Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v2023i1.268
*Biol. Clin. Sci. Res. J., Volume, **2023**: 268*
Original Research Article

EVALUATION OF GENETIC VARIABILITY AND HERITABILITY OF WHEAT GENOTYPES UNDER LATE SOWING EFFECTS

REHMAN AU[1], KHAN MF[2], ABBAS A[1], JAVED M[1], ABBAS MZ[1], HUSSAIN M[1], Ul-ALLAH S[3]

[1]Department of Plant Breeding and Genetics, Faculty of Agricultural Sciences, University of The Punjab, Lahore, Pakistan
[2]Pulses Section, Regional Agriculture Research Institute, Bahawalpur, Pakistan
[3]College of Agricultural Sciences, BZU, Bahadur Sub Campus Layyah, Pakistan
**Correspondence author: email address: faheemkhandr@gmail.com*

(Received, 31th March 2022, Revised 27th January 2023, Published 30th January 2023)

Abstract: *Wheat (Triticum aestivum L.) is a staple food for more than half of the world's population. In the present study, 10 genotypes were sown to check the wheat genotype's genetic variability and under late sowing. Exploration occurred at the Department of Agriculture, BZU, Bahadur sub-Campus, Layyah, during 2019-2020. The investigation was spread out in understanding to Randomized Complete Block Design (RCBD). Perceptions on various Traits of wheat Genotype to check the late effect were recorded from 3 plants of every wheat genotype. Information was recorded to evaluate the late sowing effect (Plant Height, Spike Length, No. of Spikelet's, No. of Tillers, Grain yield per plant and Biological Yield). FSD-83 show great resistance against late sowing, and their traits are less affected by late sowing. FSD-83 has high grain yield than other varieties in late sowing. Each trait of FSD-83 resists better against late sowing than different varieties. Extreme yield trait of LY-73 effects by late sowing. Information indicated that late sowing decreases grain production of each wheat Genotype. So, it is recommended that the breeder should sow wheat genotypes at an ideal time on 25 October – 15 November. Present discoveries show that each trait of wheat genotype, especially grain yield, affects late sowing and decreases grain yield of every wheat genotype. However, FSD-83 resist better and shows less effect of late sowing on grain yield*.

Keywords: *Triticum aestivum*, late sowing, genotypes, biological yield, grain yield

Introduction

Most of the Pakistan's population depends on wheat, so it is the staple food of Pakistan's people. Among cereals, wheat has more value than rice in production (FAOSTAT; 2019). That is why from 1950 to 2018, our goal was to get higher wheat production. The ever-growing population depletes all agricultural land and greatly impacts our environment (Thakur et al 2020). In Pakistan, 71.17% of wheat is sourced from Punjab.

It added 14.4% to agricultural rate of improvement a nd 3.0% to GDP. The area under wheat cultivation in Pakistan from 2006 to 2007 was 8.496 million hectares (Tahir et al 2009). Wheat harvest 23.52 million tons, with 2769 KG per hectare yield (Anonymous, 2007; Sabre et al., 1993). Many biotic and abiotic factors affect the yield of crop when wheat is grown late. Early sowing weakens the plant's roots which has reason to increase in optimum temperature. Increases in the optimum temperature cause variable germination, and the embryo generally dies. Endosperm breaks down due to bacterial and fungal activity. Poor farming and usually slow harvesting result from late sowing as temperatures drop. When we grow short- duration varieties late, they fill their grains before the temperature rises (Phadnawis and Saini 1992; Ansary et al.1989) states that late sowing of wheat hinders production because the contact of the yielding trait is affected, resulting in a decrease in the number of grains and the number of tillers and the number of grains in per spike (Rajput and verma1994) reported that we can get a larger grain yield by planting earlier rather than later. After November 20th, the later will cause a low yield of 39 kg per hectare per day (Singh and Uttam 1999). Late wheat sowing can reduce yield up to 30 to 40% (Khalil et al 2016). The short duration of winter leads to high temperatures which affect flowering and grain filling (Hazra et al 2019). If the heat intensifies, it can damage production by up to 40% (Hays et al, 2007; Ali et al., 2017; Hafeez et al., 2021; Javed et al., 2016). We will face a 3 to 4% drop in production if the temperature increases to 28 degrees centigrade (Reynolds et al 1994). Late sowing of wheat crop poses a serious problem to us at the stage of crop

[Citation: Rehman, A.U., Khan, M.F., Abbas, A. Javed, M., Abbas, M.Z., Hussain, M., Ul-Allah, S. (2023). Evaluation of genetic variability and heritability of wheat genotypes under late sowing effects. *Biol. Clin. Sci. Res. J.,* **2023***: 268*. doi: https://doi.org/10.54112/bcsrj.v2023i1.268]

loading with grain e.g., High Temperature. When the temperature is high, it will reduce crop yield (Aslam et al., 1989). It was discovered that the intensity of 35 to 37 degree centigrade for 3 to 4 days reduce the grain size and modifies grain morphology (Wardlaw and Wrigley 1994). In many areas, the temperature stays between 25 to 30 degrees centigrade or sometimes even higher, and wheat is grown there (Porch and Jahn, 2001; Stone 2001). High temperatures affect every aspect of the crop, affecting the flowering process and reducing the time of spike development, leading to fewer spikelet's in a spike and harmful to pollen formation (Mitra and bhatia 2008). The Global Community is growing fast, so we must expand the fertile land and the world's fertile regions to warmer climates (Modarresi et al., 2009). At high temperatures, the cultivar's defect increases as the plant condition changes; all development steps are injured by heat stress to some limit (Wahid et al 2007; Naveed et al., 2012; Puspito et al., 2015; Waseem et al., 2014; Zafar et al., 2022). The post-anthesis phase of plant growth is highly sensitive to temperature extremes. It primarily influences the starch formation and breakdown in the maturing grain, as well as nutrient accessibility and translocation of photosynthates to the cereal, and it causes adverse effects on the weight and yield of the grain. Genotype-phenotype variance ratio is heritability. Genetic building populations and environmental factors create heritability (Khalil et al.,2016). Heritability is mostly polygenic traits. Heritability for yield-related traits is often low. Heritability is broadly used in installing breeding programs and formulating selection indexes (Khalil et al., 2016). Climate change is a source of environmental pressure that reduce wheat quality (Lou et al 2020). If the duration of anthesis changes, it affects physiological maturity (GS3), which induces a decrease in the total weight of the grain (Warrington et al 1977). This research examines the impact of late showing on genetic variability and heritability of wheat genotype (Aaliya et al., 2016; Abbas et al., 2015, 2016; Ahmad et al., 2012; Ali et al., 2010ab, 2011ab, 2013, 2014ab, 2016). Here you will find out (1) the effect of late sowing of wheat on yield (2) what type of factors affect the grain of wheat due to late sowing.

Materials and Methods

Experimental site and location

The investigation was carried out on the BZU Bahadur sub-Campus Layyah, dated 07-11-2019 and 10-12-2019, to check the effect of late sowing on genetic variability and Heritability of wheat genotypes in Layyah (latitude and longitude 31.25 N 73.03 E). The area has a desert climate with long, sweltering, humid, and clear summers; winters tend to be brief, mild, and cloudless.

Soil and climatic conditions

The experiment was conducted in sandy soil. The temperature typically varies from 45 F to 106 F and rarely below 40 F or 113F. The soil of the area is sandy. The average yearly temperature is 25.2˚ C | 77.3˚ F. The annual rainfall is 195mm | 7.7 inches.

Experimental layout

A Randomize Complete Block Design was used for the experiment. The experiment was replicated three times with row distance of 1 ft and each row of 5 ft.

Treatments

There are two treatments one is early sowing, and the other is late sowing.

Crop Husbandry

Ten advanced wheat genotypes from various national wheat breeding programs in Pakistan. Plant-to-plant distance was not measured, but the row-to-row space was 1ft. The total areas of early and late sowing are 4 marls. In sowing time, give the DAP fertilizer, and in first irrigation, apply the urea and then give calcium ammonium nitrate. The total irrigations are 5, first after 20 days, and late sowing has 4 irrigation and the last irrigation in the botting stage to give and other to check the moisture level and irrigate.

Data collection

Wheat genotypes, including advanced wheat lines were selected to investigate their performance in early and late sowing. After maturation, the below-mentioned six morphological traits were recorded.

Procedure used for recording data

Agronomic parameters

Plant height at maturity (cm)

Three plants in each replication of each genotype were randomly selected. A total of 9 plants were to be chosen. Plant height was calculated from ground level to the apex of the ear, using measuring tape and then calculated the average height.

Number of tillers/plants

The number of tillers was determined by counting them from Nine plants in each plot, and their average was calculated.

Number of spikelets per spike

Each replication of three plants spikelet is to be counted separately to calculate the average of each replication plants and other replication.

Spike length (cm)

The main spike of each plant is to be selected. Their length was measured using measuring tape, and then the average apex length was calculated.

Biological yield (g)

Nine plants from each genotype were weighed using a weighing balance, and their means were worked out.

Grain yield/plant (g)

After harvesting the grain, the yield per genotype was calculated.

Statistical Analysis

Fisher's analysis of variances was used to analyses the results for morphological characteristics. The least significant difference (LSD) test at the 5% level of

[Citation: Rehman, A.U., Khan, M.F., Abbas, A. Javed, M., Abbas, M.Z., Hussain, M., Ul-Allah, S. (2023). Evaluation of genetic variability and heritability of wheat genotypes under late sowing effects. *Biol. Clin. Sci. Res. J.,* **2023***: 268*. doi: https://doi.org/10.54112/bcsrj.v2023i1.268]

probabilities was used to evaluate treatment means (Steel et al., 1997). MS Excel is used to calculate the correlation and path coefficients. Using the SPSS programmed, several attributes were calculated using the method provided by Steel and Torrie (1980).

Results

ANOVA

ANOVA (Analysis of variance) was used to check the difference between genotype and traits. The ANOVA showed the different values of traits and the difference among the traits. Through the ANOVA method, we ensured the correction of data. Treatments and interaction of treatments with genotypes were tested at 5% probability. If the P value is smaller than 0.05, our data is authentic and correct. For the field experiment, the value of P is 0.05and its value is 0.01 in the case of lab experiment.

Path coefficient

The data were analyzed using path coefficient analysis to evaluate different direct and indirect effects of different traits on each other and, ultimately, on the yield per plant. We studied how a trait is directly effecting the yield and how it was affecting yield indirectly by simulating another trait which made an impact on the yield per plant from this information, we can summarize which traits are affecting yield positively either by its direct impact or indirectly by another trait and which traits have a negative effect directly and indirectly so that we can utilize this knowledge in our breeding program for trait selection and we will carry only those traits for our future breeding program which show a positive impact on the yield (Figures 7 and 8).

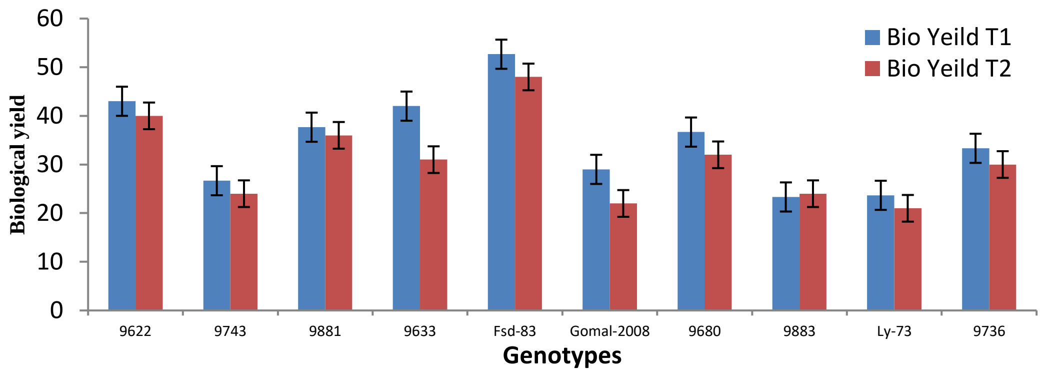

Figure 1. Biological yiled of wheat genotypes under different sowing dates

The figure 1 shows the Biological Yield of two Treatments' In treatment T1, there are 10 wheat genotypes which sow early compared to treatment 2. This graph shows that T1 Fsd-83 has the highest biological yield value of 53g and 9883 has the lowest biological yield of 23g in early sowing. In T2 There is a decline in Biological Yield due to late sowing because there are different factors which affect the yield Environment (Less Chilling Temperature), and Time duration. We can compare that in T1 Fsd-83 has 53g biological yield value, but T2 Fsd-83had 47g biological yield value which is less than T1 due to late sowing and T1 Ly-73 has 24g biological yield value in early sowing But T2 Ly-73 has 21g biological yield value which is less than T1 due to late sowing. So, T1, in which the Wheat genotypes sow early have a higher biological yield value Than T2 wheat genotypes sow late.

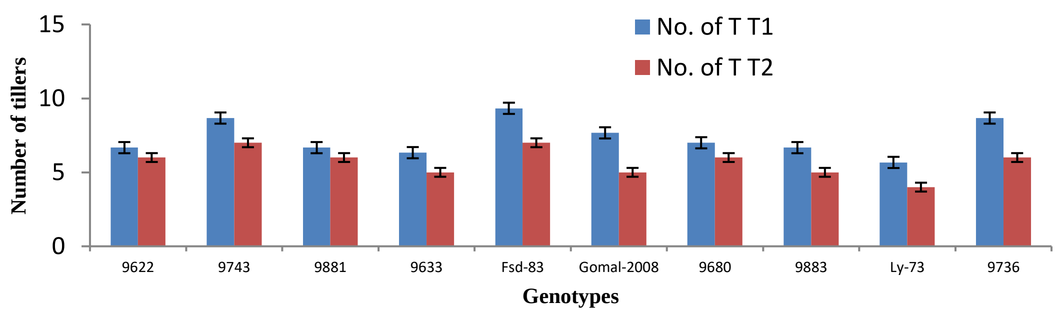

Figure 2. Number of tillers of wheat genotypes under different sowing dates

The figure 2 shows the No of Tillers of 10 wheat Genotypes of two treatments. The T1 wheat genotypes has higher No. Of Tillers due to early Sowing as compared to Wheat Genotypes which sown late in T2. The T1 Fsd-83 has a higher number of Tillers 9 than other varieties, and Ly-73 has the lowest number of Tillers 6. In T2 there is a decline of no of Tillers in every wheat genotype due to late sowing. In T2 Fsd-83 has 7 no of Tillers, which is the highest compared to other varieties in T2, and Ly-73 has the lowest no of Tillers 4 compared to other varieties of wheat Genotypes.

[Citation: Rehman, A.U., Khan, M.F., Abbas, A. Javed, M., Abbas, M.Z., Hussain, M., Ul-Allah, S. (2023). Evaluation of genetic variability and heritability of wheat genotypes under late sowing effects. *Biol. Clin. Sci. Res. J.*, **2023**: *268*. doi: https://doi.org/10.54112/bcsrj.v2023i1.268]

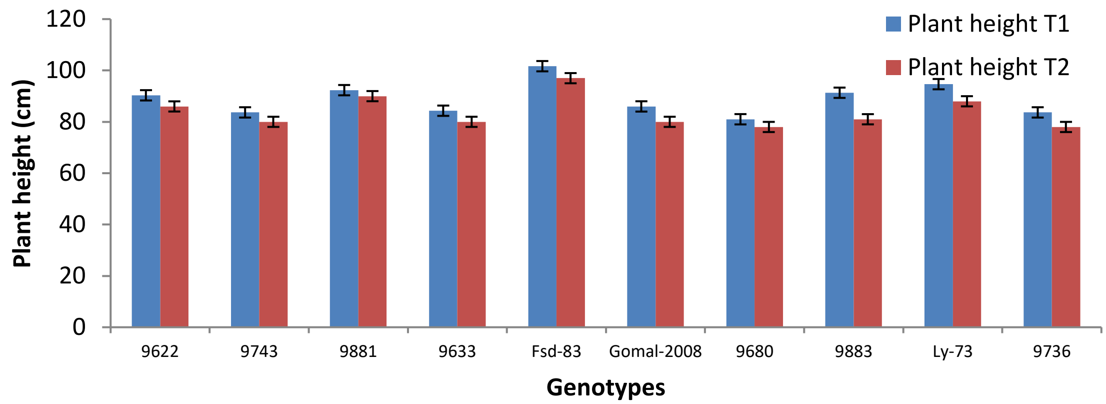

Figure 3. Plant height of wheat genotypes under different sowing dates

The figure 3 shows the Plant Height of two treatments. T1 Fsd-83 has the highest value of Plant Height 101cm to other varieties, and 9680 has the lowest value of 80cm than other varieties in early sowing. In T2, Plant Height is declining due to late sowing compared to T1. In T2 Fsd-83 variety plant height is 97cm decline from 101cm and 9680 has a plant height value 76cm decline from 80cm due to late sowing. So, the wheat genotypes which sow early in T1 have a greater value of Plant Height than late sowing in T2, and there is a decline in plant height value in every wheat genotype that sown late in T2.

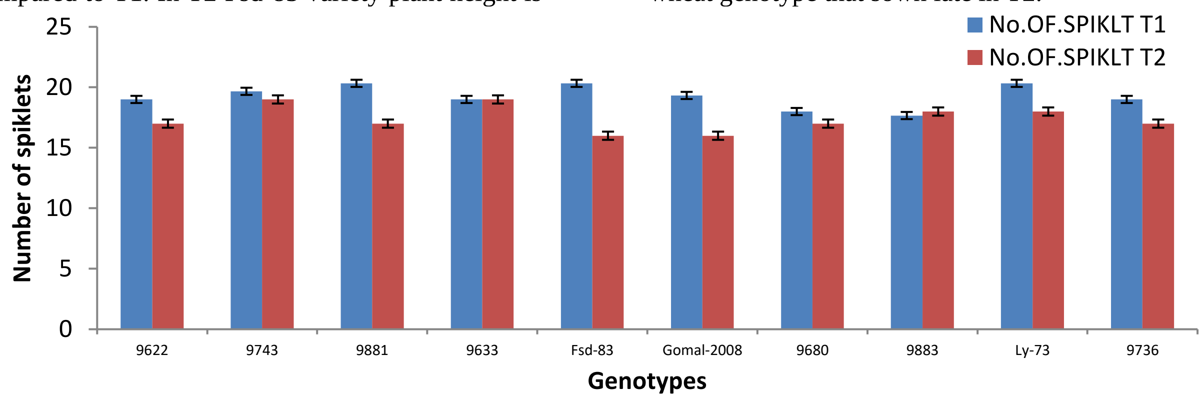

Figure 4. Number of spikelets of wheat genotypes under different sowing dates

The figure 4 shows the No of Spikelet's of two treatments. In T1 Fsd-83 has the highest No of spikelet's 21 compared to other varieties, and 9883 has the lowest No of spikelet's 18 compared to different varieties. T2 wheat Genotypes have less spikelet's than T1 wheat Genotypes due to late sowing. In T2 9743 and 9633 varieties have the same No of spikelets and highest no of spikelet as other varieties, and Fsd-83 and Gomal-2008 have the lowest value of No of spikelet's 16 as compared to different varieties in T2.

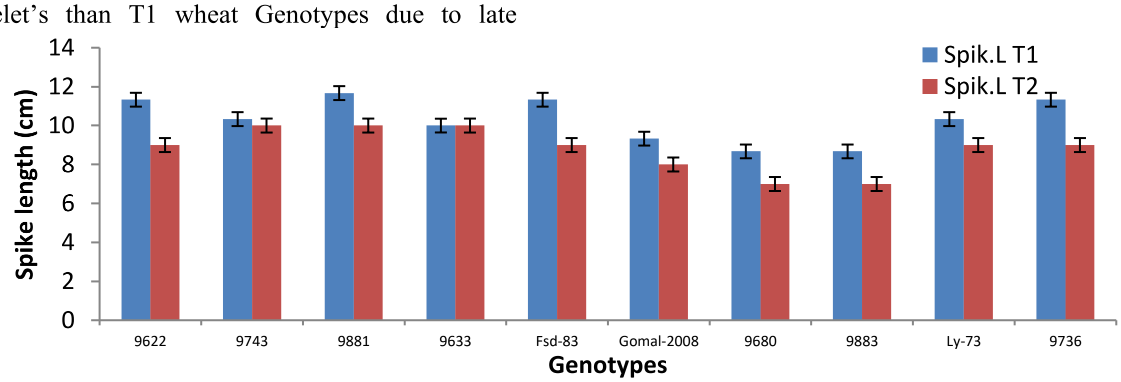

Figure 5. Spike length of wheat genotypes under different sowing dates

The figure 5 shows the Spike length of Wheat genotype of two Treatments. In T1 9881 genotype has the highest Spike Length 11.55cm, and 9680 ,9883 has the lowest spike Length 8.85cm compared to other varieties in T1. In T2 9743,9881and 9633 have the same and highest Spike Length 10cm compared to

[Citation: Rehman, A.U., Khan, M.F., Abbas, A. Javed, M., Abbas, M.Z., Hussain, M., Ul-Allah, S. (2023). Evaluation of genetic variability and heritability of wheat genotypes under late sowing effects. *Biol. Clin. Sci. Res. J.*, **2023***: 268*. doi: https://doi.org/10.54112/bcsrj.v2023i1.268]

others and 9680,9883 have the same and lowest value 7cm compared to others. There is one important thing that 9633 has the same result in T1 early sowing and T2 late sowing.

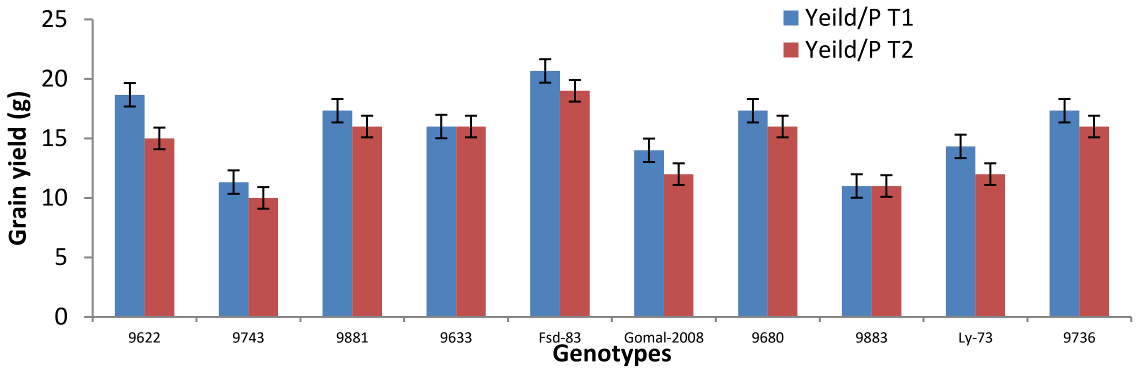

Figure 6. Grian yield of wheat genotypes under different sowing dates

The figure 6 shows the grain yield per plant of wheat Genotypes of two Treatments. In T1 Fsd-83 has the highest value of grain yield 21g, compared to other varieties and 9743 has the lowest value of grain yield 12g, compared to other verities. InT2 Fsd-83 has the highest value of grain yield 19g, and 9743 has the lowest value of 10g. In T2 there is a decline of yield in wheat Genotypes but there are two varieties 9633 and 9883 which have the same result in early sowing T1 and late sowing T2.

Discussion

Results showed the Biological Yield of two Treatments. In treatment T1, there are 10 wheat genotypes which sow early compared to treatment 2. This result showed that in T1 Fsd-83 has the highest biological yield value 53g, and 9883 has the lowest biological yield value 23g in early sowing. In T2 There is decline in Biological Yield due to late sowing because there are different factors which affect the yield Environment (Less Chilling Temperature), and Time duration. We can compare that in T1 Fsd-83 has 53g biological yield value, but T2 Fsd-83 had 47g biological yield value which is less than T1 due to late sowing, and T1 Ly-73 has 24g biological yield value in early sowing But T2 Ly-73 has 21g biological yield value which is less than T1 due to late sowing. So, T1 in which the Wheat genotypes sow early have higher biological yield value Than T2 wheat genotypes sow late. Among various factors, sowing time is also one factor which creates problems of low yield of wheat crop in the country, wheat grown in winter has its special temperature and light, which affect the emergence growth and flowering of plant. (Sabre et al 1993) And the result showed the grain yield per plant of wheat Genotypes of two Treatments. In T1 Fsd-83 has highest value of grain yield compared to other varieties and 9743 has lowest value of grain yield 12g compared to other varieties. In T2 Fsd-83 has highest value of grain yield 19g, and 9743 has the lowest value of 10g. In T2 there is a decline of yield in wheat Genotypes but there are two varieties 9633 and 9883 which have the same result in early sowing T1 and late sowing T2. The result shows the No of Tillers of 10 wheat Genotypes of two treatments. The T1 wheat genotypes has higher No. Of Tillers due to early Sowing as compared to Wheat Genotypes, which sown late in T2. T1 Fsd-83 has a higher no of Tillers 9 than other varieties, and Ly-73 has the lowest no of Tillers 6. In T2 there is a decline of no of Tillers in every wheat genotype due to late sowing. In T2 Fsd-83 has 7 no. of Tillers, which is highest compared to other varieties in T2 and Ly-73 has the lowest no of Tillers 4 compared to other varieties of wheat Genotypes. (Ansary et al.1989) states that late sowing of wheat hinders production because the contact of the yielding trait is affected, resulting in a decrease in the number of grains and the number of tillers and the number of grains in per spike. (Rajput and verma1994) reported that we can get higher grain yield in time sowing than in late sowing. In time sowing we can get high yield than in late sowing. After November 20th, the later will cause low yield of 39 kg per hectare per day. (Singh and uttam 1999). Late wheat sowing can reduce yield of up to 30 to 40%. (Khalil et al 2016). Late sowing of wheat crop poses a serious problem to us at the time of grain filling which is the rise in temperature as when the temperature is high it will reduce our crop yield (Aslam et al 1989). Result shows the Plant Height of two treatments. In T1 Fsd-83 has highest value of Plant Height 101cm than other varieties and 9680 has lowest value of 80cm then other varieties in early sowing. In T2 there is decline in Plant Height due to late sowing as compared to T1. In T2 Fsd-83 variety plant height is 97cm decline from 101cm and 9680 has plant height value 76cm decline from 80cm due to late sowing. So, the wheat genotypes that sow early in T1 have greater value of Plant Height than late sowing in T2 and decline in plant height value in every wheat genotype that sown late in T2. Result shows the No of Spikelet's of the two treatments. In T1 Fsd-83 has highest No of spikelet's 21 compared to other varieties and 9883 has lowest No of spikelet's 18 compared to other varieties. T2 wheat Genotypes has

[Citation: Rehman, A.U., Khan, M.F., Abbas, A. Javed, M., Abbas, M.Z., Hussain, M., Ul-Allah, S. (2023). Evaluation of genetic variability and heritability of wheat genotypes under late sowing effects. *Biol. Clin. Sci. Res. J.*, **2023**: 268. doi: https://doi.org/10.54112/bcsrj.v2023i1.268]

less spikelet's than T1 wheat Genotypes due to late sowing. In T2 9743 and 9633 varieties have the same No of spikelets and highest no of spikelet's as compared to other varieties and Fsd-83 and Gomal 2008 has and lowest value of No of spikelet's 16 as compared to other varieties in T2. The result shows the Spike length of Wheat genotype of two Treatments. The T1 9881 genotype has the highest Spike Length 11.55cm, and 9680, 9883 has the lowest spike Length 8.85cm, compared to other varieties in T1. In T2 9743, 9881and 9633 have the same and highest Spike Length 10cm compared to other and 9680,9883 have same and lowest value 7cm compared to others. There is one important thing that 9633 has the same result in T1 early sowing and T2 late sowing. High temperature affects every aspect of the crop, affecting the flowering process and reducing the time of spike development, leading to fewer spikelets in a spike and bad affecting pollen development (Ayeneh et al., 2002; Wahid et al., 2007; Mitra and bhatia 2008). Many biotic and abiotic factors affect the yield of crop when wheat is grown late. Early sowing weakens the roots of the plant, which has reason to increase in optimum temperature; increasing the optimum temperature cause variable germination and the embryo generally dies, and the endosperm breaks down due to bacterial and fungal activity. Poor farming and usually slow harvesting result from late sowing as temperatures drop. When we grow short-duration varieties late, they fill their grains before the temperature rises (Phadnawis And Saini 1992).

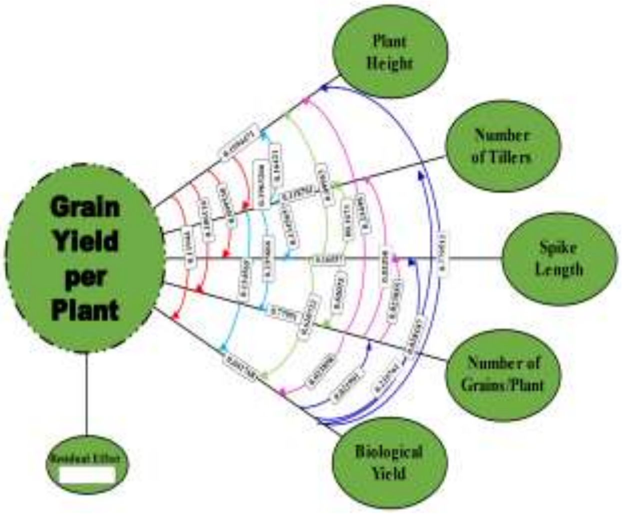

Figure 7. Path coefficient analysis of wheat genotypes under normal sowing date

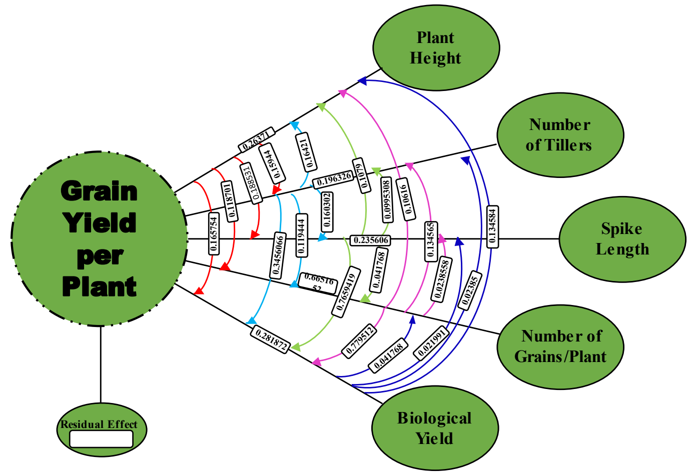

Figure 8. Path coefficient analysis of wheat genotypes under late sowing date

Conflict of interest

The authors declared the absence of conflict of interest.

References

Aaliya, K., Qamar, Z., Ahmad, N. I., Ali, Q., Munim, F. A., & Husnain, T. (2016). Transformation, evaluation of gtgene and multivariate genetic analysis for morpho-physiological and yield attributing traits in Zea mays. *Genetika*, **48**(1), 423-433.

Abbas, H. G., Mahmood, A., & Ali, Q. (2015). Genetic variability and correlation analysis for various yield traits of cotton (*Gossypium hirsutum* L.). *Journal of Agricultural Research*, **53**(4), 481-491.

Abbas, H. G., Mahmood, A., & Ali, Q. (2016). Zero tillage: a potential technology to improve cotton yield. *Genetika*, *48*(2), 761-776.

Ahmad, H. M., Ahsan, M., Ali, Q., & Javed, I. (2012). Genetic variability, heritability and correlation studies of various quantitative traits of *mung bean* (Vigna radiate L.) at different radiation levels. *International Research Journal of Microbiology*, **3**(11), 352-362.

Ajmal, S. U., Zakir, N., & Mujahid, M. Y. (2009). Estimation of genetic parameters and character association in wheat. *Journal of Agricultural and Biological Sciences*, **1**(1), 15-18.

Akçura, M. (2009). Genetic variability and interrelationship among grain yield and some quality traits in Turkish winter durum wheat landraces. *Turkish Journal of Agriculture and Forestry*, **33**(6), 547-556.

Ali, F., Ahsan, M., Ali, Q., & Kanwal, N. (2017). Phenotypic stability of Zea mays grain yield and its attributing traits under drought stress. *Frontiers in plant science*, *8*, 1397.

Ali, Q. and M. Ahsan, (2012). Estimation of genetic variability and correlation analysis for

[Citation: Rehman, A.U., Khan, M.F., Abbas, A. Javed, M., Abbas, M.Z., Hussain, M., Ul-Allah, S. (2023). Evaluation of genetic variability and heritability of wheat genotypes under late sowing effects. *Biol. Clin. Sci. Res. J.*, **2023***: 268*. doi: https://doi.org/10.54112/bcsrj.v2023i1.268]

quantitative traits in chickpea (*Cicer arietinum* L.). *International Journal of Agro-Veterinary and Medical Sciences*, **6**(4): 241-249.

Ali, Q., Ahsan, M., & Saleem, M. (2010a). Genetic variability and trait association in chickpea (Cicer arietinum L.). *Electronic Journal of Plant Breeding*, **1**(3), 328-333.

Ali, Q., Ahsan, M., Ali, F., Aslam, M., Khan, N. H., Munzoor, M., ... & Muhammad, S. (2013). Heritability, heterosis and heterobeltiosis studies for morphological traits of maize (Zea mays L.) seedlings. *Advancements in Life Sciences*, **1**(1):52-63.

Ali, Q., Ahsan, M., Kanwal, N., Ali, F., Ali, A., Ahmed, W., ... & Saleem, M. (2016). Screening for drought tolerance: comparison of maize hybrids under water deficit condition. *Advancements in Life Sciences*, **3**(2), 51-58.

Ali, Q., Ahsan, M., Khaliq, I., Elahi, M., Shahbaz, M., Ahmed, W., & Naees, M. (2011a). Estimation of genetic association of yield and quality traits in chickpea (Cicer arietinum L.). *International Research Journal Plant Science*, **2**(6), 166-169.

Ali, Q., Ahsan, M., Tahir, M. H. N., Elahi, M., Farooq, J., Waseem, M., & Sadique, M. (2011b). Genetic variability for grain yield and quality traits in chickpea. *International Journal of Agro-Veterinary and Medical Sciences*, **5**, 201-208.

Ali, Q., Ali, A., Ahsan, M., Nasir, I. A., Abbas, H. G., & Ashraf, M. A. (2014a). Line× Tester analysis for morpho-physiological traits of Zea mays L seedlings. *Advancements in Life sciences*, **1**(4), 242-253.

Ali, Q., Ali, A., Awan, M. F., Tariq, M., Ali, S., Samiullah, T. R., ... & Hussain, T. (2014b). Combining ability analysis for various physiological, grain yield and quality traits of Zea mays L. *Life Sci J*, **11**(8s), 540-551.

Ali, Q., Elahi, M., Ahsan, M., Tahir, M. H. N., Khaliq, I., Kashif, M., ... & Ejaz, M. (2012). Genetic analysis of Morpho-Physiological and quality traits in chickpea genotypes (Cicer arietinum L.). *African Journal of Agriculture Research*, **7**(23), 3403-3412.

Ali, Q., Muhammad, A., & Farooq, J. (2010b). Genetic variability and trait association in chickpea (Cicer arietinum L.) genotypes at seedling stage. *Electronic Journal of Plant Breeding*, **1**(3), 334-341.

Allard, R. W. (1960). Principles of plant breeding. John Willey and Sons. Inc. New York, 485.

ANAS, M. (2021). Genetic variability and heritability for yield and yield associated traits of wheat genotypes in peshawar valley (Doctoral dissertation, University of Agriculture Peshawar).

Ansari, B. A., Rajper, A., & Mari, S. M. (2005). Heterotic performance in F1 hybrids derived from diallel crosses for tillers per plant in wheat under fertility regimes. *Industrial Journal Agriculture Engineering and Veterinary Science* **19**, 28-31.

Ansari, A. H., Khushk, A. M., Sethar, M. A., Arain, N. A., & Memon, M. Y. (1989). Effect of sowing dates on the growth and yield of wheat cultivars. Pakistan Journal of Scientific and Industrial Research (Pakistan).

Ansari, K. A., Ansari, B. A., & Khund, A. (2004). Extent of heterosis and heritability in some quantitative characters of bread wheat. *Indus Journal of Plant Sciences*, **3**(2), 189-192.

Aslam, M., Majid, A., Hobbs, P. R., Hashmi, N. I., & Byerlee, D. (1989). Wheat in the rice-wheat cropping system of the Punjab: A synthesis of On-farm research results 1984-1988.

Aycicek, M. E. H. M. E. T., & Yildirim, T. E. L. A. T. (2006). Heritability of yield and some yield components in bread wheat (Triticum aestivum L.) genotypes. *Bangladesh Journal of Botany*, **35**(1), 17-22.

Aziz, T., Khalil, I. H., Hussain, Q., Shah, T., Ahmad, N., & Sohail, A. (2018). Heritability and selection response for grain yield and associated traits in F 3 wheat populations. *Sarhad Journal of Agriculture*, **34**(4), 767-774.

Baloch, M. J., Baloch, E., Jatoi, W. A., & Veesar, N. F. (2013). Correlations and heritability estimates of yield and yield attributing traits in wheat (Triticum aestivum L.). *Pakistan Journal of Agriculture, Agricultural Engineering, Veterinary Sciences*, **29**(2), 96-105.

Bhargava, A., Shukla, S., Katiyar, R. S., & Ohri, D. (2003). Selection parameters for genetic improvement in Chenopodium grain yield in sodic soil. *Journal of Applied Horticulture*, **5**(1), 45-48.

Bhutta, W. M. (2006). Role of some agronomic traits for grain yield production in wheat (Triticum aestivum L.) genotypes under drought conditions. Revista Científica UDO Agrícola, 6(1), 11-19.

Camargo, C. E. D. O. (1984). Wheat breeding: X. Heritability estimates and associations of tolerance to aluminum toxicity and grain yield with other agronomic characteristics in wheat. Bragantia, 43, 615-628.

Collaku, A. (1994). Selection for yield and its components in a winter wheat population under different environmental conditions in Albania. Plant Breeding, 112(1), 40-46.

FAO (2019). Statistical database. www.Fao.org.

Hafeez, M. N., Khan, M. A., Sarwar, B., Hassan, S., Ali, Q., Husnain, T., & Rashid, B. (2021). Mutant Gossypium universal stress protein-2 (GUSP-2) gene confers resistance to various abiotic stresses in *E. coli* BL-21 and CIM-496-*Gossypium* hirsutum. *Scientific Reports*, **11**(1), 20466.

Hailegiorgis, D., Mesfin, M., & Genet, T. (2011). Genetic divergence analysis on some bread wheat genotypes grown in Ethiopia. *Journal of Central European Agriculture*, **12**(2), 0-0.

Hays, D., Mason, E., Do, J. H., Menz, M., & Reynolds, M. (2007). Expression quantitative trait loci mapping heat tolerance during reproductive development in wheat (Triticum aestivum). In Wheat Production in Stressed Environments: Proceedings of the 7th International Wheat Conference, 27 November–2 December 2005, Mar del Plata, Argentina (pp. 373-382). Springer Netherlands.

Jan, S., Mohammad, F., & Khan, F. U. (2015). Genetic potential and heritability estimates of yield traits in F3 segregating populations of bread wheat. *International journal of environment*, **4**(2), 106-115.

Javed, I., Ahsan, M., Ahmad, H. M., & Ali, Q. (2016). Role of mutation breeding to improve Mungbean (Vigna radiata L. Wilczek) yield: An overview. *Nature Science*, **14**(1), 63-77.

Khan, S. A. (2013). Genetic Variability and Heritability Estimates in F^ sub 2^ wheat Genotypes. International *Journal of Agriculture and Crop Sciences*, **5**(9), 983.

Kumar, S. (2013). Study of genetic variability and heritability over extended dates of sowing in bread wheat (Triticum aestivum L.). Research in Plant Biology.

Mahmood, M. T., Khan, S. J., Ali, I., Hussain, S., Shah, S. A. S., Sadiq, M. A., ... & Ali, F. (2016). Estimation of genetic variation for agro-economic traits in wheat (Triticum aestivum L.). *Journla of Environmental Agricultural Sciences*, **9**, 10-14.

Mitra, R., & Bhatia, C. R. (2008). Bioenergetic cost of heat tolerance in wheat crop. Current Science, 1049-1053.

Naveed, M. T., Ali, Q., Ahsan, M., & Hussain, B. (2012). Correlation and path coefficient analysis for various quantitative traits in chickpea (Cicer arietinum L.). *International Journal for Agro Veterinary and Medical Sciences*, **6**(2), 97-106.

Prasad, B., Carver, B. F., Stone, M. L., Babar, M. A., Raun, W. R., & Klatt, A. R. (2007). Genetic analysis of indirect selection for winter wheat grain yield using spectral reflectance indices. *Crop science*, **47**(4), 1416-1425.

Praveen, S. (2014). Genetic divergence study in improved bread wheat varieties (Triticum aestivum). African *Journal of Agricultural Research*, **9**(4), 507-512.

Puspito, A. N., Rao, A. Q., Hafeez, M. N., Iqbal, M. S., Bajwa, K. S., Ali, Q., ... & Husnain, T. (2015). Transformation and evaluation of Cry1Ac+ Cry2A and GTGene in *Gossypium hirsutum* L. *Frontiers in Plant Science*, **6**, 943

Rajaram, S., & Braun, H. J. (2008). Wheat yield potential. In International Symposium on Wheat Yield Potential: Challenges to International Wheat Breeding (pp. 103-107). CIMMYT (International Maize and Wheat Improvement Center), Mexico, Mexico.

Reynolds, M. P., Balota, M., Delgado, M. I. B., Amani, I., & Fischer, R. A. (1994). Physiological and morphological traits associated with spring wheat yield under hot, irrigated conditions. *Functional Plant Biology*, **21**(6), 717-730.

Saleem, B., Khan, A. S., Shahzad, M. T., & Ijaz, F. (2016). Estimation of heritability and genetic advance for various metric traits in seven F2 populations of bread wheat (Triticum aestivum L.). *Journal of Agricultural Sciences, Belgrade*, **61**(1), 1-9.

Sharma, S., & Sharma, Y. (2007). Estimates of variation and heritability of some quantitative and quality characters in Triticum turgidum L. ssp. durum (Desf.). *Acta Agronomica Hungarica*, **55**(2), 261-264.

Thakur, P., Prasad, L. C., Prasad, R., & Chandra, K. (2020). Estimation of genetic variability, heat susceptibility index and tolerance efficiency of wheat (Triticum aestivum L.) for timely and late sown environments. *Electronic Journal of Plant Breeding*, **11**(03), 769-775.

Wardlaw, I. F., & Wrigley, C. W. (1994). Heat tolerance in temperate cereals: an overview. *Functional Plant Biology*, **21**(6), 695-703.

Waseem, M., Ali, Q., Ali, A., Samiullah, T. R., Ahmad, S., Baloch, D. M., ... & Bajwa, K. S. (2014). Genetic analysis for various traits of Cicer arietinum under different spacing. *Life Sci J*, **11**(12s), 14-21.

Zafar, M. M., Mustafa, G., Shoukat, F., Idrees, A., Ali, A., Sharif, F., ... & Li, F. (2022). Heterologous expression of cry3Bb1 and cry3 genes for enhanced resistance against insect pests in cotton. *Scientific Reports*, **12**(1), 10878.

[Citation: Rehman, A.U., Khan, M.F., Abbas, A. Javed, M., Abbas, M.Z., Hussain, M., Ul-Allah, S. (2023). Evaluation of genetic variability and heritability of wheat genotypes under late sowing effects. *Biol. Clin. Sci. Res. J.,* **2023***: 268*. doi: https://doi.org/10.54112/bcsrj.v2023i1.268]

[Citation: Rehman, A.U., Khan, M.F., Abbas, A. Javed, M., Abbas, M.Z., Hussain, M., Ul-Allah, S. (2023). Evaluation of genetic variability and heritability of wheat genotypes under late sowing effects. *Biol. Clin. Sci. Res. J.*, **2023***: 268*. doi: https://doi.org/10.54112/bcsrj.v2023i1.268]