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Variability and Correlation Study of Morphological Traits in Bread Wheat Genotypes

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Abstract

The morphological traits of wheat grain strongly influence the yield and directly affect the grain yield of the crop. The necessity to overcome the human demand of wheat, the grain yield should be increased. The current experiment was organized to study the morphological traits of wheat and their association with yield related traits. The experiment was done in the randomized complete block design including three replications and twenty genotypes under normal condition in the cropping season of 2021. The result revealed by the analysis of variance indicated that there is highly significant difference among the studied genotypes, traits like spikelet per spike (SPS), flag leaf area (FLA), grain yield per spike (GYS), number of grains per spike (GPS), biological yield (BY) and grain yield per plant (GYP) showed the genetic potential and variability among the mwhile the traits like plant height (PH) and peduncle length (PL) are significant. Correlation analysis showed that grain yield per plant is highly associated with flag leaf area (0.78**) followed by biological yield which is highly correlated with plant height (0.77**) and number of grain per spike was also highly correlated with spikelet per spike (0.70**)while spikelet per spike and number of grains per spike associated non-significantly with plant height (0.21ns), (0.23ns)and biological yield correlated non-significantly with spikelet per spike (0.21ns).The highest mean values recorded by the genotype G6 (ASS-11) for the traits SPS (21.22), PL (16.74) and BY (23.33), followed by the genotype G9 (Lasani-08) for the traits SPS (23.22), PL (17.36), FLA (15), GPS (35.83) and by the genotype G12 (Chakwal-97) for the traits PH (94.63), BY (22.23), GPS (33.16). Hence, these genotypes would be utilized in breeding or selection programs to develop wheat cultivars with high yields. The yield related traits that are listed and highlighted in this experiment should be given importance in the breeding of wheat to increase the yield of the wheat plant that have strong association with the yield.

Keywords: Grain yield; Analysis of variance; Correlation; flag leaf area; Wheat; biological yield; association.

Introduction

Wheat *(Triticum aestivum)* is the main crop which belongs to the cereal group and it is cultivated all around the world. Wheat is one of the primary cereal cropwhich have important values for human beings and animals. Wheat has the great nutritional values and has direct effect on human nutrition (Sun *et al.*, 2015). Wheat crop occupy the first rank according to the cultivated area, distribution and trade volume (Zhao *et al.,* 2011). Wheat is an important source of human nutrition and wheat is a cereal that is cultivated in the world on a large scale. Wheat is largely cultivated to fulfil the human's food needs and animal's feeds. Wheat is an important staple food for large world population. Wheat crop status is essential among cereal crops due to its nutritional content and high consumption. Scientists working on wheat have new problems in developing wheat varieties with increased yield, quality, and resilience to biotic and abiotic stressors due to the fast growth in population and improved lifestyle (ÇİFÇİ *et al.,* 2012). Approximately, about 35% of world population, where the wheat is used as main part of food and feed and it provide about the 20 % daily protein. Wheat is also main source of food calories. It provides food calories approximately to the 4.6 billion world population (Flister *et al.,* 2016). Wheat *(T. aestivum)* is also one of the main crop of Pakistan and this crop is raised on larger cultivated area of Pakistan. Wheat is the primary source of food for the people. A larger population of Pakistan population depends on the wheat crop. In the last cropping season of 2021-22, the wheat was sown on 8976 thousands hectares with the production of 26394 tons with an average yield of 2940 kg per hectare while the world-wide production was 771 million tons (Shaikh, 2022). Wheat crop has the major contribution to the national GDP of Pakistan. The rise in production of wheat was due to use of better agriculture inputs (Ujan *et al.,* 2019). Wheat *(T. aestivum)* is in one of the first domesticated crops. "Fertile Crescent" is to be thought origin of wheat crop. Fertile crescent is the region in the Middle East. This region thought to be origin where human civilization and new invention, agriculture reforms starts first. It was assuming that cultivation of wheat starts about 11000 years ago and its cultivation spreads to other regions of world like Great Britain, Ethiopia, India, Syria before 5000 years ago

(Dubcovsky *et al.*, 2007). It is believe that wheat plant is among the first plants which were cultivated by the humans, approximately in-between 7000 and 9000 B.C. As the human population increased, the wheat cultivation also increased and the cultivation started to other areas of world. Then the time come when the wheat crop became the staple food for many civilizations like Europe, Asia, Africa about 8000 years ago. The cultivation in Southeast Asia is started about 10,000 years ago (Vesohoski *et al.*, 2011). Wheat *(T. aestivum)* importance is further highlighted by its role in human nutrition. Wheat contains dietary fibers, calcium, potassium, magnesium, phosphorus. All of these substances are essential to human nutrition. By using wheat, these components provide all of the nutrients that people require. (Shewry *et al.*, 2015). Human population is rising day by day. So, the demand for human food is also increasing continuously. There is need to enhance the production of food to fulfil the demand of population. As the population is increasing, there is also increasing of wheat demand. Because wheat is the main food crop. It is also expected that the demand of wheat will increase up to 40% in 2030. So, the wheat production should be increased to secure long term food security. Wheat production can also be enhanced by using new technology, new varieties and old varieties which performed best in any environment. By using new technology, our production can be increased (Ahamed *et al.*, 2018). The morphological traits of wheat plant have positive effect on the weight and size of the grain and its yield. Flag leaf area, peduncle length, spikelet per spike, plant height are major contributing traits in wheat grain. These traits are positively correlated with grain yield of wheat plant. These traits have direct positive effect on wheat yield (Allahverdiyev *et al.*, 2015). The present research indicates the importance of grain yield and its interrelated traits. Morphological traits also have great influence on the grain yield of wheat crop. This study revealed the significance of grain and its morphological traits. Among the given studied 20 genotypes, a few perform very well in normal condition. Our primary objective in this work is to boost grain output by enhancing and emphasising morphological attributes that are closely related to grain yield, such as the number of spikelets per spike and the size of the flag leaves, both of which have a major impact on grain yield. Growing these genotypes for better production will be advantageous for new researchers and farmers.

Materials and Methods

Plant Material:

Research design: This experiment was performed in the experimental area of department of Plant Breeding and Genetics, The Islamia University of Bahawalpur during the cropping year 2021-22 under normal condition. 20 genotypes of wheat are selected and collected for grain yield and other yield traits. These varieties were collected from the Regional Agricultural Research Institute, Bahawalpur (RARI) during the crop season 2021-22 with sowing date 15 Nov, 2021. Table No. 1 showed the list of the given genotypes that were used to conduct the experiment. The seeds of these varieties were sown in experimental area using the randomized complete block design (RCBD) within 3 replications during the season 2021-22. The plant to plant distance was kept 15 cm and row to row distance was kept 30 cm. All the agriculture inputs were applied before or after sowing of wheat for better yield.

Experimental site: The land for the cultivation of crop prepared by rotavating, deep ploughing and then planked. The fertilizers were applied in the row of 100:70:30 kg of N: P: K per hectare. First water applied to wheat crop after the 30 day of sowing. Three more water applications also applied at different growing stages of crop such as flowering, anthesis and filling of the grains. Total 10 random plants which were in good health and vigor selected at the time of maturity and data was collected for plant height, peduncle length, spikelet per spike, flag leaf area, grain yield per spike, , grains per spike ,biological yield, and grain yield per plant. Height of plant was measured from top to bottom with the hepl of scale. Peduncle length mesured at maturity level from node to base of spike. Flag leaf area measured with the help of following formula reported by (Muller, 1991)

Flag leaf area = Flag leaf length × Flag leaf Width × 0.74

Biological yield is total plant weight is calculated by electric balance (Compax- Cx-600).

Statistical analysis: The statistix version 8.1 software used for analysis of variance and Pearson's correlation of collected data. The data was interpreted by the analysis of variance (ANOVA) technique (Steel *et al.*, 1997). RADAR graph was analyzed by Microsoft word 2015 (Ahmed *et al.*, 2019) in which it displays the values of examined traits relative to center point in figures.

Results and Discussion

The analyzed results for the analysis of variance for the given different traits following the 20 genotypes characterized under normal condition by using the statistix 8.1 shown in the table 2. Analysis of variance between the 20 genotypes showed that there are significant differences indicating the presence of variability between all the studied genotypes. Similar conclusion was found by the researcher in his research (Yadav *et al.*, 2020). The highest value exhibited for the mean square was showed by the variable plant height (26.76) and the lowest value of mean square revealed in the grain yield per spike (0.344) in 20 wheat genotypes. The mean square value exhibited for plant height (26.76) observed in the analysis of variance as shown in table 1. The mean value of plant height (88.32) was observed while S.D value for plant height was ±2.98 and CV was 3.38 as shown in Table No. 3.The observed study showed that the plant height was positively correlated and highly significant with the peduncle length (0.56**) and biological yield (0.77**),while the plant height was significantly positive associated with flag leaf area (0.44*) and grain yield per spike (0.35*). Plant height was non-significantly associated with spikelet per spike (0.21ns), grains per spike (0.23ns) and grain yield per plant (0.23ns) as shown in the Table No. 5. Plant height exhibited positive and highly significant association with peduncle length and biological yield which indicated that plant height is strongly correlated with peduncle length and biological yield. When the plant height will increase or decreases, it will also have effect on the flag leaf area and biological yield. These results are agreeing with the researcher (Mecha *et al.*, 2017). He stated that more the height of the plant more will be the flag leaf area and biological yield. The plant height had direct effect with the biological yield. The genotype G12, G6 and G9 have the maximum plant height (94.3cm), (93cm) and (91 cm) respectively, as compared to other genotypes and genotype G18, G20 and G13 have the lowest plant height value (82.54 cm), (84.88cm) and (84.62cm) among others genotypes as shown in the figure 1.

The analysis of variance revealed the mean square value for the peduncle length was (6.29) as shown in the Table No. 2. The standard deviation for peduncle length observed as ± 1.44 and CV was 9.39as mentioned in Table No. 3. The present study observed the results that peduncle length has highly-significant positive correlation with the flag leaf area (0.56**) and biological yield (0.55**). Peduncle length also revealed significant positive association with spikelet per spike (0.28*), grain yield per spike (0.29*) and grains per spike (0.31*), while peduncle length has non-significant and positive correlation with grain yield per plant (0.21ns) as indicated in Table No.. 2. In our research, peduncle length showed the positive correlation and highly significant with flag leaf area and biological yield, which showed that these traits have positive direct effect on each other and are strongly associated. Peduncle length showed positive correlation and significantly related with spikelet per spike, grain yield per spike and grains per spike, which showed that these traits have direct effect on each other, while peduncle length non-significantly associated with grain yield per plant, which revealed that they are not interlinked. They don't have effect on each other. Such findings are related with the researcher (Amiri *et al.*, 2013)A; (Khan *et al.*, 2010). The genotype G6, G12 and G9 has the highest value of peduncle length (17.36cm), (17cm) and (16.74cm) as compared to other genotypes while the genotype G18, G13 and G20 has the lowest value of peduncle length (11.5cm), (13.5cm) and (13.8cm) as shown in the figure 1.

The mean square value exhibited by the analysis of variance for the trait flag leaf area was (4.80) as shown in the Table No. 2. The standard deviation for this traits was noted as ±1.44 and CV was 12.53as showed in Table No. 3. In recent experiment, the flag leaf area showed highly significant and positive association with grain yield per spike (0.54**), biological yield (0.56**) and grain yield per plant (0.78**). Flag leaf area has significant positive association with spikelet per spike (0.46*), grain per spike (0.49*) as showed in the Table No. 5. Flag leaf area has the strongest relation with grain yield per plant because when the flag leaf area increases, the yield also increases. Flag leaf area is the power house of energy that plays an important role in grain filling. Similar results collaborated with the researcher which revealed that the higher the flag leaf area more will the grain yield of the plant. According to breeders, grain output increases when flag leaf area is reduced because the grain rolls more quickly (Amiri *et al.*, 2013). According to a study, more flag leaf surface area led to more photosynthesis. In cereals like wheat, flag leaf is crucial because it offers the greatest quantity of photosynthetic assimilates that may be stored in the grains. The genotype G6, G12 and G9 has the maximum flag leaf area (14.02), (14) and (12.90) from all other traits while genotype G13, G18 and G20 has worst value of flag leaf area having mean values (8.92), (9.84) and (10.55) as shown in the figure 1.

The mean square value observed for spikelet per spike was (4.598) as in Table No. 2. The CV value for this trait was 6.08 and standard deviation was ±1.23as observed in Table No. 3. In the current study, the spikelet per spike was positively and highly associated with the grain yield per spike (0.51**), grain per spike (0.70**) and grain yield per plant (0.66**), while it was non-significantly associated with biological yield (0.21ns) as shown in the Table No. 5. In this study, spikelet per spike has great impact on grain yield per spike, grain per spike and grain yield per plant. When the spikelet per spike increases, there is an increase in the grain yield per spike and vice versa which directly have effect on the grain yield per plant because these have strong link with each other. Plant scientists (Mwadzingeni *et al.*, 2016) also revealed the positive and strong association between the SPS and grain yield per spike, biological yield and grain yield per plant. (Baloch *et al.*, 2021) also reported the same work in his research. The genotype G6, G9 and G12 has the highest spikelet per spike value (21.22), (22.33) and (23.22) while as compared to other genotypes G13, G18 and G20 has the lowest SPS value (19.44), (17.66) and (18.55) among other genotypes as shown in the figure 2.

The analysis of variance observed for the grain yield per spike exhibited the mean square value was (0.344) as shown in the Table No. 2. The trait exhibited the standard deviation as ±0.27 and CV was 9.96as mentioned in Table No. 3. There was positive and highly significant association seen between the grain yield per spike, biological yield (0.56**) and grain yield per plant (0.61**). A positive, significant correlation was seen between grain yield per spike and grains per spike (0.39*) shown in the Table No. 5. In the current study, the results revealed high significantly positive correlation between grain yield per spike, biological yield and grain yield per plant. They revealed that they have more direct influence on each other. When the grain yield per spike increases, the biological yield and grain yield per plant also increases. While there is also positive association between grain yield per spike and grains per spike. They are also interlinked because of positive correlation between them. These conclusion were in compliance with the work of (Bano *et al.*, 2012). The genotype G12, G9 and G6 has the best grain yield per spike as compared to other traits with the mean value (3.7), (3.4) and (3.43) and the genotype G18, G20 and G13 performing not good and has the low grain yield per spike (2.66), (2.7) and (2.93) as shown in the figure 1.

The mean square value observed for the trait grains per spike was (10.42) by using the ANOVA as shown in the Table No. 2. The standard deviation for this trait was ±1.59 and CV value was 4.92as showed in Table No. 3. According to this study, the grain per spike significantly positive associated with biological yield (0.33*) and grain yield per plant (0.44*) as expressed in table no. 2. The current analysis revealed that grains per spike have the positive association with biological yield and grain yield per plant. If the grain per spike increases, biological yield and grain yield per plant will also increases. Grains per spike have great impact on grain yield per plant. When the grains per spike increases, there will automatically increase grain yield per plant. Because they were positively associated (Nasri *et al.*, 2014). Similar calculation was seen in the research work of (Mollasadeghi *et al.*, 2011) indicated that grain per spike have the positive and direct effect on the biological yield and grain yield per plant. If the grains per spike increases, there was also enhancement of production of grain yield. The genotype G9, G12 and G6 shows the highest grains per spike (36.16), (35.16) and (33.76) as compared to other genotypes and genotype G20, G13 and G18 shows the lowest grains per spike (27.59), (33.02) and (30.98) among other genotypes as shown in the figure 2.

The mean square value for the biological yield was (4.53) as shown in the Table No. 2. The standard deviation observed for this traits was 1.15 and CV was 5.57as expressed in Table No. 3. In this study, the biological yield non-significantly correlated with grain yield per plant (0.24ns) as shown in the Table No. 5. Biological yield showed the non-significantly relation with grain yield per plant. This means that they have no effect on each other. If one trait increases or decreases, it does not affect the performance of the other trait. (Kumar *et al.*, 2017) also stated the similar research that biological yield has the non-significant correlated with grain yield per plant. The genotype G6, G9and G12 shows the highest biological yield (23.33 cm), (22.46cm) and (22.23) as compared to other genotypes and the genotypes G18, G20and G13 shows the lowest biological yield with the mean values (19.68), (19.3) and (19.1) as compare to other genotypes as shown in the figure 2.

The grain yield per plant observed the mean square value was (6.76) as shown in the table no. 2. The standard deviation observed for this traits was 1.47 and CV was 14.6as showed in Table No. 3. The genotypes G9, G6 and G12 have the best grain yield per plant (12), (12) and (11.86) from all other genotypes and genotypes G13, G18 and G20 performing worst for grain yield per plant observing the mean values (7.73), (8.26) and (8.1) as shown in the figure 1.

The genotypes that show variability among the studied traits were mention in Table No.4. The best and worst performing genotype along with yield and yield related trait were discussed in the table no.3.

Conclusions

Overall study concluded that, the analysis of variance (ANOVA) for bread wheat genotypes was significantly distinct for all the traits viz; spikelet per spike, grain yield per spike, grain yield per plant, peduncle length, plant height and biological yield. The results exhibited the significant variance in the mean characterization of genotypes. Mostly the highly significant differences were identified by ANOVA among the bread wheat varieties evaluated by all the 8 studied traits. Correlation revealed that there were positive and highly significant association between GYP and FLA, pursued by BY, PH and also in between GPS, SPS. The best performing genotypes were G6(ASS-11), G9 (Lasani-09) and G12 (Chakwal-97). Thus estimation of analysis of variance, correlation and radar analysis among yield and yield related characters give the suitable selection criteria to enhance the wheat grain yield.On the basis of these selection criteria, the traits like spikelet per spike and flag leaf area that are strongly related to the yield would be improved to increase the yield of the wheat plant. The current study can help us for production of new varieties that will help for more production of wheat and to fulfill the demand of the people by improved grain yeild.

Table No.1 Shows the list of the given genotypes that were used for the experiment

Genotypes	Name	Genotypes	Name
G1	Pakistan-13	G11	Bhakkar-02
G2	Shahkar-13	G12	Chakwal-97
G3	Aanmol-91	G13	Inqalab-91
G4	AARI-11	G14	Pirsabak-91
G5	Punjab-11	G15	Bwp-97
G6	AAS-11	G16	Chakwal-86
G7	Millet-11	G17	Barani-83
G8	Chakwal-50	G18	Sarhad-82
G9	Lasani-08	G19	Pak-81
G10	Pirsabak-05	G20	Bahawalpur-79

Table No.2 shows the analysis of variance among given 20 genotypes.

	DF	**PH**	**PL**	**SPS**	**FLA**	**GYS**	**GPS**	**BY**	**GYP**
REP	2	216.9	0.789	8.67	1.04	2.085	1.98	2.41	0.018
Get	19	26.764*	6.29*	4.598**	4.80**	0.344**	10.42**	4.53**	6.76**
Error	38	12.56	0.96	1.08	1.43	0.13	0.71	1.31	0.28
Total	59								

DF=degree of freedom PH=plant height, PL=Peduncle length, SPS=spikelet per spike, FLA=flag leaf area, GYS=grain yield per spike, GPS=grains per spike, BY= Biological Yield GYP=grain yield per plant, * = significant, ** = highly significant.

Table No.3 shows the Standard deviation, Grand mean and C.V. among given 20 genotypes.

Variable	Mean	SD	C.V.	Minimum	Maximum
SPS	20.356	1.2381	6.0825	17.667	23.222
PH	88.32	2.9868	3.3819	82.544	94.633
PL	15.429	1.4489	9.391	11.5	17.367
FLA	11.503	1.442	12.535	8.9208	15
GYS	2.8	0.2789	9.9602	2.1667	3.2333
GYP	10.11	1.4761	14.6	7.1333	12.2
BY	20.638	1.1504	5.5741	19.3	23.333
GPS	32.4	1.5944	4.921	28.833	35.833

Table No.4 shows the Pearson's correlation coefficient among the given yield related traits.

	PH	PL	FLA	SPS	GYS	GPS	BY
PL	0.56**						
FLA	0.44*	0.56**					
SPS	0.21ns	0.28*	0.46*				
GYS	0.35*	0.29*	0.54**	0.51**			
GPS	0.23ns	0.31*	0.49*	0.70**	0.39*		
BY	0.77**	0.55**	0.56**	0.21ns	0.56**	0.33*	
GYP	0.23ns	0.21ns	0.78**	0.66**	0.61**	0.44*	0.24ns

* = significant, ** = highly significant, ns = non-significant, DF=degree of freedom, PH=plant height, PL=Peduncle length, SPS=spikelet per spike, FLA=flag leaf area, GYS=grain yield per spike, GPS=grains per spike, BY= Biological Yield GYP=grain yield per plant,

Table No.5; Best and worst performing wheat genotype using yield and yield related traits.

Traits	**Best performing genotypes and their mean values**	**Worst performing genotypes and their mean values**
Spikelet per spike (SPS)	G6 (21.22), G9 (22.33), G12 (23.22)	G13 (19.44), G618(17.66), G20 (18.55)
Plant Height (PH)	G12 (94.63) G6 (93.86), G9(91.10),	G18 (82.54), G20 (84.88),G13 (84.62)
Peduncle Length (PL)	G6 (17.36), G12 (17), G9 (16.74)	G18 (11.5), G13 (13.5), G20 (13.8)
Flag Leaf Area (FLA)	G6 (14.025) G12 (14) G9 (12.908)	G13 (8.92), G18 (9.84), G20 (10.55)
Grain Yield per Spike (GYS)	G12 (3.7), G9 (3.4), G6 (3.43)	G18 (2.66), G20 (2.7), G13 (2.93)
Grain Yield per plant (GYP)	G9 (12), G6 (12), G12(11.867)	G13 (7.73), G18 (8.26), G20 (8.1)
Biological Yield (BY)	G6 (23.33), G9 (22.46), G12 (22.23)	G18 (19.68), G20 (19.3), G13 (19.1)
Grains per Spike (GPS)	G9 (36.16), G12 (35.16), G6 (33.76)	G20 (27.59), G13 (33.02), G18 (30.98)

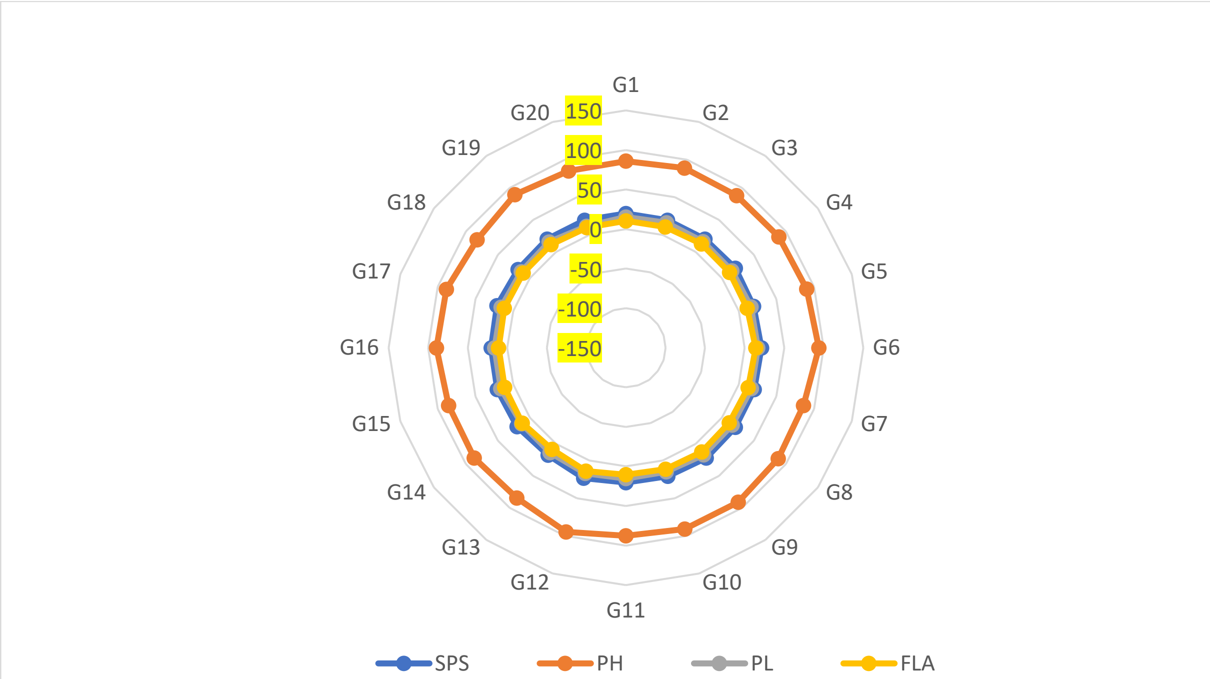

Figure No. 1 shows the mean performance of the given 20 genotypes, where SPS = spikelet per spike, PH = Plant height, PL = Peduncle length, FLA = Flag leaf area

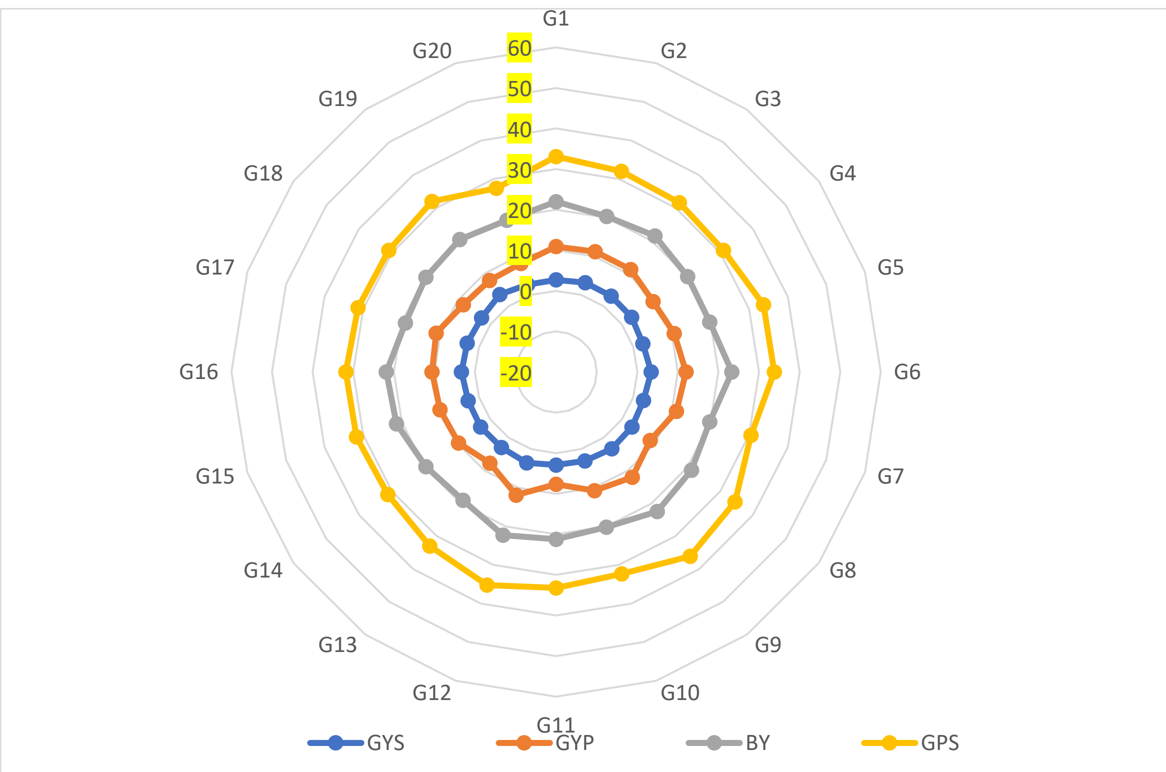

Figure No. 2 shows the average mean performance of the given 20 wheat genotypes, where GYS = Grain Yield per spike, GYP = Grain yield per plant, BY = Biological Yield, GPS = Grain per spike

Conflict of Interest :

Authors have no conflict of interest

Reference

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