

Short Communication

Assessing drought tolerance genotypes of Indian mustard [*Brassica juncea* (L.) Czern and Coss] using the drought susceptibility index

Omesh Kumar^{1,4*}, Kartikeya Srivastava¹, Sheo Pratap Singh¹, Girish Tantuway²,
Aditi Eliza Tirkey³ and Ashish Sheera⁴

¹Department of Genetics and Plant Breeding, Institute of Agricultural Sciences,
Banaras Hindu University, Varanasi 221 005, Uttar Pradesh, India

²Department of Genetics and Plant Breeding, Rajiv Gandhi South Campus,
Banaras Hindu University, Barkachha, Mirzapur-231 001, Uttar Pradesh, India

³Department of Genetics and Plant Breeding, Rabindra Nath Tagore Agriculture College,
Birsā Agricultural University, Mohanpur 814 157, Deoghar, Jharkhand, India

⁴Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan, India

*Corresponding author: meenaomesh704@gmail.com

<https://doi.org/10.56093/job.v17i2.15>

Received date : 15 April 2026; Revised date : 10 June 2026; Accepted date : 14 June 2026

Abstract

Fluctuations in climate, such as drought, significantly impact the yield of rainfed crops like mustard. This research aimed to examine the influence and selection of drought-tolerant parent plants and hybrids concerning the yield and its components in Indian mustard. Based on both average performance and Drought Susceptibility Index (DSI) values, parental genotypes Giriraj, RH-749, and RGN-73 demonstrated high yield under irrigated conditions but showed lower tolerance to drought. Conversely, the remaining parental genotypes exhibited moderate to high levels of drought tolerance. DRMR150-35 was identified as having high drought tolerance for seed yield, while RGN-229, RGN-298, Pusa Bold, NRCHB-101, Vardan, PM-27, and PM-28 displayed moderate tolerance. Crosses involving high-yielding, susceptible genotypes as female parents and drought-tolerant genotypes as male parents, such as Giriraj × DRMR 150-35, RH-749 × RH-406, RH-749 × DRMR150-35, and RGN-73 × DRMR150-35, demonstrated varying degrees of drought tolerance for almost all the traits examined. The donors identified in this study, possessing multiple characteristics for drought tolerance, should be prioritized in future breeding programs.

Keywords: *Brassica juncea*, drought, drought susceptibility index, genotypes, tolerance, yield

Introduction

Indian mustard (*Brassica juncea* (L.) Czern. & Coss, AAB 2n = 36) is a natural amphidiploid that combines the genomes of two species, *Brassica campestris* (*Brassica rapa* L.) (AA, 2n = 20) and *Brassica nigra* (BB, 2n = 16). (Nagaharu 1935). *Brassica* are produced for a variety of uses, including oil, meal, spices, lubricants, medicinal and sauces. Rapeseed-mustard is the third most important oilseed crop in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis* Jacq.) oil. Among the abiotic stress, drought is the major problem for current global agriculture, which affects 40% of the world's crop land area. Even the relatively short period of water stress during the reproductive stage significantly reduces the seed yield (Ahmadi and Bahrani 2009). Further, it leads to a reduction in the oil content and oil yield of oilseed crops. The seed production of mustard is most affected

by the lack of water during the flowering and pollination stages (Fernandez 1992). The mustard crop is primarily cultivated in India's dry and semi-arid regions. These areas face a number of challenges, including limited water supplies, growing population pressure, depletion of other natural resource bases, and most importantly, anthropogenic climate change. Because drought conditions regularly occur throughout the growth season for crops and have a detrimental impact, it is necessary to identify and develop genotypes that are tolerant to drought (Singh *et al.*, 2011).

Due to the scarcity of water resources, deficit irrigation is used as an efficient option for increasing productivity under water shortage conditions. Another strategy is using plant genetic engineering and breeding to develop drought-tolerant genotypes. Clarke *et al.* (1992) opined that selection for yield under dry conditions alone should

be a more productive avenue for improving drought resistance until more rapid and effective screening procedures can be developed. Drought susceptibility index (Singh and Chaudhary 2003; Chauhan *et al.*, 2007) have been found to be associated with drought tolerance. DSI values and seed yield under drought conditions are used as selection criteria for Indian mustard (Singh and Choudhary 2003). DSI characterizes the stability of yield between two environments (Singh *et al.*, 2018). It expresses the separate effects of yield potential and drought susceptibility on yields under drought. In these terms, lower DSI is considered synonymous with higher drought resistance (Fischer and Maurer 1978). In view of above facts, present study is aimed at investigating the effects of drought on yield attributing traits with, the objective of identifying Indian mustard genotypes and their hybrids which can withstand water stress with minimum loss in yield. We have made efforts in this direction by attempting crosses among reported high yielding tolerant genotypes for moisture stress tolerance, to identify and classify germplasms that includes parents and F₁ hybrids on the basis of DSI. The Drought Susceptibility Index (DSI) has been used as an important parameter for the identification of moisture stress genotypes and their cross-combinations. It compares the performance between irrigated and unirrigated conditions and characterizes yield stability (Fischer and Maurer 1978).

Materials and Methods

The experimental material comprised thirteen parental genotypes among them ten lines viz., RH-406; RGN-229; RH-119; RGN-298; Vardan; PM-27; PM-28; NRCHB-101; Pusa Bold; and DRMR 150-35, with three established testers, viz., Giriraj; RH-749; and RGN-73, were crossed in a line $\times$ tester mating design to generate 30 F₁. These F₁, along with parents were grown in 3 rows of 3-meter length with a spacing of 45 $\times$ 10 cm in a randomized block design with three replications in two conditions (one normally irrigated and another rainfed condition) during the years 2018–2019. All recommended agronomic package of practices were followed to raise a healthy crop in both the trials except the irrigation in rainfed condition. Pre-sowing irrigation was given in both the conditions to ensure the germination. Furthermore, the irrigated trials received two irrigations at 40 and 80 days after sowing. The temperature regime during the cropping season was ranged between 32.23°C (max.) to 17.12°C (min.). The total precipitation during the above period was recorded to be 37 mm.

Observations and evaluation

Observations were recorded on five randomly selected plants of each genotype from each replication for plant height, number of primary branches per plant, number of secondary branches per plant, number of siliqua per plant, 1000-seed weight, seed yield per plant and oil content (%). The effect of drought was assessed as percentage reduction in mean performance of a trait under rain-fed conditions relative to, its performance under irrigated conditions. Accordingly, DSI for yield and its traits was calculated using, the following formula (Fischer and Maurer 1978): $DSI = (1 - Y_s/Y_i) / (1 - X_s/X_i)$ Where, Y_s = mean seed yield of a genotype in a water stress environment, Y_i = mean seed yield of same genotype in a stress free environment (irrigated), X_s = mean seed yield of all genotypes in water stress environment and X_i = mean seed yield of all genotypes in stress free environment (irrigated). In the present study, DSI values for different traits were calculated and genotypes were classified into four different categories: Drought tolerant (DSI < 0.50), moderately drought tolerant (DSI 0.51 to 1.0), moderately drought susceptible (DSI 1.0 to 1.50) and highly drought susceptible (DSI > 1.50) (Yang *et al.*, 2002).

Results and Discussion

Performance of genotypes

Significant differences among genotypes for all studied traits were revealed by statistical analysis. Performance of all the agro-morphological characteristics, were reduced under rainfed condition when compared with irrigated conditions in both, parents and F₁s (Tables 1 & 2). In irrigated condition Giriraj followed by RH-749 had highest seed yield per plant whereas in rainfed conditions RGN-229 followed by Pusa bold and DRMR150-35 had highest seed yield per plant. Among the hybrids, GIRIRAJ $\times$ DRMR 150-35 followed by RGN73 $\times$ DRMR150-35 had highest seed yield while in rainfed condition GIRIRAJ $\times$ DRMR 150-35 followed by RH749 $\times$ DRMR150-35 and RH749 $\times$ RH 406 had highest seed yield per plant. The reduction in seed yield can be ascribed to the relative more reduction in the growth parameters including stem, root and leaf growth, further decreasing number of siliqua per plant, siliqua length and 1000 seed weight. According to Chouhan *et al.* (2007), under rainfed condition, plant height, primary branches, secondary branches per plant, 1000-seed weight, and seed yield were reduced. Alipour and Zahedi (2016) reported that the highest seed yield in mustard can be obtained by regular irrigation, while the oil yield loss was because of lack of soil moisture at the flowering stage, reducing photosynthesis and photosynthetic partitioning to various plant parts. The

decrease in siliqua per plant and seed yield recorded in our study is in confirmation with the study of Mirzaei *et al.* (2013) who stated that moisture stress had significant effect on seed yield, number of seeds/pod, number of pod per plant, number of branches per plant, 1000-seed weight, plant height and oil content of cultivars (Hyola-401, Hyola-308, Zarfam and PF) in Iran. This could be due to water stress during flowering stage which, causes decreased seed yield due to reduction in seed weight (Pandey *et al.*, 2001)

Drought susceptibility index

Mean and DSI for various characteristics is presented in Tables 1 and 2. Larger DSI values indicate greater drought susceptibility (Winter *et al.*, 1988). It can be observed in Table 1 that among the thirteen selected genotypes, for plant height genotypes RGN-229, NRCHB-101, and PM-27 were highly tolerant to drought whereas RGN-298 and PM-28 were showing moderate drought tolerance. The genotype such as RGN-73, Pusa bold, were highly tolerant, while RGN-229, NRCHB-101, DRMR150-35, RH-119, Vardan, PM-27 and PM-28 were moderate tolerant for number of primary branches. For number of secondary branches the parental genotypes such as RGN-229 and PM-28 were found high drought tolerant whereas RGN-73, Pusa Bold, NRCHB-101, RH-406, DRMR150-35, Vardan and PM-27 had moderate tolerant. For number of siliquae per plant, NRCHB-101 was highly tolerant while Pusa Bold, RH-406, DRMR-150-35, RH119, Vardan, PM-27, and PM-28 had moderate DSI value. Seed yield per plant is most important trait to be focussed in any hybridisation programme. Genotype DRMR150-35 was found as drought tolerant whereas genotypes RGN 229, RGN-298, Pusa Bold, NRCHB-101, Vardan, PM-27 and PM-28 were found as moderately drought tolerant for seed yield per plant. For test weight DRMR150-35, RH-119 and PM-28 were found high tolerant. Oil content (%) is another important trait in mustard since it is the third leading source of vegetable oil in the world after soybean and palm oils. Considering DSI for oil content, Giriraj, RGN-298, PM-27 and PM-28 were found tolerant to drought while NRCHB-101 and Vardan had moderate drought tolerant. DSI results were in agreement with the studies of Chauhan *et al.* (2007), who reported the top six drought tolerant genotypes for seed yield as indicated by their lower drought susceptibility index. Likewise, Singh and Chaudhary (2003) used DSI values and seed yield as selection criteria under drought condition.

Among the hybrids RH-749 × RH-406, RH-749 × DRMR-150-35 and RGN-73 × DRMR-150-35 for plant height; Giriraj × PUSA BOLD, Giriraj × RH-119, RH-749 × RH-406, RH-

Table 1: DSI based on mean performance of parents under irrigated and rainfed conditions

Genotypes	Plant height (cm)			Primary branches (no.)			Secondary branches (no.)			Siliquae/plant (no.)			Yield/plant (g)			Test weight (g)			Oil content (%)		
	I*	R*	DSI	I*	R*	DSI	I*	R*	DSI	I*	R*	DSI	I*	R*	DSI	I*	R*	DSI	I*	R*	DSI
GIRIRAJ	207.00	183.67	1.41	8.50	6.56	1.87	13.58	9.42	1.78	460.67	331.67	1.63	14.03	11.33	1.47	5.94	5.15	1.51	40.47	40.33	0.13
RH-749	197.00	175.67	1.35	6.56	5.33	1.52	12.08	8.89	1.53	368.67	271.00	1.54	13.43	10.35	1.75	5.33	4.79	1.15	41.40	39.49	1.80
RGN-73	177.56	161.00	1.17	4.67	4.39	0.49	9.03	7.63	0.90	332.33	243.83	1.55	12.85	10.77	1.24	5.08	4.76	0.71	40.51	38.56	1.89
RGN-229	186.33	183.33	0.20	5.33	4.83	0.77	11.55	10.67	0.44	339.17	247.00	1.58	13.33	12.40	0.53	4.97	4.58	0.89	41.46	39.92	1.46
RGN-298	184.67	170.33	0.97	7.50	6.00	1.63	13.19	10.77	1.07	296.00	239.67	1.11	12.33	11.42	0.57	4.91	4.12	1.85	40.67	40.61	0.06
PUSA BOLD	175.89	151.00	1.77	5.56	5.50	0.08	11.73	10.17	0.78	316.00	266.33	0.91	13.30	11.69	0.93	5.91	5.62	0.57	43.44	41.16	2.05
NRCHB-101	171.67	165.33	0.46	6.50	6.00	0.63	10.83	9.57	0.68	396.67	376.67	0.29	11.06	10.12	0.65	4.97	4.58	0.88	42.54	41.53	0.94
RH-406	172.50	157.67	1.07	4.00	3.50	1.02	9.39	8.33	0.65	331.67	275.78	0.98	9.16	7.86	1.08	5.48	5.02	0.96	41.58	40.38	1.13
DRMR150-35	206.33	188.33	1.09	5.83	5.22	0.86	11.22	9.56	0.86	304.67	277.67	0.51	12.25	11.66	0.37	5.04	4.90	0.33	39.98	38.62	1.33
RH-119	177.33	160.33	1.20	6.83	6.05	0.94	9.83	6.17	2.17	407.00	361.00	0.66	11.44	9.15	1.53	4.69	4.56	0.32	41.65	40.56	1.02
VARDAN	189.33	170.33	1.25	5.33	4.83	0.77	9.50	8.50	0.61	327.00	278.00	0.87	11.22	9.85	0.93	5.55	4.85	1.43	42.14	41.38	0.70
PM-27	180.56	175.00	0.38	4.78	4.33	0.76	12.63	10.89	0.80	384.89	342.00	0.65	13.01	11.33	0.98	5.18	4.22	2.12	40.02	39.98	0.03
PM-28	200.33	190.33	0.62	4.67	4.20	0.82	9.12	8.40	0.46	312.00	278.33	0.63	10.92	9.68	0.87	4.54	4.52	0.06	39.18	38.84	0.34

I* (Irrigated condition), R* (Rainfed Condition), DSI (Drought susceptibility Index)

Table 2: DSI based on mean performance of hybrids under irrigated and rainfed conditions

Genotypes	Plant height (cm)		Primary branches (no.)		Secondary branches (no.)		Siliques /plant (no.)		Yield /plant (g)		Test weight (g)		Oil content (%)	
	I*	R*	DSI	I*	R*	DSI	I*	R*	DSI	I*	R*	DSI	I*	R*
GIRIRAJ × RGN-229	187.33	169.00	0.85	5.56	4.83	0.76	9.94	7.47	0.99	328.89	243.00	1.26	11.71	9.22
GIRIRAJ × RGN-298	198.19	176.67	0.94	5.61	4.56	1.10	11.82	8.97	0.96	229.00	177.11	1.09	11.42	8.33
GIRIRAJ × PUSA BOLD	159.33	140.67	1.02	8.17	7.50	0.48	8.67	6.17	1.14	399.67	323.53	0.92	14.00	11.67
GIRIRAJ × NRCHB-101	171.00	151.00	1.01	7.44	4.67	2.18	8.56	6.56	0.93	329.22	231.13	1.43	10.90	8.47
GIRIRAJ × RH-406	200.00	175.33	1.07	4.67	3.43	1.54	6.22	3.52	1.72	344.00	279.67	0.90	12.04	9.33
GIRIRAJ × DRMR 150-35	208.67	169.67	1.62	7.11	6.33	0.64	14.19	11.33	0.80	471.00	424.00	0.48	15.05	14.05
GIRIRAJ × RH-119	166.67	148.00	0.97	3.22	3.20	0.04	5.79	4.08	1.17	277.33	220.00	0.99	8.06	6.80
GIRIRAJ × VARDAN	192.33	169.33	1.04	4.17	3.17	1.40	8.33	3.50	2.30	341.22	268.00	1.03	9.97	7.06
GIRIRAJ × PM-27	182.78	163.00	0.94	4.67	3.70	1.21	7.78	5.89	0.96	145.22	116.67	0.95	9.98	8.05
GIRIRAJ × PM-28	197.56	173.33	1.06	5.22	4.39	0.93	10.12	8.50	0.63	293.11	233.67	0.98	13.67	11.14
RH-749 × RGN-229	208.22	181.33	1.12	7.11	5.17	1.60	10.56	7.33	1.21	275.89	208.67	1.17	10.29	8.36
RH-749 × RGN-298	192.89	169.67	1.04	6.44	5.33	1.01	8.22	6.00	1.07	306.44	238.67	1.06	10.97	9.51
RH-749 × PUSA BOLD	173.42	154.56	0.94	4.87	4.11	0.91	5.83	4.45	0.94	271.33	208.33	1.12	7.51	6.15
RH-749 × NRCHB-101	180.11	161.67	0.89	4.94	3.00	2.30	7.22	5.53	0.93	279.00	215.67	1.09	10.54	8.33
RH-749 × RH-406	202.83	192.33	0.45	6.56	6.39	0.15	12.31	11.17	0.37	388.83	344.67	0.55	13.65	13.10
RH-749 × DRMR150-35	197.67	188.33	0.41	8.67	8.11	0.37	14.00	12.68	0.37	440.33	401.67	0.42	14.57	13.42
RH-749 × RH-119	190.11	175.00	0.69	5.11	4.22	1.02	7.50	6.39	0.59	262.89	171.78	1.67	12.33	9.17
RH-749 × VARDAN	209.00	182.67	1.09	5.50	4.55	1.00	8.33	5.11	1.53	275.44	220.00	0.97	10.15	7.70
RH-749 × PM-27	193.67	168.00	1.15	5.33	4.22	1.22	10.03	7.39	1.04	159.22	123.33	1.08	12.25	9.92
RH-749 × PM-28	177.67	156.33	1.04	5.17	5.11	0.06	7.67	5.22	1.26	214.33	170.44	0.98	11.74	9.48
RGN-73 × RGN-229	188.67	163.67	1.15	4.78	3.67	1.36	6.61	5.06	0.93	272.11	213.67	1.03	10.76	8.70
RGN-73 × RGN-298	192.56	169.78	1.03	5.44	4.50	1.01	8.89	6.00	1.29	347.67	272.00	1.05	12.33	9.60
RGN-73 × PUSA BOLD	184.18	162.33	1.03	4.45	3.44	1.31	10.48	7.17	1.25	235.00	184.67	1.03	13.85	11.04
RGN-73 × NRCHB-101	181.67	160.00	1.03	5.56	4.50	1.11	11.44	11.00	0.15	322.67	248.33	1.11	14.08	11.00
RGN-73 × RH-406	198.67	175.00	1.03	5.56	4.67	0.93	12.11	7.59	1.48	311.56	229.33	1.27	11.31	9.19
RGN-73 × DRMR150-35	200.00	192.00	0.35	3.89	3.33	0.83	14.33	10.27	1.12	196.00	184.00	0.29	14.65	13.03
RGN-73 × RH-119	175.33	138.78	1.81	5.00	4.28	0.84	7.33	5.33	1.08	253.33	186.78	1.26	7.29	6.00
RGN-73 × VARDAN	204.51	183.67	0.88	5.17	4.70	0.53	10.83	8.22	0.95	313.33	248.11	1.00	12.08	9.50
RGN-73 × PM-27	193.17	171.00	0.99	6.00	4.44	1.51	8.89	6.44	1.09	273.83	216.44	1.01	13.33	10.36
RGN-73 × PM-28	187.33	156.33	1.43	5.00	4.33	0.78	8.57	6.89	0.77	350.33	252.22	1.35	8.41	6.84

I* (Irrigated condition), R* (Rainfed Condition), DSI (Drought susceptibility Index)

749 × DRMR150-35 and RH-749 × PM-28 for primary branches per plant; RH-749 × RH-406, RH-749 × DRMR150-35, and RGN-73 × NRCHB101 for secondary branches per plant; Giriraj × DRMR 150-35, RH-749 × DRMR150-35 and RGN-73 × DRMR150-35 for number of siliqua per plant were found as drought tolerant. The high drought tolerant hybrids for seed yield per plant were Giriraj × DRMR 150-35, RH-749 × RH 406, and RH-749 × DRMR150-35. The crosses such as RH-749 × RH-406, RH-749 × DRMR150-35, and RH-749 × RH-119 had high drought tolerance according to DSI value. For oil content drought tolerant genotypes were, Giriraj × DRMR 150-35 and RH-749 × RH-406. In present study, almost all parents except Giriraj, RH749 and RGN 73 were found tolerant to moderately tolerant for almost all the studied traits therefore, hybrids involving these tolerant genotypes as male parent and high yielding drought susceptible genotypes (Giriraj, RH-749 and RGN-73) as female parent genotypes were found moderate to high tolerant. For seed yield per plant DRMR150-35 was found to be highly drought tolerant among all lines therefore hybrid involving this line had moderate to high tolerant for yield per plant.

Alipour and Zahedi (2016) reported that the highest seed yield was obtained by regular irrigation. Also, the oil yield loss can be caused by lack of soil moisture at flowering stage, reducing photosynthesis and photosynthetic production to various plant parts. Singh *et al.* (2014) found that overall mean performance of *Brassica* progenies was comparatively higher in irrigated environment for days to 50% flowering, siliquae per plant, 1000 seed weight, seed yield per plant and protein content and genotypes 07-547, 07-515 and 07-510 which showed lower DSI values (< or ~0.00), were rated as drought tolerant. Similarly, Chauhan *et al.* (2007) reported top six drought tolerant genotypes for seed yield at either or both locations (Bharatpur and Jobner) as JMMWR-941, RC 1446, PSR 20, RH-819, Varuna and RC-53, as indicated by their relatively low DSI. Singh and Choudhary (2003) used DSI values and seed yield under drought conditions as a selection criterion for drought tolerance in Indian mustard. Drought is considered as a major factor of yield penalty for all important agricultural crops. Water stress during and after the flowering stage has a more adverse effect on seed yield than during other stages of plant development (Champolivier and Merrien 1996). Generally, abiotic stresses including drought are controlled by multiple genes with complex underpinning mechanisms and are of great importance in selecting desirable parents for executing effective breeding program to evolve efficient varieties for stress condition (Lamaoui *et al.*, 2018). Genotypes of *Brassica* species with drought-

tolerance traits are known to produce the highest seed yield under drought conditions (Singh *et al.*, 1988 and Kumawat *et al.*, 1997).

Conclusion

Based on both average performance and Drought Susceptibility Index (DSI) values, parental genotypes Giriraj, RH-749, and RGN-73 exhibited high yield but demonstrated low drought tolerance. Conversely, the remaining parental genotypes displayed moderate to high levels of drought tolerance. DRMR150-35 demonstrated high drought tolerance for seed yield, while RGN-229, RGN-298, Pusa Bold, NRCHB-101, Vardan, PM-27, and PM 28 showed moderate tolerance. Crosses involving susceptible but high-yielding genotypes in irrigated condition with drought-tolerant genotypes, such as Giriraj × DRMR 150-35, RH-749 × RH-406, RH-749 × DRMR150-35, and RGN-73 × DRMR150-35, displayed various degrees of drought tolerance for almost all the traits examined. The donors identified in this study, possessing multiple characteristics for drought tolerance, should therefore be incorporated into breeding programs.

References

- Ahmadi M and Bahrani MJ. 2009. Yield and yield components of rapeseed as influenced by water stress at different growth stages and nitrogen levels. *American-Eurasian J Agric Environ Sci* 5: 755–761.
- Alipour A and Zahedi H. 2016. Difference in drought resistance among three Brassica species at different growing stage and application of zeolite. *Ind J Agric Res* 50: 193-196. doi 10.18805/ijare.v0i0F.9359.
- Champolivier L and Merrien A. 1996. Effects of water stress applied at different growth stages to *Brassica napus* L. var. *oliefera* on yield, yield components and seed quality. *Euro J Agron* 5: 153-160. doi: 10.1016/S1161-0301(96)02004-7.
- Chauhan JS, Tyagi MK, Kumar A, Nashaat NI, Singh M, Singh NB, Jakhar ML and Welham SJ. 2007. Drought effects on yield and its component in Indian mustard (*Brassica Juncea* L.). *Plant Breed* 126: 399-402. doi:10.1111/j.1439-0523.2007.01394.x.
- Clarke JM, DePauw RM, Townley Smith TF. 1992. Evaluation of methods for quantification of drought tolerance in wheat. *Crop Sci* 32: 723–728.
- Fernandez GCJ. 1992. Effective selection criteria for assessing stress tolerance. In: Kuo, C.G. (Ed.). Proceedings of the international symposium on adaptation of vegetables and other food crops in temperature and water stress, Tainan, Taiwan.
- Fischer RA and Maurer R. 1978. Drought resistance in spring wheat cultivars: I. Seed yields responses. *Aus*

- J Agric Res* **29**: 897-907. doi: 10.1071/AR9780897.
- Kumawat BL, Sharma DD and Jat SC. 1997. Effect of brassinosteroid on yield and yield attributing characteristics under water deficit stress condition in mustard (*Brassica Juncea* L.) *Ann Bio* **13**: 91-93.
- Lamaoui M, Jemo M, Datla R and Bekkaoui F. 2018. Heat and drought stresses in crops and approaches for their mitigation. *Front Chem* **6**: 26. doi: 10.3389/fchem.2018.00026.
- Marzaei A, Naseri R, Moghadam A and Jahromi ME. 2013. The effects of drought stress on seed yield and some agronomic traits of canola cultivars at different growth stages. *Bull Environ Pharma Life Sci* **2**: 115-121.
- Nagaharu U. 1935. Genome analysis in brassica with special reference to the experimental formation of *Brassica napus* and peculiar mode of fertilization. *Japanese J Bot* **7**: 389-452.
- Pandey PK, Maranville JW and Admou A. 2001. Tropical wheat response to irrigation and nitrogen in a Sahelian environment - Grain yield, yield components and water use efficiency. *Eur J Agron* **15**: 93-105.
- Singh RP, Singh DP and Singh P. 1988. Variation for plant water relation and yield structure in *Brassica juncea* L. under drought conditions. *Narendra Deva J Agric Res* **3**: 91-98.
- Singh SP and Choudhary AK. 2003. Selection criteria for drought tolerance in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. *Ind J Genet Plant Breed* **63**: 263-264.
- Singh VV, Rai PK, Siddiqui SK, Verma V and Yadav R. 2011. Genetic variability and relative drought tolerance in interspecific progenies of *Brassica juncea*. *Agri Biol J North Am* **2**: 34-41.
- Singh VV, Ram B, Singh M, Meena ML and Chauhan JS. 2014. Generation mean analysis of water stress tolerance parameters in Indian mustard [*Brassica juncea* (L.) Czern and coss] crosses. *SABRAO J Breed Genet* **46**: 76-80.
- Winter SR, Musick JT and Porter KB. 1988. Evaluation of screening techniques for breeding drought resistance winter wheat. *Crop Sci* **28**: 512-516. doi: 10.2135/cropsci1988.0011183X002800030018x.
- Yang J, Sears RG, Gill BS and Paulsen GM. 2002. Genotypic differences in utilization of assimilate sources during maturation of wheat under chronic heat and heat shock stresses. *Euphytica* **125**: 179-188.