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Disclosure of stress driver's traits related to reliability in normal, drought and heat prone settings in bread wheat advanced lines.

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Abstract

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A panel of forty eight future advanced lines with three productive checks was planted in three divergent trials under normal, drought and heat prone settings. The multivariate technique and stability analysis was subjected on drought and heat adaptive/yield drivers traits. The late phenological traits such as canopy temperature and normalized difference vegetation index at anthesis (CTA and NIA) displayed higher interface proportion with lines as compared to early traits like canopy temperature at booting and normalized difference vegetation index at booting (CTB and NIB). The changes in CTA and NIA effectively represented changes in comparative water gratified (RWG) and yield (YLD) under heat and drought settings, respectively. Dumpy YLD with high RWG and CTA readings, high yield but occurrence of reduced canopy temperature and RWG value demonstrating lines had cooler canopy and water retention were more mutual in normal, drought and then heat settings, correspondingly. The cluster two and four delimited lines with high yield but exposed lesser CTB and CTA values and vice versa for RWG, NIB and NIA. Nine lines were common in all three settings. NIA, RWG and NIB had positive correlation with YLD in heat, drought and normal setting, respectively while CTB and CTA were somewhat negatively linked with yield in entire three settings. In heat CTA and CTB, in drought, RWG and YLD and in normal CTB and YLD was highest discerning while NIB in heat and drought and CTA in normal setting were least discriminating. Nine lines in normal, and eight lines each drought and heat three settings established conquests due to stable climax placed on joined equality lines dispersal on polygon.

Keywords: Disclosure; stress driver's traits; reliability; drought; heat; bread wheat

Introduction

Demand of wheat is mounting and it is projected that by 2050 the prerequisite of wheat will be 60% upper than the current year on the sphere. In Pakistan, wheat hierarchical at 1[st]place both in sequence of area and yield displaying extraordinary status among cereal crops. The cultivation of wheat is utmost pretentious because it is vulnerable to mounting heat and drought stresses during their phenological phases. Drought and heat stresses in wheat are itemized at the uppermost among the dynamics that distress food security worldwide. In Pakistan wheat after cotton and rice is the major crop rotation. Late harvesting of cotton and rice crops is the major time conflict in the rotation resulting low wheat yield potential (Nasrullah et al., 2017).Terminal heat stress, where the planting date is delayed, this exposes the wheat crop to high temperature during the reproductive and after phases. (Akter et al., 2017)Drought stress befalls when environ temperature is elevated, soil and atmospheric humidity is squat while heat stress ensues when air and soil temperature become across a verge level. It has been projected that half of the wheat yield losses are activated by drought and heat stresses exclusively when they seemed collectively since both stresses manifestations are erratic at any stage but frequently ascend concurrently at anthesis and during the grain filling periods (Qaseem et al., 2019).Therefore, integrating drought, heat discretely or preferably in combination will upsurge wheat yield significantly under the circumstances where they show concentrated profit and appropriate finest.

Hence, our vital objective was to address both stresses together in comparison with normal for yield by manipulating genetic stability and reliability by dissecting genotype, environments and genotype by environments interaction. The AMMI and GGE biplot analysis is chief model for yield stability suitability measurement in drought and heat lying backdrops. Our valuation in this scenario will support the development of new high yielding, resistant to drought and heat vigorous wheat varieties.

Materials and method

The tryout was piloted in three sets (normal, drought and disposed to heat settings)in the plot dimension of 2.5mx2 rows via RCB design at Wheat Research Institute, Faisalabad, Pakistan (31°25′ N, 73°04′ E and 610 feet above the sea level). Each set consisted of 48 genotypes including three standard checks (Akbar-19, Anaj-17, Ujala-16). The first set was sown under usual irrigation (tillering, booting and grain filling periods). The second set was established under drought ailment (only pre sowing irrigation). For revelation to heat stress the late sowing was done in the third set. Data on drought and heat adaptive/yield drivers (comparative water gratified (%) (RWG), normalized vegetation index (NIB, NIA), canopy temperature (^{0}C) (CTB, CTA) at booting and anthesis stages) and yield (kg h^{-1}) (YLD) were documented. Balota et al; 2007 used these traits as rapid and effective selection criterion to improve tolerance to heat and drought. Data for canopy temperature and normalized difference vegetation index at both stages were recorded with sense infrared thermometer (LT.300) and green seeker (handheld-505), respectively during sunny days with least wind speed at noon time when the dew had dried off from the plant canopy. RWG was calculated by using the formula:

RWG (%) = {(fresh weight of leaves – dry weight of leaves)/(turgid weight of leaves – dry weight of leaves)}*100

All routine agronomic follows were fulfilled. For future statistical analysis, the two years (2018-19 and 2019-20) data were pooled for middling of two reading using multi environment trial analysis (Alvarado et al; 2015) and statistical software packages of SPSS-12, STATISTICA-5.0 (Sneath and Sokal, 2014).

Results and Discussion

The combine analysis of variance was performed. The mean squares from analysis of variance (Table 1) signposted that genotypes differences were vastly significant (P≤0.01) in wholly settings signifying massive settings and genotypes x settings discrepancy and ample difference in genotypes retaliation across settings for all traits except CTB and NIB which were significant (P ≤ 0.05).The Interaction proportion of deviation, upshot of settings was effective chiefly on yield (63.6%),RWG (58.4%)and CTB (57.4 %) followed by genotype variation for NIA (26.3%)and CTA (25.7) and genotypes x settings for CTA (35.4 %) and NIA (25.3%).The late phenological traits (CTA and NIA) showed higher interaction proportion with genotypes as compared to early traits (CTB and NIB). This signifies that the genotypes have potential and variation to with stand these stress drivers. Crain et al., 2018.Plentiful readings ratify such highly imperative interface (Zamalotshwa et al., 2019) which vindicated the application of multivariate and stability approaches to define the conduct of lines in three environs.

The range of apiece variable stretches an instant scope of diversity (Table 2). High CTA values in heat setting

Table 1. Combined analysis of variance for interaction proportion for stately characters in overall accession in three environs

Source	DF	YLD	RWG	CTB	CTA	NIB	NIA
Genotypes	47	0.81**	10.2**	8.1*	5.8**	0.0123*	0.0121**
Interaction proportion	16.6	18.2	19.9	25.7	18.8	26.3	
Settings	2	58.9**	1798.6**	599.3**	201.2**	0.7234**	0.8539**
Interaction proportion	63.6	58.4	57.4	38.9	40.3	48.4	
Genotypes x settings	94	0.333**	11.8**	10.3**	5.3	0.0093**	0.0134**
Interaction proportion	19.8	23.4	22.7	35.4	21.5	25.3	

** = P ≤ 0.0, * = P ≤ 0.05

*YLD-yield (kgha^{-1}), RWG-comparative water gratified (%), CTB-canopy temperature at booting (°C), CTA-canopy temperature at anthesis (°C), NIB-normalized difference vegetation index at booting and NIA-normalized difference vegetation index at anthesis

Table 2. Range values for exalted variables in normal, drought and heat settings

Variables	Normal		Drought		Heat	
	Ranges	Mean	Ranges	Mean	Ranges	Mean
CTB	16.5-18.3	14.8±1.21	11.7-21.2	16.1±1.11	12.2-22.4	13.6±1.32
CTA	11.6-20.4	16.2±1.36	12.3-22.7	17.4±1.33	14.2-24.1	19.1±1.43
NIB	0.66-0.83	0.74±0.044	0.62-0.77	0.69±0.037	0.54-0.73	0.65±0.049
NIA	0.56-0.72	0.65±0.031	0.51-0.66	0.57±0.034	0.42-0.61	0.52±0.053
RWG	25-37	27.9±2.13	45-88	59.8±2.02	31-63	38.9±2.46
YLD	58.7-78.3	67.7±3.16	42.1-56.2	54.2±3.71	39.2-42.8	41.8±3.42

(14.2-24.1) reduce the duration and rate of the grain filling which eventually reduces the YLD (39.2-42.8), indicating that cooler canopy genotypes has higher duration and rate of the grain filling. (Khan et al., 2014)Nevertheless, genotypes with cooler canopy temperature at booting and anthesis stages did tend to yield more in stress settings due to stomatal conductance. Likewise, high NIB (0.66-0.83) and NIA (0.56-0.72) values showed high grain yield indicating that high yielding (58.7-78.3) genotypes can prolong carbon assimilation that generally showed a slower decline in chlorophyll contents particularly after anthesis. RWG is an indicator to measure dehydration and desiccation resistance which gives the level of water deficit idea especially under drought settings (45-88). The genotypes with relatively high relative water content have low transpiration and stomatal conductance and have high water use efficiency due to high osmotic adjustment and longer root depth. The changes in CTA and NIA effectively represented changes in RWG and YLD under heat and drought settings, respectively. (Jiang et al., 2009). These suggest that the genotypes that maintain a relatively high NDVI, CT and RWC at booting and especially at anthesis stage could be considered a measure of heat and drought tolerance. Hasanuzzaman *et al*. (2012) also suggested that NDVI, CT and RWG can be used as indirect selection criterion to predict grain yield in stress settings.

Clusters exploration

The lines in cluster 1 validated squat yield with low RWG, NIB and NIA readings. The cluster 2 and 4 contained lines with high yield but displayed lesser CTB and CTA values and vice versa for RWG, NIB and NIA. The minimum values in these clusters signifying lines had cooler canopy that is why firstly, the lines in these cluster have high yield and have less reduction in RWG and were more common in heat and then drought sensitive settings (Table 3). Ramya et al., 2016 also revealed that cooler canopy and better primary potency contributed to drought tolerance. The members of cluster 3 and 5 remained almost average in all respect while cluster 6 remained lowest.

Regarding the number of lines, under normal setting 4, 5, 3, 2, 2, 1 lines and in drought setting3, 2, 2, 3, 5 while in heat setting5, 3, 2, 3, 3 lines were settled in cluster I, II, III,IV, V and VI respectively with substantial variances between all clusters in all trials. Ali et al., 2011 also demonstrated different extensive discrepancies between all clusters under stress

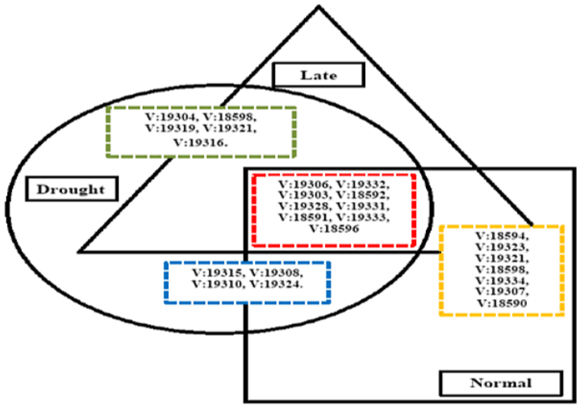

Fig. 1. Venn diagram showing distribution of common lines in three settings

Table 3. Genotypes allied to various clusters under three settings

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
YLD	4980	6602	5161	5538	5239	4345
CTB	22.1	14.5	19.6	15.3	18.1	22.4
CTA	24.2	15.9	21.7	16.8	18.9	25.1
NIB	0.48	0.75	0.53	0.73	0.67	0.46
NIA	0.43	0.68	0.48	0.54	0.46	0.40
RWG	27.8	55.4	32.2	40.3	35.5	26.2

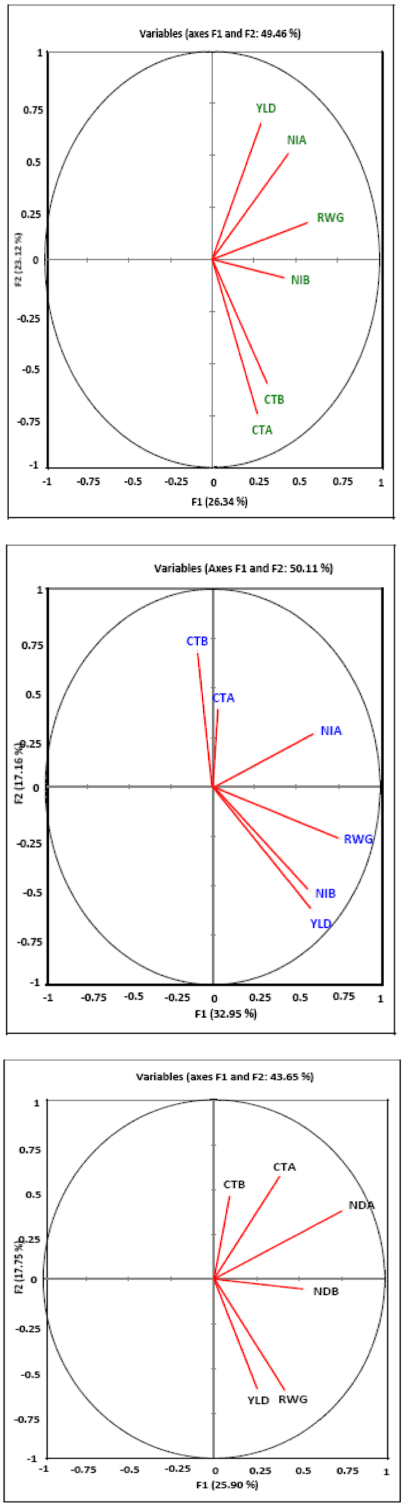

Fig. 2. Appearance of adaptive/yield drivers in three settings

disposed environ. The lines V:19306, V:19332, V:19303, V:18592, V:19328, V:19331, V:18591, V:19333, V:18596 were common in all three environ. The lines which were mutual in drought and heat settings were V:19304, V:18598, V:19319, V:19321, V:19316. The lines which were shared in normal and heat settings were V:18594, V:19323, V:19321, V:18598, V:19334, V:19307, V:18590 and the lines which were jointed in normal and drought were V:19315, V:19308, V:19310, V:19324. (Figure 1). Badu et al., 2017 also find combine genotypes in heat, drought and combine settings. Therefore, the respective genotypes can be used in breeding package with an extensive group of flexibility in behaviors within and between settings revealed.

Traits assessment in three settings

The biplots were raised in two dimensioned for valuation of adaptive/yield drivers traits in three settings.

Assessment of traits connections

The projection of traits on PC1 and PC2 revealed that NIA, RWG and NIB had positive correlation with YLD in heat, drought and normal setting, respectively (acute angles). This depicted that these are key yield contributing traits in their respective settings. (Shiferaw et al., 2016) CTB and CTA were slightly negatively correlated (obtuse angles) with yield in whole three settings. (Mason et al., 2014). The incidence of inclusive obtuse angles between established settings is sign of sturdy edge of GxE interface. At this point the biggest incline is marginally superior to 90° (between CTB and CTA with yield) which suggest moderately large GxE contact. Due to right angles, NIA with CTA in heat setting, CTA and NIA with YLD in drought and normal settings were not correlated.

Assessment of traits discerning aptitude

The length of the settings vectors describes the discriminating ability of the traits as it is directly proportionate to the standard deviation inside the own setting. Hence, in heat CTA and CTB, in drought, RWG and YLD and in normal CTB and YLD were utmost discerning (informative) while NIB in heat and drought and CTA in normal setting were slightest discriminating (Figure 2).

Determination of retention of factors

A scree plot that defines the major group of variables was done. Eigenvalue declined gradually in descending order of magnitude almost in the form of semi curve bars for three settings and helps the analyst visualize the relative importance of the PCs (Cai et al., 2015). Out of 6 PCs, the first

Table 4. Eigenvalue, variability and cumulative in three settings

PCs	PC1	PC2	PC3	PC4	PC5	PC6
Eigenvalue	2.2263! 2.3312! 2.8404!	1.9992 1.5973 1.4256	1.3992 1.3236 1.1269	1.1207 1.1190 1.0807	0.8399 0.8006 1.0835	0.6628 0.6366 0.6475
Variability, %	26.0292 28.1083 33.2183	23.7055 19.9540 17.4981	16.9390 16.9132 14.1787	13.8442 14.6398 13.6663	10.7248 11.1016 12.5859	8.7573 9.2789 8.8524
Cumulative, %	24.7366 25.9023 31.5603	46.9496 43.6505 47.4005	62.4961 58.3577 59.9212	74.9478 70.7915 71.9294	84.2802 79.6871 82.8573	91.6450 86.7600 90.0517

!=1st, 2nd and 3rd values designate heat, drought and normal settings.

five exhibited eigenvalue greater than one (significant) for normal and first four for drought and heat settings. The rest PCs explained trivial (nonsignificant) amount of variation and were not worth interpreting. Similarly, the only first two PCs in heat, drought and normal settings accounted 49.73, 48.06 and 50.72% variation, respectively in comparison with succeeding four PCs. (Fig. and table cumulative). Therefore, the two components had high variability for all traits except CTB and CTB and were considered representative of the data (Table 4, Figure 3).

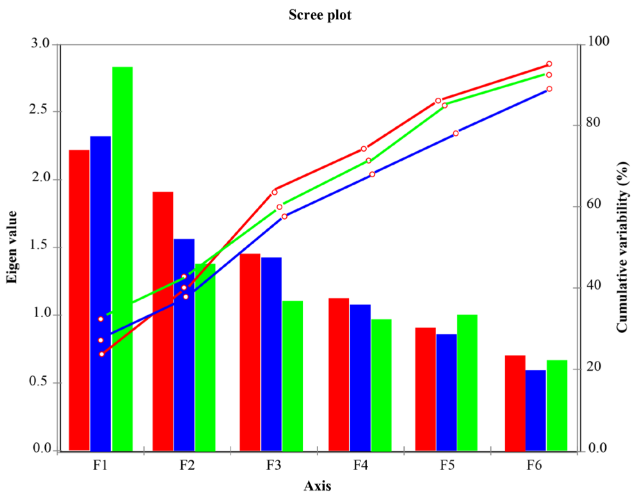

Fig. 3. Scree diagram representativeness in three settings

Which-won-where in three settings

To partition the genotypes and genotype by environment effects, the two peaks mutable PCs were planned for yield trait only by polygon imagining which has capability to display which won where arrangement of a genotype in different environmental settings. In this case perpendicular lines among the genotypes which are at peak from the biplot foundation are drawn in such a way that all additional genotypes were limited inside the polygon (Figure 4).

The equality lines distributed the biplot into segments and stable apex positioned lines (winning) were precisely appropriate to matching environ (Castillo et al., 2012). For instance, in normal setting genotypes V: 19308 and V:18592, in drought setting genotypes V:19315 and 19328 and in heat setting genotypes V:19307 and V:19319 connect other genotypes on the lines.

This means that genotypes V:19308>V:19332>V:19325>V:19306>V:19310>19312>Akbar19>V:19309>V:18592, genotypes V:19315>Anaj.17>V:19329>V:18596>V:19331>V:18591,>V:19302, >V:19328 and genotypes V:19307>V:19334>V:18594>V:19303>V:18598>V:19333>Faisalabad.08>V:19319 in normal, drought and heat settings erected victories and were factual in their own settings. Thus, these lines in specific settings are more valuable and skimpy for disposal unbalanced genotypes (Farshadfar *et al.*, 2012). The inclusive divergence in amid genotypes is guesses by expanse among them which actually denote the Euclidean distance and due to variation in genotypes mean yield or/and in interaction with the settings. For example, V:19305 and V:19324 in normal, V:19301 and V:19314 in drought

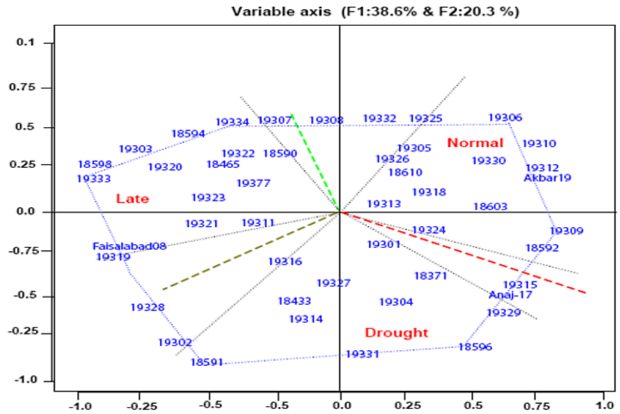

Fig. 4. Genotypes stability representativeness in three settings

and V:18590 and V:19321 in heat are very different whereas V:19326 and V:18610 in normal, V:18433 and V:19314 in drought and V:19322 and V:18465 in heat are quite similar. Situation lighting of other genotypes can be prepared similarly.

Conclusion

1-It is established from the results of current study that the stress adaptive/yield drivers traits were massively affected by lines inconsistency and settings. The changes in CTA and NIA effectively represented changes in RWG and YLD under heat and drought settings, respectively.

The late phenological traits (CTA and NIA) displayed higher interface proportion with lines as compared to early traits (CTB and NIB).

2- Owing to angles position, CTB and CTA were somewhat negatively linked with yield in entire three settings. NIA in heat, RWG drought and NIB in normal had positive correlation with YLD.

3- The common lines in all settings, surely fitting lines to corresponding settings and apex positioned lines encouraged that these are vibrant and could be respected and revealing for developing drought and heat tolerant wheat varieties.

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