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Assessment of Wheat Genotypes for Quality Attributes Grown under Irrigated and Rainfed Conditions

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WHEAT (*Triticum aestivum*) is utilized as a staple food in several countries because of its exceptional quality properties compared with other grain crops. Wheat can be grown under diverse climatic conditions; however, several biotic and abiotic factors influence the grain quality of wheat. Dry seasons and high temperatures are the fundamental abiotic factors that decrease the yield and influence the grain quality of wheat. In this study, we utilized 18 wheat genotypes that were grown under irrigated and rainfed conditions. The major objective of this study was screening of the best wheat genotypes with improved grain quality and yield which performed better under irrigated and rainfed conditions. The five quality parameters (thousand grains weight (TGW), test weight, protein percentage, gluten percentage, and starch percentage) were studied during two years in irrigated and rainfed conditions. The BWP-122559 performed better regarding to TGW (39.04g) under irrigated and rainfed conditions. Cluster analysis was utilized to assemble the genotypes on the basis of quality parameters. The 18 genotypes were assembled into three clusters; cluster-1 (4 genotypes), cluster-2 (7 genotypes), and cluster-3 (7 genotypes). The cluster-1 (NR-443, IV-II, WBG-14, CT-12176) genotypes were higher in TGW, protein percentage, and gluten percentage which differed in relation to these clusters. These four genotypes were selected based on their performance under irrigated and rainfed conditions. These selected genotypes can be utilized in wheat breeding and crop improvement programme.

Keywords: Cluster analysis, Correlation, Quality parameters, Wheat.

Introduction

Wheat has acquired significant position because of its development all over the world. Increase of the anticipated population of 2050 generally gauge that a 60% increase in wheat yield is required (Ray et al., 2013). Grain weight (GW) is significant when estimating the yield in wheat, and accordingly plant breeders and researchers take distinct fascination to increase the yield to fulfill total worldwide food prerequisites. What's more, high grain weight additionally considered as a superior processing and quality end-use (Gegas et. al., 2010). GW is controlled by a complex hereditary system that is expressed at various phases of growth, which is viewed as a steady yield factor with profound inheritance. The grain filling in wheat is a critical stage that decides the grain weight thus improving this stage is significant for high grain weight and yield (Chen et al., 2013). GW is generally influenced by the rate and duration of grain development during the grain filling stage (Fischer, 2011).

Quality of wheat is determined by the wheat grains and wheat final products. Quality relies upon processing, nourishment, and consumer decision. The wheat quality investigation is much complex among all cereal grains because of the gigantic hereditary of wheat. Wheat has specific qualities that are different from other cereal grains because of the extraordinary properties

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of its storage proteins in the endosperm (gluten). Gluten is a novel protein that portrays the viscous and elastic properties after hydrated and blended by hand or machine. Such properties of gluten form a membrane during fermenting doughs. The other parameter to evaluate wheat quality is wheat flour. Flour quality is evaluated by two classifications: Utilization of final product taste and segment test that flour has better or low quality (Morris, 2016). Starch is a significant element of flour quality and contributes towards the improvement of food quality. It may be helpful in the development of bread and an enormous amount of starch in flour enhances the struggle to the development of dough, while little starch increment improves the extensibility (Erbs et. al., 2010; Larsson et. al., 1997).

Wheat has the capacity to be grown effectively in a wide range of climatic conditions, yet numerous biotic (insect pest, diseases, weeds) and abiotic factors (high temperature, drought, salinity, and nutrient deficiency) reduce yield (Hossain et. al., 2012 a&b). Dry spells (Drought) and high temperatures are significant abiotic factors which impact the grain quality and wheat yield. Wheat quality characteristics rely upon genotypes, the environment, and their interactions (Hossain et. al., 2013). The combination of water stress and high temperatures is an issue in arid and semi-arid regions (Kotak et. al., 2007; Sumesh et. al., 2008). The anthesis and grain filling in wheat is the most significant development stages and if there arises an occurrence of ominous climatic conditions at this stage then negative effects on wheat grain quality occur. High temperature and dry seasons combine to impact the grain quality because of late planting that is late flowering compelling the less time for grain filling (Jiang et. al., 2009; Hakim et. al., 2012).

The development of wheat genotypes with improving bread-making quality is a challenge in wheat breeding programs (Branlard & Dardevet, 1985; Kaya & Akcura, 2014). In this manner, the main objectives are (1) The improvement of new wheat genotypes that have the capacity to produce a high yield with great grain quality under favorable or unfriendly climatic conditions. (2) The screen out of best wheat genotypes which have good protein, gluten, and starch accumulation under various climatic conditions and to create various methodologies to improve grain quality of wheat under irrigated and rainfed conditions.

Materials and Methods

Field experiment

A field experiment comprised of 18 bread wheat strains developed by breeders of various research institutes of Pakistan, including two modern check varieties (FSD-08 and PAKISTAN-13) were grown during two crop seasons (2015-16 and 2016-17). The trial was planted with 3 repeats at two different conditions: E1 (irrigated); E2 (Rainfed). The trials were planted in November and fertilizer was applied in all trials as recommended. To keep the trials free from weeds and diseases, suggested pesticides and herbicides were utilized. For examination of quality traits, 1.2kg seed from two repeats was taken at the time of maturity.

Quality parameters

The tests were completed in Grain Quality Laboratory, Wheat Research Institute (WRI-Faisalabad). Test weight (kg/hL) and thousand-grain weight (g) were obtained by utilization of seed counter. Grain protein content, gluten, and starch content were estimated by near-infrared spectroscopy (NIR System).

Protein contents

Protein contents were estimated by several techniques and CNA Combustion Nitrogen Analysis is one of these techniques. A flour sample is weighed and placed into a CNA protein analyzer. This is a programmed measure by putting the sample into oven at 95^0C. The nitrogen gas release was estimated and the equation was applied to convert this estimated sum into protein contents.

Gluten contents

A flour sample of wheat was taken close around 10 grams and set the sample into glutomatic washing chamber. The sample was blended and washed with a 2% salt solution for 5min. The wet gluten were placed it in a centrifuge holder for centrifugation. The residue remaining after washing was the wet gluten.

Results

Thousand grain weight (g)

This trait is significant in wheat it straightforwardly correlates the yield with higher grain weight. Figure 1 presents the average values of 18 genotypes for 1000 grain weight (TGW) in both environments (irrigated and rainfed). The TGW had the highest values in rainfed condition for the two years and irrigated condition comparatively gave less grain weight (Fig. 2). Whereas the overall performance of varieties is concerned, the four genotypes (BWP-122559; NR-443; IV-II; Pakistan-13) perform superbly in irrigated and rainfed conditions during the two years (2016 and 2017). In irrigated and rainfed conditions, TGW ranged from 28.68 to 40.60 g and 33.43 to 42.83g, respectively (Table 1). The BWP-122559 is the best genotype that performed amazingly in TGW (39.04 g) under both conditions during 2016 and 2017. This genotype was developed by a group of breeders from the Regional Agricultural Research Institute (RARI), Bahawalpur (Table 2).

Test weight

Test weight is used for the grading of wheat grains and it shows the quality of wheat grain. The least value for the test weight was obtained from wheat genotypes which were planted in the irrigated conditions during both years 2016 (74.85kg/hL) and 2017 (69.57kg/hL). Whereas, the performance of genotypes under rainfed conditions in the two years 2016 (79.37kg/hL) and 2017 (75.13kg/hL) (Fig. 3). Overall the wheat genotypes performed great during 2016 in irrigated and rainfed conditions when compared with the year 2017 (Fig. 4). The average data of all genotypes in irrigated and rainfed conditions with the two years; a genotype (V-12066) gave the most elevated worth (77.15kg/hL) for test weight from 18 genotypes (Table 2).

Correlation

The correlation between quality attributes were seen in 18 genotypes which indicated that TGW is negatively correlated with test weight and gluten percentage and demonstrated a positive correlation with protein and starch percentage. Also, test weight indicated a negative correlation with TGW while positively correlated with other characteristics. As concerned about protein % it indicated a positive correlation with all characteristics except starch percentage. The starch percentage demonstrated a positive correlation with TGW and test weight but had a negative correlation with protein and gluten percentage (Table 3).

Cluster analysis

From cluster analysis, it is found that 18 genotypes were assembled into three primary groups based on quality characteristics. Cluster 1 (4 genotypes), Cluster 2 (7 genotypes) and Cluster 3 (7 genotypes). These clusters formed on-premise of similarity and distinction between genotypes.

Discussion

Environmental change is a fundamental factor which changes the quality of the grain. Abrupt environmental changes or stress will change the quality and yield of wheat. Grain quality is a range of physical and compositional properties that are set by the utilization of necessities. Grain quality is affected by three central points, i.e. hereditary qualities, management, and environment.

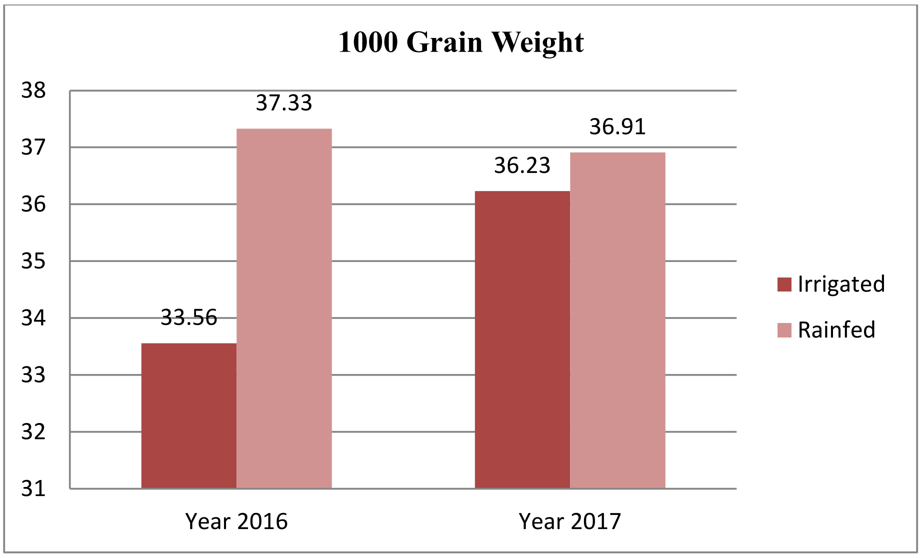

Fig. 1. 1000 grain weight in irrigated and rainfed conditions under 2016 and 2017

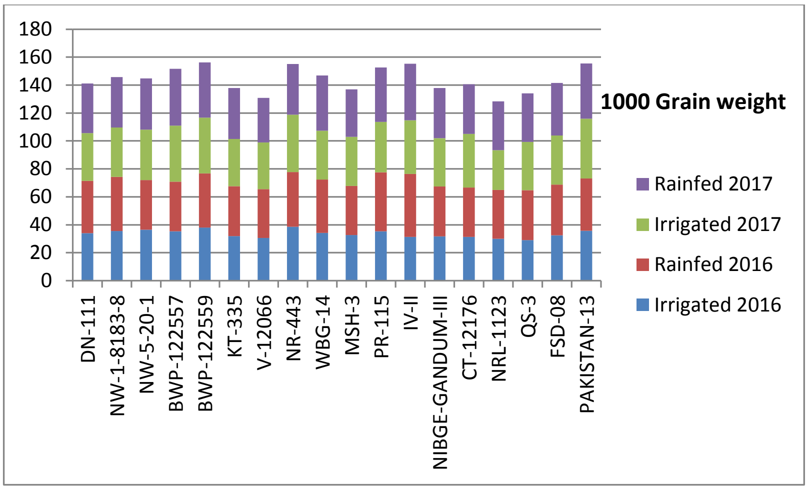

Fig. 2. 1000 grain weight of 18 wheat genotypes in irrigated and rainfed conditions under 2016 and 2017

TABLE 1. The quality of 18 wheat genotypes under irrigated and rainfed conditions

	Irrigated			Rainfed		
Variables	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
1000 grain weight (g)	28.68	40.60	34.90	33.43	42.83	37.26
Test Weight (kg/hL)	68.18	76.05	72.21	73.58	79.88	77.36
Protein percentage	14.00	15.83	14.90	13.90	15.85	14.80
Starch percentage	51.23	56.13	54.17	50.43	56.13	53.79
Gluten percentage	26.00	34.75	30.03	25.50	32.50	28.97

Min: Minimum average value; Max: Maximum average value; g: Grams; kg/hL: Kilograms per hectoliter.

TABLE 2.The performance of 18 wheat genotypes under irrigated and rainfed conditions under 2016 and 2017

Genotype	1000 grain weight	Test weight	Protein percentage	Starch percentage	Gluten percentage
DN-111	35.28	74.41	14.44	53.55	29.00
NW-1-8183-8	36.43	73.98	14.39	55.05	27.50
NW-5-20-1	36.20	75.46	14.29	55.54	27.75
BWP-122557	37.90	74.14	14.43	54.63	27.25
BWP-122559	39.04	76.36	15.20	55.11	29.13
KT-335	34.45	73.09	14.99	52.65	29.75
V-12066	32.70	77.15	15.30	53.84	31.63
NR-443	38.78	71.81	15.49	53.53	31.38
WBG-14	36.70	74.20	15.50	53.34	31.88
MSH-3	34.24	76.48	15.51	54.01	31.00
PR-115	38.14	75.03	14.79	54.03	28.38
IV-II	38.80	74.60	15.11	53.08	31.63
NIBGE-GANDUM-III	34.48	74.21	14.15	54.90	27.13
CT-12176	35.16	74.09	15.40	53.56	30.88
NRL-1123	32.08	75.58	14.79	54.03	30.00
QS-3	33.50	75.60	14.71	54.15	29.50
FSD-08	35.38	74.31	14.30	52.50	29.25
PAKISTAN-13	38.88	74.63	14.94	54.60	29.13

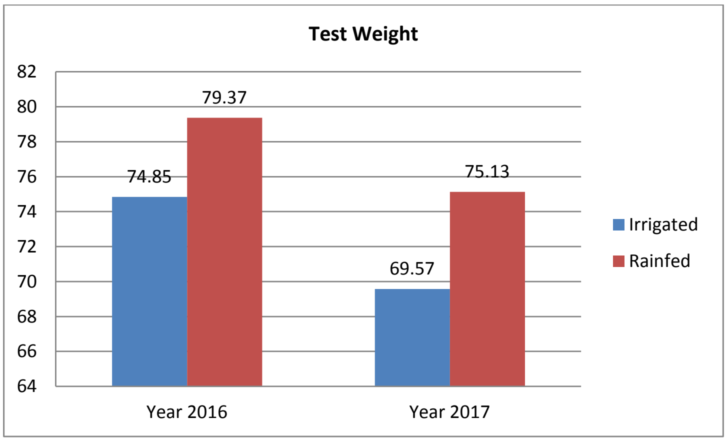

Fig. 3. Test weight in irrigated and rainfed conditions under 2016 and 2017

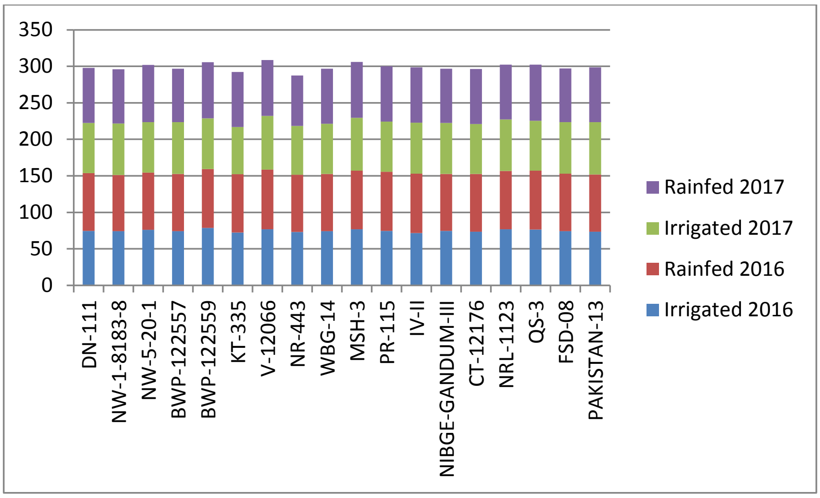

Fig. 4. Test weight of 18 wheat genotypes in irrigated and rainfed conditions under 2016 and 2017

TABLE 3. Correlation between wheat quality parameters

	1000 grain weight	Test weight	Protein %	Starch %	Gluten %
1000 grain weight	1				
Test weight	-0.13725	1			
Protein %	0.065574	0.091804	1		
Starch %	0.039344	0.170493	-0.31579	1	
Gluten %	-0.125	0.085528	0.646868	-0.4884	1

TGW is a perplexing yield characteristic that is inherited by polygenes. TGW is additionally isolated into various segments including physical parameters (grain length, width, area) and grain filling (Gegas et al., 2010). Thousand-grain weight is increased in rainfed stress in the two years when contrasted with irrigated conditions. The TGW was diminished due to diminishing grain length, width, and area (shriveled grains) in irrigated conditions. The genotypes indicated hereditary potential and perform distinctive in TGW in the two years in irrigated and rainfed conditions. The genotype BWP-122559 performs well in the two seasons (rainfed and watered). The genotype has the best hereditary potential and delivered high TGW and its performance was not influenced in water restricted conditions (rainfed) when contrasted with different genotypes.

The wheat test weight is a significant quality characteristic that represents the sample of wheat crop and compares the wheat crop per international standards. The low value of test weight represents the low wheat quality and higher value acquires the best market value. Numerous components impact the test weight like water accessibility, hereditary contrasts among genotypes, and other ecological variables. In the light of these variables, results demonstrated that estimated value of test weight was significantly decreased in irrigated conditions, while test stays higher in rainfed conditions. At the point when the performance of genotypes was seen with respect to test weight, it is uncovered that various genotypes perform contrastingly in watered and rainfed conditions. The genotypic contrasts among the varieties were seen during the two years and conditions. The performance of genotype (V-12066) stays amazing from the 18 genotypes (Table 2) and got the best hereditary potential on an average performance.

Correlation is effective statistical tool which determines relationship between different characters in genetic variable population for the improvement of crop (Kandel et. al., 2018; Dhami et. al., 2018). The correlation plays an important role in plant breeding programmes because it reflects the relationship between two or more traits. In wheat, many scientists explain the relationship among grain yield, quality traits and morphological traits through correlation analysis. Phenotypic variation was present between the quality traits in both seasons. Significant correlation was observed within and across the quality parameters, either it may positive or negative. The highest negative correlation of TGW was observed between the test weight (-0.13) and gluten percentage (-0.12) (Table 3). It represents the correlation relationship of the degree of increase in TGW which ultimately decrease the test weight and gluten percentage. Protein percentage is important quality trait which defines the nutritional and other properties like dough strength, development time, breakdown and loaf volume which directly affect the bread making quality. The grain protein and gluten were highly positive correlated with each other. These characters have great importance for the quality of wheat because it directly affects the flour function of wheat. The grain protein in soft wheat requires low gluten and protein contents as compared to hard wheat to minimize the gluten formation and mixing strength (Souza et al., 2012).

The cluster analysis is a multivariate statistical protocol that clusters genotypes based on qualities. Thus, the genotypes with comparable characters are assembled into the same group. The clusters shaped include high similarity inside the cluster while high contrasts between the clusters. The cluster analysis gathered into three clusters based on the following quality characters, for example, TGW, test weight, protein percentage, starch, and gluten percentage. The cluster-1 (NR-443, IV-II, WBG-14, CT-12176) comprises of four genotypes which are assembled based on similitude between the quality attributes. These four genotypes were higher in TGW and protein and gluten percentage when contrasted with others clusters however decrease in test weight (Table 2 and Fig. 5). These genotypes were chosen on three quality parameters referenced above and included in plant breeding program. The cluster- 2 and cluster-3 comprises of seven and seven genotypes which include likeness inside genotypes and contrasts between the clusters which are assembled based on quality characteristics (Fig. 5).

Conclusion

Environmental change is the primary factor that changes the quality of wheat grains. Various genotypes perform diverse for quality characteristics in irrigated and rainfed conditions. TGW is a more influenced attribute in rainfed conditions compared with irrigated conditions. The BWP-122559 genotype indicates the best hereditary potential when contrasted with different genotypes. The significant correlation was observed among the quality traits. The cluster analysis technique was utilized to decide the closeness and contrast among genotypes and three main clusters were framed on-premise of wheat quality characteristics and cluster-1 comprised of four wheat genotypes that performed better under irrigated and rainfed conditions. These four genotypes can be used in wheat breeding and crop improvement programs.

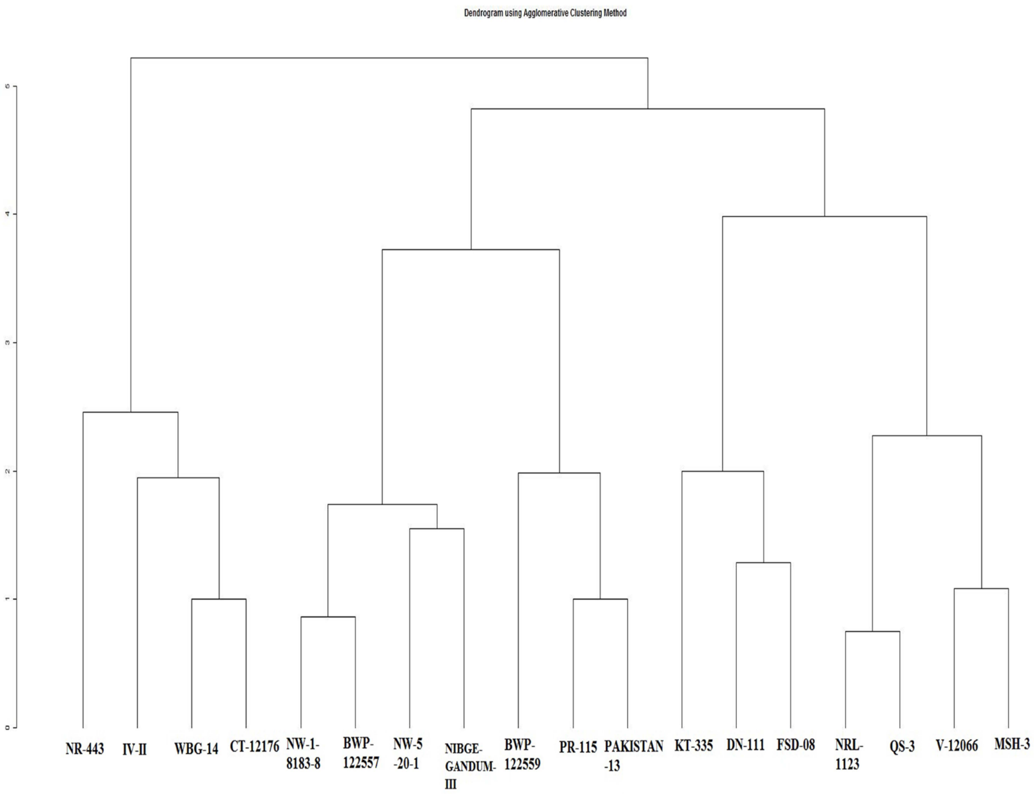

Fig.5. Cluster analysis of 18 wheat genotypes on basis of quality parameters

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