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Original Research Article

DISSECTING THE ROLE OF MAJOR YIELD CONTRIBUTING TRAITS IN FINAL YIELD POTENTIAL IN RICE HYBRID

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Abstract *Rice is the second most important crop which feeds almost half of the population on this globe. It is widely cultivated in all parts of the world and has special importance in Asia and Africa. Currently, all agronomic crops including rice are being affected adversely by changes induced by global warming in almost all parts of the world. There is a need to find new ways to tackle these door-threatening issues which will complex the situation further soon. Genetic improvements in plants with better trait profiles for high yields and resilience towards climatic conditions offer a flexible and permanent solution in such situations. This study was carried out at Rice Research Institute, Kala Shah Kaku to dissect the contributing role of some major plant traits like no of tillers per plant, no of grains per panicle, and grain weight in rice hybrid plant yield. Results showed that all these traits add their part positively to the final yield potential in such a way that no of tillers per plant comes at 1st with an optimum value of 15 tillers per plant. It has its yield-enhancing role individually as well as collectively with two other traits. Grain number per panicle boosted yield in rice hybrids when fixed at 186 while thousand-grain weight with a value of 30 g was the best option to increase yield and productivity in rice. Negative individual coefficients of all these traits were estimated while positive coefficients with a high contribution towards yield were observed for combined effects of tillers per plant along with no of grains per panicle and grain weight. These findings will assist the researcher in the selection of criteria crops especially improvements in rice hybrids.*

Keywords*:* *Rice hybrid; Yield Contributing Traits; Yield Improvement; Productivity; Hybrid Technology*

Introduction

The agricultural productivity is significantly influenced by the climate. Several plant species are temperature-sensitive, and research has shown that crops and agriculture are adversely affected by increasing global temperatures (Appiah et al., 2018; Asumadu-Sarkodie & Owusu, 2017). Pakistan's agriculture was seriously impacted by weather changes in 2011, following its designation as the world's most afflicted country by climate-related disasters in 2010 (Ahmed et al., 2016; Ali et al., 2017). The yield of rice is anticipated to be affected by the changes in temperature, carbon dioxide levels, and rainfall that are a result of global warming. The detrimental effects of extreme weather serve as a sharp reminder of the speed at which climate change is affecting rice production systems and food security.

Rice cultivation occupies the majority of Pakistan's cultivated land, with Basmati and IRRI varieties comprising approximately 11% of the total. Conversely, Sindh and Punjab provinces in Pakistan are responsible for the cultivation of approximately 90% of the crop. Rice is considered a fundamental sustenance in indigenous populations and a significant source of foreign exchange revenue. The majority of the country's rice is exported to Afghanistan, Iran, Saudi Arabia, and the United Arab Emirates (Chandio et al., 2019).

The selection of naturally occurring variations is the foundation of plant breeding (Liang et al., 2021).

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Approximately 10,000 years ago, beneficial genes were introduced into rice plants through artificial or spontaneous crossings, resulting in a continuous improvement of their characteristics (Saini et al., 2020). The systematic plant breeding theories, which were based on contemporary Mendelian genetics, were widely adopted in the previous century. The issue with this strategy is that the processes regulating genetic control of quantitative traits, such as crop yield, are rarely understood or used, although we can partially regulate the resulting phenotypes. The increased emphasis on genetic dissection of quantitative traits over the past decade has led to the emergence of a new paradigm in plant genetics (Bernardo, 2020). The idea behind the concept was to gain a better understanding of the genetic basis of many "quantitative traits" that were observed in cultivated plants and seemed to vary throughout varieties, such as crop yield. The objective of the current study was to dissect the contributing role of some major plant traits like no of tillers per plant, no of grains per panicle, and grain weight in rice hybrid plant yield.

Material and methods

This study was conducted at the Rice Research Institute, Kala Shah Kaku where One thirty (130) rice hybrids were planted under national uniform hybrid rice yield trials to check their performance. During the rice season, the seed rice hybrids were sown on raised wet beds on 10th June, 2023. The rice season nursery was transplanted in the other with planting geometry having 5.5-meter row length, 20 cm plant to plant, and row to row distance. All time-to-time agronomic practices regarding plant nutrition and protection measures were adopted accordingly. Proper gap filling, rouging, and fertilizer application plan at standardized rate N:P: K @ 177:85:62 opted subsequently. 1/3 of nitrogen was applied at the time of transplanting whereas 2nd and 3rd dose nitrogen were applied after 25 and 45 days of transplantation. Pre-emergence weedicide like machete @ 800 ml /acre was applied after 4 days of transplantation, Zinc Sulphate 33% @ 5 kg/ acre after 12 days of transplantation, granular application (2 doses of cartap @ 9 kg per acre) was performed as per recommendation. Proper water management practices were also adopted as per recommendations for healthy crop stands. Data related to plant and yield traits like PH: Plant height (cm), NTPP: No. of tillers Per Plant, PL: Panicle Length (cm), NGPP: No. of Grains Per Panicle, GW: Grain weight (g), GY: Grain Yield (kg / ha), MD: Maturity Days (No.), DTF: Day to Flowering (No.) was taken at maturity.

Results

One thirty (130) rice hybrids were planted under national uniform hybrid rice yield trials at the rice research institute, Kala Shah Kaku. Evaluation regarding different plant and yield traits was performed at each specific stage of the rice plant. Maximum and minimum data values of the mentioned traits of these 130 rice hybrids are given in Table 1 along with six (6) clusters from C1 to C6 according to their yield performance. Cluster 1 shared the highest values for NTPP (12.5), NGPP (168.6), GW (0.026), and GY (7260 kg / ha) while Cluster 6 is with lowest values. Plant height ranged from 93 to 137 cm, No. of tillers Per Plant from 5 to 19, Panicle Length from 13 to 31, No. of Grains Per Panicle from 77 to 269, maturity days between 119 to 145, and flowering time from 89 to 115 days while maximum and minimum grain yield was recorded for these rice hybrids as 7768 and 3471 kg / ha.

Table 1. Trait description and categorization of rice hybrids according to their yield potential

Hybrid Cluster	No. of hybrids	PH	NTPP	PL	NGPP	GW	GY	MD	DTF
C1: Rice hybrids > 7 t/hac	12	126.39	12.57	26.65	168.63	0.0261	7260.62	127.81	97.81
C2: Rice hybrids = 6.5 - 7 t/hac	18	122.56	11.62	26.14	149.94	0.0251	6696.85	126.83	96.83
C3: Rice hybrids = 6 - 6.5 t/hac	36	123.35	10.74	25.76	160.49	0.0252	6263.04	125.77	95.77
C4: Rice hybrids = 5.5 - 6 t/hac	32	121.54	10.30	25.13	144.55	0.0243	5756.06	125.10	95.10
C5: Rice hybrids = 5 - 5.5 t/hac	19	123.09	9.73	25.89	155.50	0.0250	5254.78	125.19	95.19
C6: Rice hybrids < 5 t/hac	13	115.74	10.52	25.62	142.94	0.0226	4551.86	126.38	96.38
Overall Maximum		137.67	19.63	31.50	269.55	0.0332	7768.06	145.00	115.00
Overall Minimum		93.33	5.08	13.67	77.33	0.0168	3471.23	119.67	89.67

PH: Plant height (cm), NTPP: No. of tillers Per Plant, PL: Panicle Length, NGPP: No. of Grains Per Panicle, GW: Grain weight, GY: Grain Yield, MD: Maturity Days, DTF: Day to Flowering

Linear modal of regression was applied to data of these hybrids to estimate the contributing performance of three main yield deciding factors; No. of tillers Per Plant, No. of Grains Per Panicle, and Grain weight. Analysis of variance (ANOVA) for their individual and interactive effects on final yield was performed and significance was assessed through P value (Table 2). It was observed that each of the three traits affected the final grain yield of rice hybrids significantly individually and also in association. The combined effect of No. of tillers Per Plant with No. of Grains Per Panicle andGrain,

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weight showed significant contributions to the yield estimation of rice plants.

Table 2. ANOVA for yield contributing traits and their interective effects of grain yield of rice hybrids

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
NTPP	1	31985889	31985888.7	38.846449	0.0000000
NGPP	1	23455264	23455263.7	28.486115	0.0000002
GW	1	34469262	34469262.3	41.862474	0.0000000
NTPP:NGPP	1	20893202	20893201.6	25.374524	0.0000007
NTPP:GW	1	14056565	14056565.1	17.071517	0.0000443
NGPP:GW	1	2921396	2921395.7	3.547997	0.0603767
NTPP:NGPP:GW	1	1250440	1250440.2	1.518643	0.2185828
Residuals	382	314536072	823392.9	NA	NA

The coefficient of these variation-causing agents (NTPP, NGPP, GW, NTPP.NGPP, and NTPP.GW) were estimated and illustrated in Table 3. negative sign with coefficients of each factor (NTPP, NGPP, GW) indicated that there might be reverse contribution when these traits were improved solely. Only coefficients of combined effects were impacting yield potential positively and that shows the importance of trait pyramiding to achieve higher yield. No. of tillers Per Plant emerged as a key trait and imparted a very positive impact in association with NGPP and GW. All individual and combined estimates were highly significant.

Table 3. Coefficients of variation of for final yield of rice hybrids through contributing traits and their interection

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	9.822924e+03	1.754074e+03	5.600062	0.0000000
NTPP	-6.415675e+02	1.426256e+02	-4.498262	0.0000091
NGPP	-1.188170e+01	4.039107e+00	-2.941665	0.0034624
GW	-1.649924e+05	6.407741e+04	-2.574891	0.0104007
NTPP:NGPP	1.840224e+00	3.614273e-01	5.091548	0.0000006
NTPP:GW	2.259037e+04	5.489271e+03	4.115369	0.0000473

The progression pattern of GY of all entries (rice hybrids) in the replicated trial was sketched in Figure 1 along with No. of tillers Per Plant with No. of Grains Per Panicle and Grain weight. Grain yield approached a maximum of 200 mounds/ acre with the lowest value at 77 mounds/ acre. All the other yield contributing factors showed a scattered response when their progression was drawn on grain yield inclination.

The individual effect of the number of tillers per plant on the regression line for grain yield was estimated and depicted in Figure 2. The maximum number of tillers per plant was determined at the peak of the regression line and it was 15 tillers per plant up to which grain yield increased and the maximum yield was 6368 kg/ha. Afterward, there was a decline in yield in rice hybrids. Error margin squeezed around 15 tillers per plant and then opened up which indicated the unsustainability of tillers-dependent yield potential in rice hybrids.

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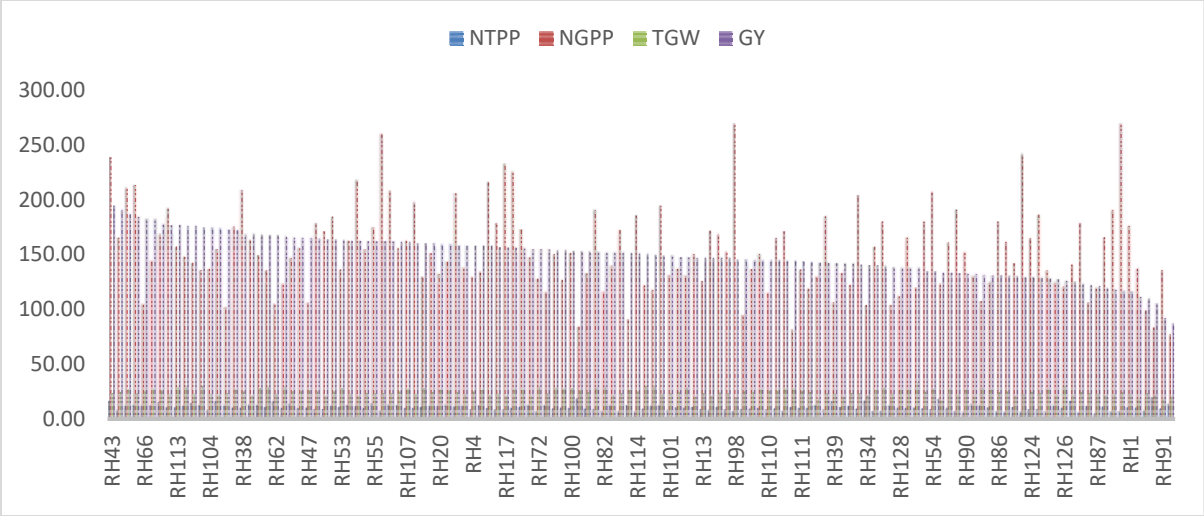

Figure 1. Progression of grain yield and other yield contributing traits of rice hybrids

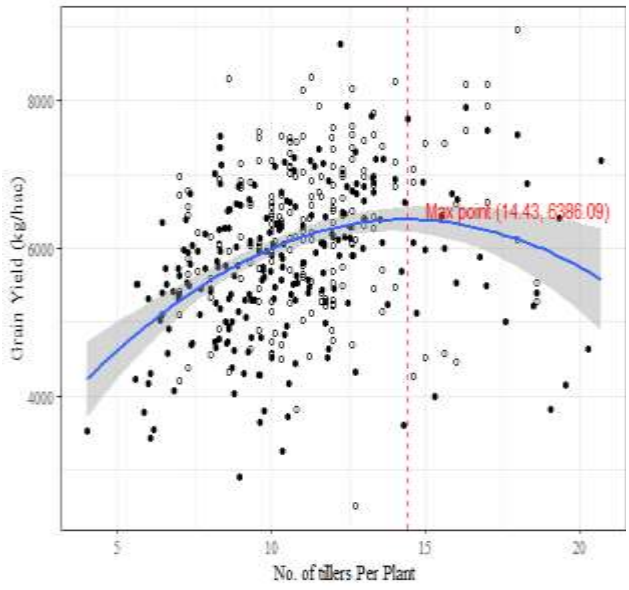

Figure 2. Effect of No. of tillers Per Plant on final Grain Yield in rice hybrids

The individual effect of the number of no. of grains per panicle through regressing the grain yield was estimated and depicted in Figure 3. Maximum of No. of grains per panicle were determined at the peak of the regression line and it was 186 grains per panicle up to which grain yield increased and maximum yield this was 6235 kg/ha. Afterward, there was a decline in yield in rice hybrids. Error margin squeezed around 186 tillers per plant and then opened up which indicated the unsustainability of grain-dependent yield potential in rice hybrids.

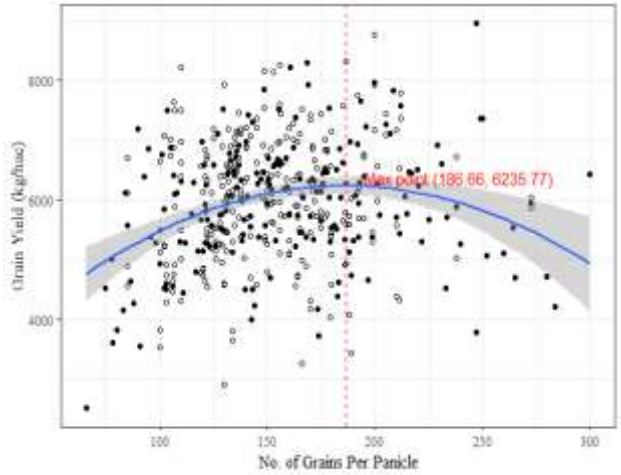

Figure 3. Effect of No. of Grains Per Panicle on final Grain Yield in rice hybrids

The individual effect of the number grain weight through regressing the grain yield was estimated and depicted in Figure 4. Maximum grain weight was computed at the peak of the regression line and it was 0.030 g up to which grain yield increased and maximum yield was 6160 kg/hac and there was a decline of yield in rice hybrids afterward.

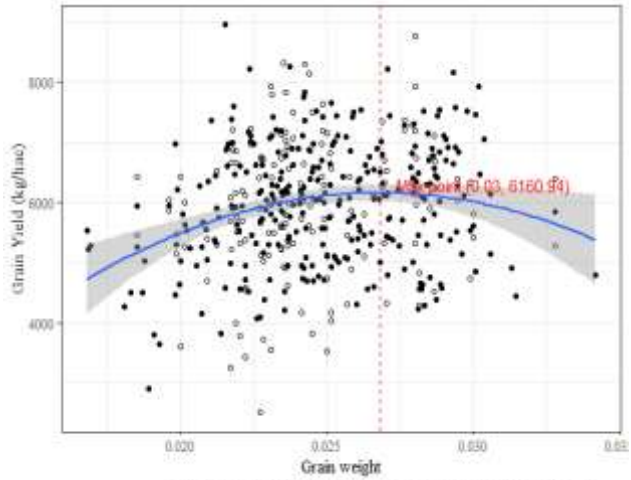

Figure 4. Effect of Grain weight on final Grain Yield in rice hybrids

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The combined effect of the number of tillers per plant in association with no. of grains per panicle on grain yield was computed and depicted in Figure 5. The combined effect of both of these factors has a very positive impact as indicated in the figure where the upward steep incline of the regression line goes up to the end where outliers alone. Maximum grain weight was computed at the peak of the regression line and it was 4653 grains per plant up to this grain yield increased and the maximum yield was 7469 kg/ha which was quite close to the maximum value of this trial.

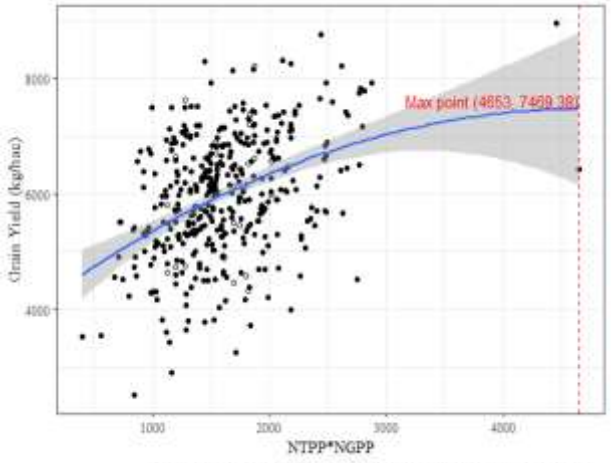

Figure 5. Effect of NTPP*NGPP on final Grain Yield in rice hybrids

The combined effect of the number of tillers per plant in association with grain weight on grain yield was computed and depicted in Figure 6. The combined effect of both of these factors has also a high impact as indicated in the figure where the upward incline of the regression line goes up to the end of the data. Maximum grain weight was computed at the peak of the regression line and it was 0.49 g per plant up to this grain yield increased and the maximum yield was 6718 kg/ha.

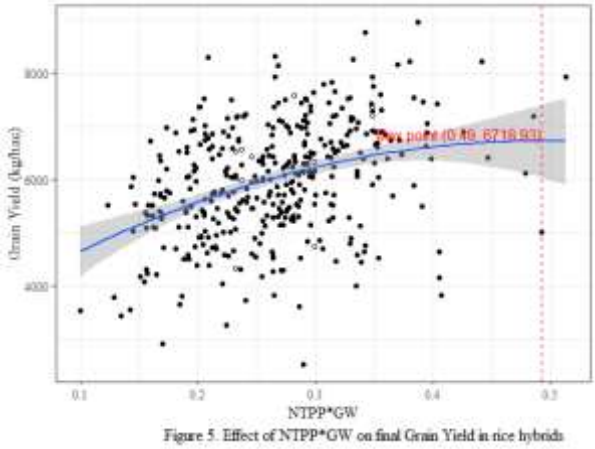

Figure 5. Effect of NTPP*GW on final Grain Yield in rice hybrids

Discussion

In plant breeding, high yielding ability of a genotype entails its genetic superiority in various plant characteristics which are specifically characterized as yield and its contributing traits (Gaballahet al., 2022). These yield-contributing characters interact with each other in a highly specified and correlated manner throughout the growing season; while each of them pours its final contribution in the form of yield (Sarker, 2020). In the present study, higher estimates of various growth and yield-related attributes showed an increase in paddy yield in a diverse panel of rice hybrids. Akbar et al., (2021) identified various yield-contributing traits in rice i.e., the number of productive tillers/plants and 1000 grain weight being the chief cause of high yielding ability in certain rice genotypes. Therefore, breeding for high-yielding varieties in rice primarily focuses on indirect selection for various growth characteristics i.e., number of tillers/plants, number of grains per panicle 1000 grain weight etc.

The tillering ability of a rice genotype is a complex genetic character that greatly influences paddy yield (Srimathi and Subramanian, 2022). In the present study, higher estimates of the number of tillers per plant were observed in certain evaluated rice hybrids showcasing the chief cause of high yield. Similarly, Huang et al. (2020) also identified the number of primary tillers per plant as the major contributor (50%) to the final yield in rice. In addition to this, higher estimates for the number of filled grains per panicle and 1000-grain weight further strengthen the selection criteria for high-yielding rice genotypes (Mai et al., 2021). The higher number of filled spikelets per panicle also depicts the resilience of the evaluated genotypes against various abiotic stressors i.e., heat, drought, and salinity stresses, thus providing additional information about climate resiliency (Wu et al., 2021). In the present study, higher estimates for the number of filled spikelets per panicle along with 1000 grain weight were observed in certain high-yielding rice genotypes. It further uncovered a strong association of these independent variables with the paddy yield thus providing basic criteria for selecting high-yielding cultivars.

References

Ahmed, A., Devadason, E. S., & Al-Amin, A. Q. (2016). Implications of climate change damage for agriculture: sectoral evidence from Pakistan. *Environmental science and pollution research* ***23***, 20688-20699.

Akbar, M. R., Purwoko, B. S., Dewi, I. S., Suwarno, W. B., Sugiyanta, S., & Anshori, M. F. (2021). Agronomic and yield selection of doubled haploid lines of rainfed lowland rice in advanced yield trials. *Biodiversitas Journal of Biological Diversity* **22**.

Ali, S., Liu, Y., Ishaq, M., Shah, T., Abdullah, Ilyas, A., & Din, I. U. (2017). Climate change and its impact on the yield of major food crops: Evidence from Pakistan. *Foods* ***6***, 39.

[Citation: Javed, H.M., Ijaz, M., Sabar, M., Khan, S.U., Shamim, F., Khan, N.H., Aziz, S., Arif M., Khaliq, A., Aslam, M., Ahmad, M.I., Akber, A.R. (2024). Dissecting the role of major yield contributing traits in final yield potential in rice hybrid. *Biol. Clin. Sci. Res. J.*, **2024***:* 851. doi: https://doi.org/10.54112/bcsrj.v2024i1.851]

Appiah, K., Du, J., & Poku, J. (2018). Causal relationship between agricultural production and carbon dioxide emissions in selected emerging economies. *Environmental science and pollution research **25***, 24764-24777.

Asumadu-Sarkodie, S., & Owusu, P. A. (2017). The causal nexus between carbon dioxide emissions and agricultural ecosystem—an econometric approach. *Environmental science and pollution research **24***, 1608-1618.

Bernardo, R. (2020). Reinventing quantitative genetics for plant breeding: something old, something new, something borrowed, something BLUE. *Heredity **125***, 375-385.

Chandio, A. A., Jiang, Y., Gessesse, A. T., & Dunya, R. (2019). The nexus of agricultural credit, farm size and technical efficiency in Sindh, Pakistan: A stochastic production frontier approach. *Journal of the Saudi Society of Agricultural Sciences **18***, 348-354.

Gaballah, M. M., Attia, K. A., Ghoneim, A. M., Khan, N., El-Ezz, A. F., Yang, B., ... & Al-Doss, A. A. (2022). Assessment of genetic parameters and gene action associated with heterosis for enhancing yield characters in novel hybrid rice parental lines. *Plants* **11**, 266.

Huang, M., Shan, S., Cao, J., Fang, S., Tian, A., Liu, Y., ... & Zou, Y. (2020). Primary-tiller panicle number is critical to achieving high grain yields in machine-transplanted hybrid rice. *Scientific Reports* **10**, 2811.

Liang, Y., Liu, H.-J., Yan, J., & Tian, F. (2021). Natural variation in crops: realized understanding, continuing promise. *Annual review of plant biology **72***, 357-385.

Mai, W., Abliz, B., & Xue, X. (2021). Increased number of spikelets per panicle is the main factor in higher yield of transplanted vs. Direct-seeded rice. *Agronomy* **11**, 2479.

Saini, P., Saini, P., Kaur, J. J., Francies, R. M., Gani, M., Rajendra, A. A., Negi, N., Jagtap, A., Kadam, A., & Singh, C. (2020). Molecular approaches for harvesting natural diversity for crop improvement. *Rediscovery of genetic and genomic resources for future food security*, 67-169.

Sarker, U. (2020). Variability, heritability, character association, and path coefficient analysis in advanced breeding lines of rice (Oryza sativa L.). *Genetika* **52**, 711-726.

Srimathi, K., & Subramanian, E. (2022). Evaluation of tillering behaviour and yielding ability of different rice varieties under unpuddled conditions. *Current Journal of Applied Science and Technology* **41,** 26-32.

Wu, C., Cui, K., Li, Q., Li, L., Wang, W., Hu, Q., ... & Peng, S. (2021). Estimating the yield stability of heat-tolerant rice genotypes under various heat conditions across reproductive stages: a 5-year case study. *Scientific Reports* **11**, 13604.

Declaration

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

The study was approved by authors.

Funding Statement

Not applicable

Conflict of Interest

There is no conflict of interest among the authors regarding this case study.

Authors Contribution

Javed HM, Ijaz M and Sabar M conducted this research work and all other authors assisted in writeup, data analysis, revision, editing and proof reading equally.