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M Sc Thesis Award

Evaluation of advanced lines of *Brassica carinata* for drought response

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Abstract

Ethiopean mustard (*Brassica carinata*) is one of the six commercially important *Brassica* species and is considered to be tolerant to drought, diseases and insect-pest so better adapted to problematic areas. Drought is an abiotic stress which hampers the yield and productivity of crop. The present investigation aimed at evaluation of advanced lines of *Brassica carinata* for drought response. The experiment was conducted at G.B. Pant University of Agriculture and Technology, Pantnagar, India. The experimental material consisted of thirty seven advanced lines of *B. carinata* along with three checks, two of *B. carinata* cultivar Pusa Swarnim and Kiran and one of *B. juncea* cultivar Giriraj. Relative leaf water content, Water saturation deficit and electrolyte leakage were taken as indicators of drought response. ANOVA revealed significant differences for all three drought related parameters among genotypes. Kiran showed excellent capacity to manage the stress condition through high relative leaf water content, low water saturation deficit and moderate electrolyte leakage. 30 lines showed significant better response in relation to electrolyte leakage than Kiran. Indian mustard check Giriraj showed poorest response towards the stress condition. For other parameters lines showed intermediate response towards drought. The genotypes identified better for stress condition after confirmation can be further used either as one of the parent for hybridization programme targeted for stress condition. Therefore, with better insight of exploitable variability maximum gain in form of potential cultivar can be achieved to meet out future challenges.

Keywords: *Brassica carinata, drought response, exploitable variability*

Introduction

Drought is one of the major constraints which affects the yield and productivity of agricultural crops. The effects of drought may be long lasting, even after the commencement of drought and can adversely affect the crop for many years. The first one to be affected by drought is usually farmers because of their dependence on stored water and long dry spell causes the loss of yield and sometimes the total crop failure. Assessment of drought resistance of a genotype is important for understanding its association with different conditions viz., soil moisture availability and their distribution along rainfall gradients etc and also for understanding the role of underlying morphological and physiological mechanisms. Then the improvisation of the genotype can be done accordingly.

Water stress can lower leaf water potential, leading to reduced turgor, stomatal conductance and photosynthesis, and ultimately to reduced growth and lower yields (Kumar and Singh, 1997). Drought and salinity are the major abiotic stresses that dramatically threaten the food supply in the world (Nevo & Chen, 2010). Brassica crops are generally grown under marginal land under rainfed conditions and total loss due to drought to brassicas is ~37%. *B. carinata* is said to be drought tolerant crop thus screening for drought becomes important to assess the potential of genotypes to withstand drought. Relative leaf water content, electrolyte leakage and water saturation deficit are used as predictive indicators for drought study. Cell membrane is a site which first responds to the stress and gets damaged, as a result of which electrolytes and other substances gets leached out. So, the amount of electrolyte leached can give a measure of drought response of a genotype (Bajji *et al*., 2002).

Ethiopian mustard (*B. carinata*) has shown good yields in wider range of environments and also has shown better environmental adaptation and substantial resistance to pests and diseases (Katiyar *et al*, 1986), but the oil of Ethiopian mustard has got some anti-nutritional factors viz., glucosinolates and erucic acid which also affects the taste of oil and for this reason the crop needs improvement. It is also considered to be drought tolerant, a feature to which plant breeders are interested. As per data India needs to produce 17.84 Mt of vegetable oils to meet the nutritional fat demand of projected population of 1685 million by 2050 (Prem Narayan, 2016). To meet the edible oils demands of increasing population, quantity and quality of oil both are required to be improvised. Ethiopian mustard after improvements is considered to give better results in terms of adaptation, yield and quality in comparison to other *Brassica* species especially in problematic areas.

Materials and Methods

The study was conducted at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand, India for evaluation of drought response among advanced lines of *B. carinata*. The study was conducted during rabi season of 2017-18. The experimental material consisted of 37 advanced lines of *B. carinata* along with three checks, two of *B. carinata* cultivar Pusa Swarnim and Kiran and one of *B. juncea* cultivar Giriraj. List of experimental material is mentioned in Table 1.

Table 1: List of experimental materials used for the study

Genotype	Genotype
MCB-1-1-6-3	IARI-20
IARI-5	IARI-15
MCB-1-2-3-7	MCB-1-1-5-1
Kiran (Check)	IARI-3
IARI-12	IARI-10
IARI-4	IARI-14
MCB-1-2-3-2-4	IARI-23
TARI-8	MCB-1-2-3-1-3-1
MCB-1-2-3-13-5	IARI-18
IARI-21	IARI-9
IARI-6	IARI-22
MCB-1-2-3-5-1	IARI-17
IARI-24	MCB-1-2-3-1
IARI-2	IARI-19
MCB-1-2-3-2-1	IARI-27
IARI-16	MCB-1-1-4-1
PUSA Swarnim (check)	IARI-11
IARI-28	Giriraj (check)
IARI-1	IARI-25
MCB-1-2-3-2-5	IARI-7

The above Forty lines (37 advanced lines along with 3 checks) were grown in Randomized block design (RBD), with three replications. The plant to plant distance was maintained 10 cm by thinning 25 days after sowing. The Experiment was preliminary evaluation for drought response. Observations on three parameters were taken viz., Relative Leaf Water Content (RLWC), Water Saturation Deficit (WSD) and Electrolyte Leakage (EL). Leaf samples from two replications were collected and were evaluated for the above three parameters.

Estimation of RLWC

For RLWC, the leaf samples for all the genotypes were collected from field and were washed thoroughly in the lab and dried with the help of tissue paper. Samples were then cut into small pieces (around 1cm) and were weighed (fresh weight). 2gm sample for each genotype was taken and was put in the labeled petriplates. The samples were then soaked in double distilled water for 24 hours and then their turgid (saturated) weight was taken. After this the leaf samples were dried in oven and dry weight was taken. On the basis of the fresh weight, turgid weight and dry weight RLWC was estimated by the formula:

RLWC= (Fresh weight – dry weight) / (turgid weight – Dry weight)

Estimation of WSD

Procedure was same as Relative Leaf Water Content and on the basis of the values of fresh weight, turgid weight and dry weight the WSD was estimated likewise:

WSD= (Turgid weight – fresh weight)/ (turgid weight – dry weight)

Estimation of electrolyte leakage

The steps involved in the estimation of electrolyte leakage were as described by Bajji *et al.* (2001) with slight modifications. For this the leaf samples of fully expanded upper leaves were collected from field and were weighed immediately. The samples were then washed thoroughly and were cut into segments of around 1cm. These segments were then washed slowly with distilled water at room temperature to remove the solutes from leaf surface and damaged cells due to cutting. These segments were then put in a broad mouthed labeled test tube and 10 ml distilled water was poured in each test tube. The Electric conductivity of each sample was taken after 1 hour, which was the control reading. Then the samples were allowed to stand in 30% PEG solution for 15 hours and after 15 hours the samples were washed quickly for 3 times with distilled water and then immersed in distilled water. Immediately its electric conductivity was recorded which was the initial EC i.e., ECi at the beginning of the rehydration period. After four hours again the electric conductivity was taken i.e., EC of the rehydrated segments (ECf). Then the segments were autoclaved and EC of the autoclaved segments was also taken i.e., ECt. On the basis of the above said values the Electrolyte Leakage was calculated likewise:

$$\text{Electrolyte Leakage} = \left[\frac{ECf - ECi}{ECt - ECi}\right] X\ 100$$

The mean values of both the replications were then used for statistical analysis using Complete Randomized Design.

Results and Discussion

ANOVA table (Table 2) revealed that the mean sum of squares among the genotypes for all the characters were highly significant. RLWC was found highest in Kiran (0.939) followed by IARI-27 (0.934) and MCB-1-2-3-1 (0.920), while was lowest in Giriraj (0.720). All the advanced lines showed intermediate level of relative leaf water content. All the lines were significantly low for their RLWC content as compare to best Ethiopian mustard check Kiran, except IARI-18, IARI-22, MCB-1-2-3-1 and IARI-27. In comparison with mustard check Giriraj all the advanced lines were significantly superior.

Minimum WSD was registered in check Kiran (0.057) while maximum was noticed in Giriraj (0.280). Genotypes with low WSD were IARI-18 (0.093) and IARI-27 (0.076). Rest of the entries has shown intermediate to high

Table 2: Analysis of Variance for preliminary evaluation of *B. carinata* lines for drought

Characters	Tr.	Error	CD at 5%	CD at 1%	CV%
Relative leaf water content	0.00237**	0.00029	0.035	0.047	1.97
Water saturation deficit	0.00205**	0.00004	0.013	0.017	4.72
Electrolyte leakage	287.33**	0.63301	1.608	2.151	3.78

Table 3: Mean Performance of advanced lines of *Brassica carinata* for drought related characters

Genotypes	Relative Leaf Water Content (45cm)	Water Saturation Deficit	Electrolyte Leakage (45cm)
MCB-1-1-6-3	0.837	0.157	44.473
IARI-5	0.857	0.134	26.736
MCB-1-2-3-7	0.857	0.131	34.289
KIRAN (C)	0.939	0.057	34.286
IARI-12	0.898	0.136	25.740
IARI-4	0.897	0.105	24.068
MCB-1-2-3-2-4	0.866	0.123	1.188
IARI-8	0.882	0.133	17.927
MCB-1-2-3-13-5	0.865	0.137	17.021
IARI-21	0.847	0.153	41.079
IARI-6	0.859	0.141	25.108
MCB-1-2-3-5-1	0.892	0.113	18.827
IARI-24	0.863	0.140	34.056
IARI-2	0.856	0.143	36.195
MCB-1-2-3-2-1	0.842	0.161	16.739
IARI-16	0.878	0.132	14.109
PUSA SWARNIM (C)	0.827	0.163	36.397
IARI-28	0.832	0.168	25.235
IARI-1	0.762	0.243	12.612
MCB-1-2-3-2-5	0.853	0.147	16.981
IARI-20	0.884	0.126	12.151
IARI-15	0.876	0.114	36.956
MCB-1-1-5-1	0.854	0.146	0.614
IARI-3	0.889	0.111	32.550
IARI-10	0.868	0.132	15.974
IARI-14	0.869	0.131	32.155
IARI-23	0.843	0.157	24.362
MCB-1-2-3-1-3-1	0.880	0.106	26.517
IARI-18	0.907	0.093	43.584

IARI-9	0.882	0.123	28.831
IARI-22	0.919	0.106	24.004
IARI-17	0.897	0.103	3.895
MCB-1-2-3-1	0.920	0.102	5.514
IARI-19	0.871	0.134	18.385
IARI-27	0.934	0.076	7.905
MCB-1-1-4-1	0.874	0.131	10.817
IARI-11	0.892	0.108	11.791
GIRIRAJ (C)	0.720	0.280	75.627
IARI-25	0.886	0.119	2.883
IARI-7	0.819	0.204	10.297
GM	0.867	0.135	22.81
Sem±	0.012	0.004	0.562
CD at 5%	0.035	0.012	1.607
CD at 1%	0.047	0.017	2.151
CV	1.99	4.16	3.49

estimates of WSD.

Lowest estimate of electrolyte leakage was found in MCB-1-5-1 (0.61) followed by MCB-1-2-3-2-4 (1.19) and IARI-25 (2.88). Giriraj (75.63) showed maximum electrolyte leakage. The genotypes with significantly high membrane stability were IARI-17 (3.90), MCB-1-2-3-1 (5.51), IARI-27 (7.91), IARI-7 (10.297), MCB-1-1-4-1 (10.82), IARI-11 (11.791), IARI-20 (12.151), IARI-1 (12.612), IARI-16 (14.11), IARI-10 (15.974), MCB-1-2-3-2-1 (16.739), MCB-1-2-3-2-5 (16.981), MCB-1-2-3-13-15 (17.02), IARI-8 (17.93), IARI-19 (18.39), MCB-1-2-3-5-1 (18.83), IARI-22(24.004), IARI-4 (24.07), IARI-23(24.36), IARI-6 (25.11), IARI-28 (25.24), IARI-12 (25.74), MCB-1-2-3-1-3-1 (26.52), IARI-5 (26.74), IARI-9 (28.83), IARI-14 (32.16) and IARI-3 (32.55) as compare to best check Kiran (34.29). The mean performance of lines for drought parameters is represented in table 3.

The genotypes with high relative leaf water content are considered to manage the water stress better as compared to those having less relative leaf water content. Water saturation deficit is the minimum water requirement of plant for its normal growth and hence low WSD indicates better response towards stress. Electrolyte leakage is an indicative of membrane stability. Less electrolyte leakage reflect better membrane stability hence a better stress management. Less membrane damage was correlated with an increased capacity to accumulate sugars at the leaf level during water stress (Bajji, 1999; Bajji *et al.*, 2000c). Non-reducing disaccharides such as sucrose and trehalose (in few species) interact with cellular membranes to increase the stability of the lipid layers (Nilsen and Orcutt, 1996). Increased accumulation of such compatible solutes in leaf tissues of the drought resistant cultivars would reduce dehydration damage and promote growth during and after water stress (Bajji *et al.*, 2000c).

Table 3 shows that Kiran possessed excellent capacity to manage the stress condition through its high relative leaf water content, low water saturation deficit and moderate electrolyte leakage. Thirty advanced lines showed significantly better response towards drought in terms of electrolyte leakage as compared to check Kiran. Indian mustard check Giriraj showed poorest response for the stress condition. Rest of the advanced lines showed intermediate response towards the drought, reason being these lines were developed by interspecific hybridization between Indian mustard and Ethiopian mustard. Electrolyte leakage method demonstrated the maintenance of membrane integrity under osmotic stress which ultimately correlates with the drought tolerance. Therefore, electrolyte leakage with Relative leaf water content and water saturation deficit can be used as "predictive" criterion of putative water stress resistance in whole plants (Bajji, 1999; Bajji *et al.*, 2000a, 2000c).

Conclusion

Genotypes showed significant differences for all the three parameters associated with drought. Kiran possessed excellent capacity to manage the stress condition through high relative water content, low water saturation deficit and moderate electrolyte leakage. Thirty lines showed significantly low electrolyte leakage as compare to check Kiran. For rest of two the parameters advanced lines showed intermediate response towards the drought reason being these lines were developed by inter-specific hybridization between Indian mustard and Ethiopian mustard. Indian mustard check Giriraj showed poorest response for the stress condition.

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