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Evaluation of bread wheat (*Triticum aestivum*) genotypes using drought susceptible and tolerance efficiency indices under irrigated and drought stress environment

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ABSTRACT

Drought stress is one of the foremost severe abiotic stresses responsible for drastic reduction in wheat production under arid and semi-arid environments. Breeding for drought tolerance is very confounded by an inability to create defined, precise and repeatable stress conditions and inadequacy of an efficient, reproducible screening technique. Therefore, the present investigation was laid out to screening of twenty advance wheat lines for drought stress in RBD with two replications under Irrigated) and drought conditions during rabi, 2019-20 at Wheat Research Station, Sardarkrushinagar Dantiwada Agricultural University, Vijapur, India. Phenotyping was performed for 11 morphological and four physiological traits distinctively. The analysis of variance revealed that component of variance for genotypes was significant for all traits, revealed the presence of enough genetic variability in the material under studied. Based on *per se* performance revealed that genotypes GW 511, VL 967, GW 11 and GW 512 produced higher grain yield compared to other genotypes in both irrigated and drought conditions. Genotype DBW-154 followed by GW-510 and GW-506 recorded lowest value of drought susceptible index (DSI) and highest value of drought tolerance efficiency (DTE), indicating potentiality to produce with minor yield losses under drought conditions in comparison to normal conditions. Grain yield and its related traits *viz.*, grains per spike, 1000 grain weight and grain weight per spike exhibited moderate to high heritability and expected genetic advance as percent of mean under both stress and non stress condition and these traits could be considered as suitable selection criteria for the development of high yielding bread wheat varieties. Under irrigated condition grain yield showed strong positive association with tillers, 1000 grain weight and biomass yield, similarly in drought condition biomass yield showed strong correlation with grain yield, followed by NDVI II, grain weight/spike, 1000 grain weight, tillers and grains/spike. Under stress CT-II was negatively correlated with GW/SPK (-0.631), biomass yield (-0.611), grain yield (-0.423) and 1000 grain weight (-0.345), indicating genotypes has canopy cooling ability to produced higher grain yield, biomass, TGW and GW/SPK under drought stress. So, these traits should be consideration while selection under drought stress and select the drought tolerance genotypes with superior performance, this can be potentially used in future for improvement of bread wheat yield and yield related traits against the drought.

Key words : Correlation, drought response indices, genetic variation, heritability, wheat

INTRODUCTION

Wheat (*Triticum aestivum*) is highly sensitive to biotic and abiotic stresses and environment fluctuation. In India wide range of agro-climate condition, under which wheat crop grown in our country cause considerable influence on yield and quality. Drought stress is one of the most limiting environmental stresses which affect the crop growth and development processes of crop depending on duration of exposure and crop growth stages

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(Juenger, 2013). Drought stress is one of the foremost severe abiotic stresses responsible for drastic reduction in wheat production under arid and semi-arid environments (Maiti and Singh, 2019). Breeding for drought tolerance is very confounded by an inability to create defined, precise and repeatable stress conditions and inadequacy of an efficient, reproducible screening technique (Learnmore *et al.*, 2016).

Knowledge of phenotypic traits contributing to improved yields under stress is fundamental to the understanding of the complex physiological and genetic mechanisms of wheat adaptability (Reynolds *et al.*, 2005; Kebede and Tesso, 2021). The breeders are interested in selection of superior genotypes based on their phenotypic expression in stress and stress free environments. Wheat has broad based genetic variability can be explored with germplasm from its centers of diversity. Besides cultivated wheat varieties and breeding stocks, extraordinary variability for drought tolerance remains within wild relatives and landraces. Manipulation of this diversity or variability to improve drought tolerance among cultivars may be achieved through trait identification, trait introgression or selection for adaptive mechanisms including drought escape, dehydration avoidance and dehydration tolerance (Blum, 2010; Lawal *et al.*, 2020). The presence and magnitude of genetic variability in a gene pool is the pre-requisite of a crop improvement programme and knowledge of certain genetic parameters is essential for proper understanding followed by their manipulation during plant breeding (Nayana and Fakrudin, 2020). Therefore, the estimation of genetic parameters such as GCV, PCV, heritability, genetic advance and correlation coefficient are useful biometric tools for determination of genetic variability. The knowledge of heritability and genetic advance of traits helps the plant breeder in predicting the behavior of the succeeding generation and making desirable selections. Several morpho-physiological traits are reported to be associated with drought tolerance. Therefore, in present investigation twenty wheat genotypes screened for drought tolerance and phenotyping was performed for 11 morphological and four physiological traits distinctively. Objective of this experiment was screening of wheat lines against the drought stress with morpho-physiological traits and estimate the level of genetic coefficient of variation, heritability, genetic advance and the genetic correlation of grain yield with yield components to develop appropriate selection indices against the drought stress for the increased grain production under drought conditions.

MATERIALS AND METHODS

Two experiments were laid out as randomized block design (RBD) with two replications under non-stress (irrigated) and drought stress (non-irrigated) conditions. Twenty bread wheat genotypes were evaluated during *rabi* 2019-20 at Wheat Research Station, Sardar Krushinagar Dantiwada Agricultural University, Vijapur, India with latitude, 23° 34' 12.00" N, longitude, 72° 45' 0.00" E and 129 m above mean sea level. The mean minimum and maximum temperature were 11.3 and 27.1°C, respectively throughout crop growth period. The weather conditions during the vegetative growth period recorded were mean daily temperature 17.0°C and, during flowering and grain filling periods the mean daily temperature was 15.7°C which was favorable for raising the good crop. Single experimental site was used to avoid any soil interactions. Moreover, all the data were collected at almost the same stages of crop in both experiments to clearly examine the effects of terminal drought stress. The soil texture of experimental field was loamy sand with pH value 7.43 and EC 0.29 ds/m. In case of water stress experiment, only pre sown irrigation was given for germination and later on no irrigation was applied till the maturity. Four irrigations were applied at critical growth stages to the second experiment (irrigated). The whole dose of nutrients *i.e.*, N_20 60 kg/ha and P_2O_5 30 kg/ha was applied at the time of seedbed preparation in drought regime plots whereas in well watered plots 60 kg P_2O_5 and 60 kg N_20 was applied at the time of seedbed preparation and remaining 60 kg N_20 was applied 21 days after sowing. In water stress experiment, weeds were controlled manually (hoeing) but in irrigated experiment weeds were controlled by spraying the chemicals. Grain yield/net plot (GY/NP) in kg and biomass yield/net plot (BM/NP) in kg were recorded on the basis of harvest taken from 1.2 m^2 area of each plot. In addition, some parameters such as tillers (TIL), spike length (SL) in cm, plant height (PH) in cm, grains/spike (G/S), grain weight/spike (GW/S) in grams, 1000 grain weight (TGW) in grams and harvest index (HI) were recorded at maturity stage whereas, normalized difference vegetation index I (NDVI I) and normalized difference vegetation index II (NDVI II) and, canopy temperature I (CT I) and canopy temperature II (CT II) were measured after 7 and 15 days of anthesis stage by using green seeker and infrared thermometer, respectively. Data collected for two experiments were separately analyzed for each condition. The data recorded on the above thirteen characters were subjected to the statistical analysis *i.e.,* Analysis of Variance (ANOVA), co-efficient of variance (GCV and PCV), heritability (broad sense), genetic advance, expressed as percentage of mean and genotypic correlation of coefficient. Statistical analysis was carried out by using replicated data over sample plants through statistical software INDOSTATE. Drought susceptibility index (DSI) was calculated by the formula given by Fischer and Maurer (1978). Drought tolerance efficiency (DTE) was estimated by using the formula suggested by Fischer and Wood (1979). Harvest index was calculated by formula proposed by Donald and Hamblin (1976). The phenotypic and genotypic coefficients of variation in percentage, heritability (H) in broad sense and genetic advance (GA) expressed as percentage of mean was calculated using the formulae given by Allard (1960).

RESULTS AND DISCUSSION

Analysis of Variance and Mean Performance

The analysis of variance revealed that component of variance for genotypes was significant for all the yield related characters of twenty advance breeding lines under both normal and drought environments revealed the presence of enough genetic variability in the material under study (except number of tillers, 1000 grain weight and biomass/net plot under irrigated and spike length, plant height, NDVI II and canopy temperature I and II under drought condition) (Table 1). This suggests that there is an opportunity for the genetic improvement of the bread wheat for these traits for grain yield and drought stress related trait. Daily minimum and maximum temperature and rainfall were recorded throughout the crop season. The mean minimum and maximum temperature were 11.3 and 27.1°C, respectively throughout crop growth period. The weather conditions during the crop season throughout the state were quite favorable. For timely sown wheat, during the vegetative growth period mean daily temperature recorded was 17.0°C which was favorable for raising the good crop. During flowering and grain filling period the mean daily temperature of 15.7°C was also favorable for timely sown condition. There was no adverse effect of temperature at terminal stage also. Under natural condition crop was free from any disease and pest. Drought environments decreased grain yield and yield related traits performance compared to normal environments. Similar research results were also reported by Gholipour *et al.* (2009), Anwar *et al.* (2011), Patel *et al.* (2019) and Patel *et al.* (2020). Differences were observed in canopy temperature at anthesis and post anthesis under irrigated and drought conditions. Mean base data comparison in both irrigated and drought environments, among all fifteen traits, only four traits namely days to heading (-58.20 cm), 1000 grain weight (42.80 g), NDVI I (0.24) and CT I (23.46) exhibited higher mean under drought condition and remaining traits exhibited higher mean value under irrigated condition (Table 1). Among twenty genotypes, GW 511 (0.940 kg) followed by GW 509 (0.860 Kg), HD 3133 (0.828 kg), VL 967 (0.805 kg), GW 11 (0.775 kg) and GW 512 (0.713 kg) produced higher yield under irrigated environments. Similarly, DBW 154 (0.430 kg) followed by GW 173 (0.383 kg), GW 511 (0.348 kg), GW 510, GW 512 and GW 505 (0.345 kg), VL 967 (0.335 kg) and GW 11 (0.333 kg) produced higher yield under drought environments, although reduced grain yield under moisture stress compared to irrigated condition (Table 2). Genotypes GW 511, VL 967, GW 11 and GW 512 performed better compared to other genotypes in both irrigated and drought conditions.

Drought indices which provide a measure of drought tolerance based on yield loss under drought conditions in comparison to normal conditions have been used for screening drought tolerant genotypes (Mitra,

Table 1. Mean, genotypic mean square and variances, phenotypic and genotypic coefficients of variation, heritability (b. s.) and genetic advance expressed as per cent of mean for 17 variables under irrigated and drought condition in bread wheat

S. P.	Envi.	DH	TIL	SL	PH	G/S (g)	GW/S (g)	T GW	MD	BM/NP (kg)	HI%	NDVI I	NDVI II	CT I	CTII	GY/NP (kg)	DSI	DTE
Mean	Irrigated	62.00	93.04	9.54	92.10	53.63	2.19	41.41	115.70	2.00	34.42	0.23	0.55	22.77	27.00	0.68		
	Drought	58.20	77.58	8.04	72.58	43.25	1.83	42.80	101.75	0.89	33.41	0.24	0.42	23.46	26.94	0.30	0.98	45.20
Genotype MS	Irrigated	38.42*	639.82	4.02*	150.51*	160.99*	0.24*	47.16	13.07*	0.23	40.69*	0.001*	0.008*	2.23*	3.42*	0.03*		
	Drought	41.92*	319.91*	1.62	48.86	130.55*	0.20*	48.12*	42.24*	0.04*	33.38*	0.001*	0.003	2.92	1.64	0.009*	0.08*	233.38*
CV%	Irrigated	2.03	19.97	11.41	4.08	10.85	14.74	11.85	0.60	20.64	12.14	7.90	10.71	2.77	3.33	12.32		
	Drought	1.19	15.24	12.34	6.97	11.71	15.66	7.46	0.87	13.60	10.80	5.94	10.28	7.23	3.82	16.72	15.05	13.87
SE	Irrigated	0.89	15.10	0.77	2.66	4.12	0.23	3.47	0.49	0.29	4.18	0.01	0.04	0.45	0.64	0.06		
	Drought	0.49	8.36	0.70	3.58	3.58	0.20	2.26	0.63	0.09	2.55	0.01	0.03	1.20	0.83	5.34	0.03	0.10
EV	Irrigated	0.790	227.895	0.592	7.050	16.934	0.052	12.039	0.240	0.085	8.733	0.000	0.002	0.198	0.404	0.004		
	Drought	0.240	69.865	0.492	12.797	12.826	0.041	5.097	0.395	0.007	6.509	0.000	0.001	1.438	0.690	0.001	0.009	28.549
GV	Irrigated	18.421	92.015	1.417	68.203	63.563	0.067	11.540	6.297	0.029	11.610	0.001	0.002	0.918	1.308	0.010		
	Drought	20.718	90.090	0.318	11.632	52.450	0.061	18.962	20.724	0.012	10.181	0.000	0.001	0.023	0.130	0.004	0.029	88.140
PV	Irrigated	19.211	319.91	2.009	75.253	80.497	0.120	23.579	6.537	0.114	20.343	0.001	0.004	1.116	1.712	0.013		
	Drought	20.958	159.955	0.810	24.428	65.276	0.102	24.059	21.118	0.020	16.691	0.001	0.001	1.461	0.820	0.005	0.038	116.689
GCV%	Irrigated	6.923	10.310	12.480	8.967	14.867	11.839	8.203	2.169	8.468	9.899	10.262	8.498	4.208	4.236	14.616		
	Drought	7.821	12.235	7.013	4.699	16.745	13.428	10.175	4.474	12.512	9.551	8.275	5.132	0.643	1.338	19.566	17.183	20.771
PCV%	Irrigated	7.069	19.22	14.861	9.419	16.731	15.772	11.726	2.210	16.876	13.103	11.684	11.384	4.640	4.846	17.015		
	Drought	7.866	16.303	11.193	6.810	18.681	17.403	11.462	4.516	15.781	12.229	9.279	8.900	5.151	3.361	22.274	19.786	23.900
H2bs	Irrigated	95.900	28.760	70.500	90.600	79.000	56.300	48.900	96.300	25.200	57.100	77.100	55.700	82.200	76.400	73.800		
	Drought	98.900	56.300	39.300	47.600	80.400	59.500	78.800	98.100	62.900	61.000	79.500	33.300	1.600	15.854	77.200	75.400	75.500
GA (%)	Irrigated	13.964	11.389	21.589	17.585	27.216	18.305	11.822	4.385	8.752	15.405	18.565	13.069	7.861	7.628	25.866		
	Drought	16.019	18.916	9.051	6.680	30.921	21.345	18.609	9.130	20.436	15.367	15.201	6.096	0.166	1.094	35.405	30.740	37.188

DH: Day to heading; TIL: Tillers; SL: Spike Length; PH: Plant height; G/S: Grains/Spike; GW/S: Grain Weight/Spike; TGW: 1000 Grain Weight; MD: Maturity Days; BM/NP: Biomass/ Net Plot; HI: Harvest Index: NDVI I & NDVI II: Normalized Difference Vegetation Index One & Two; CT I & CT II: Canopy Temperature One & Two; GY/NP: Grain Yield/ Net Plot; * : Significant at P=0.05 level of probability.

2001). Different drought tolerance indices were calculated on the basis of grain yield of the genotypes under irrigated (Yp) and stressed (Ys) conditions (Table 2). The Drought susceptibility index (DSI) and Drought tolerance efficiency designed bases on mean yield of plants under irrigated and drought stress conditions. A low magnitude of DSI is due to low change of plant yield in stress condition in comparison to non-stress condition which results in more drought tolerance of the plant (Fischer and Maurer, 1978). Based on DSI among all genotypes, eight genotypes exhibited low drought susceptibility index (DSI- value 0.5 to 1), which suggested moderately tolerance against drought stress, while twelve genotype recorded relatively high drought susceptible index (DSI- value >1) indicating susceptibility against drought (Table 2). Genotypes DBW-154 (0.52) followed by GW-510 (0.69) and GW-506 (0.77) recorded lower value of DSI as compared to the best check GW 173 (0.81) and genotypes DBW 110 (70.90%) followed by GW 510 (60.82%) and GW 506 (57.35%) recorded higher value of DTE as compared with best check GW 173 (54.84%), indicating potentiality of these genotypes under irrigated and drought condition to produce higher grain yield. Several researchers also reported the similar results for grain yield and its component traits under normal and drought conditions by Jatav and Kandalkar (2014), Patel *et al.* (2019) and Patel *et al.* (2020). For the drought tolerance indices by Gholipour *et al.* (2009) and Anwar *et al.* (2011) concluded that drought tolerance indices, considered as the best possible selection criteria for distinguished large number of diverse genotypes into different group of genotypes for medium to highly drought tolerance.

Genetic Variability, Heritability and Expected Genetic Advance

The results pertaining to genotypic and phenotypic variance, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2bs) and expected genetic advance as percent of mean (GAPM) for all the characters studied under irrigated and drought condition are depicted in Table 1. It was evident from the results that the magnitude of phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the characters investigated under irrigated and drought conditions. This indicates that the apparent variation was not only due to genotypes but also due to influences of environments and other uncontrolled errors. The characters like grain yield followed by

Table 2. Grain yield under irrigated and drought condition, drought susceptible index (DSI) and drought tolerant efficiency (DTE) of twenty genotypes of bread wheat

Genotypes	Grain yield under irrigated condition (kg)	Grain yield under drought Condition (kg)	Drought Susceptible Index (DSI) (%)	Drought Tolerant Efficiency (DTE) (%)
GW 505	0.645	0.345	0.84	53.36
GW 506	0.545	0.313	0.77	57.35
GW 507	0.585	0.250	1.03	42.79
GW 508	0.638	0.185	1.28	29.06
GW 509	0.860	0.320	1.13	37.31
GW 510	0.560	0.345	0.69	60.82
GW 511	0.940	0.348	1.13	36.98
GW 512	0.713	0.345	0.93	48.28
HD 3133	0.828	0.293	1.16	35.01
VL 1004	0.648	0.308	0.94	47.84
HS 595	0.540	0.273	0.89	51.56
HD 3146	0.643	0.315	0.92	49.06
HUW 677	0.538	0.195	1.14	37.21
DBW 129	0.655	0.188	1.28	28.85
VL 967	0.805	0.335	1.05	41.66
DBW 154	0.608	0.430	0.52	70.90
PBW 695	0.575	0.200	1.17	37.05
GW 451 ©	0.693	0.280	1.07	40.75
GW 11 ©	0.775	0.333	1.03	43.30
GW 173 ©	0.698	0.383	0.81	54.84

grains per spike, grain weight per spike, tillers, harvest index and NDVI I exhibited higher phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) under both irrigated and drought condition. The differences between GCV and PCV magnitude were very small, with less effects of environment on characters, that evident from their high variability that in turn offers good scope for selection and improvement of grain yield and yield related traits under drought stress.

Heritability is a useful quantitative parameter, which considers the role of heredity and environment determining the expression of a trait (Allard, 1960). Heritability values are useful in predicting the expected progress to be achieved through the process of selection. Genetic coefficient variation along with heritability estimate provides a reliable estimate of the amount of genetic advance to be expected through phenotypic selection (Johnson *et al.*, 1955). According to Singh (2001), heritability values greater than 80% are very high, values from 60 to 79% are moderately high and values from 40 to 59% are low. Characters showing very high heritability were days to maturity (96.30%), days to flowering (95.90%), plant height (90.60%) and CT I (82.20%) under irrigated whereas, days to flowering (98.90%), days to maturity (98.10%) and grains per spike (80.40%) showed very high heritability under drought condition. Grain yield (73.80%), grains per spike (79.00%), spike length (70.50%), NDVI I (77.10%) and CT II (76.40%) under irrigated condition as well as grain yield (77.20%), 1000 grain weight (78.80%), harvest index (61.00%), biomass yield (62.90%) and NDVI I 79.50%) under drought condition reported moderately high heritability performance and remaining all the traits exhibited low heritability under both irrigated and drought condition. Expected genetic advance as percent of mean indicates the expected genetic progress for particular trait under selection cycle and measures the extent of its stability under selection pressure. Highest expected genetic advance as percent of mean reported traits were grains per spike (27.21) followed by grain yield (25.88) and spike length (21.58) under irrigated condition whereas under drought condition grain yield (35.40) showed expected genetic advance as percent of mean followed by grains per spike (30.92) and grain weight per spike (21.34).

Above results revealed that grain yield and its related traits viz. grains per spike, 1000 grain weight and grain weight per spike exhibited moderate to high heritability coupled with high genetic advance as percent of mean, provided that these parameters were under the control of additive genetic effects. This indicates that selection should lead to speedy genetic improvement of the material under irrigated and drought condition. Similar results were reported by Tripathi *et al.* (2011), Baranwal *et al.* (2012), Patel *et al.* (2019) and Patel *et al.* (2020). With respect to drought response indices the data presented in Table 1 revealed that the higher and almost equal magnitude of GCV and PCV for the DSI, DTE and grain yield in drought condition, indicating that this parameter is less influenced by environments. DSI, DTE and grain yield exhibited high to moderate heritability and expected genetic advance as percent of mean under moisture stress, indicating that the drought indices may help as selection criteria to improvement in genetic gain for grain yield. Similar findings were also reported by Gholipour *et al.* (2009), Anwar *et al.* (2011), Ahmadizadeh *et al.* (2012) and Jatav and Kandalkar (2014).

Genotypic Correlation Analysis

The data pertaining to genotypic correlation coefficient among 15 characters under irrigated and drought condition are presented in Table 3. Correlation analysis under irrigated condition revealed that grain yield showed strong positive association with tillers (0.853), 1000 grain weight (0.847) and biomass yield (0.631), whereas moderate correlation with grain weight per spike (0.179) and CT- I (0.135) was observed with grain yield. However, negative correlation exhibited with days to maturity (-0.698), days to heading (-0.632), spike length (-0.659), grains/spike (-0.377), NDVI- I and NDVI- II (-0.698 and -0.318), plant height (-0.160) and CT-I (-0.117). Tillers, 1000 grain weight, biomass yield, days to heading and days to maturity were closely related to grain yield and help in selection for grain yield improvement and early maturing genotypes but spike length and grain/spike reported negative correlation under irrigated

Table 3. Genotypic (rg) correlation coefficients among the quantitative traits and physiological traits under drought and irrigated condition in bread wheat

Environment		IRRIGATED													
	Characters	DH	TIL	SL	PH	G/S	GW/S	TGW	MD	BM/NP	NDVI I	NDVI II	CT I	CTII	GY/NP
DROUGHT	DH	1.000	0.453	0.887	0.447	0.797	0.175	-0.206	0.916	0.377	0.680	0.853	0.446	-0.234	-0.632
	TIL	0.311	1.000	0.481	0.842	0.750	0.899	-0.638	0.116	0.524	0.874	-0.319	0.696	0.039	-0.855
	SL	0.891	-0.383	1.000	0.775	0.876	0.405	-0.907	0.664	0.464	0.999	0.316	0.446	-0.275	-0.659
	PH	-0.228	-0.590	-0.009	1.000	0.704	0.931	0.039	0.474	0.496	0.633	-0.288	0.508	0.042	-0.160
	G/S	0.724	0.157	0.818	-0.423	1.000	0.714	-0.704	0.659	0.157	0.777	0.561	0.466	-0.067	-0.377
	GW/S	0.407	-0.073	0.828	-0.240	0.843	1.000	-0.005	0.061	0.135	0.432	-0.133	0.195	0.127	0.179
	100 GW	-0.681	-0.287	-0.401	0.418	-0.623	-0.104	1.000	-1.000	0.019	-0.703	-0.971	-0.291	0.519	0.847
	MD	0.734	0.145	0.222	-0.672	0.526	0.202	-0.584	1.000	0.465	0.567	0.875	0.495	-0.088	-0.698
	BM/PL	-0.237	0.482	-0.118	-0.491	0.255	0.332	0.091	0.076	1.000	0.337	0.840	0.891	0.100	0.631
	NDVI I	0.601	0.410	0.671	-0.217	0.395	0.331	-0.335	0.204	-0.028	1.000	0.195	0.511	0.180	-0.420
	NDVI II	0.769	0.712	0.600	-0.393	0.510	0.655	0.081	0.801	0.614	0.150	1.000	0.044	-0.321	-0.318
	CT I	0.590	0.719	0.494	0.209	0.214	0.391	-0.831	0.950	0.903	0.824	0.787	1.000	0.442	-0.117
	CTII	0.011	-0.332	0.067	-0.310	-0.229	-0.631	-0.345	0.144	-0.611	-0.292	-0.190	0.686	1.000	0.135
	GY/PL	-0.491	0.200	-0.467	-0.497	0.077	0.259	0.256	-0.158	0.905	-0.183	0.448	0.410	-0.423	1.000

DH: Day to heading; TIL: Tillers; SL: Spike Length; PH: Plant height; G/S: Grains/Spike; GW/S: Grain Weight/Spike; TGW: 1000 Grain Weight; MD: Maturity Days; BM/NP: Biomass/ Net Plot; HI: Harvest Index: NDVI I and NDVI II: Normalized.

condition and these traits are most important for grain yield improvement. So direct selection for these traits may not be effective under irrigated condition. Under drought condition grain yield showed strong positive correlation with biomass yield (0.905), followed by NDVI- II (0.448), grain weight/spike (0.259), 1000 grain weight (0.256) and tillers (0.200). Traits like days to heading (-0.491), plant height (-0.497), spike length (-0.467), CT-II (-0.423), days to maturity (-0.158) and NDVI-I (-0.183) were exhibited negative correlation with grain yield under drought condition, which indicated that genotypes having early maturity are capable to escaping the drought or moisture stress and these traits are helpful for direct selection for yield and drought tolerant trait improvement. Under drought stress spike length showed the positive correlation grain/spike and grain weight/ spike but negative correlation with 1000 grain weight and grain yield indicating that increasing in grains/spike, there would be decreased grain weight due to poor sink-source relation under stress, which ultimately recorded reduction in grain yield. Similar findings were reported by Degewione *et al.* (2013), Jasmine and Kumar (2017) and Patel *et al.* (2020).

Under moisture stress, CT-II was negatively correlated with GW/SPK (-0.631), biomass yield (-0.611), grain yield (-0.423) and 1000 grain weight (-0.345), which indicated that genotype have cooling canopy ability and cooler genotypes could produce higher grain yield, biomass, TGW and GW/SPK. So, these physiological traits are important for selection of tolerant genotypes under drought stress. Sakhare and Ghawat (2011), Singh *et al.* (2012), Nukasani *et al.* (2013) and Patel *et al.* (2020) reported stronger or weaker association of yield with yield component traits in wheat and suggested that wheat crop grain yield potential under irrigated and moisture stress can be effectively improved by obtaining the maximum expression of yield contributing characters showing the stronger association with grain yield in desirable direction.

CONCLUSION

Drought environments decreased grain yield and yield related traits performance compared to normal environments. Differences were observed in canopy temperature at anthesis and post anthesis under irrigated and drought conditions. Wheat genotypes GW 511, VL 967, GW 11 and GW 512 performed better compared to other genotypes in both irrigated and drought conditions. Drought indices which provide a best measure of drought tolerance based on yield loss under drought conditions in comparison to normal conditions have been used for screening drought tolerant genotypes. Higher and almost equal magnitude of GCV and PCV for the DSI, DTE and grain yield under drought condition, indicating this parameter is less influenced by environments. Grain yield and its related traits exhibited high to moderate heritability, expected genetic advance as percent of mean and correlation under moisture stress, indicating that the drought indices may help as selection criteria to improvement in genetic gain for grain yield and also for increasing of drought tolerant efficiency of wheat genotype.

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