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RESEARCH ARTICLE

Association of Quantitative Attributes in Rice Genotypes

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ABSTRACT

This study aims to elucidate correlations among diverse traits within 150 rice genotypes, with the ultimate goal of advancing high-yield rice varieties. Key attributes such as tillering, grain count per panicle, plant height, panicle length, grain size, and grain weight collectively influence plant architecture-a pivotal determinant of rice grain production. This article fundamentally delves into the profound impact of both morphological and agronomic variables on rice grain output. Among the observed correlations, panicle length displays substantial positive correlation with plant height (0.5341**). Conversely, tiller count per plant exhibits no significant correlation with plant height (0.1333ns) or panicle length (0.0108ns). Meanwhile, grain count per panicle demonstrates a notable positive correlation with both plant height (0.3708**) and panicle length (0.4913**). In terms of hundred grain weight, it showcases negligible negative correlation with plant height (-0.002ns), whereas it yields a significant correlation with grain count per panicle (0.1591*) and highly significant correlations with grain length (0.2688**) and grain width (0.4423**). Furthermore, grain length displays a significant positive correlation with panicle length (0.3412**). In contrast, grain width exhibits no significant correlation with plant height (correlation coefficient: 0.0513ns), tiller count per plant (0.1566ns), grain count per panicle (0.0619ns), or grain length (0.1272ns). Additionally, grain width displays a negligible negative correlation with panicle length (correlation coefficient: -0.0419ns). Consequently, manipulating these agronomic traits offers a promising avenue for augmenting or reducing grain yield. The outcomes of this research furnish valuable guidance for plant breeders, enabling them to harness the full potential of the best-performing cultivars for subsequent research endeavors.

Key words: Rice, Correlation, Panicle length, RADAR graph.

INTRODUCTION

Rice (Oryza sativa), having a historical lineage spanning 8,200 to 13,500 years, stands as one of the most ancient and vital cereal crops globally (Razzaq *et al*., 2020). Rice (Oryza sativa L.) is a staple food for more than half of the global population, playing a pivotal role in ensuring food security and addressing nutritional needs. With an ever-growing global population and the challenges posed by changing climatic conditions, there is an increasing demand for rice varieties that exhibit enhanced yield, resilience, and nutritional value. One of the fundamental factors that underpins the development of such improved rice cultivars is genetic variability within rice genotypes (Faysal *et al*., 2022).

Genetic variability, the diversity in genetic makeup among individuals within a species, serves as the raw material for the process of natural selection and artificial selection. In the context of rice genotypes, genetic variability encompasses the wide spectrum of genetic differences present among individual rice plants, populations, or cultivars. This variability arises from the accumulation of mutations, genetic recombination, and other genetic processes over time. It forms the basis upon which breeders can select and develop rice varieties with desired traits, ultimately leading to increased productivity and adaptability (Demeke *et al.,* 2023).

The study of genetic variability in rice genotypes involves the analysis of a multitude of traits at both the morphological and molecular levels. Morphological

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traits include plant height, panicle length, tiller count, grain size, and other characteristics that contribute to overall plant architecture and yield potential (Kulsum *et al.,* 2022).

In rice, yield is one of the most essential and significant features. It is controlled by external environmental conditions and is governed by genes known as quantitative trait loci (Sakran *et al*., 2022). Morphological attributes serve as valuable instruments for assessing plant growth, progression and the impact of biotic and abiotic pressures on yield. Plant height, closely linked to biomass production, stands as a significant morphological attribute impacting yield efficiency. Grain weight is mostly affected by grain size, which is defined by three dimensions (length, breadth, and thickness) as well as filling degree. Commercial rice types typically have a 1,000-grain weight of 25–35 g (Anwar *et al*., 2022). Tillering is a key agronomic characteristic in rice (Oryza sativa L.) for panicle number per unit land area as well as grain output. Rice grain yield is influenced by the panicle-bearing tiller rate, excessive tillering causes high tiller abortion, poor grain setting, small panicle size, and additional grain yield loss (Balasubramanian and Vennila, 2022).

MATERIALS AND METHODS

This experiment was conducted in the field area of Department of plant breeding and genetics, The Islamia University of Bahawalpur, Pakistan during 2021-22. To study the effect of different morphological traits on yield of rice crop. Different 150 genotypes were grown on 20 may 2021 and then transferred to the field after 30 to 40 days with normal farm practices. Thus, we studied the traits of 150 genotypes. The traits we studied were as follow: plant height, number of tillers per plant, panicle length, grains per panicle, grain length, grain width and grain weight.

Plant height was measured in (cm) from the plant base to the spike tip with the help of meter rod. Tiller number was counted from 6 plants of each genotype manually. To measure panicle length in (cm) we use meter rod as measuring scale. Hundred grains weight was also recorded for each plant of genotypes on analytical weight balance. The number of grains per panicle was recorded by counting grains manually for each plant of each genotype. Grain length was recorded in (mm) by using Vernier caliper. Grain width was also recorded in (mm) by using vernier caliper.

Statistical Analysis

Correlation

Correlation is a measure of genotypic relationship between characters that indicates which characters are more beneficial. It also aid in the identification of characters who are irrelevant to the selecting process. It is vital to investigate the nature of the character's association with grain yield in order to make a good decision (Gerema, 2020). Karl Pearson's correlation coefficient was computed to establish the linear relation between diverse physiological and morphological traits, employing the subsequent formula:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Where, r is represented by Pearson's correlation coefficient, X and Y represented by the variables for which the correlation has been measured, and n is represented by the number of observations.

Analysis of Variance (Anova)

SPSS (version 8.1) software was used for statistical analysis.

RESULTS AND DISCUSSION

Plant height is a critical agronomic trait in rice that is closely linked to plant yield, displaying variations across different varieties and environmental conditions. The analysis of variance for rice plant height is presented in Table 2, revealing a significant disparity among genotypes. The overall mean for all genotypes stands at 87.011, with a variance correlation of 9.36 across the entire genotype range. Notably, the mean square value for plant height among all genotypes is 719.713**, as displayed in Table 2. In terms of mean comparison, the genotypes exhibiting lower average plant height are G18 (58.33), G87 (57.67), and G75 (60.83). Conversely, those displaying a greater average plant height include G100 (116.33), G70 (114.33), and G112 (113.33), as evidenced in Table 1.

The augmentation of panicle architecture and grain yield in rice hinges significantly on panicle length. The analysis of variance for rice panicle length is detailed in Table 2, showcasing notable disparities among various genotypes. The collective mean for all genotypes registers at 22.273, accompanied by a variance correlation of 15.38, as indicated in Table 2. The mean square value for panicle length across all genotypes is computed at 37.1636. Upon scrutinizing mean comparisons, genotypes displaying a greater average panicle length encompass G4 (16.667), G114 (16), and G154 (15). Conversely, those with a comparatively lesser average panicle length encompass G26 (30), G122 (38.333), and G100 (29.333), as observed in Table 2.

Tillering constitutes a pivotal agronomic characteristic in rice (Oryza sativa L.), bearing considerable influence on yield determination. The yield of rice grains is intrinsically tied to the rate of tiller-bearing panicles. The analysis of variance for rice tiller number is outlined in Table 2, substantiating a significant differentiation among diverse genotypes. The mean square value for tiller number across all genotypes notably amounts to 69.918**, as depicted in Table 2. Delving into mean comparisons, genotypes showcasing a higher average tiller number comprise G106 (39), G107 (34.333), and G27 (30.667). Conversely, those demonstrating a relatively lower average tiller number include G69 (7), G47 (7), and G147 (8), as delineated in Table 1.

Table: 1: Best & the worst performing rice genotypes for various morphological and agronomic traits.

Traits	Best	Worst
PH	G100(116.33) followed by G70(114.33) ,G112(113.33)	G87(57.67) followed by G18(58.33) ,G75(60.83)
PL	G122(38.333) followed by G26(30) ,G100(29.333)	G154(15) followed by G114(16) ,G4(16.667)
TN	G106(39) followed by G107(34.333) ,G27(30.667)	G69(7) followed by G47(7) ,G147(8)
GPP	G91(151.67) followed by G45(147.67) , G41(143.33)	G145(54.67) followed by G127(56.67) ,G28(60.32)
G wt	G90(23.15) followed by G28(23.04) ,G97(22.707)	G75(20.04) followed by G30(20.483 ,G124(20.372)
GL	G118(6.104) followed by G12(6.0967),G49(6.06)	G18(5.35) followed by G103(5.43),G87(5.43)
GW	G83(2.6233) followed by G75(2.62) , G119(2.5233)	G126(2.19) followed by G118(2.2) ,G145(2.2)

Table 2: ANOVA of various morphological attributes

Source	DF	(PH)	(PL)	(TN)	(GPP)	(100G wt)	(GL)	(GW)
REP	2	30.718	22.7217	160.487	42.99	15.9003	30.7362	2.56134
Genotype	149	719.713**	37.1636**	69.918	1710.01	0.9509*	0.0925	0.02799
Error	298	66.378	11.7351	29.469	28.23	1.2662	0.1582	0.01304
Total	449							

PH: Plant height, PL: Panicle length, TPP: Tiller per plant, GPP: Grain per panicle, GL: Grain length, GW: Grain width, 100GW: Grain weight, ns: non- significant , * :significant , **: highly significant .

Plant height and tillering play pivotal roles in determining the overall architecture of rice plants. Taller plants with increased tillering potential can capture more sunlight, leading to enhanced photosynthesis and better utilization of available resources. This often results in greater grain production per plant. Studies have shown a positive correlation between plant height, tiller count, and yield components, highlighting the potential of selecting taller genotypes with optimal tillering for improved yields (Asante *et al.,* 2019). The number of grains per panicle stands as a vital determinant of overall yield, and undoubtedly holds the potential to significantly enhance yield outcomes. The analysis of variance pertaining to rice grain number per panicle is presented in Table 2, revealing noteworthy distinctions among the different genotypes. The aggregate mean for all genotypes is calculated at 98.327, with a variance correlation of 5.40, as elaborated in Table 2. Importantly, the mean square value concerning grain count per panicle across the entire range of genotypes is significantly marked at 1710.01**, as outlined in Table 2.

When assessing mean comparisons, it becomes evident that genotypes showcasing a higher average grain count per panicle include G91 (151.67), G45 (147.67), and G41 (143.33). Conversely, genotypes exhibiting a relatively lower average grain count per panicle encompass G145 (54.67), G127 (56.67), and G28 (60.32), as illustrated in Table 1.

Intriguingly, a comprehensive overview of all studied morphological traits, including plant height and grain count per panicle, demonstrates fluctuations in the mean values across the majority of genotypes. This discernible pattern is effectively illustrated through the RADAR graph presented in Fig. 1.

Panicle length and the number of grains per panicle significantly contribute to rice yield. Longer panicles provide more space for grain development, allowing for increased grain filling and consequently higher yield potential. Moreover, a higher grains-per-panicle count directly contributes to increased yield per plant. Research has indicated that manipulating these traits through breeding can lead to substantial yield improvements (Donde *et al*., 2019). This Radar graph was first exploited in plant sciences by Fernandes *et al*., (2022). Grain yield was moderately influenced by the 100-grain weight trait. Grain weight is determined by the trio of geometric measurements - grain length, width, and thickness - along with the extent of grain filling. Analysis of variance for rice thousand grain weight is given in Table 2 which shows significant difference among genotypes. The grand mean of the all genotypes is 21.399 and the correlation of variance of all genotype is 5.26 as seen in Table 2. The mean square value of hundred grain weight for all genotypes is 0.9509*. Mean comparison of the genotypes exhibit greater mean value of hundred grain weight are followed by G90 (23.15), G28 (23.07) and G97 (22.707). The genotypes exhibited lesser mean value of hundred grain weight are followed by G75 (20.04), G30 (20.483) and G124 (20.372) (Table 1). Grain size in rice is determined by its three geometrical factors (grain length, width and thickness) which influence the yield of rice crop. Rice milling, cooking, and eating quality are profoundly influenced by the dimensions and form of the grains, making grain length and shape pivotal agricultural factors within the realm of rice breeding (Tiwari *et al*., 2004). The size and weight of individual rice grains are integral determinants of yield. Longer and wider grains have been associated with increased yield due to their higher grain weight and enhanced filling capacity. Grain size is also linked to commercial and culinary preferences. Selecting genotypes with larger grains can lead to a significant increase in overall yield and market value (Amegan *et al*., 2021). Analysis of variance for rice grain length is given in (Table 2) which showed significant difference among genotypes. The grand mean of the all genotypes is 5.6503 and the correlation of variance of all genotype is 7.04 (Table 2). The mean square value of grain length for all genotypes is 0.0925** (Table 2). Mean comparison of the genotypes exhibit greater mean value of grain length are G118 (6.107), followed G12 (6.0967) and G49 (6.06). The genotypes exhibited lesser mean value of grain length are G18 (5.35), followed by G103 (5.43) and

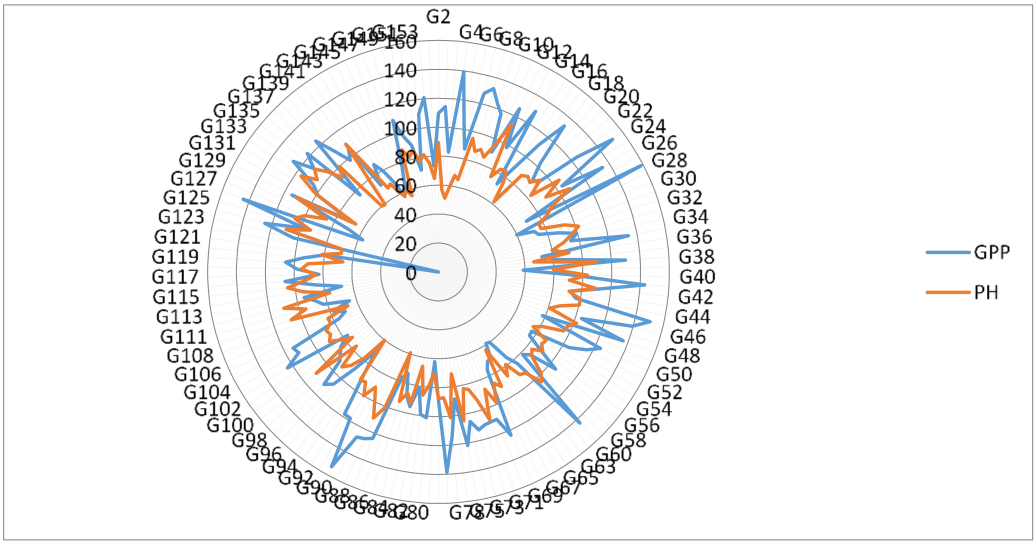

Fig. 1: Radar graph of grain per panicle and Plant height.

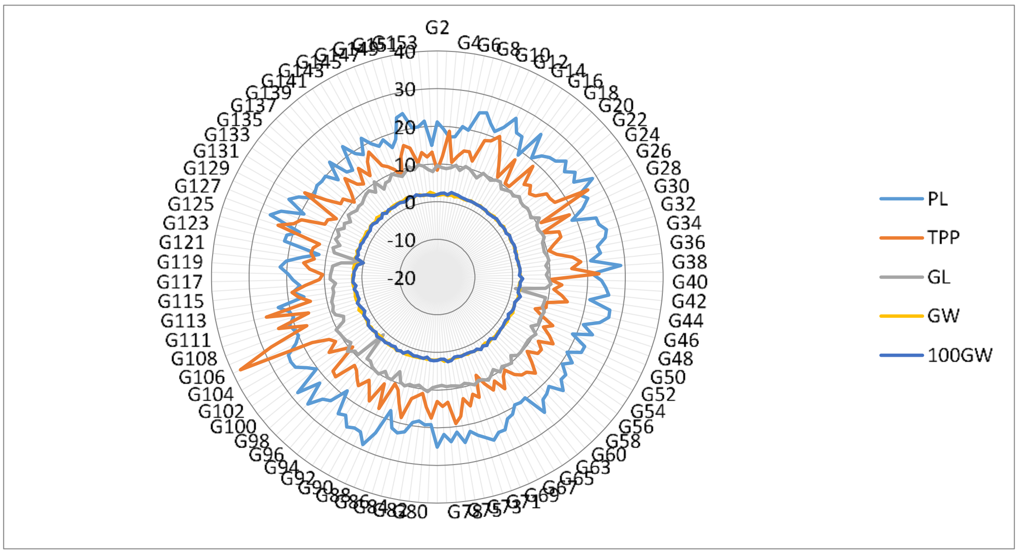

Fig. 2: PL=Panicle length, TPP=Tiller per panicle, GL=Grain length, GW=Grain width, 100GW=Grain weight.

G87 (5.43) as seen in Table 1. Enhancing yield in rice relies significantly on grain size, a pivotal agronomic characteristic. This size is governed by three geometric attributes - grain length, width, and thickness - collectively impacting the rice crop's overall yield (Saha *et al.*, 2019). Analysis of variance for rice grain width is given in Table 2 which shows significant difference among genotypes. The grand mean of the all genotypes is 2.3507 and the correlation of variance of all genotype is 4.86 (Table 2). The mean square value of grain width for all genotypes is 0.02799** (Table 2). Mean comparison of the genotypes exhibit greater mean value of grain width are G83 (2.6233), followed G75 (2.62) and G119 (2.5233). The genotypes exhibited lesser mean value of grain width are G126 (2.19), followed by G118 (2.2) and G145 (2.2) as seen in Table 1. All studied morphological characters such as tiller number, grain per panicle, 100 grain weight, grain length and width showed alteration in the mean value for most genotypes as shown in RADAR graph (Fig. 2).

Correlation

Correlation is a measure of genotypic relationship between characters that indicates which characters are more beneficial. It aids in the identification of characters who are irrelevant to the selecting process. It is vital to investigate the nature of the character's association with grain yield in order to make a good decision (Balasubramanian and Vennila, 2022).

Plant height exerts indirect effects on grain yield through its influence on maturity, the number of filled grains per panicle, and the count of spikelets per panicle. This intricate relationship has been supported by various researchers, with Nithya *et al.* (2020) reporting a positive correlation between plant height and yield. The highly significant correlation observed between panicle length and plant height (0.5341**) is presented in Table 3. Notably, panicle length demonstrates a strong correlation with plant height, with a decrease in plant height directly impacting panicle length. Studies suggest that panicle length wields a pronounced direct influence

Table 3: Correlation analysis for various morphological and agronomic traits in studied rice genotypes

	PH	PL	TPP	GPP	GL	GW	100GW
PH							
PL	0.53**						
TPP	0.13^{ns}	0.01^{ns}					
GPP	0.37**	0.49**	-0.16*				
GL	0.06^{ns}	0.34**	-0.08^{ns}	0.18*			
GW	0.05^{ns}	-0.04^{ns}	0.15^{ns}	0.06^{ns}	0.12^{ns}		
100 GW	-0.002^{ns}	0.15^{ns}	-0.03^{ns}	0.15*	0.26**	0.44**	

PH: Plant height, PL: Panicle length, TPP: Tiller per plant, GPP: Grain per panicle, GL: Grain length, GW: Grain width, 100GW: Grain weight, ns: non- significant , * :significant , **: highly significant .

on grain yield (Nihad *et al*., 2021). Moreover, the positive association between panicle length and grain yield has been corroborated by Yadav *et al.* (2022), indicating that an increase in panicle length corresponds to an enhanced yield potential.

The correlation between tiller number per plant and both plant height (0.1333ns) and panicle length (0.0108ns), as revealed in Table 3, is deemed statistically insignificant. However, Nihad *et al*. (2021) established a positive correlation between rice tiller number and grain yield. Significantly, grain count per panicle exhibits a robust correlation with plant height (0.3708**) and panicle length (0.4913**), while demonstrating a negative correlation with tiller number per plant (-0.1674*), as delineated in Table 3. This relationship has been underscored by several researchers, including Saleh *et al.* (2020), who reported similar positive correlations between grain count per panicle and grain yield. Notably, an increase in the number of grains per panicle is touted to bolster overall yield.

Examining hundred grain weight, a non-significant negative correlation with plant height (-0.002ns) is noted, while non-significant positive correlations are observed with panicle length (0.1534ns) and tiller number per plant (0.0368ns). Nevertheless, a significant positive correlation is evident between hundred grain weight and both grain count per panicle (0.1591*) and grain dimensions such as length (0.2688**) and width (0.4423**), as highlighted in Table 3. Additionally, the indirect positive impact of hundred grain weight through the number of productive tillers per hill has been reported (Das, 2021).

Turning to grain length, a non-significant correlation is noted with plant height (0.0674ns), while a highly significant positive correlation emerges with panicle length (0.3412**). Grain length also exhibits a negative non-significant correlation with tiller number per plant (-0.0842ns) and a significant positive correlation with grain count per panicle (0.1894*), as depicted in Table 3. Arya *et al*. (2020) documented a positive correlation between yield and the count of panicles, filled grains, and hundred grain weight, while observing a significant negative relationship with grain length.

Considering grain width, no significant correlations are established with plant height (0.0513ns), tiller number per plant (0.1566ns), grain count per panicle (0.0619ns), and grain length (0.1272ns). Furthermore, a non-significant negative correlation surfaces with panicle length (-0.0419ns), as outlined in Table 3. According to Li et al. (2018), grain weight is positively associated with grain size, thereby emphasizing the pivotal role of grain size in enhancing rice yield. Notably, grain yield experiences a negative impact from plant height (-0.122), panicle length (-0.099), and grain width (-0.142).

Grain size is also linked to commercial and culinary preferences. Selecting genotypes with larger grains can lead to a significant increase in overall yield and market value (Nithya *et al*., 2020).

Conclusion

In conclusion, the association of morphological traits and grain characteristics has a profound impact on rice yield. Plant height, tillering, panicle length, grains per panicle, grain length, grain width, and grain weight collectively influence the overall yield potential of rice genotypes. The genetic variability within these traits offers a valuable resource for breeders striving to develop high-yielding and adaptable rice varieties. Through careful selection, breeding, and deployment, these traits can be harnessed to address the global challenge of food security and contribute to sustainable agriculture.

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