Genetic Analysis of Grain Yield and its Associated traits in Rice (*Oryza sativa* L.)

ABSTRACT

In this current study, a comprehensive examination of 72 distinct rice genotypes from the Germplasm collection was conducted. Notable checks, Sarjoo-52, NDR-2065, and MTU-7029, exhibited a broad spectrum of variations in multiple traits during the kharif season of 2022. The assessment, conducted at CRS Masodha of Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya, (U.P.). The parameters under scrutiny included days to 50% flowering, days to maturity, plant height, panicle length, number of productive tillers per plant, flag leaf area, fertile spikelets per panicle, spikelet fertility percentage per panicle, biological yield, harvest index, 1000-grain weight, and grain yield. The resulting data were utilized for mean estimation, range determination, least significant differences, correlation analysis, path-coefficients, and genetic divergence exploration. Remarkably, the genotype Lajkulired (53.30), followed closely by Pancham (45.963) and Lakrawa (44.540), demonstrated the highest grain yield per plant. These particular lines showcase promising potential as parental candidates in hybridization programs aiming for the development of high-yielding rice varieties. The association between grain yield per plant, biological yield per plant, and the number of productive tillers per plant was notably strong. Path analysis highlighted biological yield per plant and harvest index as major contributors directly influencing grain yield per plant. Additionally, flag leaf area (cm2), panicle length (cm), and the number of productive tillers per plant emerged as crucial indirect yield components associated with biological yield.

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Keywords: Genetic variability, path analysis, correlation analysis, heritability, rice

Introduction

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Rice, scientifically known as *Oryza sativa* L., stands as a paramount global sustenance, feeding approximately 40% of the world's populace. The pivotal role of rice is especially pronounced in underdeveloped nations, where around 90% of its cultivation and consumption occurs. Archaeological traces of Indian rice cultivation trace back to 1500-1000BC, unveiling its historical significance. Although 42 countries contribute to rice production globally, the primary epicenters are unmistakably China and India. The versatile growth of rice spans varied agro-climatic conditions, from elevated terrains to lowland deltas, covering latitudes from 53°N to 35°S. A staggering 60% of dietary intake in South-East Asia and approximately 35% in East and South Asia is derived from rice. Nations like Bangladesh, Cambodia, Indonesia, Laos, Myanmar, Thailand, and Vietnam exhibit the highest per capita rice consumption, emphasizing its cultural centrality **(Kenneth and Kriemhild, 2000)**. Over the past half-century, the global rice area expanded by 1.37 times, while yield soared threefold and productivity surged 2.3 times. Notably, China stands as the foremost rice producer, generating nearly 125 mt, closely followed by India, contributing a quarter of Asia's total production **(Moya *et al.*, 2004)**. The effectiveness of future rice improvement programs hinges on the judicious use of diverse germplasm from across the globe **(Gomez-Galera *et al.*, 2010)**. As we face constraints such as land and water scarcity, climate changes, urbanization, and population growth **(Couch *et al.*, 2012)**. In the context of Indian agriculture, rice plays a pivotal role, serving as the staple food for over 70% of the nation's population and more than half of the global populace. India's notable rice production has propelled it to the status of the fourth-largest rice exporter globally **(World meters, 2020)**. West Bengal, aptly known as the "rice bowl of India," emerges as the leading rice producer in the country, solidifying its position in international trade. As we navigate the intricate web of agriculture and sustenance, rice remains a linchpin in our global food landscape **(FAOSTAT, 2020)**.

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Materials and Methods

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The study aimed to scrutinize 72 rice germplasm, alongside three benchmark varieties—Sarjoo-52, MTU-7029, and NDR-2065—within an Augmented Block Design at Crop Research Station Masodha, Ayodhya. This diverse set of genotypes exhibited a rich tapestry of variations in various agronomical and morphological traits. The experimental field was divided into 8

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blocks, each housing 12 plots. Within each block, 9 genotypes and 3 checks found their place. The plots, organized into three rows of 3 m length, maintained a spacing of 10 cm between plants and 20 cm between rows. Adhering to recommended cultural practices, the aim was to cultivate a robust and normal crop. Data collection encompassed key parameters such as days to 50% flowering, days to maturity, plant height (cm), number of productive tillers per plant, panicle length (cm), flag leaf area (cm2), number of fertile spikelets per panicle, spikelet fertility (%), biological yield per plant (g), harvest index (%), 1000-grain weight (g), and grain yield per plant (g). The analysis of variance, following **Federer (1956),** scrutinized diverse traits in the augmented design. Variability estimation for different characters aligned with **Burton and de Vane's (1953)** guidelines**.** Broad-sense heritability (h2) employed **Hanson *et al*.**'s formula **(1956),** while the expected genetic advance (GA) relied on **Johnson *et al*.**'s formula **(1955).** Correlations between characters were assessed in line with **Searle's (1961)** methodology**.** Path coefficient analysis following **Dewey and Lu's (1959)** **approach** unveiled insights into the intricate relationships.

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Results and Discussion

Analysis of variance (Table 2) unfolds the distinctive outcomes derived from the scrutiny of augmented design, encompassing all 12-character traits. Significance echoes through the variation attributed to blocks, with marked or highly significant implications for all the characters examined, except for 1000-economic weight, where the mean squares took a non-significant stance. Notably, the panorama of check varieties reveals a tapestry of significance, with pronounced or highly significant disparities across all scrutinized characters—except in the realm of Spikelet fertility (%), where the mean squares tread the path of non-significance. This exploration sheds light on the intricate interplay of variables, unveiling a nuanced spectrum of statistical significance. Also, the similar finding, Analysis of variance revealed that wide range of variability was observed among 36 genotypes of rice for all the traits except number of productive tillers per m^2 under study **(Sreedhar et al. 2017)**. The present investigation was carried out to study genetic variability in sixty-four low land rice genotypes for twelve traits. Analysis of variance (ANOVA) revealed significant differences among the genotypes for all the studied characteristics **(Dey et al. 2019)**.

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Estimation of Genetic variability, heritability and genetic advance exploring the heritability and genetic advancements in the realm of twelve distinct characters, a captivating landscape of genetic dynamics emerges. Noteworthy instances of broad-sense heritability exceeding 70% were witnessed in Fertile Spikelets per panicle (97.57), Biological yield per plant (94.97 g), and 1000-grain weight (92.29 g). Conversely, characters such as Panicle length (25.55 cm) and Number of productive tillers/plant (02.28) displayed a comparatively lower heritability, lingering below the 50% mark. Venturing into the realm of genetic advancement, striking instances of significant progress exceeding 15% unfolded in Biological yield per plant (g). On the flip side modest strides, falling below the 15% benchmark characterized Harvest index % (11.98) and Days to 50% flowering (10.82). This nuanced exploration delves into the genetic intricacies shaping these traits, underscoring the varying degrees of their responsiveness to selective pressures. In a broader context, the phenotypic coefficient of variation showcased a tendency to outpace its genotypic counterpart for all characters, with conspicuous disparities surpassing 20%. Notable instances include Biological yield per plant (29.32g) for GCV and (30.08g) for PCV, as well as Grain yield per plant (28.60) for GCV and (31.29) for PCV. In the middle ground, characters like 1000-grain weight (g) exhibited a moderate estimate (10-20%) for both GCV (12.42) and PCV (12.93). This intricate dance of genetic and phenotypic variations adds depth to our understanding of the diverse traits under scrutiny. The same results found that, high to moderate phenotypic and genotypic coefficient of variation were observed for number of panicles per hill and number of tillers per hill, number of tillers per hill, grain yield per hill, test weight and flag leaf length, indicating that these traits are most probably under the control of additive gene action and hence these traits can be fixed by proper selection **(Rajasekhar et al.).** Eleven rice hybrids including two check varieties were evaluated to approximate their genetic variability, heritability and genetic advance for ten quantitative traits. The genotypes G3 and G6 were selected as high response superior promising rice hybrids for achievable yield advantage 49% and 23%, respectively over best check varieties **(Lipi et al. 2020)**.

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Correlation coefficient the intricate choreography of correlations unfolds a captivating narrative within the realm of rice plant dynamics. The spotlight shines brightly on grain yield per plant, intricately linked with biological yield per plant (0.678), Number of productive tillers per plant (0.299), Flag leaf area cm2 (0.271), 1000-grain weight g. (0.265), Panicle length (cm) (0.252), and Number of fertile spikelets per panicle (0.216). However, a non-significant positive

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correlation weaves through Spikelet fertility % (0.104) and Harvest index (0.042). On the flip side, a compelling negative correlation takes center stage with Days to maturity (-0.265), while non-significant threads intertwine with Days to 50% flowering (-0.037) and Plant height cm (0.121). Days to maturity, a pivotal character in this botanical tale, engages in a highly significant and positive dance with Days to 50% flowering (0.651). Biological yield per plant finds harmony with Flag leaf area (0.386), panicle length (0.354), Number of productive tillers per plant (0.289), Plant height (0.237), and 1000-grain weight, forming a symphony with biological yield per plant (0.347), Days to 50% flowering (0.253), and Spikelet fertility %. This intricate dance of correlations further unfolds with Number of fertile spikelets per panicle (0.305), panicle length (0.261), and Harvest index (0.278). Panicle length and Flag leaf area engage in a dynamic interplay with plant height (0.227) and the number of productive tillers per panicle.

Path analysis embarking on a nuanced exploration, path coefficient analysis unfurls its insights by employing simple correlation coefficients to decipher the intricate interplay of eleven independent characters on the coveted dependent character—grain yield per plant. The tableau of direct and indirect effects elegantly unfolds in Table 5, where Biological yield per plant takes the lead with a formidable direct effect of 0.7665. Harvest index follows suit with a noteworthy direct effect of 0.3246, accompanied by the impactful contributions of days to 50% flowering (0.2413), number of productive tillers per plant (0.1219), and panicle length (0.1210), all exerting a highly positive and significant influence on grain yield per plant. In the intricate web of indirect effects, Flag leaf area (0.2959), panicle length (0.2714), 1000-grain weight (0.2660), and number of productive tillers per plant (0.2215) weave a symphony of positive influences on grain yield per plant. However, the saga takes a contrasting turn with days to maturity (-0.3037) and plant height (-0.1661) projecting considerable negative direct effects on the coveted grain yield per plant. Days to 50% flowering (-0.1357) and days to maturity (-0.1211) follow suit, exhibiting considerable negative indirect effects. and the similar results found that, the path analysis studies revealed that kernel length was the major contributor for grain yield plant-1 followed by plant height, spikelet fertility, number of grains per panicle, 1000 grain weight, milling %, gel consistency, amylose content and alkali spreading value. These characters showed direct positive effects for grain yield plant-1. From the study it can be concluded that the above

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characters can be used directly as the selection criteria in any rice yield improvement breeding programs **(Vennela et al. 2021)**.

Conclusion:

This study provides valuable insight into genetic variability, heredity, and interactions between the most important agricultural properties in a variety of rice-based plasmas. The significant variation observed in genotypes of most traits highlights the abundant genetic diversity available in future breeding programs. Analysis of correlation and pathway coefficients showed that biological yield per plant, number of productive mushrooms, and weight of 1000 grains not only had a positive association with corner yield, but also had a strong direct effect on yield improvement strategies with reliable selection criteria. Conversely, characteristics such as the day to maturation showed a negative link to horn yield. This illustrates a compromise that must be taken into consideration in the development of early high-wave varieties. The promising genotypes and traits identified here may serve as important factors in future breeding programs for sustainable and highly renewable rice production.

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Table 1: Analysis of variance of augmented design for 12 characters in rice germplasm

	D.F.	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of productive tillers/plant	Panicle length (cm)	Leaf area index (cm^2)	Fertile Spikelets / panicle	Spikelets fertility %	Biological yield / plant (g)	Harvest index %	1000-grain weight (g)	Grain yield /plant
Block (ignoring Treatments)	7	192.208 **	97.423**	217.047*	36.718	12.565 *	41.035**	858.363 **	70.374 *	339.624 **	82.555*	5.365**	149.159**
Treatment (eliminating Blocks)	74	41.065**	49.440**	258.721**	21.017	9.390*	53.371**	731.927 **	128.317**	334.691 **	68.808*	11.604 **	71.904**
Varieties	71	53.252 **	56.590 **	258.731 **	18.482	5.258	36.920 **	840.456 **	101.321 **	226.025 **	48.482	11.325 **	75.467**
Checks	2	165.167 **	124.625 **	201.988	57.093	133.856 **	525.409 **	226.255 **	1182.671 **	189.742 **	209.688 **	40.526 ***	134.697**
Checks vs. Varieties	1	253.125 **	28.125	1429.342 **	223.979 **	123.114**	531.326 **	27.720	266.843 **	10601.260 **	1732.103 **	6.805**	673.047**
ERROR	14	11.119	7.577	65.832	17.963	3.689	5.511	16.536	22.507	9.258	22.242	0.715	10.339

*, and ** Significant at 5% and 1% level, respectively

Table 2: Estimation of Mean, Range, Heritability, genetic advance and coefficient of variability analysis in Rice

Characters	Mean	Min	Max	GCV (%)	PCV (%)	Heritability (%)	GA % Mean
Days to 50% flowering	96.14	78.20	111.20	6.05	6.97	75.35	10.82
Days to maturity	119.07	101.21	136.88	5.27	5.76	83.92	9.96
Plant height (cm)	116.91	85.47	170.47	10.70	12.76	70.27	18.48
No. of productive tillers/plant	11.93	04.55	25.20	5.49	36.36	02.28	1.70
Panicle length (cm)	24.36	19.40	31.04	04.83	09.17	25.55	04.82
Leaf area index (cm^2)	25.24	12.48	39.09	20.13	22.19	82.14	37.55
Fertile Spikelets/ panicle	90.34	29.21	183.96	28.55	28.90	97.57	58.10
Spikelets fertility %	79.10	57.68	100.33	10.06	11.70	73.86	17.81
Biological yield / plant (g)	46.07	19.83	90.15	29.32	30.08	94.97	58.86
Harvest index %	54.83	38.99	70.60	08.33	11.93	48.77	11.98
1000- grain weight (g)	23.56	16.87	32.22	12.42	12.93	92.29	24.59
Grain yield /plant	25.58	12.15	53.30	28.60	31.29	83.56	53.86

Table 3: Simple correlation coefficients among different characters in rice germplasm

Traits	Days to maturity	Plant height(cm)	No. of Productive Tillers/plant	Panicle length (cm)	Flag leaf area(cm2)	No. of fertile spikelets / panicle	Spikelets fertility (%)	Biological yield /plant(g)	Harvest Index(%)	1000-grain weight(g)	Grain yield/plant(g)
Days to 50% flowering	0.651**	-0.101	-0.010	-0.383**	-0.134	-0.050	-0.036	-0.177	0.278**	0.253*	-0.037
Days to maturity		-0.075	-0.068	-0.184	-0.173	-0.047	-0.014	-0.158	0.081	-0.018	-0.265**
Plant height(cm)			-0.070	0.227*	0.170	-0.006	-0.022	0.237*	-0.480**	0.115	-0.121
No.of Productive Tillers/plant				0.030	0.213*	0.003	-0.140	0.289**	-0.241*	0.082	0.299**
Panicle length (cm)					0.073	0.088	0.261*	0.354**	-0.249*	-0.182	0.252*
Flag leaf area(cm2)						0.149	-0.232*	0.386**	-0.214*	0.188	0.271**
No.of fertile spikelets / panicle							0.305**	0.141	0.083	-0.216*	0.216*
Spikelets fertility (%)								0.022	0.115	-0.171	0.104
Biological yield /plant(g)									-0.456**	0.347**	0.678**
Harvest index (%)										-0.083	0.042
1000-grain weight(g)											0.265**

*, and ** Significant at 5% and 1% level, respectively.

Table 4: Path analysis for different characters on grain yield per plant in Rice germplasm

Traits	Days to 50% flowering	Days to maturity	Plant height(cm)	No. of Productive Tillers/plant	Panicle length (cm)	Flag leaf area(cm2)	No. of fertile spikelets / panicle	Spikelets fertility (%)	Biological yield /plant(g)	Harvest Index (%)	1000-grain weight(g)	Grain yield/plant(g)
Days to 50% flowering	**0.2413**	-0.1977	0.0168	-0.0012	-0.0464	-0.0018	-0.0030	-0.0008	-0.1357	0.0902	0.0012	-0.037
Days to maturity	0.1571	**-0.3037**	0.0125	-0.0083	-0.0223	-0.0023	-0.0028	-0.0003	-0.1211	0.0263	-0.0001	-0.265**
Plant height(cm)	-0.0244	0.0228	**-0.1661**	-0.0085	0.0275	0.0022	-0.0004	-0.0005	0.1817	-0.1558	0.0005	-0.121
No. of Productive Tillers/plant	-0.0024	0.0207	0.0116	**0.1219**	0.0036	0.0028	0.0002	-0.0031	0.2215	-0.0782	0.0004	0.299**
Panicle length (cm)	-0.0924	0.0559	-0.0377	0.0037	**0.1210**	0.0010	0.0052	0.0057	0.2714	-0.0808	-0.0008	0.252*
Flag leaf area(cm2)	-0.0323	0.0525	-0.0282	0.0260	0.0088	**0.0132**	0.0088	-0.0051	0.2959	-0.0695	0.0009	0.271**
No. of fertile spikelets / panicle	-0.0121	0.0143	0.0010	0.0004	0.0106	0.0020	**0.0591**	0.0067	0.1081	0.0269	-0.0010	0.216*
Spikelets fertility (%)	-0.0087	0.0043	0.0037	-0.0171	0.0316	-0.0031	0.0180	**0.0219**	0.0169	0.0373	-0.0008	0.104
Biological yield /plant(g)	-0.0427	0.0480	-0.0394	0.0352	0.0428	0.0051	0.0083	0.0005	**0.7665**	-0.1480	0.0016	0.678**
Harvest Index (%)	0.0671	-0.0246	0.0797	-0.0294	-0.0301	-0.0028	0.0049	0.0025	-0.3495	**0.3246**	-0.0004	0.042
1000-grain weight(g)	0.0610	0.0055	-0.0191	0.0100	-0.0220	0.0025	-0.0128	-0.0037	0.2660	-0.0269	**0.0046**	0.265**

Residual effects = 0.5368

*, and ** Significant at 5% and 1% level, respectively

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