustard) is the predominant oilseed *Brassica* in Indian subcontinent (Singh *et al*. 2011). Indian mustard is an important *rabi* oilseed crop and occupies a prime position as India ranks first both in acreage and production in Asia. In India, *Brassica juncea* occupies second largest area after groundnut with 6.32 million ha of area under cultivation producing about 7.9 million tonnes seed annually, with 17% increase in production (Anonymous 2017). Drought stress is one of the most limiting environmental stresses which affect the growth and development processes depending on duration of exposure and crop growth stages (Juenger 2013). In India, *Brassica* is mostly grown under arid and semi-arid environment, therefore, could serve as a model crop for drought related studies. Adverse environmental factors, of which water scarcity represents the most severe constraint to agriculture, account for about 70% of potential yield loses worldwide. keeping in view the above facts, it is prime need to develop mustard varieties which can tolerate water stress to increase yield and area under oilseed crops.

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The breeding strategy to derive high yielding cultivar depends upon the nature and magnitude of variation for different yield components, the assessment of genetic parameters for effective selection. The correlations and path analysis unravels the contribution of different traits towards seed yield. Present study provides information on nature of genetic variability for yield and yield components under normal and drought condition in $F_{2:3}$ populations of *Brassica juncea*. The information derived from the study may be helpful in the breeding *Brassica* for drought tolerance.

MATERIALS AND METHODS

The cross between cv. RB 50 and Kranti was made during *rabi* 2011-12 and the progeny lines along with parental genotypes were grown to get $F_{2:3}$ populations during *rabi* 2014-15 in research area of oilseed section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar (Latitude - 29°10’ N, Longitude - 75°46’ E, Altitude - 215.2 m amsl). The parental genotype RB 50 has relatively higher drought tolerance due to deeper root depth ability and higher number of siliqua/plant. While, the parental genotype Kranti is not a highly drought sensitive cultivar but it may be useful as being a national check for yield under drought stress condition. It has short and narrower leaves, small seeds and lesser number of siliqua/ plant under drought stress conditions but under irrigated conditions it has more yield than cv. RB 50.

Both parental genotypes along with the $F_{2:3}$ progeny lines of cross RB 50 × Kranti with up to 10-15 plants of each progeny, were sown in one row of 1 m length with inter row spacing of 30 cm and plant spacing of 15 cm under two environments, viz. irrigated (Control: two irrigations of 6 cm depth each at pre flowering and grain filling stage) and drought (T_1: no irrigation only seasonal rainfall of 69.4 mm during the whole crop season). Out of $F_{2:3}$ progeny lines 157 lines were chosen for phenological, physiological and morphological trait evaluation.

Phenotypic evaluation of RB 50 × Kranti derived $F_{2:3}$ populations: Phenotypic evaluation of plants grown in field was done in RB 50 × Kranti derived $F_{2:3}$ populations under both irrigated and drought conditions for morpho-physiological and yield traits during rabi 2014-15. Phenological traits included days to flower initiation, days to total siliqua development and maturity duration. Growth related traits including dry matter weight and plant height were recorded for evaluation of growth related parameters. Yield and related traits and physiological traits of relative water content, electrolyte leakage and drought susceptibility index were taken to evaluate high yielding genotypes.

Statistical analysis: Statistical analysis was done using OPSTAT software by using the phenotypic data recorded from both irrigated and drought conditions in $F_{2:3}$ generation along with parents. The mean and range values for each character were calculated. The mean squares due to genotypes and error were used for the calculation of variance components (phenotypic and genotypic coefficient of variation) as per the method suggested by Allard (1960). The broad sense heritability of a character was calculated by using the formula as suggested by Hanson *et al.* (1956). Expected genetic advance (% mean) was calculated for each character using formula suggested by Lush (1949) and Johnson *et al*. (1955). Phenotypic correlation coefficients were calculated as per the procedure given by Fisher and Yates (1963).

RESULTS AND DISCUSSION

Phenotypic evaluation of RB 50 × Kranti derived $F_{2:3}$ populations under irrigated and drought conditions: Experiments were carried out to evaluate RB 50 × Kranti derived $F_{2:3}$ populations for yield, physiological, growth related and phenological parameters under both irrigated and drought conditions and huge variation was observed for all the traits. Such variability for more than one character has been reported by Majidi *et al.* (2015). In all the experiments, drought susceptible variety Kranti, out yielded the drought tolerant variety RB 50 under irrigated conditions in $F_{2:3}$ population. Under drought conditions, however, the decrease in yield potential was comparatively less in RB 50 from irrigated to drought conditions.

In this $F_{2:3}$ segregating population, higher mean values for different quantitative characters were observed under irrigated environments, and also found higher in RB 50 under drought conditions than Kranti. Drought stress reduced the plant height, dry matter weight and relative water content of the leaf in both the parental *Brassica juncea* genotypes. Electrolyte leakage had higher value decreased under drought stress conditions (Table 1). The observed reduction in mean performance of progenies under drought stress for most of the traits may be ascribed to decreased translocation of assimilates and growth substances, impairing nitrogen metabolism, loss of turgidity and consequently reduced sink size. Singh and Choudhary (2003) and Chauhan *et al.* (2007) reported reduced yield in *Brassica* in response to water stress. Different preliminary studies show the changes in plant water relations in *Brassica* during the onset of drought stress.

We also observed reduction in relative water content (RWC) from irrigated to drought regimes in parental genotypes and $F_{2:3}$ populations with 8.94% reduction. RWC is considered a measure of plant water status, reflecting the metabolic activity in tissues and used as the most meaningful index for dehydration tolerance. A decrease in RWC in response to drought stress has been noted in wide variety of plants when leaves are subjected to drought, leaves exhibit large reductions in RWC and water potential and hence the yield (Anjum *et al.* 2011, Sepehri and Golparvar 2011). Drought stress reduced the plant height, dry matter weight and relative water content of the leaf in both the parental genotypes. Electrolyte leakage had higher value decreased under drought stress conditions. Growth and seed yield production of *Brassica* sp. significantly decreased owing to drought conditions.

Heritability indicates the effectiveness with which selection of genotypes is based on phenotypic performance. Broad sense heritability provides an idea about the relative importance of genetic effects, which the selected parents would pass on to their progenies. In present study, high heritability (broad sense) was present for drought susceptibility tolerance index followed by plant height, siliqua/plant, thousand seed weight and days to flower initiation under irrigated conditions. Similarly high heritability (broad sense) was found for siliqua/plant followed by electrolyte leakage, plant height and number of secondary branches/plant under drought stress environment. For most of the traits heritability estimates were low as a result of higher phenotypic variances, indicating great environmental influence in their expression. Traits that revealed higher heritability than seed yield/plant combined with relatively high genetic gain under irrigated conditions were plant height, drought susceptibility tolerance index, number of siliquae/plant, 1000 seeds weight, days to flowering, number of secondary branches/plant, number of seeds/siliquae, dry matter weight, siliqua length, number of days to total siliquae development, dry matter weight and number of primary branches/plant. Under drought conditions, number of siliquae/plant, electrolyte leakage, plant height, number of secondary branches/plant and number of primary branches/plant revealed higher heritability with higher genetic gain than seed yield/plant thereby selection of these traits could be effective for a breeding programme.

The values of phenotypic variances were higher than the corresponding genotypic variances. Number of branches/

Table 1 Yield related, physiological traits, range of variance components, broad sense heritability and genetic advance in RB 50 × Kranti derived $F_{2:3}$ population of Indian mustard under irrigated and drought conditions

Parameter	$F_{2:3}$ Irrigated			$F_{2:3}$ Drought		
	RB 50	Kranti	RB 50 × Kranti derived $F_{2:3}$ Population Range (mean)	RB 50	Kranti	RB5 0 × Kranti derived $F_{2:3}$ Population Range (mean)
Yield related traits						
Number of siliqua/plant	238.80±0.44	266.2±0.25	53.3-493.33 (276.95±4.67)	215.8±0.16	177.80±0.25	75-394.3 (195.34±0.21)
1000 seed weight (g)	5.18±0.07	5.50±0.02	4.17-7.17 (5.63±0.27)	6.18±0.12	4.94±0.13	3.93-6.40 (5.23±0.21)
Seed yield/plant (g)	14.17±0.12	18.14±0.25	3.74-41.53 (17.33±1.59)	15.44±0.18	9.62±0.24	2.21-28.45 (10.01±4.02)
Physiological traits						
Relative water content (%)	83.36±0.04	78.25±0.06	62.45-82.25 (73.8±0.51)	80.79±.009	74.56±0.07	43.24-77.53 (64.86±0.53)
Electrolyte leakage (%)	21.98±0.22	25.63±0.17	15.84-35.06 (24.4±0.84)	21.07±0.15	29.05±0.11	17.01-54.21 (32.07±0.64)

Mean values, range of variance components, broad sense heritability and genetic advance

	$F_{2:3}$ Irrigated					*$F_{2:3}$ Drought*				
	Mean	*GCV*	*PCV*	*Heritability (%)*	*Genetic advance as % mean*	*Mean*	*GCV*	*PCV*	*Heritability (%)*	*Genetic advance as % mean*
1000 seeds weight (g)	5.63	10.78	12.19	78.30	19.66	5.23	7.85	11.24	48.76	11.29
Number of siliqua/plant	276.95	27.62	28.94	91.09	54.30	195.34	27.88	30.45	83.82	52.58
Seed yield/plant (g)	17.33	5.85	9.37	38.94	7.52	10.01	9.79	12.91	57.48	15.29
Plant height (cm)	196.90	38.06	38.95	95.47	76.59	161.65	36.89	41.75	78.08	67.15
Dry matter weight (g)	60.39	2.37	3.09	58.80	3.74	33.91	0.97	2.50	15.12	0.78
Relative water content (%)	73.75	14.00	22.29	39.48	18.12	64.86	9.88	13.53	53.28	14.85
Electrolyte leakage (%)	24.37	16.10	24.66	42.65	21.66	32.07	41.18	45.97	80.27	76.00

Table 2 Correlation coefficient analysis of morpho-physiological traits and yield attributes in $F_{2:3}$ populations of Indian mustard under irrigated conditions

	PB	SB	RL	RS	SL	S/S	TSW	S/P	SY/P	PH	DMW	DFI	DSD	DM	RWC	EL
PB	1															
SB	0.346**	1														
RL	0.146	0.300**	1													
RS	0.142	0.226**	0.536**	1												
SL	0.07	0.049	0.274**	-0.088	1											
S/S	0.088	0.094	0.141	0.148	0.301**	1										
TSW	0.091	0.029	-0.016	-0.022	0.052	0.119	1									
S/P	0.273**	0.486**	0.089	0.164*	-0.032	0.043	0.213**	1								
SY/P	0.170*	0.542**	0.13	0.204*	0.021	0.164*	0.274**	0.853**	1							
PH	0.312**	0.079	0.213**	0.114	-0.034	-0.049	-0.098	0.079	-0.015	1						
DMW	0.175*	0.542**	0.126	0.208**	0.015	0.165*	0.266**	0.856**	0.999**	-0.005	1					
DFI	0.035	-0.092	-0.003	-0.029	0.04	-0.138	0.081	0.054	-0.075	0.073	-0.085	1				
DSD	0.072	0.041	0.083	0.073	-0.036	-0.228**	-0.064	0.296**	0.121	0.064	0.126	0.420**	1			
DM	0.245**	0.345**	0.200*	0.143	-0.034	0.088	-0.043	0.394**	0.410**	0.095	0.420**	-0.348**	-0.02	1		
RWC	0.029	0.381**	0.146	0.013	0.075	-0.068	0.066	0.335**	0.362**	-0.073	0.356**	0.001	0.091	0.310**	1	
EL	0.045	-0.017	0.044	0.013	0.018	-0.226**	-0.124	-0.173*	-0.238**	0.068	-0.236**	0.182*	0.144	-0.108	-0.229**	1

*Significant at 5%, ** significant at 1% level, PB: number of primary branches/plant, SB: number of secondary branches/plant, RL: main raceme length, RS: number of siliquae on main raceme, SL: siliqua length, S/S: number of seeds/siliqua, TSW: 1000 seeds weight, SY/P: seed yield/plant, PH: plant height, DMW: dry matter weight, DFI: days to flower initiation, DSD: days to total siliqua development, DM: days to maturity, RWC: relative water content, EL: electrolyte leakage.

plant, length of siliqua, number of seeds/siliqua, 1000 seeds weight and yield per plant showed least difference between phenotypic and genotypic variances. The values of GCV and PCV indicated that there was least variation present among most of the characters studied. Ara *et al.* (2013) observed seed yield and yield contributing characters; it was confirmed that there were considerable variation present among all the genotypes used in the experiment. Raliya *et al*. (2018) also found that phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters under study. The study also showed higher phenotypic coefficient of variation than genotypic coefficient of variation thereby showing agreement with the undertaken study.

Genetic advance as per cent of mean was also higher for 1000-seed weight, siliqua length, plant height and number of primary branches. Genetic advance as per cent of mean in the study was higher for drought susceptibility tolerance index followed by plant height, number of siliqua/plant, secondary branches/plant, siliqua length and thousand seed weight in both irrigated and drought conditions. Under drought conditions, electrolyte leakage also showed higher value for genetic advance as % of mean (Table 1).

Phenotypic correlation coefficient analysis: Phenotypic correlation coefficient was calculated to assess the association between various traits. Phenotypic correlation coefficient analysis of $F_{2:3}$ populations under irrigated conditions showed significant correlation between morpho-physiological and yield related traits. Besides electrolyte leakage (-0.238, 0.01) revealed significant negative correlation coefficient with seed yield/plant in $F_{2:3}$populations in irrigated conditions (Table 2). Seed yield/plant showed highest positive correlation with number of siliquae/plant indicating that seed yield/plant is directly related and dependent on number of siliqua/plant.

Significant correlations between seed yield and number of pods per plant, 1000 seeds weight and seed weight per pod were reported by Ivanovska *et al.* (2007), Dastidar and Patra (2004) which are in agreement with results of the present study. The attributes like number of seeds/siliqua, weight of 1000 seeds, total seed weight/plant as well as harvest index are directly correlated to the yield of any variety/species of oleiferous *Brassica* (Rai *et al*. 2005). Therefore, high yielding genotypes can be developed with more number of siliqua per plant for efficient use of scarce water resource as well as to respond favorably to input rich conditions (Singh *et al*. 2011). Assessment of relationship between seed yield as well as to determine the best indirect selection criteria for genetic improvement of seed and oil yield in rapeseed the evaluation of correlation coefficients illustrated that total dry matter, harvest index, seed weight, number of seeds per pod, number of pods per plant, plant height, days to ripening and flowering period trait had a significant positive correlation with seed yield (Khayat *et al*. 2014, Iqbal *et al*. 2014, Roy *et al*. 2016, Saleem *et al*. 2017).

Selection of promising plants: As many as 53 promising $F_{2:3}$ plants with higher seed yield were selected on the basis of agronomic performance and better physiological traits under irrigated and drought conditions. Promising plants performed better than others plants under drought stress conditions and showed considerably less difference in yield and RWC under irrigated and drought. Zhu *et al.* (2011) used principal component, regression and clustering analyses to evaluate the drought tolerance of 49 rapeseed genotypes at the flowering stage. As a result, 20 lines were classified as drought-tolerant.

A considerable variation was observed for all the traits under both irrigated and drought conditions. For most of the traits heritability estimates were low as a result of higher phenotypic variances in this study indicating role of environmental influence in their expression. Seed yield and its contributing traits showed higher genetic advance and heritability under drought stress conditions. Significant positive correlations were found between seed yield with number of secondary branches/plant, number of seeds/siliqua, number of siliqua/plant, dry matter weight and relative water content of leaf while electrolyte leakage revealed significant negative correlation coefficient with seed yield/plant in $F_{2:3}$ populations. Selected superior lines could serve as a good breeding material for improving yield in *Brassica* under drought stress.

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