Journal of Physical, Biomedical and Biological Sciences
eISSN: 3005-6489
www.jpbab.com
*J. Phys. Biomed. Biol. Sci., 2024; Volume, **3**: 31*

Original Research Article **Open Access**

EVALUATION OF GENE ACTION IN RICE (*ORYZA SATIVA* L.) FOR MORPHOLOGICAL TRAITS

KALYAR MHM[1*], TABASSUM J[1], ULLAH MA[1], KALYAR MNN[1], SHAH KD[2], ABBAS A[3], REHMAN AU[4]

[1]Department of Plant Breeding and Genetics, Faculty of Agricultural Sciences, University of the Punjab, P.O BOX. 54590, Lahore, Pakistan
[2]Department of Plant Breeding and Genetics, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi, Pakistan
[3]National Nanfan Research Institute (Sanya), Chinese Academy of Agricultural Sciences, Sanya 572024, China
[4]Biotechnology Research Institute, GSCAAS, 100081,Beijing China
**Correspondence author email address: hassaankhanniazi47@gmail.com*

(Received, 17th September 2023, Revised 10th October 2024, Published 23rd October 2024)

Abstract *Rice is an important cereal crop after wheat and maize. To study the combining ability effects of quantitative traits in rice, line × tester (4×3) progeny was generated involving 7 parents; 4 different lines, namely Super Basmati, Basmati 385, Basmati 515 and KSK 133, and 3 well-adapted testers, namely, Basmati 198, PK 386 and KS 282. Super basmati, Basmati 515, Basmati 198, Basmati 385, KSK 133, and PK 386 were found to be effective general combiners that provide excellent segregates for further selection. Basmati 385×KS 282, Super Basmati × KS 282, KSK 133 × PK 386, Super Basmati × PK 386 and Basmati 515 × KS 282 hybrid combinations have higher specific combining ability (SCA) effects on grain yield and its components and can be used to exploit hybrid vigor to increase yields. It was suggested that the genotypes Basmati 385, KS 282, Super Basmati, and PK 386 may be used for the development of high-yielding rice hybrids.*

Keywords*:* *rice; progeny; selection; grain yield; GCA; SCA*

Introduction

Rice (*Oryza sativa* L.) is a key cereal crop that nourishes more than 50% of the population worldwide. As population growth and climate change raise food security concerns, increasing rice production and stability is critical. This is particularly important in regions such as Asia, where agricultural landscapes are dominated by rice cultivation (Khush 2005). Improving rice yield is a difficult challenge due to its polygenic characteristics and multiple yield-influencing factors, such as plant height, panicle length, grain number, and thousand-grain weight (Virmani & Aquino, 1992). To significantly increase rice yields, it is crucial to understand the genetic architecture behind these traits. Traditional breeding methods, while effective to some extent, often fail to exploit the full genetic potential due to their limited ability to analyze complex relationships between genes. Quantitative genetics and biometric methods provide a precise method to assess genetic variation and interactions in rice breeding (Singh & Chaudhary, 1985).

Line × tester analysis focuses on GCA and SCA, including dominance and epistasis (Griffing, 1956). GCA is critical for identifying parents who impart desired traits to their offspring across a broad range of genetic backgrounds, while SCA reveals the unique performance of certain cross combinations. Understanding these genetic characteristics is critical to producing high-yielding rice varieties that are both productive and stable in different environments (Falconer & Mackay, 1996). Selection of superior lines and test items with high GCA and SCA values can help accelerate hybrid rice breeding. These promising parents produce rice hybrids that are superior to standard inbred varieties in terms of yield and resistance to environmental stress (Golden *et al*., 2017), and breeders can select superior parent and hybrid combinations with high hybrid vigor, thereby improving yield and traits (Saravanan *et al*., 2008). This study aimed to identify potential hybrids that can help produce high-yielding and stress-tolerant rice varieties by examining the synergistic abilities of selected parental lines. Given the ongoing difficulties faced by climate change and the growing demand for food, the need for improved varieties is greater than ever (Fageria, 2007). The study hypothesizes that by using this approach, it will be able to provide useful insights into the genetic mechanisms controlling rice productivity, thereby assisting breeding efforts to ensure future food security.

Materials and Methods

This experiment was conducted in the research area of the Department of Plant Breeding and Genetics, Faculty of Agricultural Sciences (FAS) at the University of the Punjab, Lahore during the year 2022-23. The germplasm was composed of super Basmati, Basmati 385, Basmati 515, KSK-133 (females). And the testers Basmati 198, PK 386, and KS-282 (males). The F_1 hybrids were developed by using Lines× Testers (4× 3) design (Kempthorne, 1957). The crosses among line and testers yielded 12 F_1 hybrids. During the first growing season, lines and testers were grown. At the anthesis stage, crossing was done between lines and testers to produce F_1 hybrids. In the following growing season, lines, testers, and hybrids were grown separately and compared based on multiple parameters such as plant height, spikelets/panicle, panicle length, grains yield per plant, and 1000 grains weight. The plant height was measured using a Stadiometer from the base of the stem to the top of the plant. The weight of 1000 grains was also determined by weighing them and calculating the result. The overall grain yield for each plant was also calculated. After calculating all of the factors, GCA and SCA were calculated using an Excel sheet.

After studying several aspects of rice breeding, the results revealed interesting designs and significant improvements to the crop. An important parameter that determines flowering time and maturity, the number of days to reach 50% flowering, showed significant differences between genotypes, parents, and hybrids (Table 1). This suggests that this parameter has considerable genetic influence, allowing plant breeders to select specific flowering times based on environmental conditions. Likewise, plant height and panicle length are important characteristics for yield and lodging resistance, yielding significant results on all parameters (Ali *et al*., 2014ab; Saleem *et al*., 2010). It demonstrates more genetic differences between all parameters, allowing plant breeders to modify plant structure to improve yield and performance. Grain yield per plant is the main characteristic used to calculate total yield varies significantly between genotypes, parental lines, and crosses. This shows that grain yield is influenced by genetics and environment. Plant breeders can focus on selecting superior genotypes and combinations of different parents. They must focus on agronomic measures to increase yields (Kour *et al*., 2019; Saleem *et al*., 2010).

Results and Discussion

Table 1: Mean square values of all parameters of 7 parents and 12 F_2 populations were evaluated by line× tester analysis (4× 3) of Rice during the year 2022-23 at FAS

Source of Variation (SOV)	Days to 50% Flowering	PH (cm)	Spikelets/panicle (no.)	PL (cm)	GY/P (g)	1000 GW (g)
Rep (Replications)	4.895	3.211	0.158	0.684	3.807	1.596
Gen (Genotypes)	148.994*	449.452*	250.780	26.973*	58.885*	25.195
Parents	184.079*	780.603*	393.714	43.857*	67.095*	40.206
Crosses	143.081*	294.270*	184.210	19.515*	45.422*	14.977
P×C	3.530	169.549	125.444	7.699	157.720	47.521
L (Lines)	229.667	672.917	426.620	33.407	85.583	26.250
T (Testers)	425.528	581.861	360.028	53.083	108.694	42.250
L×T	5.639	9.083	4.398	1.380	4.250	0.250
Error	43.173	59.845	45.574	5.138	18.627	6.972

General Combining Ability (GCA)

Table 2 shows the GCA effects of the parents. Regarding grain yield per plant, two lines; Basmati 385 and KSK 133 and one tester PK 386 showed significant and desirable GCA effects, in line with the work of (Mirza *et al*. 2010), who documented several promising rice genotypes with high GCA effects. For panicle length; KSK 133 among lines and PK 386 among testers showed significant and desirable GCA effects. Based on GCA effects, Super Basmati and Basmati 515 among the lines and Basmati 198 among the testers were considered to be good general combiners for reducing plant height, while Basmati 385, KSK 133 and PK 386 are considered to increase grain yield per plant. High GCA effects indicate the presence of beneficial genes with additive genetic effects. As a result, a multiple-crossing program using the good general combiners found in this work is recommended to create superior genotypes, as Nadarajan (2005) suggested.

Table 2. General combining ability effects among lines and testers for various traits were evaluated in 4 × 3 mating design of Rice during the year 2022-23

Parental Genotypes	D 50%F	PH (cm)	Spikelets/panicle (no.)	PL (cm)	GY/P (g)	1000 GW (g)
Lines						
super Basmati	-5.94	-2.47*	-2.53	-0.89	-2.03	-0.92

Basmati 385	-1.94	4.53	2.03	0.67	1.42*	1.08*
Basmati 515	2.17	-10.92*	-7.86	-2.11	-3.03	-1.92
KSK 133	5.72	8.86	8.36	2.33*	3.64*	1.75*
Testers						
Basmati 198	-5.53	-0.31*	0.53	0.33	-0.28	0.08
PK 386	-0.78	7.11	5.19	1.92*	3.14*	1.83*
KS 282	6.31	-6.81	-5.72	-2.25	-2.86	-1.92

Specific Combining Ability (SCA)

Specific combining ability (SCA) effects are presented in Table 3 and none of the hybrids showed significant and desirable SCA effects on all parameters. However, in terms of grain yield per plant, three hybrid combinations; Super Basmati× KS 282, Basmati 385× KS 282, and KSK 133× PK 386 emerged as promising specific combinations due to their SCA effect. These findings are consistent with the high SCA effects observed in several promising specific combiners to increase yield per plant (Bashir *et al*., 2019; Horgan *et al*., 2019; Singh *et al*. 2007). For other traits, different sets of cross-combinations were identified as good specific combinations based on their SCA effects. KSK 133*Basmati 198 and Basmati 385× KS 282 were effective in early flowering, while three combinations; Basmati 515× KS 282, Basmati 385× PK 386, and Super Basmati× PK 386 were found to reduce plant height. As discussed by (Shrivastava and Seshu 1983), these results are consistent with the identification of top-specific combiners of shorter plant heights.

Table 3. SCA of hybrids for all parameters

F_2 Population	Days to 50% Flowering	Plant Height (cm)	Spikelets per panicle (no.)	Panicle length (cm)	Grain Yield/Plant (g)	1000 Grains Weight (g)
super Basmati × Basmati 198	-0.14	-0.03	-0.03	-0.11	0.94*	-0.08
super Basmati × PK 386	-1.22	-1.44*	0.00	-0.36	-1.47	0.17
super Basmati × KS 282	1.36	1.47	0.03	0.47	0.53*	-0.08
Basmati 385× Basmati 198	1.53	0.31	0.03	0.33	-1.17	-0.08
Basmati 385× PK 386	-0.22	-1.44*	0.04	0.75	0.08	0.17
Basmati 385× KS 282	-1.31*	1.14	-0.07	-1.08	1.08*	-0.08
Basmati 515× Basmati 198	0.08	-0.25	0.00	0.11	0.28	-0.08
Basmati 515× PK 386	0.33	2.33	-0.02	-0.47	0.86*	0.17
Basmati 515× KS 282	-0.42	-2.08*	0.02	0.36	-1.14	-0.08
KSK 133× Basmati 198	-1.47*	-0.03	0.00	-0.33	-0.06	0.25
KSK 133× PK 386	1.11	0.56	-0.02	0.08	0.53	-0.50
KSK 133× KS 282	0.36	-0.53	0.02	0.25	-0.47	0.25

Conclusion

The study concluded that both additive and dominant gene action played an important role in the inheritance of most traits. Super Basmati, Basmati 515, Basmati 198, Basmati 385, KSK 133 and PK 386 were found to be strong general combiners. Furthermore, the hybrid combinations; Basmati 385×KS 282, Super Basmati × KS 282, KSK 133 × PK 386, Super Basmati × PK 386 and Basmati 515 × KS 282 gave higher grain yield.

References

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

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

Bashir, K., Matsui, A., Rasheed, S., Seki, M., & Nishizawa, N. K. (2019). Transcriptomic analysis of rice in response to iron deficiency and excess. Rice, **12**(1), 1-14.

Fageria, N. K. (2007). Yield physiology of rice. Journal of Plant Nutrition, **30**(6), 843-879.

Falconer, D. S., & Mackay, T. F. C. (1996). Introduction to Quantitative Genetics (4th ed.). Longman.

Golden, B. R., Lawrence, B. H., Bond, J. A., Edwards, H. M., & Walker, T. W. (2017). Clomazone and starter nitrogen fertilizer effects on growth and yield of hybrid and inbred rice cultivars. *Weed Technology*, **31**(2), 207-216.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Australian Journal of Biological Sciences, **9**(4), 463-493.

Horgan, F. G., Ramal, A. F., Villegas, J. M., & Bernal, C. C. (2019). Genetic manipulation of resistance in rice against herbivorous pests: Potential and challenges. Pest Management Science, **75**(6), 1449-1467.

Kempthorne, O. (1957). An Introduction to Genetic Statistics. John Wiley & Sons.

Khush, G. S. (2005). What it will take to feed 5.0 billion rice consumers in 2030. *Plant Molecular Biology*, **59**(1), 1-6.

Kour, A., Kumar, B., & Singh, B. (2019). Genetic evaluation of yield and yield attributing traits in rice (Oryza sativa L.) using line x tester analysis. *Electronic Journal of Plant Breeding*, **10**(1), 39-46.

Mishra, L. K., & Verma, O. P. (2002). Combining ability for yield and yield contributing characters in rice (Oryza sativa L.). *Indian Journal of Agricultural Sciences*, **72**(9), 544-547.

Nadarajan, N. (2005). *Quantitative genetics and biometrical techniques in plant breeding*. Kalyani Publishers.

Nguyen, H. T., & Ferrero, A. (2006). Meeting the challenges of global rice production. *Paddy and Water Environment*, **4**(1), 1-9.

Saleem, M. Y., Mirza, J. I., & Haq, M. A. (2010). Combining ability analysis for yield and related traits in basmati rice (Oryza sativa L.). *Pak. J. Bot*, **42**(1), 627-637.

Saravanan, K., Robin, S., & Raveendran, M. (2008). Genetic evaluation of yield and yield components using Line × Tester analysis in rice. *Journal of Agricultural Science*, **146**(1), 25-33.

Shrivastava, M. N., & Seshu, D. V. (1983). Combining Ability for Yield and Associated Characters in Rice 1. *Crop Science*, **23**(4), 741-744.

Singh, N. K., Kumar, A., & Kumar, R. (2007). Combining ability for yield and yield components in rice. *ORYZA-An International Journal on Rice*, **44**(2), 156-159.

Singh, R. K., & Chaudhary, B. D. (1985). Biometrical methods in quantitative genetic analysis. Kalyani Publishers.

Virmani, S. S., & Aquino, R. C. (1992). Genetic analysis of hybrid rice breeding: Combining ability. *Theoretical and Applied Genetics*, **84**(6), 717-723.

Declaration

Acknowledgement

Not applicable

Conflict of interest

There is no conflict of interest among the authors.

Data Availability statement

All authenticated data have been included in the manuscript.

Ethics approval and consent to participate

These aspects are not applicable in this paper.

Consent for publication

Not applicable

Funding

There were no sources providing support, for this paper.