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Assessment of Character Association of Yield, Yield Attributing Traits and Grain Quality Characters in Rice (*Oryza sativa* L.)

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ABSTRACT

Rice is an important staple crop and improvement of grain yield along with nutritional quality is a major objective in rice breeding programmes. The present investigation was undertaken to study the association among grain yield, yield contributing traits and grain quality parameters in the cross 'Swarna × Madhukar'. Six generations viz., P_1, P_2, F_1, F_2, BC_1 and BC_2 were evaluated during kharif 2012 under irrigated conditions at the Directorate of Rice Research, Hyderabad. Correlation coefficients were estimated to determine the nature and magnitude of association among the studied traits. The analysis revealed considerable variation in trait association patterns. Grain yield per plant exhibited strong positive association with productive tillers per plant, filled grains per panicle, panicle length and test weight, indicating the importance of these traits in yield improvement. Among them, productive tillers per plant showed the highest positive correlation with grain yield. Zinc concentration exhibited favourable association with productive tillers and panicle length, suggesting the possibility of simultaneous improvement of productivity and nutritional quality. In contrast, iron content showed negative association with grain yield and zinc concentration, indicating possible constraints in simultaneous enhancement of micronutrient traits. Grain quality parameters such as kernel length, kernel breadth and length/breadth ratio exhibited relatively weak association with grain yield. The results suggested that productive tillers per plant, filled grains per panicle, panicle length and test weight may serve as reliable selection criteria for developing high-yielding rice genotypes with desirable grain quality and improved zinc concentration.

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INTRODUCTION

Rice is one of the principal food crops of the world and serves as the staple diet for nearly one-third of the global population and about two-thirds of the Indian population. The crop contributes significantly towards food security by providing nearly 43 per cent of the caloric requirement and 20–25 per cent of agricultural income. Approximately 90 per cent of the world's rice is cultivated in Asian countries, highlighting its economic and nutritional importance in the region (Pathak *et al*., 2011). In India, rice occupies a prominent position due to its adaptability to diverse agro-climatic conditions and its vital role in sustaining rural livelihoods and national food security.

Despite substantial improvement in rice productivity, nutritional deficiencies, particularly iron (Fe) and zinc (Zn) malnutrition, continue to pose serious health challenges in developing countries where cereal-based diets predominate. Biofortification has therefore emerged as an effective and sustainable strategy for enhancing micronutrient concentration in rice grains through conventional and molecular breeding approaches (Bouis and Welch, 2010).

Simultaneous improvement of grain yield, grain quality and nutritional traits has become an important objective in modern rice breeding programmes.

Grain yield in rice is a complex quantitative trait governed by several interrelated component characters and environmental factors. Traits such as productive tillers per plant, panicle length, filled grains per panicle and test weight contribute directly or indirectly towards yield improvement. Therefore, knowledge of correlation among yield and its component traits, along with the identification of their direct and indirect effects, is essential for effective selection and genetic improvement in rice (Kashid, N., & Bhor, T. (2020).). Grain quality parameters including kernel length, kernel breadth and length/breadth ratio are also important as they influence consumer preference and market value.

In view of the increasing demand for high-yielding and nutritionally superior rice cultivars, the present investigation was undertaken in the cross 'Swarna × Madhukar' to study the correlation among grain yield, yield contributing traits and grain quality parameters for identifying important selection criteria useful in future rice improvement programmes.

MATERIALS AND METHODS

Experimental Material

The experimental material consisted of six generations derived from the cross 'Swarna × Madhukar', namely P_1, P_2, F_1, F_2, BC_1 and BC_2. Swarna (MTU 7029) is a high-yielding semi-dwarf variety developed from the cross Vasistha × Mahsuri, whereas Madhukar is a traditional genotype possessing desirable grain quality traits. Hybridization was carried out during rabi 2010–2011 at the Directorate of Rice Research (DRR), Hyderabad using the clipping method of emasculation followed by hand pollination. The F_1 plants were selfed to obtain the F_2 generation and backcrossed with both parents to develop BC_1 and BC_2 populations.

Experimental Design and Crop Management

The field experiment was conducted during kharif 2012 under irrigated conditions at the DRR experimental farm, Hyderabad. The experiment was laid out in a randomized complete block design with two replications. Each generation was transplanted in three rows of 3 m length with spacing of 20 cm × 10 cm. Recommended agronomic practices and plant protection measures were followed uniformly. Fertilizers were applied at the rate of 100:60:40 kg $N:P_2O_5:K_2O$ ha^{-1}.

Observations Recorded

Observations were recorded on five randomly selected plants from each replication for plant height, days to 50% flowering, panicle length, productive tillers per plant, filled grains per panicle, grain yield per plant, test weight, kernel length, kernel breadth and length/breadth ratio. Grain iron and zinc contents were estimated using Energy Dispersive X-ray Fluorescence (EDXRF) spectrometry.

Statistical Analysis

Phenotypic and genotypic correlation coefficients were computed as per Al-Jibouri *et al.* (1958). Path coefficient analysis was performed following Wright (1921) and Dewey and Lu (1959) using grain yield per plant as the dependent variable.

Results and Discussion

Correlation Analysis in the Cross 'Swarna × Madhukar'

The estimates of genotypic correlation coefficients revealed considerable variation in the magnitude and direction of association among grain yield, yield contributing traits and grain quality parameters. Since grain yield in Rice is a complex quantitative trait governed by several interrelated characters, understanding these associations is important for formulating effective selection strategies in breeding programmes.

Days to 50% Flowering

Days to 50% flowering exhibited a negative but non-significant association with grain yield per plant (-0.0192), indicating that flowering duration had limited direct influence on productivity in the present cross. This suggested that selection for earliness may not adversely affect grain yield. The trait also showed positive but non-significant association with plant height, panicle length and zinc content, indicating a tendency of relatively late flowering plants to possess better vegetative growth and micronutrient accumulation. Similar observations were reported by Meenakshi *et al.* (1999), Chauhan *et al.* (1993) and Chandra *et al.* (2009).

Plant Height

Plant height recorded significant positive association with productive tillers per plant (0.7867), filled grains per panicle (0.5131) and test weight (0.2823), suggesting that taller plants possessed better growth vigour and reproductive efficiency. The strong positive relationship between plant height and productive tillers indicated that vigorous plants produced more effective tillers, thereby contributing towards improved grain formation. Positive association with test weight further reflected better grain filling ability in taller genotypes.

Although plant height showed only a weak positive correlation with grain yield per plant (0.0771), its favourable association with major yield components indicated an indirect contribution towards yield enhancement. Similar findings were reported by Krishna Naik *et al.* (2005), Krishna Veni and Shobha Rani (2006) and Krishna *et al.* (2008).

Panicle Length

Panicle length exhibited significant positive association with productive tillers per plant, zinc content and grain yield per plant, emphasizing the importance of panicle architecture in determining productivity and nutritional quality. Longer panicles generally accommodate more grains, thereby contributing positively towards yield improvement.

A positive relationship between panicle length and zinc concentration suggested the possibility of simultaneous improvement of panicle traits and grain zinc content. However, panicle length exhibited significant negative association with iron concentration, which may be attributed to differential nutrient partitioning within the plant system. Similar results were reported by Malini *et al.* (2007).

Productive Tillers per Plant

Among the characters studied, productive tillers per plant exhibited the highest positive association with grain yield per plant (0.7867), indicating its major contribution towards productivity. The trait also showed positive association with test weight and zinc concentration, suggesting efficient grain filling and micronutrient accumulation in highly tillering genotypes.

The positive relationship between productive tillers and zinc concentration is particularly important in biofortification breeding, as it indicates the possibility of improving both yield and zinc content simultaneously. However, productive tillers exhibited negative association with length/breadth ratio, indicating a slight influence on grain shape. Similar observations were reported by Anbumalarmathi and Nadarajan (2008) and Krishna *et al.* (2008).

Filled Grains per Panicle

Filled grains per panicle exhibited strong positive association with grain yield per plant, confirming the importance of grain filling efficiency in yield determination. Increased number of filled grains enhances sink strength and ultimately contributes towards higher productivity.

The trait also showed positive association with kernel breadth, indicating that efficient grain filling resulted in comparatively bolder grains. However, a negative association was observed between filled grains per panicle and zinc concentration, suggesting a possible dilution effect in which increased grain number reduced micronutrient concentration per grain. Similar findings were reported by Krishna *et al.* (2008) and Anbumalarmathi and Nadarajan (2008).

Test Weight

Test weight recorded significant positive association with grain yield per plant, indicating the direct contribution of grain weight towards productivity enhancement. Efficient assimilate translocation and better grain development may be responsible for the simultaneous improvement in grain weight and yield. Similar findings were reported by Ekka *et al.* (2011), Padmaja *et al.* (2011) and Anbumalarmathi and Nadarajan (2008).

Kernel Length

Kernel length exhibited positive association with length/breadth ratio and negative association with kernel breadth, indicating that longer kernels contributed towards slender grain shape preferred in premium rice varieties. The trait showed only weak positive association with grain yield per plant, suggesting limited direct influence on productivity. Similar observations were reported by Krishna Veni and Shobha Rani (2006) and Krishna *et al.* (2008).

Kernel Breadth

Kernel breadth exhibited strong negative association with length/breadth ratio, as broader grains reduce grain slenderness. Although the trait showed slight positive association with grain yield per plant, excessive grain breadth may negatively affect grain appearance and market preference. Similar findings were reported by Khatun *et al.* (2003) and Subudhi *et al.* (2007).

Length/Breadth Ratio

Length/breadth ratio exhibited negative but non-significant association with grain yield per plant, indicating that grain shape and productivity may be inherited independently. This suggests the possibility of simultaneous improvement of yield and desirable grain appearance through appropriate selection strategies.

Iron and Zinc Content

Iron content exhibited significant negative association with both zinc concentration and grain yield per plant. The inverse relationship between iron and zinc concentration suggested the presence of possible physiological or genetic constraints governing micronutrient accumulation in rice grains. Similarly, the negative association between iron concentration and grain yield indicated that simultaneous improvement of these traits through direct selection may be difficult. Comparable findings were reported by Nagesh *et al.* (2013).

Recent biofortification studies have also emphasized the complexity involved in enhancing micronutrient concentration without adversely affecting grain yield because of intricate genetic and physiological interactions among traits (Chandel *et al.* 2010). In contrast, zinc concentration exhibited positive association with grain yield, panicle length and productive tillers per plant, indicating the feasibility of developing high-yielding zinc-rich rice genotypes through integrated breeding approaches. Similar observations have been reported in genomics-assisted biofortification programmes aimed at simultaneous improvement of productivity and nutritional quality (Yadav *et al.* 2021).

Overall, the correlation analysis revealed that productive tillers per plant, filled grains per panicle and test weight were the major contributors towards grain yield improvement in the cross 'Swarna × Madhukar'. Positive association of zinc concentration with important yield components indicated the possibility of simultaneous improvement of productivity and nutritional quality through appropriate selection strategies. The observed relationships among agronomic, grain quality and micronutrient traits provide useful information for developing high-yielding and nutritionally enriched rice genotypes in future breeding programmes.

Table 1: Estimates of genotypic correlation coefficients among yield, its contributing characters and grain quality parameters for Swarna X Madhukar

Trait	Days to 50% Flowering	Plant Height	Panicle Length	Productive Tillers/ Plant	Filled Grains	Test Weight	Kernel Length	Kernel Breadth	L/B Ratio	Iron Content	Zinc Content	Yield / Plant
DFF	1.0000	0.0833	0.1072	-0.0349	-0.0171	-0.0310	0.0161	0.0082	0.0055	-0.0211	0.1315	-0.0192
PH		1.0000	0.0617	0.0379	0.0604	0.0152	0.0227	0.0699	-0.0248	-0.1162	-0.1028	0.0771
PL			1.0000	0.1407*	0.0617	0.0883	0.0266	0.0999	-0.0149	-0.2279**	0.1483*	0.1460*
PT				1.0000	0.1095	0.2138**	0.0893	0.1112	0.0288	-0.1673*	0.2588**	0.7867**
FG					1.0000	0.0167	-0.0323	0.2081**	-0.1806*	0.0262	-0.1554*	0.5131**
TW						1.0000	0.0025	0.0572	0.0653	-0.1237	-0.1163	0.2823**
KL							1.0000	-0.4153**	0.4203**	-0.0746	-0.0698	0.0684
KB								1.0000	-0.8086**	0.0321	-0.0425	0.1265
L/B Ratio									1.0000	-0.0866	0.0625	-0.0151
IC										1.0000	-0.1956**	-0.1772*
ZC											1.0000	0.1372

**Significant at 5 per cent level ** Significant at 1 per cent level*

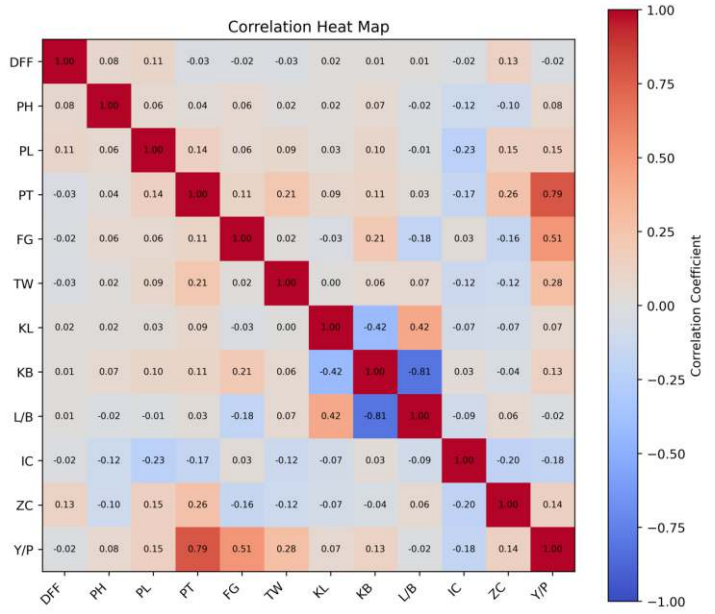

Fig.1: correlation heat map

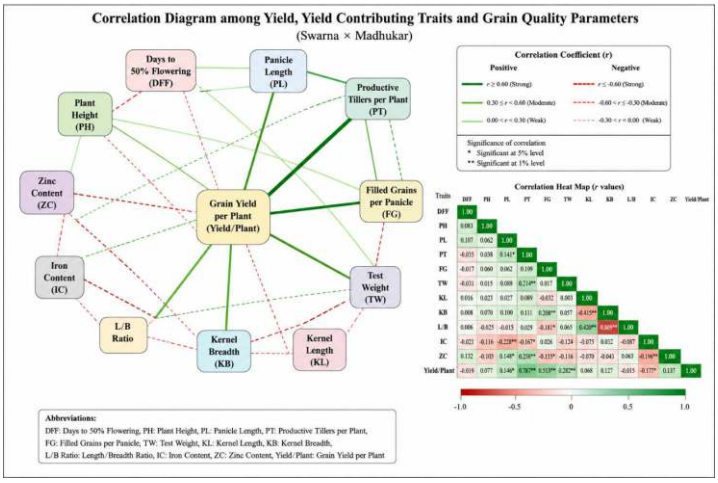

Fig. 2: Correlation Network among Yield, Yield Contributing Traits and Grain Quality Parameters in the Cross 'Swarna × Madhukar'

Conclusion

The present study revealed significant association among grain yield, yield contributing traits and grain quality parameters in the cross 'Swarna × Madhukar'. Productive tillers per plant, filled grains per panicle, panicle length and test weight exhibited positive association with grain yield per plant, indicating their importance in productivity improvement. Among these traits, productive tillers per plant showed the strongest relationship with grain yield.Positive association of zinc concentration with productive tillers and panicle length suggested the possibility of simultaneous improvement of yield and nutritional quality through appropriate selection. In contrast, iron content exhibited negative association with grain yield and zinc concentration, indicating the complexity of micronutrient improvement. Overall, the identified traits may serve as useful selection criteria for developing high-yielding rice genotypes with desirable grain quality and enhanced zinc content.

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