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AN ANALYSIS OF LARGE RAIN-FED WHEAT, MULTI-LOCATION TRAILS OF PAKISTAN USING NONPARAMETRIC METHODS

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Abstract

Ten nonparametric approaches carried out form twenty wheat genotypes crop through thirty five Environments within the rain fed areas of Pakistan for the year of 2016-17, developing periods have been used to principal cause of analyzing GEI throughout thirty five Environments. We study a few nonparametric technique were used for the Genotype's Stability based of mean yield ($\overline{Y}$), The $S^{(1)}$ statistic is used to compute the mean absolute rank difference between genotypes in different circumstances. As previously stated, $S^{(2)}$ represents the variance across environments, $S^{(3)}$ represents indicates the sum of square deviations in yield units from the mean classification, while $S^{(6)}$ represents the sum of absolute departures in yield units from the mean classification, with $S^{(3)}$ representing the variance across environments and $S^{(6)}$ representing the variance across environments. Kang's rank sum method RS, Thennarasu's four non-parametric approaches ($N^{(1)}$,$N^{(2)}$,$N^{(3)}$,$N^{(4)}$. Spearman's rank correlation. $S^{(1)}$ stable genotype is G11(NR-443) and G10 (AZRC20), unstable genotype is G3 (14C040) and G8 (AZRC11). $S^{(2)}$ stable genotype is G10 (AZRC20) and G20 (WBG-14), unstable genotype is G2 (1V-11) and G14 (NR-488). $S^{(3)}$ stable genotype is G10 (AZRC20) and G20 (WBG-14), unstable genotype is G2 (1V-11) and G12 (NR-448). $S^{(6)}$ stable genotype is G10 (AZRC20) and G20 (WBG-14),unstable genotype is G19 (SD-1013) and G12 (NR-448). $N^{(1)}$ stable genotype is G10 (AZRC20) and G20 (WBG-14),unstable genotype is G2 (1V-11) and G14 (NR-488). $N^{(2)}$ stable genotype is G7 (KT-325) and G6 (KT-335),unstable genotype is G2 (1V-11) and G8 (AZRC11). $N^{(3)}$ stable genotype is G7 (KT-325) and G19 (SD-1013),unstable genotype is G15 (NR-491) and G8 (AZRC11). $N^{(4)}$ stable genotype is G11 (NR-443) and G10 (AZRC20),unstable genotype is G3 (14C040) and G8 (AZRC11). RS stable genotype is G3 (14C040) and G4 (14C036), unstable genotype is G12 (NR-448) and G7 (KT-325).

Introduction

Wheat is a staple food in many developing nations, including Pakistan, which has a population of over 200 million people. Wheat grain is grown in Pakistan in both irrigated

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and rainy regions, including the Indus and KP regions, with a share of 70 percent and 30 percent, respectively, in irrigated and rainfall regions. In terms of total production, the Indus and KP regions account for 70 percent of Pakistan's wheat grain while rainfall regions produce 30 percent. According to an economic estimate that was created in 2015-2016, it is broken out as follows: 10 percent in agricultural areas, and 2 percent in the state's overall gross domestic product (GDP) (Chandio et al. 2017). It has been shown that in very dry and semi-arid places, the total quantity of water used for agricultural irrigation amounts to 84 percent of the entire amount of water that is consumed by humans. [Citation needed] [Citation needed] Irrigation is a critical component in increasing the amount of produce that can be harvested from agricultural land. According to Quiones et al. 1997, approximately 40 percent of the world's yield is produced in the irrigated arable region, which accounts for approximately 20 percent of the total arable land area. Asia, on the other hand, accounts for 70 percent of the total yield and accounts for approximately 20 percent of the total arable land area. Farmers have a strong interest in the development of innovative wheat genotypes because these wheat varieties may provide large yields while still maintaining a high level of quality. When calculating grain yields, it is important to take into account the major impacts that soil and climate have on such yields. Wheat is a major crop in Iran's food supply, hence attempts to breed wheat in the nation are focused mostly on boosting output while also maintaining a consistent yield. This is one of the fundamental aims of wheat breeding activities in the country (Amid 2007). In order to explore the interaction between the genotype and the environment, researchers will use both parametric and non-parametric techniques. Both of these categories of methodology are referred to as approaches. (1) Univariate analysis, which includes things like stability variance and regression analysis; and (2) Multivariate analysis, which includes things like factor analysis, principal component analyses (PCAs), cluster analyses (Cluster Analysis), and bi plot analyses (Kang and breeding 2002). Based on the information presented above, it is possible to draw the conclusion that the breeding performance of cultivars is mostly assessed out in the field, in a variety of settings. The harvests from each place are somewhat different from one another. This form of interaction arises as a result of a shift in the relative locations of numerous genotypes, which occurs as a direct result of the variety having a diversified set of characteristics. When it comes to choosing a variety for selection, this is a challenging choice for farmers to make (Gandhi 2011). When it comes to generating and improving distinct wheat genotypes that are suited for a variety of situations, breeders must pay careful attention to the interaction between the genotype and the environment. Interactions of this kind are divided into two categories: I crossover interactions, and (ii) non-crossover interactions. Interaction is the difference in yield between genotypes of different kinds that develops as a consequence of its evaluation at numerous sites; as a result, it is known as interaction. Interaction is referred to as the difference in yield between genotypes (Crossa 1990).To develop the different types of genotypes that are some ideal conditions in which they will be farmed; plant breeding programs must be directed toward a particular goal. There are at least two distinct techniques that might be employed to accomplish the objective. In an ideal

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world, the growing region would be divided into a number of agro-climatic zones with similar soil characteristics and weather patterns. Thus, genotypes may be developed to meet the unique requirements of each zone, resulting in increased production. There are certain drawbacks to this method. While the soil characteristics of a particular site remain relatively constant throughout time, the climate in that region varies from year to year. As a result, even with highly qualified zoning specialists on hand, delineating consistent zones may be difficult. Additionally, particularly in impoverished nations.

Even if the zones were practical to construct, there would not be enough skilled plant breeders available to generate specialized genotypes for each zone in an area.Attempting to propagate genotypes that are well suited to a range of environmental conditions is an alternative, and often more feasible, strategy. The breeder then selects genotypes that are stable under a number of situations, using a variety of procedures. These superior genotypes may be chosen from a pool of strong genotypes that serves as a starting point for further selection.

Materials and Methods

Material

For this study, data on genotype production were obtained from thirty five settings during 2016-17, with the assistance of the National Uniform Wheat Yield Trials programs coordinated by the National Agricultural Research Center in Islamabad.

The variations were donated by a large number of plant breading experts from around the nation who were doing study at various research institutions. In each site, 20 cultivars were sowed in an RCBD with two or more than two replicates of each cultivar. In contrast to one another, the numerous research institutions where a single factor (RCBD) was applied across thirty five habitats were not identical. They varied in terms of soil type, annual rainfall average, and altitude, among other things. 20 varieties have been applied to thirty five (35) areas, twenty-two of which were in Punjab, six of which were in Sindh, five of which were in KPK, and two of which were in Balochistan.

METHODS

Non-parametric stability measures

The following are examples of non-parametric stability indicators: (Sabaghnia et al. 2006) presented a number of non-parametric techniques that are based on genotype rankings across all locations as well as the idea of environmental resistance as a measure of stability. The term "steady" refers to variations in rank that are dependent on location. Non-parametric methods to stability, which are mostly based on rankings rather than absolute data, may be a viable alternative to the previously described parametric processes, which are primarily based on absolute data. In a range of applications, including breeding and analytic systems, the genotype ranking orders are the most crucial pieces of information to understand. No statistical assumptions about the distribution of data values are required when calculating stability measures based

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on ranking results. They are less vulnerable to measurement errors than 40 parametric measures, and they are simpler to practice and grasp than parametric measurements.

Four non-parametric measure of stability of Huhen and Nassar

Huhen and Nassar suggested the following four non-parametric stability indices: - As a consequence, Nassar and Huehn (1987) devised four non-parametric stability statistics denoted by the abbreviations $S^{(1)}$, $S^{(2)}$, $S^{(3)}$, and $S^{(6)}$. The $S^{(1)}$ statistic is used to compute the mean absolute rank difference between genotypes in different circumstances. As previously stated, $S^{(2)}$ represents the variance across environments, $S^{(3)}$ represents indicates the sum of square deviations in yield units from the mean classification, while $S^{(6)}$ represents the sum of absolute departures in yield units from the mean classification, with $S^{(3)}$ representing the variance across environments and $S^{(6)}$ representing the variance across environments. The following are the findings of the data-driven genotype yield rankings in each ecosystem:

$$S_i^{(1)} = \frac{2\sum_j^{e-1}\sum_{j+1}^{m}\left|r_{ij} - r_{ij}^{*}\right|}{e(e-1)}$$

$$S_i^{(2)} = \frac{\sum_{j=1}^{e}(r_{ij} - \bar{r}_{i.})^2}{e-1}$$

$$S_i^{(3)} = \frac{\sum_{j=1}^{e}(r_{ij} - \bar{r}_{i.})^2}{\bar{r}_{i.}}$$

$$S_i^{(6)} = \frac{\sum_{j=1}^{e}\left|r_{ij} - \bar{r}_{i.}\right|}{\bar{r}_{i.}}$$

Where i=1, 2… g j=1, 2… e

Where rij represents the genotype rank in each environment, m represents the number of environments.$r\overline{i}$.is the mean of rank across environments. Ranks are assigned to the data in ascending order.

Kang’s rank sum method:

Kang's rank sum method is another non-parametric stability process that use both mean yield and stability variance as criteria. In order to find high-yielding and stable cultivars, this index provides equal weight to yield and stability data. A rank of one is assigned to the genotype with the highest yield, while a score of one is assigned to the genotype with the lowest stability variance. Each genotype is rated in this manner, and the rankings for each genotype are added together. The genotypes with the highest RS value are the most compatible.

Thennarasu’s four non-parametric approaches:-

Thennarasu (1995) recommended the following four approaches for non-parametric stability:

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$$NP_i^{(1)} = \frac{1}{e}\sum_{j=1}^{e}\left|r_{ij}^{*} - M_{i.}^{*}\right|$$

$$NP_i^{(2)} = \frac{1}{e}\left[\frac{\sum_{j=1}^{e}\left|r_{ij}^{*} - M_{i.}^{*}\right|}{M_{i.}}\right]$$

$$NP_i^{(3)} = \frac{\sqrt{\sum(r_{ij}^{*} - \bar{r}_{i.}^{*})^2 / e}}{\bar{r}_{i.}}$$

$rij\ *$ = Rank of $Yij\ *$, and $r\overline{i*}$.and $Mi*.$ = Mean and median ranks for original values, where
$r\overline{i*}$.and
$Mi*.$= Identical parameters computed from the corrected yield values.

Spearman's rank correlation:-

On rare times, accurate individual counts are either unavailable or difficult to obtain. They are then classed based on their capacity to deliver a certain concentration characteristic, such as high or low concentration. The term "ranking" refers to this kind of planned organization, and the term "rank" refers to the order in which a person is put within that organization. Spearman's rank correlation measures the relationship between two sets of ranks of this kind. rs is the abbreviation for it.

$$r_s = 1 - \frac{6\Sigma d_i^2}{n(n^2 - 1)}$$

Where -1 < rs > 1

RESULTS AND DISCUSSIONS

Univariate Non parametric stability methods

Summarizes non-parametric stability techniques and the resulting average yield (kg/hec), while summarizes all non-parametric methodology based on ranks and Pearson rank correlation coefficients for non-parametric procedures. When we lack all of the assumptions required for test statistics, we may employ non-parametric processes rather than parametric approaches (Agrawal, 2003).

Thennarasu's Stability Measures:-

Thennarasu's non-parametric measurements were also used in this investigation. Genotypes with the lowest levels of $N^{(1)}$, $N^{(2)}$, $N^{(3)}$, and $N^{(4)}$ were found to be the most desirable (Segherloo et al., 2013). There were six wheat genotypes that were found to be stable based on the results of Thennarasu's 1st approach, whereas the other six wheat genotypes were found to be unstable based on their highest values across all

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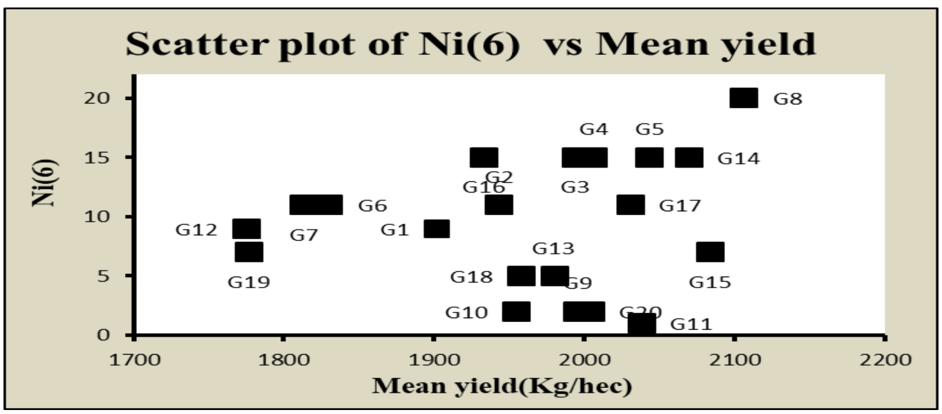
conditions. Since G19 was found to be the most stable wheat genotype in terms of low statistical values and G6 was shown to be among the most unstable wheat genotypes across ten environments in the $N^{(2)}$ results, it is followed by G7 and G10. According to $N^{(3)}$, G7, G19, G6, G10, and G16 are all stable genotypes because of their low levels. Thennarasu's 3rd approach selected G8, G15, G2 and G14 as wheat genotypes with the greatest $N^{(3)}$ values. For the most part, genotypes with the lowest values of $N^{(4)}$ (G11), followed by those with the highest values of $N^{(4)}$ (G10), were deemed superior across all settings, whereas those with the highest values of $N^{(4)}$ (G8/G3/G4/G5) were deemed bad (4). First three processes of Thennarasu's yielded the same results, thus we concluded that the first three procedures of Thennarasu's were the best for selecting the optimal genotype. Although G11 was a better genotype in $N^{(4)}$, it was shown to be a bad genotype in $N^{(2)}$ and $N^{(3)}$ in total regions.



Graph of the mean yield (kg/hec) vs. NPi (4) of the 20 genotypes across large (varieties) environments

Nassar and Huehn's Stability Measures:-

Nassar and Huehn's Stability approaches provide equal weight to all areas. Each region will benefit from a variant that includes the fewest data in the rankings. Nonparametric stability statistics $S^{(1)}$ (estimates the average absolute rank deviation of a genotype across locations), $S^{(2)}$ (variance among ranks across locations), $S^{(3)}$ (SS deviations in yield units for each classification relative to the average classification), and $S^{(6)}$ (nonparametric stability statistics) (Sum of absolute deviances in yield units of every classification related to the average classification). If $S^{(1)}$, $S^{(2)}$, $S^{(3)}$ and $S^{(6)}$ have the lowest values, a genotype is considered to be more stable (Balalic et al., 2011). The findings of $S^{(1)}$ indicated stable genotypes as G11 and G9, G10 and G20, but unstable genotypes were found as G3, G8, G4 and G16 across all settings. The best genotype was determined to be G10, followed by G20, G7, G18, and G3; G2, G14, G5, and G12 were shown to be unstable. $S^{(3)}$ classified G10, G20, G8, G18, and G13 as stable genotypes, while G28, G12, G2, G19, and G6 were classified as unstable. G10 was shown to be the most stable, followed by G20, G8, and G18, while G12, G19, G6, and G2 were determined to be the most unstable. G10 was determined to be the best

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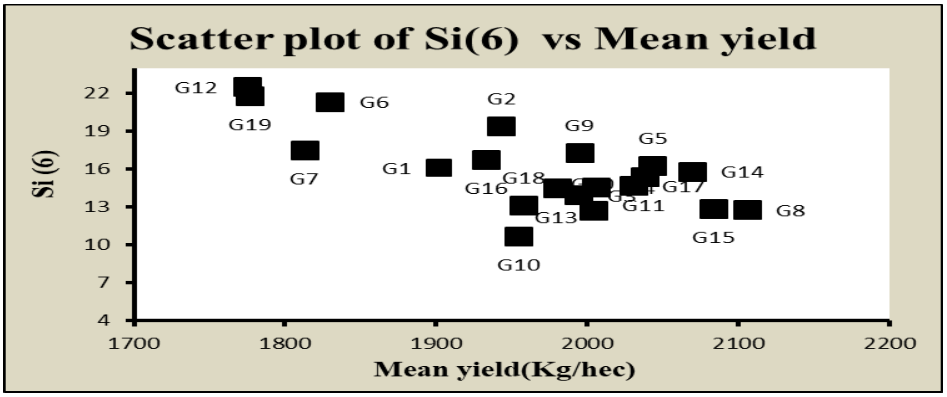
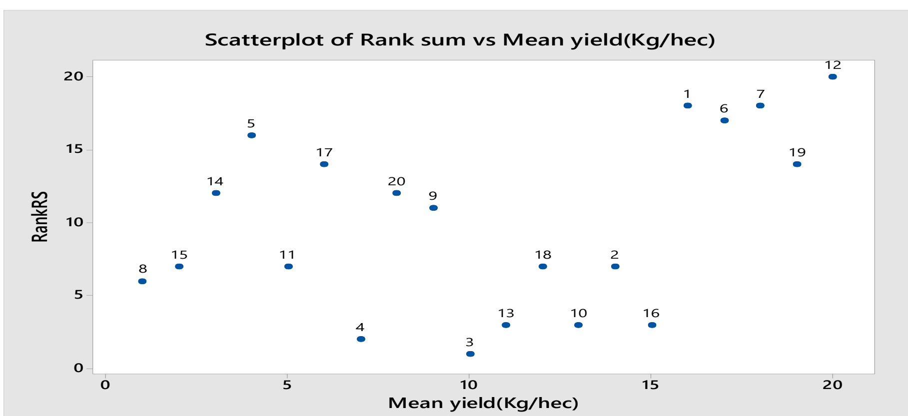
genotype in $S^{(2)}$, $S^{(3)}$, and $S^{(6)}$ due to its lowest value, followed by G20 and G18. $S^{(2)}$ and $S^{(6)}$, two of the authors, determined that the G2 genotype was unstable.



Graph of the mean yield (Y) vs. Si (6) of the Twenty Wheat genotypes across thirty five environments

Rank Sum Stability Measure:-

The rank sum was developed by Kang as a non-parametric stability measure (1988). It incorporates the ranks of the average yield (Kg/hec) and the variability of stability. It is considered to be superior than the genotype with the lowest rank sum (Segherloo et al., 2007). Using this metric, G3 was found to be the best genotype because of its low rank sum statistic; however, G12 was found to be the unstable genotype because of its high rank sum statistic, followed by G1 and G7.



Graph of the Y vs. Rank-Sum of the twenty genotypes across thirty five environments.

Spearman's rank correlation of mean yield (kg/hec) and nonparametric stability approaches:-

The Significant spearman rank association among various techniques of nonparametric is presented in (Table: 4.3). Based on the result of Spearman rank correlation Average yield of kg/hec is significant and positively linear associated with $S^{(6)}$, $N^{(2)}$, $N^{(3)}$ ($p<0.01$)

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and $S^{(3)}$, $N^{(1)}$ (P<0.05) . the negative linear correlated with $S^{(1)}$, $S^{(2)}$, $N^{(4)}$ and RS. Non-parametric method $S^{(1)}$ significant and positively linear associated with $N^{(4)}$) (P<0.01). $S^{(2)}$ is significant and positively linear associated with S $^{(3)}$, $N^{(1)}$, $N^{(2)}$,$N^{(3)}$ (P<0.01) and negative linear associated with $S^{(6)}$, $N^{(4)}$(6) and RS. Method of non-parametric stability $S^{(3)}$ significant and linear associated $S^{(6)}$ (P<0.01). $S^{(6)}$ significant and positive linear correlated with RS (P<0.01) and non-significant with $N^{(1)}$,$N^{(2)}$, $N^{(3)}$ and $N^{(4)}$. $N^{(1)}$ significant and positive linear correlated with $N^{(2)}$,$N^{(3)}$ (P<0.01) and non-significant with $N^{(4)}$ and RS. $N^{(2)}$ significant and positive linear correlated with $N^{(3)}$ (P<0.01) and non-significant with $N^{(4)}$ and RS. $N^{(3)}$ non-significant with $N^{(4)}$ and RS. $N^{(4)}$ non-significant with RS. Stability procedure $S^{(1)}$ non-significant with $\bar{Y}$. The procedure of Non-parametric $S^{(2)}$ is non-significant with $\bar{Y}$and $S^{(1)}$. Non-parametric technique $S^{(3)}$ is significant and positive correlated with$\bar{Y}$, $S^{(2)}$ (P<0.05) and $S^{(1)}$ is non-significant. Stability technique $S^{(6)}$ is significant and positively linear associated with $\bar{Y}$ and $S^{(3)}$(P<0.01) as non-significant linear associated with $S^{(1)}$ and $S^{(2)}$.Similarly Rank-sum is positively and significant correlated with $S^{(6)}$ (P<0.01) as well as $S^{(3)}$ (P<0.05)) as) non-significant with $\bar{Y}$, $S^{(1)}$, $S^{(2)}$,$N^{(1)}$, $N^{(2)}$, $N^{(3)}$ and $N^{(4)}$.

Twenty wheat genotypes data from thirty five environments were analyzed GE Interaction and stability using mean yield (kg/hec) with different non-parametric methods.

Genotype	Mean	$Si^{(1)}$	$Si^{(2)}$	$Si^{3)}$	$Si^{(6)}$	$N^{(1)}$	$N^{(2)}$	$N^{(3)}$	$N^{(4)}$	RS
G1	1902	0.008	29.311	98.669	16.084	4.485	0.39	0.491	8.00E-04	29
G2	1943	0.013	47.82	141.218	19.381	6.228	0.778	0.727	0.001	20
G3	1994	0.022	27.773	87.675	13.919	4.257	0.425	0.521	0.002	12
G4	2006	0.02	34.139	91.654	14.551	5.085	0.508	0.614	0.002	14
G5	2043	0.017	41.687	115.175	16.245	5.271	0.527	0.624	0.002	24
G6	1830	0.015	30.129	131.175	21.329	4.628	0.289	0.412	0.001	26
G7	1813	0.017	26.134	105.094	17.472	4.057	0.289	0.366	0.001	29
G8	2106	0.022	37.358	77.738	12.767	5.285	0.755	0.738	0.003	17
G9	1995	0.002	35.702	115.205	17.274	5.057	0.459	0.545	2.00E-04	21
G10	1955	0.002	19.358	60.206	10.687	3.314	0.331	0.453	2.00E-04	16
G11	2038	0	35.692	110.352	15.388	5.171	0.574	0.632	0	20
G12	1775	0.01	40.255	145.36	22.533	5	0.384	0.49	8.00E-04	30
G13	1980	0.003	27.937	84.566	14.446	4.457	0.405	0.495	3.00E-04	16
G14	2070	0.015	41.793	110.671	15.795	5.685	0.631	0.689	2.00E-03	22
G15	2084	0.003	37.588	85.574	12.871	5	0.625	0.733	4.00E-04	20
G16	1933	0.02	29.784	118.003	16.748	4.185	0.348	0.463	2.00E-03	16
G17	2031	0.012	37.902	93.516	14.666	5.342	0.534	0.618	1.00E-03	23
G18	1958	0.003	27.016	82.039	13.119	4.171	0.417	0.487	3.00E-04	20
G19	1777	0.005	31.769	133.753	21.797	4.457	0.278	0.394	4.00E-04	23
G20	2004	0.002	25.243	77.294	12.685	3.942	0.492	0.54	2.00E-04	22

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Ranks of twenty genotypes data from 35 environments were analysed GE interaction of stability using men yield (kg/hec) with nine different non- parametric methods.

Gen	Mean	$Si^{(1)}$	$Si^{(2)}$	$Si^{(3)}$	$Si^{(6)}$	$N^{(1)}$	$N^{(2)}$	$N^{(3)}$	$N^{(4)}$	RS
G1	16	9	7	10	12	9	7	8	9	18
G2	14	12	20	19	17	20	20	18	11	7
G3	10	19	5	7	6	6	10	10	15	1
G4	7	17	11	8	8	14	13	13	15	2
G5	4	15	18	14	13	16	14	15	15	16
G6	17	13	9	17	18	10	2	3	11	17
G7	18	15	3	11	16	3	2	1	11	18
G8	1	19	14	3	3	17	19	20	20	6
G9	9	2	13	15	15	13	11	12	2	11
G10	13	2	1	1	1	1	4	4	2	3
G11	5	1	12	12	10	15	16	16	1	7
G12	20	10	17	20	20	11	6	7	9	20
G13	11	5	6	5	7	7	8	9	5	3
G14	3	13	19	13	11	19	18	17	15	12
G15	2	5	15	6	4	11	17	19	7	7
G16	15	17	8	16	14	5	5	5	15	3
G17	6	11	16	9	9	18	15	14	11	14
G18	12	5	4	4	5	4	9	6	5	7
G19	19	8	10	18	19	7	1	2	7	14
G20	8	2	2	2	2	2	12	11	2	12

Tweenty Wheat genotypes Spearman's rank correlation $\bar{Y}$(Kg/hec) with non-parametric stability methods.

	Y	S1	S2	S3	S6	N1	N2	N3	N4
S1	-0.029^{ns}								
	0.902								
S2	-0.361^{ns}	0.212^{ns}							
	0.118	0.369							
S3	0.462*	0.181^{ns}	0.552*						
	0.040	0.446	0.012						
S6	0.612**	0.181^{ns}	0.391^{ns}	0.956**					
	0.004	0.446	0.088	0.000					
N1	-0.498*	0.237^{ns}	0.924**	0.381^{ns}	0.241^{ns}				
	0.025	0.314	0.000	0.097	0.306				
N2	-0.819**	0.068^{ns}	0.633**	-0.162^{ns}	-0.344^{ns}	0.746**			
	0.000	0.776	0.003	0.494	0.137	0.000			
N3	-0.842**	0.063^{ns}	0.672**	-0.140^{ns}	-0.328^{ns}	0.767**	0.978**		
	0.000	0.790	0.001	0.556	0.158	0.000	0.000		
N4	-0.173^{ns}	0.971**	0.370^{ns}	0.185^{ns}	0.146^{ns}	0.391^{ns}	0.220^{ns}	0.220^{ns}	
	0.465	0.000	0.108	0.434	0.540	0.089	0.352	0.350	
RS	0.367^{ns}	-0.106^{ns}	0.224^{ns}	0.481*	0.597**	0.102^{ns}	-0.257^{ns}	-0.248^{ns}	-0.080^{ns}
	0.111	0.658	0.342	0.032	0.005	0.668	0.274	0.291	0.737

*, ** Significant at 5 percent and 1 percent respectively. »Figures below in the second line are p-values.

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CONCLUSION

Due to the diversity of stability and adaptation approaches, researchers encounter difficulties determining which stability methods are ideal for evaluating the number of Multi-Environmental trials and selecting preferred kinds. Numerous approaches are used to examine the data from the Multi-Environmental trials, which provides statistics on the components of stability and adaptability that are selected. Maximum approaches of stability give an explanation for genotypes' efficacy. Numerous studies are used to develop ways to stability. Almost all of these studies reached almost identical findings about the use of stability techniques, which might be explained by the nature of the data under investigation. Additionally, for researchers, the model of stability may be unique, since the review describes unusual requirements of stability. A cultivar is considered acceptable if it produces a greater average yield and is consistently efficient across several areas. Flores (1988) classified stability approaches into three clusters: I one is believed to provide the most stable genotype findings, (ii) another do not produce the most effective average yield of varieties, and (iii) the third does not produce both stability and average yield concurrently.

The current research has two primary aims. The first is to analyze wheat genotypes using a variety of statistical techniques and to determine genotype environment interaction (GEI) in the rain-fed area of Pakistan using several wheat yield sites. Wheat's frequent performances in rain-fed places are determined by the soil, regional environmental conditions, and genotype selection. The second aim is to identify the most trustworthy and stable genotype capable of performing optimally in the most diverse situations. Additionally, the correlation and comparison of various stability approaches are discovered.

Twenty wheat genotypes from rained zones were evaluated in Pakistan's thirty-five settings during the 2016-17 growing season. Numerous evaluation approaches were applied, including univariate (parametric and nonparametric) and multivariate methods (GGE bi-plot). Nine non parametric stability measure $N^{(1)}$, $N^{(2)}$, $N^{(3)}$, $N^{(4)}$, $S^{(1)}$, $S^{(2)}$, $S^{(3)}$, $S^{(6)}$, RS, and Spearman's rank correlation) are presented (r). Additionally, the multivariate graphical approach GGE bi-plot was used in this work.

The first three Thennarasu's stability measures ($N^{(1)}$, $N^{(2)}$, $N^{(3)}$) designated G16 (NW-1-8183-8) as the most stable genotype across 35 settings due to its lower value than other genotypes, followed by G7 (KT-325) and G10 (AZRC-20). $N^{(1)}$ Declared unstable genotype G2 (1V-11), followed by G14 (NR-488), G17 (NW-520-1) and G8 (AZRC-11). G2 (1V-11) was declared an unstable genotype by $N^{(2)}$ followed by G8 (AZRC-11), G14 (NR-488) and G15 (NR-491).$N^{(3)}$ declared unstable genotype G8 (AZRC-11) followed by G15 (NR-491), G2 (1V-11) and G14 (NR-488).

G11 (NR-443) was designated a stable genotype by Thennarasu's stability measure since it had a lower value than other genotypes in thirty-five settings, followed by G10 (AZRC-20), G9 (AZRC-18), and G20 (WBG-14). $N^{(3)}$ was declared an unstable genotype G8 (AZRC-11), followed by G15 (NR-491), G2 (1V-11), and G14 (NR-488).

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$N^{(4)}$ G3 (14C040) was declared an un stable genotype followed by G4 (14C036), G5 (QS-3), G14 (NR-488) and G16 (NW-1-8183-8).$N^{(3)}$ And $N^{(4)}$ G8 (AZRC-11) followed by G14 (NR-488) and G5 QS-3) were considered unstable genotypes. Thennarasu's stability metrics ($N^{(1)}$, $N^{(2)}$, $N^{(3)}$, and $N^{(4)}$ were all positively correlated. $N^{(1)}$, $N^{(2)}$, and $N^{(3)}$ exhibited a negative correlation with mean yield, whereas $N^{(2)}$, $N^{(3)}$, and $N^{(4)}$ had a negative correlation with RS.

Nassar and Huehn's stability measure $S^{(1)}$ classified G11 (NR-443) as a stable genotype across 35 environments due to its lower value than other genotypes, while G10 (AZRC-20), G9 (AZRC-18), G20 (WBG-14) and G3 (14C040) were classified as unstable genotype followed by G8 (AZRC-11), G4 (14C036) and G16 (NW-1-8183-8).

Nassar and Huehn's stability measures $S^{(2)}$,$S^{(3)}$, and $S^{(6)}$ designated G10 (AZRC-20) as a stable genotype across 35 settings due to its lower value than other stable genotypes, which included G20 (WBG-14), G18 (12FJ26), and G8 (AZRC-11).

Nassar and Huehn's stability measures ($S^{(3)}$, $S^{(6)}$) were favourably connected with one another and with mean yield, while $S^{(1)}$, $S^{(2)}$ were negatively correlated with mean yield.$S^{(3)}$ and $S^{(6)}$ had a negative correlation with $N^{(2)}$ and $N^{(3)}$. $N^{(1)}$, $S^{(2)}$, $S^{(3)}$, and $S^{(6)}$ deemed G10 (AZRC-20) to be a stable genotype, but $N^{(4)}$ and $S^{(1)}$ declared G11 (NR-443) to be a stable genotype. G3 (14C040) was declared a stable genotype through thirty-five environments by the RS (Rank sum) stability measure due to its lower value than other genotypes, followed by G4 (14C036), G10 (AZRC-20), G16 (NW-1-8183-8) and G12 (NR-448) which were declared unstable genotypes, followed by G1 (1V-1), G7 (KT-325) and G6 (KT-335). Only four ($N^{(2)}$, $N^{(3)}$, $N^{(4)}$, and $S^{(1)}$) stability techniques showed a negative correlation with RS, whereas the average yield showed a positive correlation.

Recommendations:-

Non-parametric stability approaches indicate that genotypes G10 (AZRC-20), G13 (NR-487) and G20 (WBG-14) are stable with little variation, but genotypes G2 (1V-11) and G5 (QS-3) are unstable. According to nonparametric stability methodologies the genotypes G8 (AZRC-11), G15 (NR-491) and G14 (NR-488) are all high yielding and stable genotypes. The unstable genotypes G12 (NR-448) followed by G19 (SD-1013), G7 (KT-325) and G6 (KT-335) are low yielding strains with a significant degree of diversity. It's worth noting that the G8 (AZRC-11), G15 (NR-491) and G14 (NR-488) genotypes are suggested for cultivation, but the G12 (NR-448), G19 (SD-1013), G6 (KT-335), G7 (KT-325), and G1 (1V-1) genotypes may be substituted. E4 (QAARI, Larkana), E23 (WRI Faisalabad), E1 (ARI Quetta), and E20 (ARF Karore) are high yielding environments, whereas E35 (ARI -D.i.KHAN), E34 (Mardan), E25 (AZRI Bhakkar), E17 (ARF Sargoda), and E6 (NIA Tanjojam) are low yielding settings.

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