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Screening of wheat (*Triticum aestivum* L.) genotypes under limited moisture and heat stress environments

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Abstract

Moisture and high temperature stress are major constraints in wheat (*Triticum aestivum* L.) productivity. To generate information on the effect of high temperature and moisture stress on various traits which contribute for yield would be helpful in developing tolerant wheat genotypes. An experiment was conducted on a set of 27 diverse wheat genotypes, including three released cultivars for late sown and limited moisture conditions. The experiment was conducted under normal sown, with limited (one irrigation) moisture and under late sown (six irrigation) conditions. The results revealed that days to flowering, biomass yield and 1000-grain weight were less affected by the stress conditions. The genotypes WR-626, WR-631, WR-642 and PBW 373 showed better performance under both the (high temperature & low moisture) stresses with less reduction in grain yield. The characters HSI and DSI could be taken as important criteria for breading wheat genotypes suitable for stress environments.

Key words: Wheat, drought susceptibility index, heat susceptibility index, tolerant genotype

Introduction

Yield potential of any variety is combined effect of genotype and environmental interaction. Among different crop species, wheat (*Triticum aestivum* L.) is one of the most important cultivated species. Now a days global warming and scarsity of water are important factors for the wheat production through out the world. Howard [1] while analysing the factors controlling wheat production remarked that "wheat production in India is a gamble in temperature". This statement is valid even today. The cultivation of wheat is limited by abiotic stresses (moisture & temperature). The present day rice-wheat cropping system and monsoonal irregularities, has compelled wheat crop to face rapidly ascending temperatures coupled with moisture stress during the post anthesis stages. These unfavourable environmental conditions severelly affect post anthesis stages and ultimately reduce yield considerably. It has already been established that stress due to high temperature can play significant hole in reducing yield and quality of wheat [2]. Breeding for heat and moisture stress tolerance forms an integral component of wheat breeding programme at both national and international level [3]. Breeding for abiotic (thermo & moisture) tolerance in wheat cultivars requires understanding of the physiological responses of wheat crop to these stresses, which will help in identifying traits, to be used as selection criteria. The present study was carried out to understand the effect on morpho-physiological traits under high temperature and moisture stress conditions and identification of tolerant genotypes suitable for the these environments that the yield target can be met out under changing conditions.

Materials and methods

The experiment was carried out at Agri. Res. Station, Durgapura, Jaipur during the rabi season of 2001-02 with 27 genetically diverse wheat genotypes. Out of these genotypes 24 were pipeline cultures and three Raj 3765, Raj 3777 and PBW 373 were released varieties for late sown and high temperature conditions. The experiment was laid out in randomized block design with three replications in three environmental conditions *viz.*, timely sown (20th Nov.). moisture stress condition and late sown condition (14th Dec. 01). In moisture stress condition, one pre-sowing irrigation and one irrigation at 45 days after sowing was given. In normal and late sown conditions recommended agronomic practices were followed to raise a good crop. Each genotype was sown in 6 rows of 3 m length with row to row distance of 23 cm. Observations were recorded on six morpho-physiological characters *viz.*, days to flowering, plant height, biomass/ m^2, grain yield (m^2), harvest index and 1000-grain weight in each entry and in each replication in all the three sowing conditions. Heat and drought susceptibility index were calculated for grain yield and other attributes over high temperature stress and non-stress environments and moisture stress and non-stress environments by using the formula as suggested by Fischer and Maurer [4], HSI and DSI = [1-YD/YP]/D, where YD = mean of the genotype in stress environment, YP = mean of genotype under non-stress environment; D = 1-[mean YD of all genotypes/mean YP of all genotypes]. The HSI and

DSI values were used to characterise the relative tolerance of genotypes based on minimization of yield losses compared to normal environmental conditions. The difference between genotypes for different characters were tested for significance by using standard techniques for analysis of variance.

Results and discussion

The results obtained from the analysis of variance studies showed highly significant differences among all the characters and genotypes in all the sowing environments indicating the influence of sowing condition on genotypes and traits. Further it was observed that all the characters respond to high temperature and moisture stress in different way in different genotypes.

The heat susceptibility index (HSI) was calculated for various characters and presented in (Table 1) indicated that if we consider D-value, it was revealed that days to flowering and 1000-grain weight were less affected by the high temperature while grain yield/m^2 and biomass/m^2 highly suffered under high temperature. This clearly indicated that grain yield depend on biological yield. Similar type of results were also reported by Sharma [5]. The genetypes Raj 3777, PBW-373, WR-643, WR-641, WR-637, WR-633, WR-629 and WR-627 has tolerance in biomass/m^2, grain yield/m^2 and harvest index (values of HSI below unity) Blum *et al.* [6] concluded that biomass of large plants under stress were always better than the smaller counterparts, which support the result of the present investigation. They also emphasized that selection for high biomass yield should bring about positive improvement in grain yield and 1000-grain weight. Thus biomass yield could be improved by plant height and number of tillers per plant. In the present investigation plant height significantly contributed towards biomass because less reduction in plant height (D = 0.101) in stress environment.

Droughty susceptibility index (DSI) presented in (Table 2) indicated (D value) that days to flowering, 1000-grain weight and harvest index were less affected as compared to grain yield/m^2 under moisture stress conditions. These findings revealed that days to flowering, plant height and 1000-grain weight significantly contributing towards grain yield. Therefore, in drought condition 1000-grain weight is an important yield contributing traits. Results of drought susceptibility index (DSI) revealed that genotypes *viz.*, WR-623, WR-626, WR-628, WR-630, WR-642 and Raj 3765 showed tolerance in grain yield/m^2 (Value of DSI below unity) with negative values for 1000-grain weight. These results showed that in drought conditions 1000-grain weight is more important than number of grains per spike for breeding of drought tolerant genotype. Such findings

Table 1. Heat susceptibility index for different characters in bread wheat (late sown)

Charaters/ genotype	Days to flowe-ring	Height (cm)	Biomass/m^2	Yield/ m^2	Harvest index	1000-grain wt.(g)
WR-622	0.901	0.425	0.509	1.213	1.757	0.692
WR-623	0.394	0.504	0.609	1.183	1.599	0.614
WR-624	0.507	0.762	2.015	1.032	1.534	1.553
WR-625	0.859	1.594	1.625	0.947	0.372	0.357
WR-626	0.000	0.306	0.045	0.704	1.202	0.284
WR-627	0.197	0.128	0.548	0.213	0.939	0.430
WR-628	0.690	0.861	0.996	1.371	0.453	1.273
WR-629	0.859	1.178	0.887	0.839	0.429	0.363
WR-630	1.830	1.940	0.204	1.364	2.680	1.960
WR-631	1.470	0.475	0.121	0.798	1.299	1.318
WR-632	1.014	0.524	1.945	1.711	1.206	2.078
WR-633	1.154	0.217	0.179	0.454	0.599	0.480
WR-634	0.352	3.207	0.871	1.316	1.631	1.787
WR-635	0.197	1.762	1.652	2.034	2.303	2.351
WR-636	0.971	0.603	1.201	1.568	1.939	0.620
WR-637	1.154	1.198	0.905	0.949	0.676	0.111
WR-638	1.676	0.950	1.503	1.474	1.194	2.335
WR-639	1.929	1.742	1.506	0.903	0.708	0.223
WR-640	1.971	0.316	0.777	1.011	1.012	3.329
WR-641	1.394	1.980	0.911	0.327	0.465	0.340
WR-642	0.394	0.801	1.018	0.463	0.012	0.463
WR-643	0.197	1.019	0.048	0.266	0.008	0.854
WR-644	0.000	1.019	1.481	0.697	1.287	0.391
WR-645	1.225	1.118	1.545	1.451	1.032	0.960
Raj. 3765	1.591	0.425	1.082	0.642	0.785	0.279
Raj. 3777	0.661	0.227	0.597	0.559	0.242	0.558
PBW-373	1.253	0.326	0.884	0.580	0.044	0.910
D. Value	0.071	0.101	0.328	0.436	0.247	0.179

D-Value = Heat Intensity = $1 - \frac{\text{mean YD of all genotypes}}{\text{mean YP of all genotypes}}$;
YD = mean of genotype in high temperature stress environemnt; YP = mean of genotype in non stress environment

were also reported by Reynolds *et al.* [7]. Earlier Slafer *et al.* [8] revealed that the number of grains per m^2 is negatively related to individual grain weight, which supports the results of the present study.

While going through heat susceptibility index (HSI) and drought susceptibility index (DSI) it was noticed that in both type of stresses, days to flowering, 1000-grain weight and plant height showed less reduction in stress environments and the genotypes WR-626, WR-631, WR-642 and PBW-373 showed better performance in both type of stresses. Further, at least 10 percent pipe line genotypes were found better than the released varieties Raj 3765, Raj 3777 and PBW-373 These cultures need to be further tested in stress conditions and may be used for crop improvement programme. The study suggest that, breeding new varieties for heat and drought tolerant condition more emphasis should be given to selection for high biomass

Table 2. Drought susceptibility index for different characters in bread wheat (under limited moisture)

Charaters/ genotype	Days to flowe-ring	Plant height (cm)	Biomass /m^2	Yield/ m^2	Harvest index	1000-grain wt.(g)
WR-622	0.325	0.618	0.956	0.958	0.344	0.317
WR-623	0.000	0.093	0.610	0.550	1.180	–0.327
WR-624	1.200	0.834	1.873	0.242	0.508	–0.134
WR-625	0.925	1.021	1.583	1.218	0.706	0.658
WR-626	0.700	0.812	0.155	0.643	1.248	–0.317
WR-627	0.700	0.446	0.752	0.138	1.491	3.073
WR-628	0.000	1.007	0.056	0.502	1.079	–0.414
WR-629	0.325	0.935	0.825	0.735	0.096	2.195
WR-630	0.275	1.115	0.180	0.060	0.073	–1.134
WR-631	0.875	0.848	0.376	0.407	0.186	0.060
WR-632	0.300	0.978	1.715	1.970	2.717	1.292
WR-633	0.875	1.021	1.583	1.859	2.440	0.365
WR-634	0.925	2.107	1.881	2.070	2.864	0.646
WR-635	0.000	1.201	1.612	1.958	2.920	3.707
WR-636	1.000	1.532	1.182	1.395	1.361	3.341
WR-637	1.175	1.661	0.946	1.065	0.757	–0.707
WR-638	0.000	1.460	1.174	1.099	0.163	1.365
WR-639	0.275	1.266	1.075	0.424	0.316	0.658
WR-640	0.275	1.460	0.537	1.196	2.067	0.451
WR-641	0.275	1.165	0.615	0.470	1.372	2.268
WR-642	2.800	1.093	0.629	0.456	0.661	–1.585
WR-643	0.700	0.575	0.940	0.927	0.282	2.804
WR-644	0.325	1.309	1.537	1.417	0.169	2.646
WR-645	0.625	0.741	0.594	0.618	0.242	3.048
Raj. 3765	2.200	0.381	0.868	0.776	1.548	–0.609
Raj. 3777	1.175	0.086	0.774	1.007	1.011	–0.304
PBW-373	2.800	0.316	0.849	0.934	0.881	1.000
D. Value	0.040	0.139	0.372	0.412	0.177	0.082

D-Value = Drought Intensity = $1 - \frac{\text{mean YD of all genotypes}}{\text{mean YP of all genotypes}}$;

YD = mean of genotype in high temperature stress environemnt; YP = mean of genotype in non stress environment

yield and 1000-grain weight. Thus selection for biomass yield is one of the most important way to improve the productivity under stress conditions.

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