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Screening for drought tolerance in Indian mustard (*Brassica juncea* L.) genotypes based on yield contributing characters and physiological parameters

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Abstract

Fifty genotypes of *Brassica juncea* were evaluated for drought tolerance during *rabi*, 2015-16. These were grown under two environments *i.e.* irrigated and rainfed (no post sown irrigation) in the research area of Oilseeds Section, CCS HAU, Hisar. Reduction in chlorophyll content, relative water content (RWC), yield and yield attributes was observed under rainfed conditions. Out of 50 genotypes, 25 showed <10% reduction in chlorophyll content with minimum of 2.5% in DRMR-15-16 under rainfed conditions. Minimum reduction in number of siliquae on main shoot (SMS) was observed in PRD-2013-2 (2.0%) followed by DRMR 1187-71 (2.1%). 1000-seed weight also declined with minimum of 0.07% in KMR1-4 followed by 0.8% in RH 0406 and 1.2 % in NPJ-197. The genotypes LES-53 and PRD-2013-2 recorded for minimum reduction in biological yield/plant under rainfed conditions. Seed yield/plant observed with minimum reduction of 11.5% in PRD-2013-2 followed by 14.1 % in NPJ-197. The genotypes found tolerant under rainfed conditions were LES-53, PRD-2013-2, DRMR-4001, PDZ-1, RB-50, NPJ-197 and KMR (E) 15-1 on the basis of less reduction in seed yield, harvest index, 1000-seed weight and biological yield.

Key words: *Brassica juncea, drought tolerance, relative water content, seed yield, water deficit stress*

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is a premier oilseed crop which covers about 85-90% of the total area under cultivation of *Brassica* crop. In Haryana, it is grown over an area of 0.54 million ha with production of 0.88 million tons and average yield of 1639 kg/ha during 2013-2014 (Anonymous, 2015). So far significant efforts have been made for genetic enhancement of Indian mustard and as a result a number of high yielding varieties have been developed which are being grown commercially throughout the country. Now, varieties are available with more than 2.5 t/ha seed yield but when we look at the productivity scenario of this crop it fluctuated between 668 kg/ha during 1997-98 to 1.13 t/ha during 2013-14 at national level. In recent years, there are many emerging constraints including various biotic and abiotic stresses leading to the fluctuations in the area, production and productivity of this crop.

Climate change has further imposed several limitations on the productivity of Indian mustard in the form of emerging diseases, pests and abiotic stresses such as drought and heat. Drought is considered as one of the most important environmental stress limiting plant growth and crop productivity. In rain fed areas sowing of Indian mustard depends upon available conserved moisture and often due to early rains, farmers usually sow the crop early in season to avoid the moisture loss. In rainfed areas crop may usually faces water deficit/drought conditions. Drought stress causes an increase in solute concentration in the soil and root-zone of the plant, leading to an osmotic flow of water out of plant cells. This further results in high concentration of solutes in plant cell i.e. lowering water potential of cell, disrupting cell physiological processes. Plant's photosynthesis reduces under drought stress as the leaf area, plant height and lateral stem number reduce under this condition. Under drought stress, stomata become blocked or half-blocked and this leads to a decrease in absorbing CO_2 and on the other hand, the plants consume a lot of energy to absorb water, this causes a reduction in production of photosynthetic matter.

Drought stress also reduces the oil content as in case of stress, more metabolites are produced and prevent it from oxidation in the cells. These drought-stressed plants consequently exhibit poor growth and yield. In worst situations, the plants completely die. Moisture stress causes reduction in leaf chlorophyll content of plants

(Paknejad *et al*., 2007; Sun *et al*., 2011). The RWC is an important physiological attribute which determines the tolerance of plants to drought stress. It has a close relation with water potential of plants (Ober *et al*., 2005). The water deficiency has the greatest effect on the grain yield of mustard in flowering and pollination stage (Fernandez, 1992). Therefore, the present study was carried out to evaluate the response of different genotypes of Indian mustard for various physiological parameters, seed yield and its components under the drought stress and also to identify the genotypes tolerant to this stress.

Materials and Methods

Fifty genotypes of Indian mustard (*B. juncea*) collected from different sources were evaluated under irrigated and rainfed conditions during *rabi*, 2015-16. The genotypes were grown in paired rows of 4 m length each at Oilseeds Research Area, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Recommended package of practices to raise a good crop was followed. In one set, irrigation was given as per irrigation schedule i.e. no stress and in another set no post sown irrigation was given (rainfed condition). The experiment was laid out in Randomized Block Design (RBD) with three replications. The observations on relative leaf water content (%) and chlorophyll content (SPAD unit) were recorded at 50% flowering. Observations on parameters including number of siliquae on main shoot, seeds per siliqua, 1000-seed weight (g), seed yield/plant (g), biological yield/plant (g) and oil content (%) were recorded from five randomly selected plants in each genotype under irrigated and rain fed conditions. The drought parameters were calculated by using the following formulae :

1. Relative leaf water content (Barrsand Weatherley, 1962):

$$\text{RLWC} = \frac{\text{FW-DW}}{\text{TW- DW}} \times 100$$

Where,

FW= Fresh weight,
DW= Dry weight
TW= Turgid weight

2. Drought susceptibility index (Fischer and Maurer, 1978):

$$\text{DSI} = \frac{(1- Y_0/ Y_1)}{\text{DI}}$$

Where

Y_0 = Yield of individual genotype under stress conditions
Y_1= Yield of individual genotype under irrigated conditions

DI = (1- Yr/ Yi)

Yr = Mean yield of all the genotypes under stress conditions
Yi = Mean yield of all the genotypes under irrigated conditions

3. Harvest index (Donald, 1962) as follows.

$$\text{HI} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

Total rainfall recorded during the experimental period was 7.0, 2.9 and 5.3, 25.2 mm in October, November, 2015 and February, March, 2016, respectively. Soil moisture content (%) was estimated by Gravimetric method. The moisture content at 0-30 cm was recorded 12.8% (irrigated), 12.2% (rainfed) at the time of sowing and 9.1% (irrigated), 7.2 % (rainfed) at harvesting, while at 30-60 cm it was observed 15.5% (irrigated), 14.5% (rainfed) and 13.5 (irrigated), 11.0% (rainfed) at sowing and at harvesting, respectively.

Statistical analysis

The data were analyzed by two factorial RBD design using OP-STAT, online statistical portal, CCS, HAU, Hisar.

Results and Discussion

Analysis of variance of the data for physiological parameters and yield components showed that chlorophyll content, relative water content (RWC), 1000-seed weight, siliquae on main shoot, seeds/siliqua, seed yield/plant, biological yield/plant and harvest index were significantly affected by the water stress. Out of 50 genotypes, 25 genotypes showed <10% reduction in chlorophyll content under rain fed conditions with average reduction of 11.2% (Table 1). Maximum reduction of chlorophyll content (22.6%) was found in LES-49 and minimum (2.5%) was observed in DRMR-15-16. The decrease in chlorophyll content under water stress is a commonly observed process (Reynolds *et al*., 2005). Water stress causes loss of pigments and disorganization of thylakoid membranes which results in reduction in chlorophyll contents (Ashraf and Harris, 2013). Reduction in chlorophyll content under water stress might be due to oxidative damage of chloroplast lipids, pigments and proteins as reported by Tambussi *et al*. (2000). Similarly, reduction in chlorophyll content under water stress was observed by Majidi *et al.* (2015) and Shekari *et al*. (2015) in cultivars of *Brassica*.

Relative water content was lower in rainfed conditions as compared to irrigated conditions. Out of 50 genotypes 35 showed <10% reduction in RWC under rainfed conditions.

Table 1: Effect of moisture stress on chlorophyll content (SPAD), relative water content (RWC) (%), number of siliqua on main shoot (SMS) and number of seeds/siliqua

Genotypes	Chlorophyll content (SPAD value)		(RWC %)		Number of siliquae on main shoot (SMS)		Number of seeds /siliqua	
	IR	RF	IR	RF	IR	RF	IR	RF
LES-53	45.6	38.9	86.4	79.4	61.5	54.8	11.8	11.6
PRD-2013-2	42.3	41.0	86.5	78.5	62.5	61.3	14.4	13.0
LES-50	45.6	40.4	86.6	78.9	62.0	54.3	13.7	10.8
RH406	41.3	32.9	86.5	81.0	60.5	51.8	16.3	14.2
DRMR-4001	43.1	39.2	88.7	79.0	52.8	39.8	14.0	12.5
PDZ-1	36.8	33.9	88.3	75.5	52.8	44.8	14.5	12.6
RH 673	41.0	37.1	85.9	81.3	52.0	50.5	13.2	12.2
DRMR15-5	47.2	37.5	88.1	80.0	49.5	44.8	14.4	12.6
RB-80	43.1	40.5	85.6	79.0	61.3	59.3	12.2	11.5
NPJ-196	45.0	35.3	86.3	80.4	57.8	56.0	14.8	12.5
DRMR-4104	44.3	40.7	84.4	74.6	44.5	36.0	13.6	13.1
RB-50	43.9	42.2	85.3	77.7	50.3	41.0	13.4	12.8
Pusa mustard 25	42.5	39.5	83.8	79.1	55.8	54.0	16.4	15.7
NPJ-190	39.1	35.9	81.6	78.8	48.8	46.5	16.7	14.7
PDZ-2	41.4	36.7	82.5	78.8	54.0	48.0	15.1	14.0
NPJ-182	49.5	40.8	82.7	79.1	54.3	50.0	13.8	11.4
DRMR-10-40	39.0	36.7	80.6	79.8	49.0	41.0	14.9	13.8
NPJ-179	44.7	41.1	79.2	78.4	53.3	51.3	12.6	11.2
KMR(L) 1506	49.7	38.5	83.1	78.8	55.8	42.3	13.8	11.6
Kranti	43.0	41.2	83.8	78.9	60.3	51.5	12.6	12.2
NPJ-195	41.0	38.5	86.6	67.4	46.0	40.8	16.6	13.8
DRMR 541-44	40.8	37.7	87.3	57.3	48.8	45.5	13.4	12.8
NPJ-197	49.3	43.8	88.0	77.7	57.8	51.3	13.6	13.2
DRMR 1187-71	45.9	44.0	87.4	77.3	48.3	47.3	13.9	11.4
KMR(E) 1505	49.6	46.3	87.0	71.1	59.5	48.5	14.9	13.1
DRMR 1165-40	47.2	36.7	68.4	56.1	53.0	49.8	13.2	12.7
NPJ-198	46.7	41.1	84.9	60.9	53.8	51.3	14.0	10.9
KMR(E)15-1	48.9	45.5	70.3	57.9	65.3	57.5	14.2	14.0
LES-49	50.0	37.9	86.5	64.4	54.3	49.5	13.2	10.0
DRMR-1153-12	49.4	39.1	87.1	71.4	50.5	45.3	12.0	11.3
PDZ-6	40.3	37.8	86.6	80.2	60.0	57.5	15.6	15.1
LES-52	38.2	35.8	87.1	80.1	66.0	54.0	12.7	11.3
NPJ-193	38.9	36.0	88.3	79.2	44.5	34.3	13.8	13.2
DRMR-15-47	40.8	35.4	87.8	80.8	49.8	37.8	15.5	11.9
PDZ-5	36.1	33.8	88.6	80.0	61.5	53.5	15.3	14.6
NPJ-194	44.3	38.6	87.9	79.2	47.3	41.0	14.2	13.7
DRMR-15-14	44.9	43.2	87.3	80.6	53.0	46.8	15.5	14.4
PDZ-4	46.9	37.2	87.2	82.1	52.5	50.0	15.2	13.7
RGN-330	41.8	36.6	86.1	80.8	58.3	54.8	13.7	13.6
RH-1301	44.8	36.9	86.8	80.5	51.0	45.3	13.5	12.8
KMR(E)15-2	43.6	42.3	86.9	81.2	55.3	46.0	13.8	12.9
RGN-337	40.7	36.8	87.7	80.7	45.3	43.5	13.7	13.1
DRMR-15-16	40.5	39.5	84.4	80.0	47.8	41.5	15.8	13.6
RGN-368	40.6	35.9	87.4	80.5	54.0	50.0	14.6	14.2
KMR1-4	42.2	36.0	85.8	78.5	54.5	50.8	15.2	14.0
KMR 15-3	43.0	33.3	86.0	80.0	52.8	45.5	14.3	12.3

RH-30	37.7	33.5	86.3	81.0	51.3	45.0	12.6	12.0
RH-0749	47.9	39.7	87.4	72.7	59.0	45.5	14.7	11.8
RH-0119	45.4	36.7	86.5	81.1	49.0	47.8	13.6	13.1
RH-0406	48.3	41.9	87.3	81.2	47.0	44.8	13.2	11.9
Mean	43.7	38.5	85.4	76.8	53.9	48.0	14.1	12.8
CD (P=0.05)	E-0.7, G-4.0, ExG-NS		E-0.5, G-2.2, ExG-3.1		E-2.06, G-9.86, ExG-NS		E-0.38, G-1.81, ExG-NS	

I=Irrigated, RF= Rainfed, E=Environment, G=Genotypes

Maximum decline was observed in DRMR 541-44 (34.4%) followed by NPJ-198 (28.3%) while, the minimum (1.0%) reduction was observed in DRMR-10-40 and NPJ-179. Norouzi *et al*. (2008) reported that all leaf water related parameters decreased with imposed water stress. Under water stress conditions, the soil moisture content decreases which lead to further decline in leaf water potential as reported by Li *et al*. (2002). Shekari *et al.* (2015) also observed that drought stress reduced water potential and RWC in *B. napus*.

The present study showed reduction in yield and its attributes under rainfed conditions. Twenty two genotypes showed <10% reduction for number of siliquae on main shoot under rainfed conditions with average reduction of 11.0%. Minimum 2.0% reduction was observed in PRD-2013-2 followed by 2.1% in DRMR 1187-71. Thirty genotypes showed <10% reduction in number of seeds/siliqua under rain fed situation with the average reduction of 9.3% (Table 2). Nasri *et al*. (2008) observed that water stress at flowering stage caused a significant reduction in the number of siliquae/plant and number of seeds/siliqua in five cultivars of rapeseed mustard. Water deficit stress causes number of pods/ plant to reduce by shortening the flowering period, the reproductive growth duration and finally the infertility of some flowers and their abscission. Similarly, Sinaki *et al*. (2007) studied 29 rapeseed cultivars and observed reduction in number of siliquae/plant with water deficit stress during the flowering stage until the maturity. The reason for the reduction in seed number per pod during water deficit condition is reducing number of flowers and lowering number flowers which converted into seeds (Zirgoli and Kahrizi, 2015).

Seed yield/plant ranged from 10.9 g (PDZ-1) to 54.5g (LES-53) in the irrigated and from 7.3 g/plant (NPJ-182) to 44.3 g/plant (LES-53) under rain fed condition. For seed yield/ plant mean reduction (39.0%) was reported under rainfed condition. Out of 50 genotypes, 11 genotypes showed <20% reduction in seed yield/plant with minimum of 11.5% in PRD-2013-2 followed by 14.1% in NPJ-197 (Table 2). The reduction in seed yield and yield components of crop plants under water stress was observed by many workers; Gunasekara *et al*. (2006) and Naghavi *et al.* (2015) in Brassica cultivars. Seed yield reduction occurred due to low water availability during stem elongation, flowering and pod development which caused reduction of pods/ plant. Rashidi *et al*. (2012) observed that reason of seed yield reduction in different cultivars can be due to level of used stress and its effect on some yield components such as pods/plant, seeds/pods and 1000-seed weight. Water disruption during flowering and grain filling stages may increase flower and pod abortion, thus, decreasing the seed number/plant. Similar results were also reported for chickpea (Ghassemi-Golezani *et al*., 2008) and soybean (Demirtas *et al*., 2010).

Biological yield ranged from 63.3 g/plant (PDZ-1) to 180.0 g/plant (LES-53) in the irrigated conditions and 41.0 g/ plant (PDZ-5) to 167.5 g/plant ((LES-53) under the rain fed conditions. Out of 50 genotypes tested, 16 genotypes recorded less than 20% reduction in biological yield/plant under rainfed condition with the minimum reduction of 6.2% in LES-53 followed by 6.3% in PRD-2013-2 and maximum reduction was observed in PDZ-5 (67.5%). Reductions in biological yield in canola cultivars under stress conditions was also observed by Khalily *et al.* (2012) due to limited plant vegetative and reproductive growth. In general, results of this study are in accordance with Tohidi-Moghadam *et al*. (2009).

Thirty two genotypes showed <10% reduction in harvest index % (HI) under rain fed condition with mean reduction of 11.0 %. Seven genotypes showed <0.5 DSI and 19 genotypes showed DSI value between 0.5-1.0 (Table 2). The average harvest index of rapeseed genotypes under stress condition was also decreased. The results of harvest index during stress are comparable with Khalily *et al*. (2012) and Shekari *et al*. (2015). Turk *et al*. (1980) advocated that due to stress and water deficiency, the transmission of photosynthetic substances to shoot organs decreases and finally the yield components reduces. Indeed, with the reduction of these components, the harvest index rate also decreases. Average reduction of 2.6% in oil content was observed under rainfed condition. Maximum oil content 40.9% and 39.3% was observed in NPJ-182 under irrigated and rainfed

Table 2: Effect of moisture stress on seed yield/plant, biological yield, 1000-seed weight, harvest index, drought susceptibility index (DSI) and oil content

Genotypes	1000-Seed weight (g)		Biological yield/plant (g)		Seed yield/plant (g)		Harvest index %		DSI	Oil content (%)	
	IR	RF	IR	RF	IR	RF	IR	RF		IR	RF
LES-53	6.5	6.1	180.0	167.5	54.5	44.3	30.3	26.4	0.48	40.0	38.7
PRD-2013-2	3.6	3.3	107.5	100.8	15.3	13.5	14.2	13.4	0.29	40.3	38.5
LES-50	6.4	4.9	153.0	114.0	25.8	17.3	16.8	15.1	0.84	39.7	38.8
RH406	5.5	5.2	107.8	76.5	26.4	18.0	24.4	23.6	0.81	40.4	38.8
DRMR-4001	4.9	4.8	92.6	82.5	18.4	15.4	20.0	18.6	0.42	39.6	38.6
PDZ-1	3.3	3.2	63.3	52.7	10.9	8.9	17.2	16.9	0.47	39.2	38.5
RH 673	6.3	5.2	112.0	89.3	21.9	16.8	19.5	18.9	0.60	40.3	38.8
DRMR15-5	6.0	4.6	118.3	59.0	35.0	15.5	29.4	26.3	1.42	39.0	38.6
RB-80	5.1	4.9	133.4	84.0	35.7	19.8	26.6	23.4	1.14	39.5	38.6
NPJ-196	4.7	4.2	94.9	82.4	14.2	10.1	15.0	12.3	0.74	38.4	38.0
DRMR-4104	5.2	4.5	89.2	43.4	21.3	9.5	23.9	21.8	1.42	39.6	38.4
RB-50	6.0	5.4	101.4	86.6	17.9	14.8	17.7	17.0	0.45	40.6	38.7
Pusa mustard 25	4.8	4.4	75.0	59.6	17.4	9.4	23.3	15.7	1.18	39.3	37.4
NPJ-190	4.4	4.1	99.0	43.8	22.8	9.3	22.9	21.3	1.52	39.6	38.8
PDZ-2	3.2	2.7	82.5	54.4	19.4	10.0	23.5	18.4	1.24	39.1	38.5
NPJ-182	5.2	5.1	73.8	50.5	14.8	7.3	20.0	14.4	1.30	40.9	39.3
DRMR-10-40	5.5	5.2	97.9	50.0	20.8	10.3	21.3	20.6	1.30	38.3	37.6
NPJ-179	5.8	5.7	88.5	62.5	21.0	13.3	23.9	21.1	0.94	40.4	38.4
KMR(L) 1506	5.5	4.6	140.0	54.0	31.3	13.0	22.7	22.1	1.49	39.7	38.6
Kranti	4.5	3.9	88.0	60.0	17.9	11.5	20.5	19.2	0.91	39.9	37.7
NPJ-195	5.3	4.8	122.4	64.5	27.8	13.5	22.7	21.0	1.32	40.5	38.6
DRMR 541-44	5.1	4.6	114.3	66.8	26.9	15.0	23.3	21.2	1.13	39.6	38.4
NPJ-197	5.3	5.2	103.9	95.2	23.5	20.2	22.8	21.3	0.36	39.6	38.7
DRMR 1187-71	5.7	5.4	119.3	99.6	27.3	20.8	22.8	20.8	0.61	38.6	38.4
KMR(E) 1505	4.9	4.8	122.5	83.6	32.7	22.0	26.7	26.0	0.83	39.8	38.3
DRMR 1165-40	5.2	4.6	117.5	64.5	26.8	14.0	22.8	21.6	1.22	38.8	37.4
NPJ-198	5.5	5.2	176.5	126.5	39.9	20.2	22.7	15.9	1.27	39.8	37.6
KMR(E)15-1	5.2	4.3	162.7	139.4	26.4	21.3	16.3	15.3	0.50	38.6	38.5
LES-49	5.7	4.6	135.2	73.9	36.5	18.1	27.1	25.6	1.29	39.4	38.4
DRMR-1153-12	6.0	5.6	103.8	74.3	23.1	16.0	22.3	21.5	0.79	38.5	38.2
PDZ-6	4.4	4.0	125.5	110.0	28.1	19.5	22.3	17.7	0.78	39.6	37.9
LES-52	6.4	5.7	147.6	116.8	31.4	23.7	21.4	20.3	0.63	39.5	38.7
NPJ-193	5.0	4.6	117.0	44.8	28.9	9.5	24.7	20.8	1.72	39.3	38.4
DRMR-15-47	5.7	5.2	107.3	49.0	23.8	9.0	22.3	17.3	1.59	39.8	39.6
PDZ-5	2.9	2.8	126.0	41.0	29.4	8.8	23.3	21.3	1.80	39.6	38.7
NPJ-194	4.3	4.3	87.5	44.0	25.8	12.8	29.6	28.9	1.29	40.3	38.9
DRMR-15-14	5.0	4.5	113.0	91.3	30.5	18.0	27.9	19.7	1.05	39.0	38.4
PDZ-4	3.4	3.3	113.3	72.3	20.9	12.9	18.4	17.9	0.98	38.6	38.6
RGN-330	4.7	4.4	127.5	110.0	34.2	22.7	27.3	20.9	0.86	40.2	38.5
RH-1301	5.7	5.4	172.0	97.0	40.0	20.5	23.2	21.8	1.25	39.0	38.6
KMR(E)15-2	5.5	4.7	100.1	63.5	23.5	13.6	23.5	21.5	1.08	39.5	38.3
RGN-337	5.0	4.7	117.5	91.2	30.6	21.4	25.9	23.4	0.77	39.4	38.8
DRMR-15-16	5.2	4.9	123.3	91.4	27.9	18.8	22.6	20.6	0.84	38.9	38.6
RGN-368	5.4	5.0	110.1	95.0	24.0	16.7	21.9	17.6	0.78	39.4	38.9
KMR1-4	4.7	4.6	146.3	82.5	32.1	15.8	22.5	18.9	1.30	39.6	38.4
KMR 15-3	5.4	5.1	118.3	59.8	28.6	13.3	24.2	22.5	1.37	39.0	38.8

RH-30	6.04	4.8	104.0	89.2	22.8	18.5	21.9	20.7	0.49	39.6	38.7
RH-0749	5.74	5.5	140.8	96.8	33.7	20.5	23.9	21.2	1.01	39.4	39.3
RH-0119	6.63	6.3	116.5	97.9	20.4	16.1	17.5	16.5	0.53	39.6	38.8
RH-0406	5.45	5.4	150.7	141.1	31.1	25.1	20.7	17.8	0.49	39.3	38.5
Mean	5.18	4.7	116.8	80.9	26.4	16.1	22.6	20.1	0.97	39.5	38.7
CD (P=0.05)	E-0.1, G-0.5 ExG=0.5		E-2.8, G-13.5, IxG-18.8		I-0.8, G-3.9, IxG-5.6		I-0.6, G-2.9, IxG=NS		I-0.07, G-0.3 IxG-0.4		

I=Irrigated, RF= Rainfed, E=Environment, G=Genotype

conditions, respectively (Table 2). Nasri *et al*. (2008) also observed that drought stress caused a significant reduction in the 1000-seed weight, seed yield, oil content and the oil yield of five rapeseed cultivars. The genotypes *viz*. LES-53, PRD-2013-2, DRMR-4001, PDZ-1, RB-50, NPJ-197 and KMR (E) 15-1 were tolerant under rainfed condition on the basis of seed yield, harvest index, 1000-seed weight and biological yield. These genotypes can be further utilized for the development of drought tolerant varieties. Hence, this study helped in understanding the drought tolerance process and selection of genotypes for dry regions.

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