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APPRAISAL OF BREAD WHEAT *(Triticum aestivum L.)* GENOTYPES UNDER NORMAL, DROUGHT AND HEAT PRONE ENVIRONMENTS FOR MORPHO-PHYSIOLOGICAL MULTIPLICITY AND CONSTANCY

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ABSTRACT

A panel of 30 advanced lines with two checks (Anaj17 and Ujala16) was grown under normal, drought and heat prone environments. The data of 9 different traits were subjected to multivariate technique and stability analysis. The positive correlation of yield with GRW, NDVIBT and NDVIAN and negative correlation with D/H, PH, CTBT and CTAN in all environments was established. A positive association of yield and GRW with NDVIBT and NDVIA data suggested an operative benchmark for screening genotypes in normal, drought and heat environment due to the presence of stay-green while negative pattern of CTBT and CTAN advocating that cooler canopies had association with higher yield. The genotypes which were mutual in cluster-1were 1 and 8, genotypes 22 and 24 in cuslter-2 in all three environments while in cluster-3 genotypes 30, 33 and 29 were common in normal and heat environment only.

For stability imagining and environmental valuation, biplots were constructed to partition the genotypes and genotype by environment effects for 6 stress adaptive traits only. All three environments were far from the biplot origin for exclusively CTBT, NDVIAN for normal, GRW for heat, CTAN for drought and heat. It is exposed that normal environment is comparatively high contributor to the stability of genotypes for yield and heat environment for NDVIBT trait as indicated by the shorter distance between its pointer and the origin. As concern relationship among the genotypes, 20, 19, 29 for NDVIAN, 1, 13, 32 for CTAN, 1, 2 NDVIBT, 3 for CTBT, 11, 15 for GRW, 1, 11, 12 for yield traits were different from the others Accordingly, 6 for NDVIAN, 8, 27, 21for CTAN, 30, 13 NDVIBT, 4, 33 for CTBT, 32, 6, 7 for GRW, 3 for yield signposts their stability in performance across environments. The angle evaluates the track and magnitude of the connection between environments and genotypes. For instance, 13 was beneath average in entire environments whereas 15 was above average in entire environments. The genotypes 32 and 33 had higher yield and GRW in normal and drought while 11 and 34 had greater yield and GRW in drought and heat environments, respectively due to their crossover interface by linking them with an equality line.

Keywords: appraisal, normal, drought, heat, morpho-physiological, multiplicity, constancy, bread wheat.

INTRODUCTION

The query of hunger in Pakistan required mandatory consideration as it is one of the most pressing humanitarian as well as expansion challenge for food security. In existing and mounting climate change circumstances, drought and heat are the foremost abiotic stresses that trim down wheat productivity and fade global food security. Pakistan is no alien to impacts of climate change. Among the long-term climate risk index, Pakistan, on annual averages basis amongst the zenith ten catalogue of countries which are largely ostentation by remarkable weather trials from 1996-2015 (Sonke et al;). At an economic level, in the preceding two decades Pakistan had ached average yearly losses of $2 billion on the crushed intense weather proceedings. Pakistan countenance about yearly total cost of $ 6-16 billion to adjust to climate transformation and magnitude of this cost will increased day by day (Malik et al; 2011). The models project average temperature will boost within the array of 1.3-1.5 ^{0}C by the 2020 and 2.5-2.8 ^{0}C by the 2050, escort by increased harshness of drought and other extreme weather events (PC-GoP, 2010).

In Pakistan, summers are steadily becoming longer and winters shorter, dropping the duration of wheat mounting period. As wheat needs moisture and coolness to rise, it is one of the first crops to be affected by drought and heat stresses. Therefore, among the different abiotic stresses distressing wheat, drought and lofty temperature harmfully affect wheat growth and development subsequently, a sharp decreased of wheat productivity results. It has been estimated that half of the yield losses are triggers by drought and heat stresses (Gaur et al; 2012). Drought and high temperature stresses commonly arise simultaneously at anthesis and during the grain filling stage on wheat which decreases grain number and grain weight by prompting anthesis indehiscence, pollen fertility and ovary extension (Ji et al; 2010). From grain set to physiological adulthood both stresses decline leaf chlorophyll content and speed up senescence leading to a shorter grain sizable length with an eventual decrease in grain yield (Zhao et al; 2007).

Conventional plant breeding has had inequitable triumph in fading both stresses simultaneously which may be due to the hurdle linked with traits strained by a number of genes present at plentiful quantitative traits loci (Parmar et al; 2017). The multiparty upshot of drought and heat is elevated than when taken separately, therefore it is imperative that both should be deliberated jointly. Thus a better perceptive of their collective effect will become progressively more noteworthy if wheat development blue prints are able to keep celerity with climate change. The objective of this study was to identify the stress adaptive morpho-physiological fragment having

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

the main impact on yield and their stability by dissecting genotypes by environment interaction against adverse effect of normal, heat and drought prone settings. This kind of try-out will help in developing new high yielding, resistant to drought and heat resilient wheat varieties.

MATERIAL AND METHODS

The material was planted in randomized completed block design with 3 replications under normal, drought and heat prone environments with the plot size 2.5mx2 rows. One set of experiment was sown in tunnel for exposure to heat stress by covering the tunnel with plastic sheet for two weeks (11^{th} -25^{th} March). Daily temperature inside and outside the tunnel was recorded and maintained above 32 ^{0}C inside the tunnel. The second set was planted under drought condition (pre sowing irrigation only), while the third normal set was irrigated at tillering, booting and grain filling stage. All standard agronomic practices were implemented. Data on morpho-physiological traits viz; plant height (cm), days to heading (50%), days to maturity (50%),normalized difference vegetation index (at booting and anthesis stages), canopy temperature ((at booting and anthesis stages), 1000 grain weight (g), yield (kg ha^{-1}) were recorded. For canopy temperature (^{0}C), data was recorded with LT.300 6^{th} Sense Infrared Thermometer (IRT) and for recording the value of NDVI, green seeker (handheld-505) was used. Both the readings (CT and NDVI) at booting and anthesis stage were taken during sunny days with least wind speed at noon time during 11 am to 1 pm when the dew dried off from the plant canopy. The two years (2016-17 and 2017-18) observations were pooled for an average of two readings was calculated for use in future statistical analysis. The average data of both the years were subjected to statistical analysis, using statistical software packages of SPSS version 12, STATISTICA version 5.0 (Sneath and Sokal, 2014) and multi environment trial analysis (META-R) (Alvarado et al; 2015).

RESULTS AND DISCUSSION

The analysis of variance of all measured 9 traits was carried out. The mean squares from analysis of variance given in table 1 indicated that genotypic differences were highly significant ($P \leq 0.01$) except PC3 for PH and GRW which were found significant ($P \leq 0.05$) indicating the presence of sufficient variability to identify potential genotypes. From the prime fragment of the discrepancy, effect of environment was accountable especially on DM (95.8%), D/H (89.7%), PH (79.5%), and yield (75.6%) lagged by ENV*GEN exclusively on CTAN (33.8%), NDVIBT (27.5%) and CTBT (26.2%). The genotypes variation effect was effective for GRW (36.5%) only. The ENV*GEN was split into 3 fragments of interaction. The PC! Score highly significant especially for GRW (80.0%), NDVIAN (65.9%), PH (63.4%), PC2 stood in medium order for D/M (37.1%) yield (33.6%), CTBT (30%) and PC3 in lesser order for CTAN (25.1%), D/H (19.9%) and D/M (14%) (Table 1). Numerous studies endorse such highly significant interaction

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

(Chapman, 2007) because of disparity retort of genotypes to series of drought and heat stresses stirring through crop advancement. These traits variation justified the utilization of multivariate and stability methods to describe the behaviour of genotypes under three environments.

Table 1: Summarized analysis of variance and interaction percentage for dignified traits of wheat accessions in three environments.

Variables	ENV	GEN	ENV*GEN	PC1	PC2	PC3	Residual
P/H	7207.9**†	67.3**	21.1**	68.4**	27.8**	13.3*	8.5
	79.9†	12.3	7.7	64.3	24.6	11.1	0
D/H	3636.2**	12.5**	6.4**	13.1**	6.9**	5.5**	2.0
	89.7	5.1	5.1	53.5	26.6	19.9	0
D/M	3427.5**	3.7**	2.7**	4.4**	3.5**	1.4**	0.89
	95.8	1.7	2.5	48.8	37.1	14.0	0
NDVIBT	0.6352**	0.0111**	0.0094**	0.0173**	0.0067**	0.0061**	0.0011
	56.3	16.2	27.5	59.6	21.8	18.6	0
CTBT	560.3**	6.0**	7.1**	11.1**	6.2**	3.0**	1.5
	62.7	11.1	26.2	56.5	30.0	13.5	0
NDVIAN	0.8779**	0.0091**	0.0081**	0.0161**	0.0061**	0.0029**	0.0013
	67.8	11.6	20.5	65.9	23.5	10.6	0
CTAN	184.9	4.9**	4.1**	6.3**	3.5**	3.6**	2.07
	40.6	20.	33.8	49.0	25.9	25.1	0
GRW	1243.6**	55.6**	10.6**	60.0**	11.0**	4.9*	3.2
	49.5	36.5	14.0	80.3	13.8	5.8	0
Yield	55.373**	0.587**	0.247**	0.588**	0.374**	0.123**	0.018
	75.6	13.2	11.1	56.1	33.6	10.5	0
DF	2	33	66	34	32	30	-

* = $P \leq 0.05$,**= $P \leq 0.01$, †=The upper values indicate sum of squares and the lower values indicate explained variation (%), P/H=plant height (cm), D/H=days to heading, D/M=days to maturity, NDVIBT=normalized vegetation index at booting, CTBT= canopy temperature at booting (C^0), NDVIAN=normalized vegetation index at anthesis and CTAN=canopy temperature at anthesis(C^0), GRW=1000 grain weight (g) and yield ($Kgha^{-1}$)

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

Traits correlation pattern

A simple correlation “all against all” publicized significant interaction among 9 traits of 34 genotypes in three environments (Table 2). The positive correlation of yield with GRW, NDVIBT and NDVIAN (Ram et al; 2011) and negative correlation with D/H, PH, CTBT and CTAN in all environments was established which advocate that these traits are vital for unswerving selection in high yielding genotypes. The negative association of yield within plant height is a useful finding that would empower breeders to evolved varieties with higher yield to have middling physique to be receptive for great inputs. El-Mohsen et al; (2012) also reported preventive traits for grain yield upgrading because this trait demonstrated negative association with yield. Manson and Singh (2014) also stated positive correlation of yield with GRW and NDVI and negative correlation with CT at diverse phase of wheat. A positive association of yield and GRW with NDVIBT and NDVICT data suggested that lines with high chlorophyll content at booting and anthesis phase had higher yield and may be possibly be used as an operative benchmark for screening genotypes in normal and drought environments due to the presence of stay-green. In normal and drought environments, positive pattern of NDVIBT and NDVIAN while negative pattern of CTBT and CTAN with yield is due to the fact that as the booting and then anthesis period advanced, NDVI values in the genotypes lessened while CY amplified which leads to terminal heat stress. Preceding studies by Mondal et al, (2015) and Hayset et al, (2007) have described alike affiliation with yield in reply to high temperature stress. Likewise, this negative relationship in all environments suggests canopy temperature had a negative incline, advocating that cooler canopies had association with high yields because cooler canopies recover functional and metabolic roles related to adaptation underneath stress. Such retaliation to canopy cooling has been attested by Pecetti and Damania (1994). Correspondingly, CT at booting and anthesis is a good pointer of genotypes stability against heat and drought stresses and this trait may be used as a selection gears for developing hat and drought stress tolerant genotypes. The highest CT values observed in normal environment while minimum values were related to drought and heat sensitive environment signifying genotypes in normal environment had cooler canopy than drought and heat (Scotford and Miller, 2005). CTBT found positive correlation with D/H and negative with D/M while CTAN was found to be positive with both the traits. In normal environment, NDVIAN and NDVIBT have negative relation with D/H and D/M, respectively. While a value of D/H and D/m found to be positive with these two measured traits in all environments. Early heading entries generally performed well in suffering environments as it escape the heat and drought stresses during grain filling stages. It was perceived that the varieties have ranged between early to normal heading accomplished well in all environments that may be due to the fact that heading and maturity time is considered as a covariate to control yield and yield related components. Gomez et al; (2014) also suggested that

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

these morphological attributes contribute to grain yield and yield components like grain weight by maintaining rate and duration of days to heading and maturity.

Table 2: Correlation coefficients for dignified traits of wheat accessions in three environments.

Variables	P/H	D/H	D/M	NDVIBT	CTBT	NDVIAN	CTAN	GRW	Yield
P/H	1								
D/H	-0.01 -0.04 -0.23	1							
D/M	0.19 0.36* 0.33	0.08 0.07 0.18	1						
NDVIBT	0.21 0.41* 0.54*	-0.03 0.12 0.10	0.16 0.43* 0.44*	1					
CTBT	0.06 -0.02 0.06	0.08 0.23 0.31	-0.14 -0.26 -0.01	-0.24 -0.07 0.22	1				
NDVIAN	0.25 0.30 0.11	0.20 0.17 0.07	-0.15 0.01 0.02	0.60* 0.30 0.41*	-0.18 0.03 0.22	1			
CTAN	-0.03 0.05 -0.11	0.03 0.13 0.07	0.07 0.25 0.39*	0.16 0.25 -0.12	0.08 0.01 -0.04	0.03 0.00 -0.03	1		
GRW	0.16 0.20 0.09	0.02 0.03 -0.02	-0.01 0.12 0.25	0.75* 0.47* -0.02	-0.05 -0.07 -0.04	0.65* -0.05 -0.23	0.09 0.27 0.28	1	

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

Yield	-0.16 -0.12 -0.04	-0.08 -0.08 -0.16	-0.16 0.03 0.27	0.49* 0.25* 0.11*	-0.25 -0.01 -0.06	0.39* 0.01 -0.10	-0.17 -0.01 -0.09	0.52* 0.50* o.79*	1

* = P ≤ 0.05, Upper value parade normal, middle value drought and lower value heat environment

Cluster analysis

The dignified traits disjointed into 3 clusters comprising 9, 16, 14 genotypes in cluster1, 15, 5, 17 in cluster-2 and 10, 13, 3 in cluster-3 of normal, drought and heat environment, correspondingly with significant differences among all groups in all clusters. The genotypes which were mutual in cluster-1were 1 and 8, genotypes 22 and 24 in cuslter-2 in all three environments while in cluster-3 genotypes 30, 33 and 29 were common in normal and heat environment only (Table 3). In normal environment, minimum distance to centroid was found to be 3.0, 3.2, 2.4, in drought, 1.8, 1.9, 1.3 while in heat 1.1, 1.4 and 2.9 in cluster-1, 2 and 3, respectively. Likewise the same maximum values were measured as 7.4, 9.8, 8.4 in normal, 6.0, 4.3, 3.6 in drought, 4.9, 5.2 and 4.1 in heat environment between three clusters, respectively. The ultimate readings among clusters showed that these clusters were genetically more deviating from each other while minimum distance indicated that the bread wheat genotypes in these cluster were not genetically multifarious or there was slight genetic uniformity between these clusters. The broader distances between the clusters could be consumed in breeding program with a broad collection of adaptability in traits among environments reflected.

Table 3: Wheat accessions allied to various clusters under three environments.

Cluster No.	Accessions		
	Normal	**Drought**	**Heat**
Cluster-1	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 12, 7, 8, 11, 13, 14, 15, 16, 17, 18, 26, 29, 30, 33, 34	1, 2, 4, 8, 11, 12, 15, 17, 18, 21, 23, 26, 32, 34
Cluster-2	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24	3, 5, 9, 22, 24	3, 5, 6, 7, 9, 10, 13, 14, 16, 19, 20, 22, 24, 25, 27, 28, 31
Cluster-3	25, 26, 27, 28, 29, 30, 31, 32, 33, 34	4, 6, 10, 12, 19, 20, 21, 23, 25, 27, 28, 31, 32	29, 30, 33

1=SATYT2, 2=SATYT8, 3=V14268, 4=HYT20-19, 5=V12066, 6=V15309, 7=V15212, 8=SATYT24, 9=SATYT10, 10=Aanaj-17, 11=V14124, 12=SATYT34, 13=V14270, 14=SATYT21, 15=V12304, 16=V15235, 17=SATYT36, 18=SATYT18, 19=SATYT44, 20=SATYT46, 21=Ujala16, 22=V14168, 23=SATYT35, 24=V15099, 25=V14225, 26=V15100, 27=HYT55-33, 28=V15235, 29=SATYT13, 30=V16005, 31=V14227, 32=V15166, 33=V14154, 34=HYT80-34

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

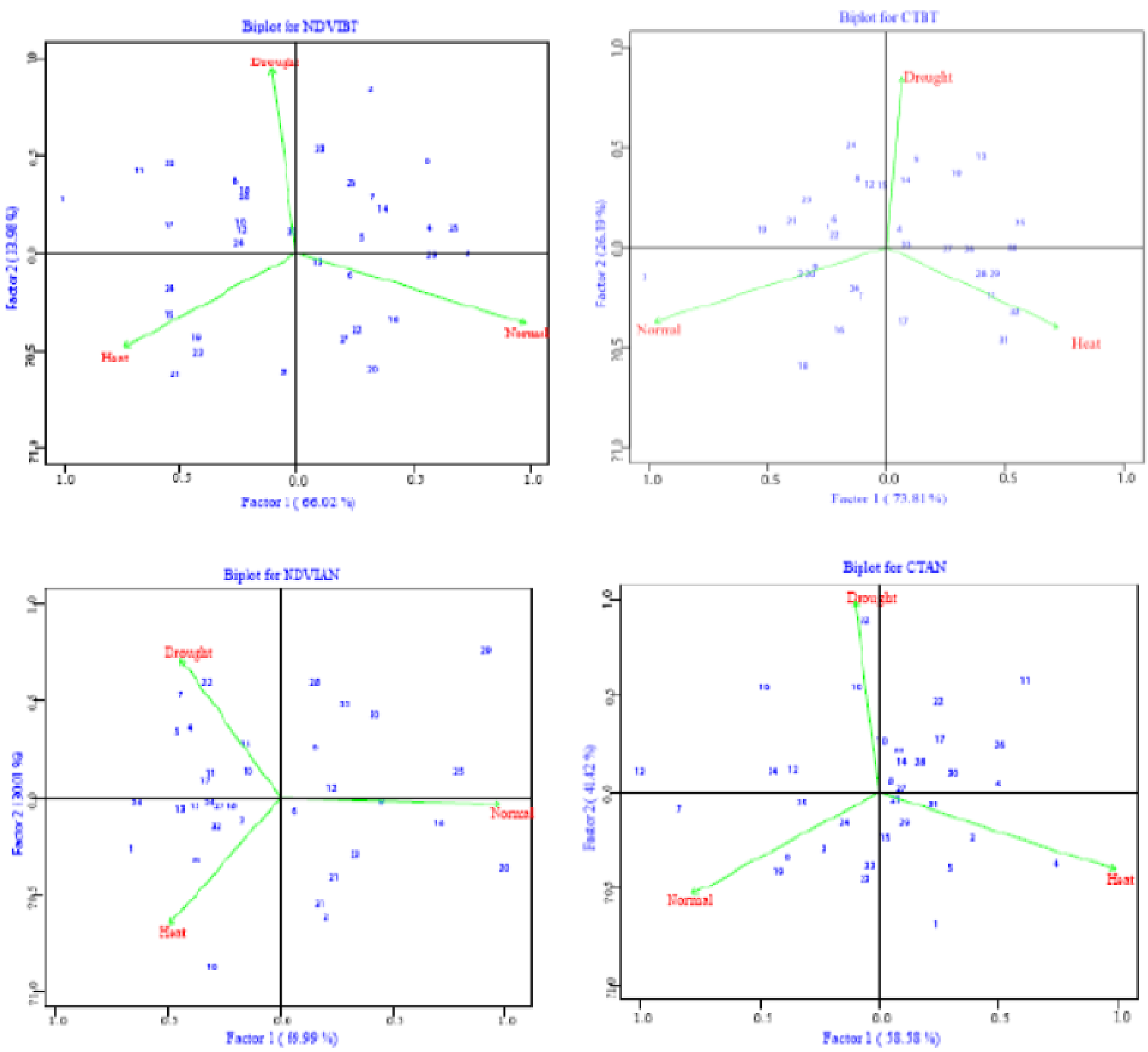
Stability imagining and environmental valuation

The biplots were constructed to partition the genotypes and genotype by environment effects for yield, GRW and stress adaptive/yield drivers traits (NDVIAN, NDVIBT, CTAN, CTBT) which are reported to be linked with drought and heat tolerance in wheat (Cao et al; 2015) (Figure 1). In these biplots, environments which positioned adjacent the origin with low scores for factor-1 (PC1) and factor-2 (PC2) had minor influence to the GE interaction, but outsized contribution to the stability of genotypes. In this context, all three environments were far from the biplot origin for exclusively CTBT, NDVIAN for normal, GRW for heat, CTAN for drought and heat. The expansion between three environments measures their contrast in discriminating the genotypes. Therefore, these genotypes traits among precise environments were most informative and are useful for dumping unstable genotypes. It is also exposed that normal environment is comparatively high contributor to the stability of genotypes for yield and heat environment for NDVIBT trait as indicated by the shorter distance between its pointer and the origin. Ezatollah et al, (2012) also founded normal environment as high yielder and stable for genotypes studied. As concern relationship among the genotypes, 20, 19, 29 for NDVIAN, 1, 13, 32 for CTAN, 1, 2 NDVIBT, 3 for CTBT, 11, 15 for GRW, 1, 11, 12 for yield traits were different from the others and unhinged due to their far apart. This dissimilarity can be due to the disparity in mean yield and GRW and/or in interface with the environment means. Accordingly, 6 for NDVIAN, 8, 27, 21for CTAN, 30, 13 NDVIBT, 4, 33 for CTBT, 32, 6, 7 for GRW, 3 for yield were positioned closer to the origin which signposts their stability in performance were toughly negatively correlated (an obtuse angle) and drought and heat were almost not correlated (almost a right angle). The performance of a genotype in an environment is healthier than middling if the angle between its vector and the environment's vector is lesser than 90°, it is inferior than average if the angle is greater than the 90°, and it is close average if the angle is around 90^0 (Kanduset al., 2010). For instance, 13 was beneath average in entire environments (obtuse angles) whereas 15 was above average in entire environments (acute angles). The average genotypes have no impact to both genotype and genotype and environment interaction. Ranking elucidation can be done likewise. Two genotypes can be visually matched with crossover interface by linking them with a straight/equality line of two genotypes, trailed by sketching a vertical line that passes through the biplotorigin. The genotype has higher values in environments that are situated on its side of the equality line. This 32 and 33 had higher yield and GRW in normal and drought while 11 and 34 had greater yield and GRW in drought and heat environments, correspondingly. Another consideration in stability constancy is grounded on regression coefficient and deviation from regression. The genotypes with bi values higherthan 1 had greater GWT and yield and smaller valueof Sd^2 indicated high level of stability. Regarding, GRW 15 was adopted and stable, 21, 26, 14, 10, 6, 7 were adaptable with higher GRW, 32, 11 were stable with higher GRW, 16, 22, 34 stable with low GRW while all others showed no significant effect in all environments.

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

Likewise for yield parameter 11 found to be adopted and stable, 21, 13 10 were adaptable with higher yield, 1, 24, 12 were stable while all others showed no significant consequences in all environments (Figure 2). The three most variable principal components were plotted in three dimensioned for GWT and yield only, respectively. The area of 3D plot was divided into 4 regions, A, B, C and D. The three PCs were significant accounting cumulative variability 80.34, 13.84 and 5.28 % for GWT and 56.8, 33.58 and 10.33 % for yield (Figure 3), For GWT, more variable genotypes were placed in a region of drought and heat environments while for yield more variable genotypes were found in normal and drought environment (Figure 3).



ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

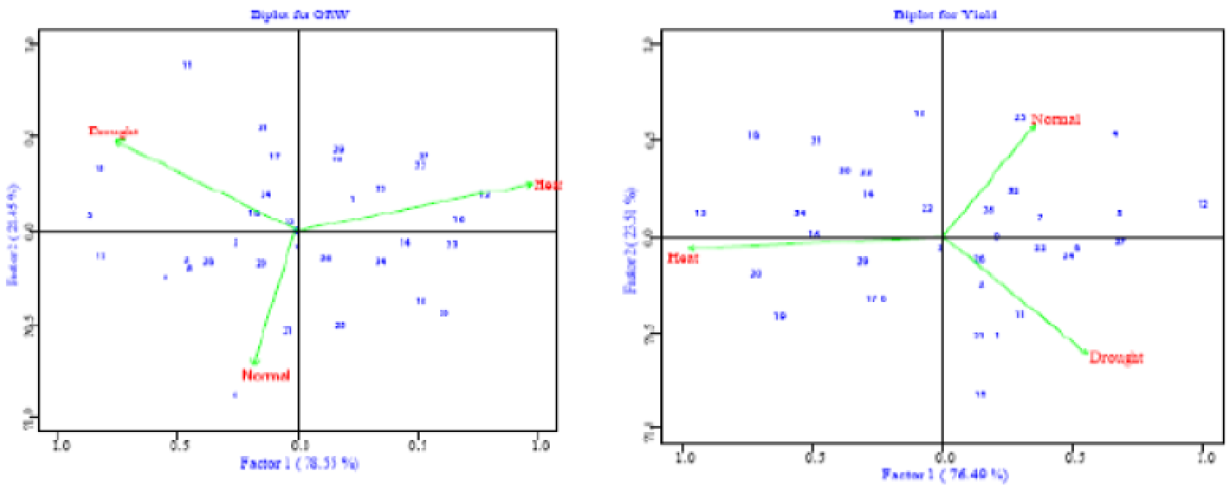
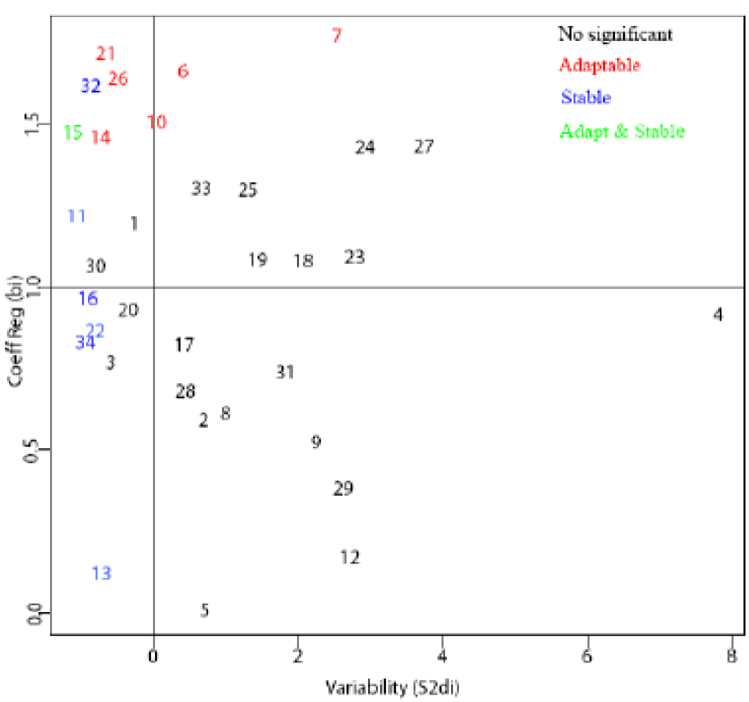


Figure 1: Biplots presenting the performance of different traits of genotypes in each environment



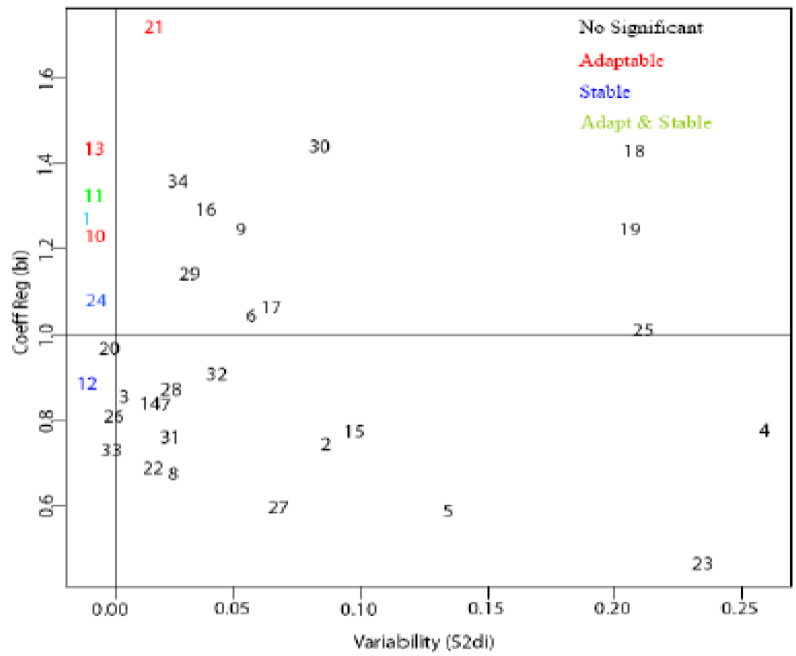
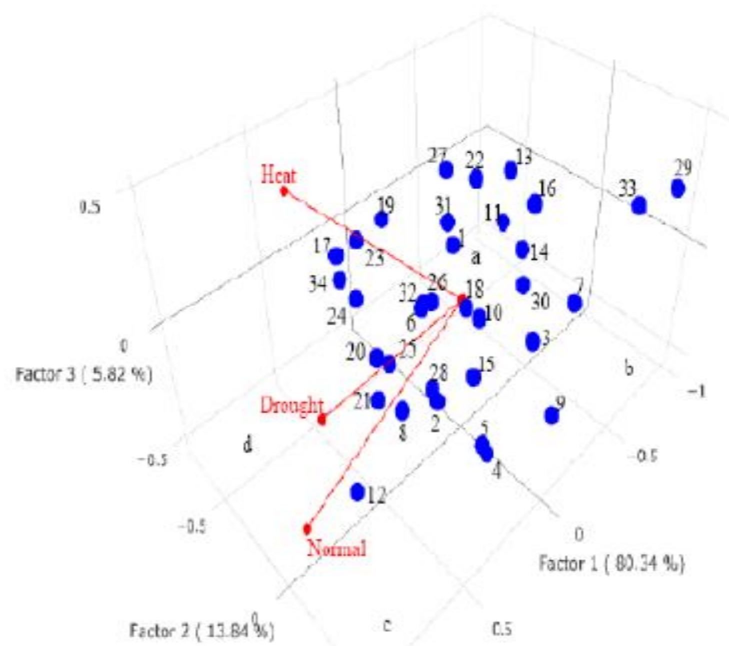


Figure 2: GRW and yield of measured genotypes, respectively based on regression coefficient and deviation from regression.



ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

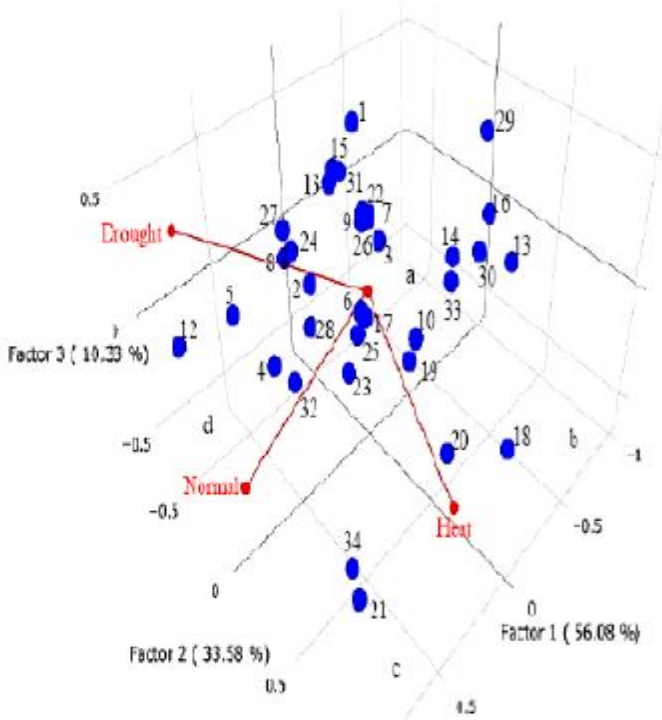


Figure 3: 3D plots of principal components in three environments from GWT and yield, respectively

CONCLUSION

1. From the results of present probe, it is clinched that the positive correlation of yield with GRW, NDVIBT and NDVIAN and negative correlation with CTBT and CTAN in all environments and the genotypes which were mutual in different clusters in different environments advocated that these traits and genotypes are vital and could be used as an effective criterion for screening and developing heat and drought tolerant varieties.

2. The measured traits were highly affected by genotypes disparity and environmental circumstances. All three environments were far from the biplot origin for exclusively CTBT, NDVIAN for normal, GRW for heat, CTAN for drought and heat. Genotypes, 20, 19, 29 for NDVIAN, 1, 13, 32 for CTAN, 1, 2 NDVIBT, 3 for CTBT, 11, 15 for GRW, 1, 11, 12 for yield traits were different from the others while genotype 6 for NDVIAN, 8, 27, 21for CTAN, 30, 13 NDVIBT, 4, 33 for CTBT, 32, 6, 7 for GRW, 3 for yield were positioned closer to the origin which indicate their stability in performance across environments for these dignified traits. Due to their crossover interface by linking, the genotypes 32 and 33 had higher yield and GRW in normal and drought while 11 and 34 had greater yield and GRW in drought and heat environments, respectively.

ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

3. The heat and drought tolerant genotypes can be used as genetic resources for undertaking growing heat and drought stress as a upshot of climate change and food security through introgression of heat and drought tolerance trait into high yielding wheat cultivars.

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ISSN: 2455-6939

Volume:04, Issue:06 "November-December 2018"

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