The Pharma Innovation Journal 2018; 7(8): 517-525

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(8): 517-525

www.thepharmajournal.com
Received: 05-06-2018
Accepted: 10-07-2018

Khushboo Chandra
Department of Plant Breeding and Genetics Dr. Rajendra Prasad Central Agricultural University, Pusa, Samatipur, Bihar, India

Anil Pandey
Department of Plant Breeding and Genetics Dr. Rajendra Prasad Central Agricultural University, Pusa, Samatipur, Bihar, India

SB Mishra
Department of Plant Breeding and Genetics Dr. Rajendra Prasad Central Agricultural University, Pusa, Samatipur, Bihar, India

Kavita
Department of Plant Breeding and Genetics Dr. Rajendra Prasad Central Agricultural University, Pusa, Samatipur, Bihar, India

Correspondence
Khushboo Chandra
Department of Plant Breeding and Genetics Dr. Rajendra Prasad Central Agricultural University, Pusa, Samatipur, Bihar, India

Genetic variability of physiological parameters among Indian mustard (*Brassica juncea* L. Czern & Coss) genotypes under non-irrigated and irrigated condition

Khushboo Chandra, Anil Pandey, SB Mishra and Kavita

Abstract
Increasing pace towards water crisis results in demand of screening of drought tolerant genotypes which were suitable for both non-irrigated as well as in irrigated condition. Keeping consideration over this experiment was designed to study genetic variability and heritability under non- irrigated and irrigated condition on some physiological and quality traits an experiment on Indian mustard (*Brassica juncea* L. Czern & Coss), was conducted in Randomized Complete Block Design (RBCD) accommodating 20 genotypes, from various Rapeseed & Mustard centres located across country, randomly in three replications during *Rabi* 2016-17, one subjected to a drought regime inside the Rainout shelter under non- irrigated condition which was also devoid of rainfall and another one provided with normal irrigated field condition in Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur. Analysis of variance for the studied traits revealed considerably exploitable variability. Out of 20 genotypes under both non-irrigated as well as irrigated condition, Rajendra Suphalam showed tolerance towards water stressed condition and perform well in terms of productivity in irrigated situation for traits namely Tap Root Length, Root Volume, Root Mass, Relative Water Content, Leaf Membrane Stability Index, Excised Leaf Water Loss, Chlorophyll Content, Catalase Activity, Peroxidase Activity, Proline Accumulation, Relative Growth Rate, Leaf Area Index, Specific Leaf Weight, Drought Tolerance Index, Stress Intensity, Oil Yield, Grain Yield/Plot. Under NI condition high heritability coupled with high GAM for traits namely, RL, RGR, LAI, LMSI, RWC, ELWL; RM only in irrigated and RV, SLW, CA under both conditions which were indicative of preponderance of additive gene action for expression of these traits, hence are acquiescent for simple selection.

Keywords: *Brassica juncea* L., drought tolerance index, stress intensity, leaf area, deficit irrigation

Introduction

Drought is the most solemn problem for global agriculture, roughly affecting 40% of the world's land area. Global climate change is predicted to lead to extreme temperatures and severe prolonged drought in some parts of the world, which will have a dramatic impact on crop growth and productivity (Trenberth *et al.* 2014) [43]. The average annual yield loss of crops due to drought in the world is about 17 percent that can increase to more than 70 percent a year. Currently, around 7% of the world's population lives in areas that suffer from water shortage and this could increase to 67 percent by 2050. Under this water scarce situation growing population too have to meet their food demands. Due to scarcity of water resources, deficit irrigation is used as an efficient option for increasing productivity under water shortage. Another strategy is using plant genetic engineering and breeding to develop drought-tolerant genotypes is mainly due to the quantitative nature of stress tolerance (Ehsani and Khaledi *et al*, 2004) [16]. Clarke *et al.*, (1984) [13] opined that selection for yield under dry condition should alone be more productive avenue for improvement of drought resistance until more rapid and effective screening procedures could be developed. DSI values and seed yield under drought conditions as a selection criterion in Indian mustard (Singh and Choudhary, 2003) [39].

Availability of genetic variability for the component characters is a major asset for initiating a fruitful crop improvement programme. A purposeful management of variability is a pre-requisite before embarking on any breeding method. For successful utilization of genetic variability crop breeders emphatically search for the traits of importance and subsequently to incorporate it genetically into an usable variety.

Material and Methods

The experiment consisting of 20 Indian mustard genotypes was planted on October 2016 under two conditions i.e. non-irrigated and irrigated (two irrigation) condition, laid out in Randomized Complete Block Design (RCBD) with three replications during *Rabi* season (2015-16), including check for variability and heritability study, received from different All India Co-ordinated Research Project- Rapeseed & Mustard centres: DRMR, Bharatpur, Rajasthan, CCSHAU, Hisar, Haryana, BARC, Trombay, Maharastra, GBPUAT, Pantnagar, Uttarakhand, CSAUAT, Kanpur, U.P, IARI, New Delhi, ARS, RAU, Sriganganagar, Rajasthan and DR.RPCAU, Dholi, Bihar, providing only basal dose of fertilizers i.e. N:P_2O_5:K_2O:S:: 40:40:40:40 kg/ha under residual moisture conditions inside rainout shelter and 40 Basal dose of fertilizer N:20 P_2O_5:20 K_2O:40 S kg/ha and other at green siliqua stage (E_4,65DAS) required 40 N for top dressing after pre flowering stage at Research Farm of Dr. Rajendra Prasad Central Agricultural University Farm (25.29^0 N, 85.40^0 E and 51.80 m MSL), Pusa, Samastipur, Bihar. Keeping row to row and plant to plant distance 30cm and 10cm, respectively. The spacing between plants was maintained at 10cm by thinning at 14 DAS.

The observations were recorded for Tap Root Length (RL), Root Volume (RV), Root Mass (RM), Relative Water Content (RWC), Leaf Membrane Stability Index (LMSI), Excised Leaf Water Loss (ELWL), Chlorophyll Content (CC), Catalase Activity (CA), Peroxidase Activity (PERO), Proline Accumulation (PRO), Relative Growth Rate (RGR), Leaf Area Index (LAI), Specific Leaf Weight (SLW), Drought Tolerance Index (DTI), Stress Intensity (SI), Oil Yield(kg/ha) (OY), Grain Yield/Plot (kg/ha) (GY/P). The data were recorded on five randomly selected plants from each genotype in each replication leaving the border rows to avoid the sampling error. The observations were recorded using standard methodology. Readings from five plants were averaged replication-wise and the mean data subjected for analysis by using statistical package WINDOSTAT version 9.2 (INDOSTAT Service, Hyderabad) for yield and its morpho-physio-quality traits.

The phenotypic variance was partitioned into genotypic and environmental variances for a clear understanding of the pattern of variations. The GCV, PCV, heritability, genetic advance, GAM were calculated following standard statistical methods (Burton, 1952; Lush, 1949; Burton and Devane, 1953 and Johnson *et al.*, 1955) [9, 25, 10, 22].

The leaf area index was calculated according to the formula given by Watson (1947) [44] as mentioned below

$$\text{LAI} = \frac{\text{Leaf Area}}{\text{Ground Area}}$$

The amount of total chlorophyll present in the extract was calculated in terms of milligrams of chlorophyll per gram of leaf tissue extracted as per following equations-

Total Chlorophyll mg /g tissue = 20.0(OD 645) +8.02(OD 663) x V 1000 x W

Where, OD is the optical density obtained of the extract at the wave lengths specified, V the final volume of the extract and W the fresh weight in grams of the tissue extracted.

The Specific Leaf Weight was calculated by formula given by Pearce *et al.* (1968) [31] in alfalfa

$$\text{SLW} = \frac{\text{Leaf weight}}{\text{Leaf area}}$$

Drought Tolerance Index can be calculated as mention below by Fischer and Maurer (1978) [17] in wheat.

$S= (1-Y/Y_p)/ (1-X/X_p)$

Y=Mean seed yield of a genotype in a stress environment

Y_p=Mean seed yield of a genotype in a stress free environment

X=Mean seed yield of all genotype in a stress environment

X_p=Mean seed yield of all genotype in a stress free environment

Stress Intensity can be calculated as mention below by Lewis (1954) [24]:

$$SI= (1- Y_s/Y_n) \times 100$$

Y_s=Yield under stress

Y_n=Yield under normal condition

Results and Discussion

In a study of Indian mustard (*B. juncea* L.), on perusal of Table 1 Analysis of variance indicated presence of exploitable variability among the genotypes for all the 11 traits except RGR, LAI,CC, DTI, SI and PRO.

On comparison (Table 2) between mean values under non-irrigated (NI) and irrigated (TI) condition for root length three genotypes namely, Rajendra Suphalam, Pusa Mahak and TM151 showed longer root in NI condition Roots are believed to play an important role in drought response, because they are the major organs for water uptake and can first experience and sense water deficit. This suggested the plant develop its survival mechanism and escape from the water inadequate condition by increasing length of root. These findings were in agreement with Blum, 1988. Root volume under NI condition is more as compared to TI indicated under moisture stress condition root expands its capillaries more in order to receive water from deep down water table from lateral percolation and seepage of water. But root mass is lesser as in NI due to non-availability of water roots are almost shrinked. These results were in accordance to Hashem *et al*., 1998; Qaderi *et al*., 2012; Ashraf *et al*., 2013; Shafiq *et al*., 2014 [21, 33, 35]. In NI condition due to low water potential inside the leaf surface leaf resulting in less accumulation of sink in terms to photosynthates as source reduces its biomass. Under NI condition it viewed that LAI and RGR are less in value as in TI suggesting that decrease in area of leaf under moisture stress reduces LAI in turn and RGR due to reduced leaf biomass. Similar findings of Hashem *et al*., 1998; Qaderi I., 2012; Moaveni *et al.* 2010 [21, 33, 27]. NI condition has low water potential in leaf surface which reduces RWC and LMSI. This findings were also suggested by Alikhan *et al.* 2010; Fushieng *et al*., 2006; Baji 2001 [1, 18]. Rajendra Suphlam has more RWC supported with its deepest root system have more power in water uptake from the soil and maintaining more moisture in their leaves. These results were in agreement Kage *et al.*, 2004 [23]. Proline content is more in NI than in TI that too Rajendra Suphlam, the drought-tolerant genotype was observed to have a higher proline contents to adjust the redox potential as an energy source, and eliminates the active oxygen species and provides the conditions required for continued absorption of water from root.. Similar findings were of Phutela *et al.* 2000; Din *et al*., 2011, Omidi *et al*., 2010 [32, 15, 29]. Proline acts as a nitrogen storage tank or soluble substance that reduces the cytoplasm osmotic potential and helps plant in stress tolerance (Ehsani *et al*., 2004) [16]. Peroxidase and Catalase activity enhances under NI than in TI suggesting that again Rajendra Suphlam have higher yields under drought stress have higher levels of catalase activity and peroxidase activity; also more DSI as compared to other genotypes as a defense mechanism to plant stress as well as stops damage from free radicals to membranes and vital component of the cell. These results were in accordance with Bakke and Skinners, 2003; Boon *et al*., 2007 [4, 8].

Grain yield is greatly reduced under NI condition. Our findings in agreement with Chauhan *et al.* 2007; Mendham and Salisbury, 1995 [12, 26]. The reproductive phase of the plant is more susceptible to drought stress (Hall 1992; Poulsen, 1994) [20, 30]. Drought stress caused a significant reduction on seed oil yield and compared to irrigation stop in flowering and grain filling, respectively 40 and 21% oil yield decreased. Decrease in oil yield was the reason of decrease in oil percent yield in non-irrigated condition. Oil yield loss caused by drought stress has been reported by many researchers (Champolivier, 1996; Tesfamariam *et al.* (2010); Nilsson *et al.* 1997; Sinki *et al.* (2007). Gunasekara *et al*., 2006; Szumigalski, and Van Acker, 2006; Tesfamariam *et al*., 2010) [11, 41, 28, 38, 19, 40, 41]. DTI value is maximum for Rajendra Suphlam indicating that under water stress condition this genotype is more tolerant to rest of the genotypes.

Under NI condition (Table 3) showed wider range for root parameters, LAI, SLW, LMSI, RWC and ELWL as compared to TI indicated presence of maximum variability among genotypes for particular traits which can be further exploited in breeding programme.

On perusal (table 4) under both the conditions, the genotypic and phenotypic coefficient of variation showed very meager difference indicated that there is little influence of environment on the traits except grain and oil yield. The GCV estimates had close agreement with PCV estimates for traits namely Tap Root Length, Root Volume, Root Mass, Relative Water Content, Leaf Membrane Stability Index, Excised Leaf Water Loss, Chlorophyll Content, Catalase Activity, Peroxidase Activity, Proline Accumulation, Relative Growth Rate, Leaf Area Index, Specific Leaf Weight, Stress Intensity indicating that these characters were mostly governed by genetic factors as the role of environment deviating the expression of these traits was meagre except, DTI, GY and OY presence of wide gap between indicated that an. environmental factor strongly affects traits.

High heritability for all traits implicated high magnitude of heritable portion of variation that could be exploited for selection of superior genotypes on basis of phenotypic performance under both conditions except CC, DTI, SI under non-irrigated and GY, OY under both conditions.

Under NI condition high heritability coupled with high GAM for traits namely, RL, RGR, LAI, LMSI, RWC, ELWL; RM only in irrigated and RV, SLW, CA under both conditions which were indicative of preponderance of additive gene action for expression of these traits, hence are amenable for simple selection.

Table 1: Analysis of variance for physio- morphological and quality characters in Indian mustard under non- irrigated and irrigated condition

Source of Variation	Environments	D.F.	Mean squares										
			Tap root length	Root volume	Root mass	Relative growth rate ($x*10^{-3}$)	Leaf area index	Specific leaf weight	Chlorophyll content	Leaf membrane stability index	Relative water content	Excised leaf water loss	Drought tolerance index
Replication	NI	2	0.051	0.212	0.008	0.517	0.007	0.101	0.001	0.206	2.025	1.067	0.044
	TI	2	0.261	0.382	0.001	0.650	0.074	0.311	0.004	2.166	0.000	0.273	-
Genotype	NI	19	21.466**	118.953**	2.829**	62.241	1.694	7.432**	0.015	160.937**	359.552**	138.258**	0.634
	TI	19	4.869**	73.644**	2.565**	58.473	0.510	12.669**	0.094	35.792**	70.172**	25.598**	-
Error	NI	38	0.142	0.243	0.007	2.604	0.076	0.055	0.001	0.198	2.529	0.804	0.216
	TI	38	0.116	0.278	0.002	2.825	0.033	0.336	0.004	1.253	0.122	0.773	-

Source of Variation	Environments	D.F.	Mean squares					
			Stress intensity	Catalase activity	Peroxidase activity	Proline accumulation	Grain yield ha^{-1}	Oil yield ha^{-1}
Replication	NI	2	0.002	6.32**	7.25**	0.0009	278.26**	15.98**
	TI	2	-	1.03	10.05**	0.0002	28273.82**	1948.89**
Genotype	NI	19	0.028	2475.90**	1612.33**	0.03	85216.37**	12944.62**
	TI	19	-	1500.54**	429.38**	0.02	188327.55**	28708.46**
Error	NI	38	0.009	5.86	5.79	0.0003	26870.36	4332.19
	TI	38	-	7.06	7.50	0.0001	59077.45	9858.62

*Significant at P= 0.05 ** Significant at P= 0.01

Table 2: Mean performance standard error (mean), critical difference for physio-morphological and quality characters under non- irrigated and irrigated condition

Characters / Varieties	Tap root length		Root volume		Root mass	
	NI	TI	NI	TI	NI	TI
DRMRLEJ902	9.28	9.42	8.14	5.98	1.10	2.41
DRMR150-35	7.79	9.40	12.70	8.46	0.80	2.88
NRCDR2	10.60	10.33	16.60	11.52	0.70	3.71
RH8814	9.67	10.95	8.04	6.70	0.80	5.07

TM151	13.80	10.36	11.60	8.95	0.80	4.25
TM128	8.73	9.69	8.19	7.01	0.90	2.22
KRANTI	7.73	10.26	4.51	4.40	1.40	3.15
KMR10-1	8.93	11.44	7.86	5.40	1.70	1.61
MAYA	9.29	12.34	9.29	8.22	3.00	3.40
ROHINI	8.38	11.24	5.36	3.05	4.60	3.67
PKRS28	9.20	10.54	6.79	5.20	1.90	1.87
PUSA MUSTARD 25	11.10	10.41	2.84	2.13	1.90	2.73
PUSA MUSTARD 28(NPJ-124)	10.90	9.61	5.64	3.01	1.70	2.93
RGN-13	9.97	10.52	3.93	3.46	0.90	3.04
RAURD 212	10.90	11.39	6.01	5.74	1.70	3.65
RAURD 78	11.20	11.05	7.81	7.00	1.30	2.41
VARUNA(CHECK)	12.60	9.58	5.96	5.52	0.90	1.29
PUSA BOLD	9.14	11.17	4.04	3.97	0.90	3.72
PUSA MAHAK(JD-6)	15.00	10.04	21.90	14.47	1.10	3.31
RAJENDRA SUFLAM	18.70	15.02	27.70	24.01	3.00	3.87
SEm (±)	0.22	0.20	0.28	0.30	0.05	0.02
CD (5%)	0.62	0.56	0.81	0.87	0.13	0.07
CD (1%)	0.84	0.75	1.09	1.17	0.18	0.09

Characters / **Varieties**	**Specific leaf weight**		**Chlorophyll content**		**Leaf membrane stability index**		**Relative water content**	
	NI	**TI**	**NI**	**TI**	**NI**	**TI**	**NI**	**TI**
DRMRLEJ902	3.70	8.82	0.74	1.10	24.30	48.60	20.60	84.63
DRMR150-35	4.90	9.79	0.80	1.27	27.40	50.62	31.00	88.44
NRCDR2	8.00	10.73	0.91	1.35	43.50	52.01	51.30	90.90
RH8814	6.30	14.18	0.83	1.49	31.30	52.65	40.30	92.50
TM151	6.90	10.64	0.85	1.34	34.90	51.91	45.20	90.89
TM128	7.70	7.77	0.87	1.02	37.20	46.56	50.60	82.93
KRANTI	8.00	10.57	0.89	1.30	37.70	50.96	50.60	90.88
KMR10-1	7.10	11.17	0.86	1.39	35.60	52.20	45.30	91.39
MAYA	6.70	9.64	0.84	1.26	32.50	50.26	42.60	86.46
ROHINI	8.20	11.74	0.93	1.42	46.10	52.45	52.40	91.51
PKRS28	6.80	10.17	0.84	1.29	34.70	50.82	42.90	90.02
PUSA MUSTARD 25	6.30	8.33	0.88	1.04	30.60	46.75	36.00	83.92
PUSA MUSTARD 28(NPJ-124)	8.00	9.43	0.92	1.25	45.00	49.10	51.60	86.09
RGN-13	4.40	8.60	0.78	1.06	26.70	48.29	27.60	84.09
RAURD 212	5.40	6.64	0.90	0.99	27.60	44.03	35.00	78.56
RAURD 78	7.30	9.29	0.87	1.18	36.10	48.72	50.20	84.82
VARUNA(CHECK)	4.00	7.71	0.77	1.01	25.90	45.10	24.00	80.56
PUSA BOLD	3.30	5.79	0.66	0.95	23.10	39.94	20.50	78.18
PUSA MAHAK(JD-6)	6.30	6.78	0.83	0.99	31.10	44.92	36.80	79.36
RAJENDRA SUFLAM	8.30	12.27	0.96	1.48	47.60	52.48	52.80	92.44
SEm (±)	0.10	0.33	0.014	0.04	0.26	0.65	0.92	0.20
CD (5%)	0.40	0.96	0.04	0.11	0.74	1.85	2.63	0.58
CD (1%)	0.50	1.28	0.05	0.14	0.98	2.48	3.52	0.77

Characters / **Varieties**	**Excised leaf water loss**		**Drought tolerance index**		**Stress intensity**		**Catalase activity**	
	NI	**TI**	**NI**	**TI**	**NI**	**TI**	**NI**	**TI**
DRMRLEJ902	34.30	35.95	2.30	-	0.50	-	120.30	123.60
DRMR150-35	30.80	35.38	3.10	-	0.60	-	136.50	136.98
NRCDR2	20.20	33.28	2.30	-	0.50	-	198.10	149.92
RH8814	25.10	30.01	3.40	-	0.70	-	158.60	162.16
TM151	23.60	34.10	2.70	-	0.60	-	170.10	148.26
TM128	24.40	38.13	2.30	-	0.50	-	181.30	105.67
KRANTI	22.30	34.69	2.00	-	0.40	-	196.70	146.87
KMR10-1	26.80	33.27	2.60	-	0.50	-	173.00	151.98
MAYA	23.30	35.43	2.20	-	0.50	-	165.30	130.14
ROHINI	14.40	32.55	2.70	-	0.60	-	199.90	156.59

PKRS28	24.40	35.20	2.30	-	0.50	-	169.80	139.94
PUSA MUSTARD 25	26.20	37.82	2.40	-	0.50	-	142.50	108.44
PUSA MUSTARD 28(NPJ-124)	15.90	35.53	1.80	-	0.40	-	199.40	125.96
RGN-13	33.80	37.19	2.20	-	0.50	-	130.90	115.16
RAURD 212	28.00	39.82	3.00	-	0.60	-	139.20	97.04
RAURD 78	22.90	35.93	2.20	-	0.50	-	179.80	124.02
VARUNA(CHECK)	33.10	38.41	2.50	-	0.50	-	126.10	103.69
PUSA BOLD	40.70	40.76	2.10	-	0.40	-	114.30	96.67
PUSA MAHAK(JD-6)	25.80	39.18	2.80	-	0.60	-	155.00	98.52
RAJENDRA SUFLAM	14.00	30.28	3.50	-	0.70	-	201.10	159.73
SEm (±)	0.52	0.51	0.30	-	0.10	-	1.40	1.53
CD (5%)	1.48	1.45	0.80	-	0.16	-	4.00	4.39
CD (1%)	1.99	1.95	1.00	-	0.21	-	5.36	5.88

Characters / **Varieties**	**Peroxidase activity**		**Proline accumulation**		**Relative growth rate**		**Leaf area index**	
	NI	**TI**	**NI**	**TI**	**NI**	**TI**	**NI**	**TI**
DRMRLEJ902	194.91	218.83	0.89	0.76	17.30	31.67	0.90	3.19
DRMR150-35	204.67	223.07	0.93	0.82	18.70	34.00	1.60	3.32
NRCDR2	249.46	229.95	1.12	0.86	28.30	37.33	2.70	3.52
RH8814	225.81	243.70	0.97	0.90	22.00	39.00	1.80	3.66
TM151	229.62	227.11	1.02	0.86	24.00	37.33	2.60	3.48
TM128	237.87	213.45	1.05	0.71	26.00	29.67	2.70	2.74
KRANTI	246.07	227.07	1.08	0.84	27.70	36.00	2.70	3.47
KMR10-1	231.51	234.04	1.03	0.87	25.70	37.33	2.60	3.54
MAYA	228.22	220.19	0.98	0.81	24.30	33.00	2.20	3.24
ROHINI	263.99	237.31	1.17	0.88	30.30	37.00	2.80	3.61
PKRS28	229.42	223.20	1.02	0.83	24.00	35.33	2.60	3.43
PUSA MUSTARD 25	216.86	216.73	0.94	0.74	20.70	29.67	1.70	2.78
PUSA MUSTARD 28(NPJ-124)	259.23	220.05	1.14	0.78	29.70	33.33	2.80	3.23
RGN-13	196.94	218.28	0.92	0.75	18.70	30.67	1.30	2.80
RAURD 212	212.66	205.22	0.93	0.69	19.00	25.00	1.70	2.48
RAURD 78	234.37	219.16	1.03	0.77	26.70	32.33	2.60	3.22
VARUNA(CHECK)	195.51	209.40	0.92	0.70	18.30	28.33	0.90	2.65
PUSA BOLD	192.92	195.17	0.83	0.68	16.00	25.67	0.50	2.47
PUSA MAHAK(JD-6)	219.75	207.87	0.95	0.69	21.00	26.00	1.70	2.60
RAJENDRA SUFLAM	269.20	238.09	1.19	0.89	30.00	38.33	3.00	3.64
SEm (±)	1.39	1.58	0.01	0.01	0.93	0.97	0.20	0.11
CD (5%)	3.98	4.53	0.03	0.02	2.67	2.78	0.50	0.30
CD (1%)	5.33	6.06	0.04	0.02	3.57	3.72	0.60	0.40

Characters / **Varieties**	**Grain yield ha^{-1}**		**Oil yield ha^{-1}**	
	NI	**TI**	**NI**	**TI**
DRMRLEJ902	1055.45	1944.30	411.80	716.72
DRMR150-35	1111.00	1999.80	436.80	773.34
NRCDR2	1390.60	2129.40	537.80	818.82
RH8814	1203.58	2592.30	471.00	996.02
TM151	1259.13	2092.40	512.50	811.61
TM128	1370.23	1870.20	540.60	721.48
KRANTI	1388.75	2055.40	547.30	805.33
KMR10-1	1333.20	2259.00	525.00	871.60
MAYA	1203.58	1999.80	468.20	766.82
ROHINI	1462.82	2527.50	572.60	990.32
PKRS28	1259.13	2036.80	488.90	784.95
PUSA MUSTARD 25	1129.52	1907.20	445.50	740.07
PUSA MUSTARD 28(NPJ-124)	1425.79	1972.00	560.80	770.79
RGN-13	1092.48	1944.30	423.20	747.09
RAURD 212	1129.52	1833.20	442.60	701.84
RAURD 78	1351.72	1962.80	530.90	754.84
VARUNA(CHECK)	1055.45	1870.20	407.10	718.39
PUSA BOLD	925.83	1638.70	360.70	628.77
PUSA MAHAK(JD-6)	1185.07	1851.70	465.70	704.91
RAJENDRA SUFLAM	1610.95	2536.80	616.60	957.61

SEm (±)	94.64	140.33	38.00	57.33
CD (5%)	270.95	401.75	108.80	164.12
CD (1%)	362.92	538.12	145.70	219.83

NI- Non –Irrigated TI- Irrigated (Two irrigation)

Table 3: General Mean, CV and Range of Physiological and quality characters under non- irrigated and irrigated condition

	Characters	MEAN		RANGE		CV%	
		E_1	E_4	E_1	E_4	E_1	E_4
1	Tap root length	10.64	10.74	7.73-18.69	9.40-15.02	3.55	3.17
2	Root volume	9.24	7.21	2.84-27.70	2.13-24.01	5.33	7.31
3	Root mass	1.55	3.06	0.74-4.57	1.29-5.07	5.23	1.29
4	Relative growth rate	23.42	32.85	16.00-30.33	25.00-39.00	6.89	5.117
5	Leaf area index	2.07	3.15	0.49-2.98	2.47-3.66	13.32	5.789
6	Specific leaf weight	6.38	9.50	3.33-8.30	5.79-14.18	3.69	6.099
7	Chlorophyll content	0.85	1.21	0.66-0.96	0.95-1.49	2.95	5.38
8	Leaf membrane stability index	33.94	48.92	23.10-47.57	39.94-52.65	1.31	2.29
9	Relative water content	40.36	86.43	20.45-52.78	78.18-92.50	3.94	0.40
10	Excised leaf water loss	25.49	35.65	13.97-40.67	30.01-40.76	3.52	2.47
11	Drought tolerance index	2.51	-	1.81-3.48	-	18.51	-
12	Stress intensity	0.52	-	0.38-0.73	-	18.50	-
13	Catalase activity	162.90	129.07	114.33-201.13	96.67-162.16	1.49	2.06
14	Peroxidase activity	226.95	221.39	192.92-269.20	195.17-243.70	1.06	1.24
15	Proline accumulation	1.01	0.79	0.83-1.19	0.68-0.90	1.74	1.21
16	Grain yieldha^{-1}	1247.19	2051.18	925.83-1610-95	1638.73-2592.33	13.14	11.85
17	Oil yield ha^{-1}	488.28	789.07	360.72-616.57	628.77-996.02	13.48	12.58

Table 4: Genotypic and phenotypic variance and coefficient of variation, heritability in broad sense and genetic advance as percent of mean for physio -quality characters under non- irrigated and irrigated condition

S. No.	Character	Genotypic variance		Phenotypic variance	
		E_1	E_4	E_1	E_4
1	Tap root length	7.11	1.58	7.25	1.70
2	Root volume	39.57	24.46	39.81	24.73
3	Root mass	0.94	0.85	0.95	0.86
4	Relative growth rate	19.88	23.35	22.48	23.47
5	Leaf area index	0.54	0.16	0.62	0.19
6	Specific leaf weight	2.46	4.11	2.51	4.45
7	Chlorophyll content	0.0008	0.029	0.001	0.034
8	Leaf membrane stability index	53.58	11.51	53.78	12.77
9	Relative water content	119.01	23.35	121.54	23.47
10	Excised leaf water loss	45.82	8.27	46.62	9.05
11	Drought tolerance index	0.14	-	0.36	-
12	Stress intensity	0.01	-	0.02	-
13	Catalase activity	823.35	497.83	829.20	504.89
14	Peroxidase activity	535.51	140.63	541.30	148.13
15	Proline accumulation	0.01	0.0054	0.01	0.0055
16	Grain yieldha^{-1}	19448.67	43083.37	46319.03	102160.81
17	Oil yield ha^{-1}	2870.81	6283.28	7203.00	16141.90

S. No.	Character	GCV		PCV	
		E_1	E_4	E_1	E_4
1	Tap root length	25.06	11.72	25.31	12.14
2	Root volume	68.05	68.58	68.26	68.97
3	Root mass	62.41	30.20	62.63	30.22
4	Relative growth rate	19.04	13.11	20.25	14.07
5	Leaf area index	35.52	12.64	37.94	13.90
6	Specific leaf weight	24.60	21.33	24.87	22.19
7	Chlorophyll content	8.23	14.29	8.74	15.27
8	Leaf membrane stability index	21.56	6.94	21.60	7.30
9	Relative water content	27.03	5.59	27.31	5.61
10	Excised leaf water loss	26.55	8.07	26.78	8.44
11	Drought tolerance index	14.83	-	23.71	-
12	Stress intensity	14.84	-	23.73	-
13	Catalase activity	17.61	17.29	17.68	17.41
14	Peroxidase activity	10.20	5.36	10.25	5.50
15	Proline accumulation	9.68	9.34	9.83	9.42
16	Grain yieldha^{-1}	11.18	10.12	17.26	15.58
17	Oil yield ha^{-1}	10.97	10.05	17.38	16.10

S. No.	Character	Heritability		GAM (%)	
		E_1	E_4	E_1	E_4
1	Tap root length	98.07	92.94	51.11	23.32
2	Root volume	99.40	98.91	39.76	40.48
3	Root mass	98.95	98.84	28.12	62.15
4	Relative growth rate	88.43	99.49	36.88	25.16
5	Leaf area index	87.10	84.21	68.52	23.67
6	Specific leaf weight	98.01	92.36	50.11	42.26
7	Chlorophyll content	40.00	85.29	15.97	27.55
8	Leaf membrane stability index	99.63	90.13	44.34	13.57
9	Relative water content	97.92	99.49	55.10	25.16
10	Excised leaf water loss	98.28	91.38	54.22	15.90
11	Drought tolerance index	38.89	-	19.10	-
12	Stress intensity	50.00	-	19.13	-
13	Catalase activity	99.29	98.60	36.16	35.36
14	Peroxidase activity	98.93	94.94	20.89	10.75
15	Proline accumulation	99.99	98.18	19.62	19.08
16	Grain yieldha^{-1}	41.99	42.17	14.93	13.54
17	Oil yield ha^{-1}	39.86	38.93	14.27	12.91

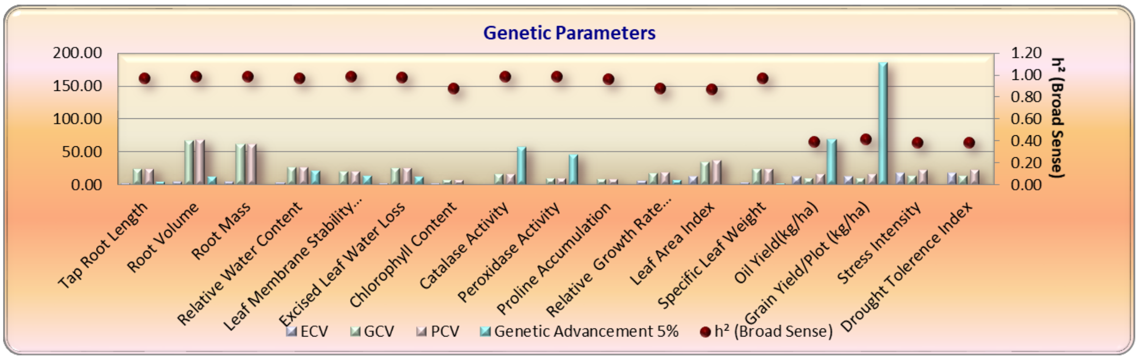

Fig 1: Genetic parameters for physio -quality characters under non- irrigated condition

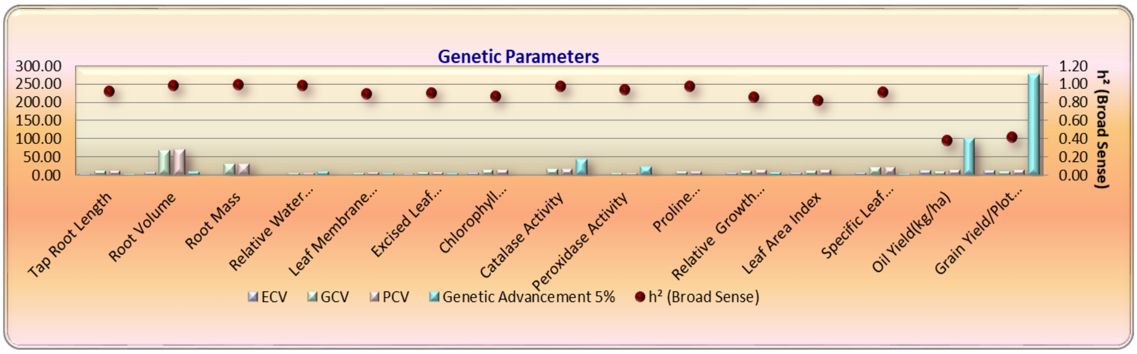

Fig 2: Genetic parameters for physio-quality characters under irrigated condition

Acknowledgement

Authors are thankful to different All India Coordinated Research Project-Rapeseed & Mustard centres namely, DRMR, Bharatpur, Rajasthan, CCSHAU, Hisar, Haryana, BARC, Trombay, Maharastra, GBPUAT, Pantnagar, Uttarakhand, CSAUAT, Kanpur, U.P, IARI, New Delhi and ARS, RAU, Sriganganagar, Rajasthan for providing genotypes of rapeseed and mustard.

References

1. Alikhan M, Ashraf MY, Mujtaba SM, Shirazi MU, Khan MA, Shereen A *et al*. Evaluation of high yielding canola type Brassica genotypes/mutants for drought tolerance using physiological indices as screening tool. Pak. J Bot. 2010; 42:3807-3816.
2. Ashraf M. Inducing drought tolerance in plants: recent advances. Biotechnology Advances. 2010; 28:169-183.
3. Aslam MN, Nelson MN, Kailis SG, Bayliss KL, Speijers J, Cowling WA. Canola oil increases in polyunsaturated fatty acids and decreases in oleic acid in drought-stressed Mediterranean type environments. Plant Breed. 2009; 128:348-355.
4. Back KH, Skinner DZ. Alteration enzyme gene expression acclimation of near isogenic wheat line. Plant Sci. 2003; 165:1221-1227.
5. Bajii M, kinet M Lutts S. The effects of the electrolyte method for assessing cell membrane stability as a water stress tolerance test in durum wheat. Plant Growth Regulation. 2001; 00:1-10.
6. Biradar KS, Sailmath PM, Ravikumar RL. Genetic variability for seedling vigour, yield and yield components in local germplasm collections of greengram (*Vigna radiata* (L.) Wilczek). Karnataka J Agric. Sci. 2007; 20(3):608-609.
7. Blum A. Plant Breeding for Stress Environments, CRC Press, Inc., Boca Raton, FL, 1988.
8. Boon EM, Downs A, Marcey D. Catalase: H2O2: H2O2

Oxidoreductase". Catalase Structural Tutorial Text. Retrieved, 2007, 02-11.
9. Burton GW. Quantitative Inheritance in Grasses.Proc. 6th Int. Grassland Congress. 1952; 1:227-283.
10. Burton GW, De Vane. Estimating heritability in tall Fescue from replicated clonal material. Agron. J. 1953; 45:475-481.
11. Champolivier L, Merrien A. Effects of water stress applied at different growth stages to Brassica napus L. var. oleifera on yield, yield components and seed quality. European Journal of Agronomy. 1996; 5:153-160.
12. Chauhan JS, Tyagi MK, Kumar A, Nashaat NI, Singh M, NB *et al*. Drought effects on yield and its components in Indian mustard (*Brassica juncea* L.). Plant Breed. 2007; 126:399-402.
13. Clarke J, Townley-Smith TF, McCaaig TN, Green DM. Growth analysis of spring wheat cultivars of varying drought resistance. Crop Science. 1984; 56:603-626.
14. Deikman J, Petracek M, Heard JE. Drought tolerance through biotechnology: improving translation from the laboratory to farmers' fields. Curr. Opin. Biotechnol. 2012; 23:243-250.
15. Din J, Khan SU, Ali I, Gurmani AR. Physiological and agronomic response of canola varieties to drought stress. The Journal of Animal & Plant Sciences. 2011; 21(1):78-82.
16. Ehsani M, Khaledi H. Recognizing and promoting the utilization of water for irrigation and food security in the country. Eleventh National Conference on Irrigation and Drainage, 2004, 675-657.
17. Fischer RA, Maurer R. Drought resistance in spring wheat cultivars. I. Grain yield responses. Australian Journal of Agricultural Research. 1978; 29:897-912.
18. Fusheing L. Potassium and water interactions. International Workshop on Soil potassium and K Fertilizer Management. Agricultural College Guangxi University, 2006, 1-32.
19. Gunasekera CP, Martin LD, Siddique KHM, Walton GH. Genotype by environment interactions of Indian mustard (*Brassica juncea* L.) and canola (*Brassica napus* L.) in Mediterranean-type environments II. Oil and protein concentrations in seed. Eur. J Agron. 2006; 25:13-21.
20. Hall AE. Breeding for heat tolerance. Plant Breed. Rev. 1992; 10:129-168.
21. Hashem A, Amin Majumdar MN, Hamid A, Hossain MM. Drought stress effects on seed yield, yield attributes, growth, cell membrane stability and gas exchange of synthesized Brassica napus L. Journal of Agronomy and Crop Science. 1998; 180:129-136.
22. Johnson HW, Robinnson HF, Comstock RE. Genotypic and phenotypic correlation in soybean and their implication in selection. Agron. J. 1955; 47:447-483.
23. Kage HM, Kochler H. stutzel. Root growth and dry matter partitioning of cauliflower under drought stress conditions: measurement and simulation. Eur. J Agron. 2004; 20:379-394.
24. Lewis FB. Gene-environment interaction. Heredity. 1954; 8:333-356.
25. Lush JL. Inter-se, correlation and regression of characters. Proc. Am. Soc. Anim. Prod. 1949; 33:293-301.
26. Mendham NJ, Salisbury PA. Physiology: Crop development, growth and yield. in D. Kimber and D. I. McGregor, ed. Brassica oilseeds: Production and utilization. CAB International, Slough, UK, 1995, Pages 11-64.
27. Moaveni PA, Ebrahimi HA, Farahani. Physiological growth indices in winter rapeseed (*Brassica napus* L.) cultivars as affected by drought stress at Iran. J Cereals Oilseeds. 2010; 1:11-16.
28. Nielsen DC. Water use and yield of canola under Dryland condition in the central Great Plains. J Prod. Agric. 1997; 10:303-313.
29. Omidi H. Changes of Proline Content and Activity of Anti oxidative Enzymes in Two Canola Genotype under Drought Stress. Am. J Plant Physiol, 2010.
30. Paulsen GM. High temperature responses of crop plants. in K. J. Boote, J. M. Bennett, T. R. Sinclair, and G.M. Paulsen, ed. Physiology and determination of crop yield. ASA, CSSA, SSSA, Madison, WI, 1994, 365-389
31. Pearce RB, Brown RK, Blaser RE. Photosynthesis of Alfalfa leaves as influenced by age and environment. Crop Science. 1968; 8:677-680.
32. Phutela A, Jain V, Dhawan K, Nainawatee HS. Proline metabolism under water stress in the leaves and roots of *Brassica juncea* cultivars differing in drought tolerance. J Plant Biochem. Biotechnol. 2000; 9:35-39.
33. Qaderi M, Kurepin VL, Reid MD. Effects of temperature and watering regime on growth, gas exchange and abscisic acid content of canola (Brassica napus) seedlings. Environmental and Experimental Botany. 2012; 75:107-113.
34. Rashidi Sh. Study of tolerance to drought stress morpho-physiologic traits in canola genotypes. Dissertations of Agriculture, Science and Research Branch of Islamic Azad University of Ahvaz, 2013, 225.
35. Shafiq S, Akram NA, Ashraf M, Arshad A. Synergistic effects of drought and ascorbic acid on growth, mineral nutrients and oxidative defense system in canola (*Brassica napus* L.) plants. Acta Physiologiae Plantarum 2014; 36:1539-1553.
36. Shao H, Liang Z, Shao M. Osmotic regulation of 10 wheat (*Triticum aestivum* L.) genotypes at soil water deficits. Colloids and Surfaces B: Bio interfaces. 2006; 47: 132-139.
37. Sharma KD, kuhad MS. Influence of potassium level and soil moisture regime on biochemical metabolites of Brassica Species. Brassica. J. 2006; 8:71-74.
38. Sinaki JM, Heravan EM, Shirani Rad AH, Noor mohammadi Gh, Zarei Gh. The effects of water deficit during growth stage of canola (*Brassica napus* L.). American- Eurasin J Agric. Environ. Sci. 2007; 2(4):417-422.
39. Singh SP, Choudhary AK. Selection criteria for drought tolerance in Indian mustard (*Brassica juncea* L.). Indian Journal of Genetics and Plant Breeding. 2003; 63:263-264.
40. Szumigalski AR, Van Acker RC. Nitrogen yield and land use efficiency in annual sole crops and intercrops. Agron. J. 2006; 98:1030-1040.
41. Tesfamariam EH, Annandale JG, Joachim M. Steyn. Water Stress Effects on Winter Canola Growth and Yield. Agronomy Journal. 2010; 102(2):658-666.
42. Touchette BW, Iannacone LR, Turner GE, Frank AR. Drought tolerance versus drought avoidance: A comparison of plant-water relations in herbaceous wetland plants subjected to water withdrawal and repletion. Wetlands. 2007; 27:656-667.

43. Trenberth KE, Dai A, van der Schrier G, Jones, J. Barichivich KR, Briffa J. Sheffield Global warming and changes in drought. Nat. Climate Change. 2014; 4:17-22.
44. Watson DJ. Comparative physiological studies in the growth of field crops. I. Variation in net assimilation rate and leaf area between species and varieties, and within and between years. Annals of Botany. 1947; 11:41-76.