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RESEARCH PAPER

Characterization of rice germplasms based on various seedling traits and growth stages

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Key Message: This research study demonstrates the diverse characteristics of rice germplasms across seedling traits and growth stages. Our study highlighted significant variations among rice genotypes, with DR-82 consistently exhibiting superior performance. These findings offer valuable insights into rice breeding and cultivation.

Abstract

Rice is very important for Pakistan's economy. To increase rice exports and ensure food security, it is essential to plan development patterns and select the best rice genotypes for cultivation. This research was done at the Agricultural Research Institute in Dera Ismail Khan, Pakistan during the Kharif season, 2020. The study characterized five rice varieties by inspecting various seedling's attributes and growth stages. A randomized complete block design with three replications was used to minimize bias in the study. Data collected at 10, 20, 30, and 40 days after transplantation (DAT) disclosed significant variations among rice genotypes. At the nursery stage, seedling length, leaf length, and leaf width varied significantly, with DR-82 showing the highest seedling length (59 cm). The number of tillers per plant, leaf length, and leaf width at 10, 20, 30, and 40 DAT also exhibited substantial differences among genotypes. DR-82 consistently displayed dominant performance in terms of tillers and leaf length. The analysis of variance (ANOVA) showed significant differences in seedling traits, and mean performance results that emphasized the unique characteristics of each genotype. The study provides valuable insights into rice breeding, cultivation, and selection of genotypes suitable for general cultivation. These findings contributed to the optimization of rice production practices, thereby enhancing the competitiveness of Pakistani rice in the international market and supporting the country's economic growth.

Keywords: Days after transplantation (DAT), Growth stages, Leaf length, Leaf width, Rice, Seedling length

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Introduction

Rice (*Oryza sativa* L.) is a grain crop that is important for the diets of over three billion people worldwide (Ibrahim et al., 2016; Rathna Priya et al., 2019). To fulfill present demand, the potential of rice cultivars has to be doubled by 2050 by harnessing valuable yield genes as well as genes possessing tolerance to biotic and abiotic stresses (Ali et al., 2019. Rice provides food for more than half of the world's population (Mather et al., 2007). Rice genotypes represent a stage of domestication between superior cultivars and wild rice, with a higher genetic diversity than commercial or elite cultivars (Londo et al., 2006). They preserve a great variability in genetic supply while making it simpler to employ in breeding programs compared to wild rice. Therefore, it is crucial to extract elite genes from rice landraces germplasm to improve the cultivated rice. The great genetic diversity found in landraces makes them important for potential use in future variety development programs. As a result, diverse genetic varieties are essential for choosing and conserving distinct landraces for future application in agricultural development initiatives (Patra, 2000). Pakistan's major crops include sugarcane, wheat, rice, cotton, and maize. These significant crops make up 25.2% of the value added in all of agriculture and contribute 5.4% of the GDP. A special place is held by rice among Pakistan's major crops.

After wheat, rice is the most important food grain crop in Pakistan. According to the Government of Pakistan (2013), rice contributes 27% and 0.60%, respectively, to value addition in agriculture and Pakistan's GDP. 10% of Pakistan's total cropland is used for the cash crop of rice (Shaikh et al., 2011). Since Pakistan does not eat rice as a major diet, thus to generate foreign cash, a sizeable amount of rice is exported annually (Government of Pakistan, 2013). Pakistan is well-known for its flavorful Basmati rice. The three primary characteristics typically used to identify fragrant rice are appearance, scent, and taste. Its grain is extremely fine and has a nice scent (Chaudhary et al., 2003). Almost 62.8% of the world's population relies on rice as a staple food, accounting for 20% of total calorie intake; in Asia, this percentage is 29.3% (Timmer, 2010). Because rice is a staple food for most people worldwide and a wonderful way to assure food security, relatively little of the world's rice production only 7.13 percent is traded internationally. 15% to 18% of the world's rice commerce is made up of fragrant rice, which includes basmati and jasmine cultivars (Baldwin & Childs, 2011). Pakistan's economy, like that of other developing nations, is mostly reliant on the export of agricultural products. Because it generates employment opportunities, exporting is crucial for the growth of any economy and is a major factor in the financial stability of any nation, assist in preserving the trade balance, promote economic expansion, and raise people's standards of living (Lee & Habte, 2004).

The Pakistani government has implemented many market-oriented measures to increase rice exports. The Rice Export Corporation of Pakistan (RECP) was only authorized to handle Pakistan's rice exports from 1987 to 1988. However, from 1988 to 1989, to foster a more competitive environment that would boost exports, the Pakistani government transferred responsibility for rice exports to the private sector. The rice exporters Association of Pakistan (REAP), an organization that conducts its operations with the collaboration and engagement of several government ministries, serves as the framework under which the private sector operates. The measuring of instability in agricultural production is significant because it helps to understand numerous food difficulties and the issues that come from the volatility in output. It also impacts on pricing, and thus the variability of the producer's return (Assouto et al., 2020). Variations in agricultural commodity production occur for a variety of causes, and this is also true in Pakistan.

Unfavorable conditions, including weather and other natural disasters such as floods and drought, have an impact on the performance of the agriculture industry, particularly crop production. Rice production changes in Pakistan can have an impact on domestic rice prices as well as Pakistan's competitiveness in the international market, causing fluctuation in export amounts of rice from Pakistan. Farmer's and exporter's returns are similarly affected by such variations. Producers benefit from instability analysis, hence by the virtue of the present study, they can make better decisions about what to grow, and this study can help policymakers identify the challenges and sources of instability and unpredictability to mitigate the potential repercussions of instability. This research study aimed to observe the growth behavior of different rice genotypes at 10, 20, 30, and 40 days after transplantation and to determine the potential/superior genotype for general cultivation.

Materials and Methods

Experimental setup and design

The present research study was conducted at the Agricultural Research Institute, Dera Ismail Khan, Pakistan during the Kharif season, 2020. The experiment involved the cultivation of five different rice varieties, and various parameters related to these varieties were observed and recorded. The research trial was laid out in a Randomized Complete Block Design (RCBD) with three replications to minimize experimental bias and increase the reliability of the results.

Transplantation and growing conditions

Seedlings of the rice varieties were transplanted into rows that were two meters in length. A spacing of 20 cm was maintained between two successive rows and between individual plants within the rows. The rice nursery was sown in the month of June, and transplantation was carried out in July.

Data collection

Data were collected at four different time points: 10 days, 20 days, 30 days, and 40 days after transplantation (DAT). The seedling length of each rice variety was measured both before transplantation and at 10-day intervals up to 40 DAT. The number of tillers per plant was counted from the seedling stage to the flowering stage. Leaf length and width were measured at 10-day intervals for each rice variety.

Results

Seedling length (cm), leaf length (cm) and leaf width (mm) at nursery stage

The results indicate a significant effect on seedling length, leaf length, and leaf width at the nursery stage for various rice genotypes (Table 1). The highest seedling length (59 cm) was observed in the DR-82 genotype, while the lowest (26 cm) was found in NUYT-RC-1951. For leaf length, the mean values ranged from 3 to 30 cm, with the highest leaf length (30 cm) being recorded for the NUYT-RC-1952 genotype and the lowest (3 cm) observed in SHUA-92. The widest leaves (11 mm) were associated with the NUYT-RC-1952 genotype, while the narrowest leaves (4 mm) were found in SHUA-92 (Table 2). These results highlight the significant variations in seedling length, leaf length, and leaf width among different rice genotypes at the nursery stage, providing valuable insights for rice breeding and cultivation strategies.

Number of tillers plant^{-1} and leaf length and width at 10 days after transplantation

Results revealed that tillers appearance was highly significant of various rice cultivars. Mean values for the number of tillers ranged from 2 to 14 in number. The maximum number of tillers (14 plant^{-1}) was recorded in DR-82, while the minimum number of tillers (2 plant^{-1}) was observed in NUYT-RC-1951 (Table 3). Analysis of data showed highly significant differences in leaf width and length (Table 3). The mean value for leaf width and length ranged from 4 to 9 mm and 3 to 37 cm, respectively. Maximum leaf width (11 mm) and length (32 cm) were recorded in SHUA-92 and DR-82, respectively. Minimum leaf width (4 mm) and length (3 cm) were observed in NUYT-RC1951 and DR-82 respectively (Table 3).

Table 1 Analysis of variance (ANOVA) for the studied parameters

	Mean squares			
Parameters	Replication	Treatment	Error	CV
Seedling length at nursery	5.252	6.58*	7.30	22.55
Leaf length at nursery	33.27	64.78**	28.55	12.9
Leaf width at nursery	0.99	1.60	2.13	19.17
Tillers after 10 days	0.14	2.51	1.06	26.29
Leaf length after 10 days	6.29	34.48*	8.49	13.26
Leaf width after 10 days	0.21	2.27	0.56	11.29
Tillers after 20 days	10.87	8.66*	9.63	39.11
Leaf length after 20 days	11.87	16.08**	14.05	12.28
Leaf width after 20 days	0.76	4.09	0.43	9.16
Tillers after 30 days	9.99	5.64**	12.82	32.03
Leaf length after 30 days	5.74	166.38*	10.46	23.21
Leaf width after 30 days	6.8	1.51	10.4	22.2
Tillers after 40 days	5.25	6.58**	7.30	22.55
Leaf length after 40 days	0.80	91.83*	17.62	9.81
Leaf width after 40 days	0.99	1.60	2.13	19.27
Plant height after 40 days	38.94	506.13*	17.86	4.94

*P<0.05; ** P<0.01; CV = Coefficient of variation

Table 2 Mean performance of different rice genotypes for various traits at nursery stage

Genotype name	Seedling length (cm)	Leaf length (cm)	Leaf width (mm)
NUYT RC 1951	10.33	45.46	7.78
NUYT RC 1952	12.22	45.38	8.44
TN1	12.78	40.44	8.00
DR82	10.67	34.11	7.00
SHUA92	13.89	41.67	6.67
Mean	11.98	41.41	7.58
LSD (0.05)	5.09	10.06	2.75
LSD (0.01)	7.40	23.20	4.00

Table 3 Mean performance of different rice genotypes for various traits at 10 days after transplantation

Genotype name	Number of tillers	Leaf length (cm)	Leaf width (mm)
NUYT RC 1951	2.89	27.06	6.11
NUYT RC 1952	3.11	23.56	6.11
TN1	4.33	21.11	5.00
DR82	5.11	18.78	6.78
SHUA92	4.11	19.39	6.22
Mean	3.91	21.98	7.33
LSD (0.05)	1.94	5.49	1.41
LSD (0.01)	2.82	7.98	2.05

Number of tillers plant^{-1} and leaf length and width at 20 days after transplantation

The mean performance of various rice genotypes was evaluated for different traits at 20 days after transplantation (Table 4). The genotypes namely NUYT RC 1951, NUYT RC 1952, TN1, DR82, and SHUA92 were assessed based on the number of tillers plant^{-1}, leaf length (cm), and leaf width (mm). Among the genotypes, DR82 exhibited the highest average number of tillers plant^{-1} (10.44) followed by NUYT RC 1952 (8.89). TN1 had the lowest average number of tillers plant^{-1} at 6.67. In terms of leaf length, TN1 displayed the longest leaves with an average of 34.39 cm, while NUYT RC 1952 had the shortest leaves at 28.94 cm. Regarding leaf width, SHUA92 exhibited the widest leaves with an average of 8.11 mm, while TN1 had the narrowest leaves at 6.22 mm (Table 4). The LSD values at 0.05 and 0.01 significance levels were provided for each trait, indicating the minimum significant differences that should be considered when comparing the genotypes.

Table 4 Mean performance of different rice genotypes for various traits at 20 days after transplantation

Genotype name	Number of tillers	Leaf length (cm)	Leaf width (mm)
NUYT RC 1951	7.22	30.17	7.56
NUYT RC 1952	8.89	28.94	7.89
TN1	6.67	34.39	6.22
DR82	10.44	30.56	7.44
SHUA92	6.44	28.56	8.11
Mean	7.93	30.52	7.444
LSD (0.05)	5.84	7.06	1.23
LSD (0.01)	8.50	10.27	1.80

Number of tillers plant^{-1} and leaf length and width at 30 days after transplantation

The mean performance of different rice genotypes was assessed for various traits 30 days after transplantation (Table 5). NUYT RC 1951 exhibited the highest average number of tillers plant^{-1} (13.44) followed by TN1 and DR82, both with an average of 11.11 tillers plant^{-1}. NUYT RC 1952 and SHUA92 had slightly lower tiller counts at 9.89 and 10.33, respectively. In terms of leaf length, NUYT RC 1951 had the shortest leaves with an average of 27.22 cm, while NUYT RC 1952, TN1, and DR82 displayed substantially shorter leaves at 9.89 and 11.11 cm. SHUA92 had the smallest leaf width at 6.00 mm, while NUYT RC 1952 had the widest leaves with an average width of 9.33 mm (Table 5).

Table 5 Mean performance of different rice genotypes for various traits at 30 days after transplantation

Genotype name	Number of tillers	Leaf length (cm)	Leaf width (mm)
NUYT RC 1951	13.44	27.22	7
NUYT RC 1952	9.89	9.89	9.33
TN1	11.11	11.11	7.33
DR82	11.11	11.11	7.00
SHUA92	10.33	10.33	6.00
Mean	11.18	13.93	7.33
LSD (0.05)	6.74	6.09	2.12
LSD (0.01)	9.81	8.86	3.09

Number of tillers plant^{-1} and leaf length and width at 40 days after transplantation

The mean performance of different rice genotypes was analyzed for various traits at 40 days after transplantation (Table 6). The highest number of tillers plant^{-1} (12.22) was recorded in NUYT RC 1952followed closely by TN1 at 12.78. Slightly lower tiller counts were found in NUYT RC 1951, DR82, and SHUA92. In terms of leaf length, TN1 had the longest leaves with an average of 41.22 cm, followed by NUYT RC 1952 at 47.78 cm. DR82 had the shortest leaves at 35.33 cm. Regarding leaf width, NUYT RC 1952 displayed the widest leaves with an average width of 8.44 mm, while SHUA92 had the narrowest leaves at 6.67 mm. In terms of plant height, TN1 reached the tallest height with an average of 98.89 cm, followed by NUYT RC 1952 at 95.67 cm. DR82 and SHUA92 exhibited shorter plant heights.

Table 6 Mean performance of different rice genotypes for various traits at 40 days after transplantation

Genotype name	Number of tillers	Leaf length (cm)	Leaf width (mm)	Plant height (cm)
NUYT RC 1951	10.33	48.74	7.78	87.78
NUYT RC 1952	12.22	47.78	8.44	95.67
TN1	12.78	41.22	8.00	98.89
DR82	10.67	35.33	7.00	78.22
SHUA92	13.89	40.78	6.67	67.22
Mean	11.98	42.77	7.58	85.56
LSD (0.05)	5.087	7.90	2.75	7.96
LSD (0.01)	7.401	11.50	4.00	11.58

Discussion

Tolerance to biotic and abiotic stressors, high production potential, and desired grain quality are the main objectives of rice breeding efforts worldwide. The main objective of a breeder is having adequate genetic heterogeneity in the germplasm. Breeders frequently trade germplasm both inside and outside of their countries to accomplish their breeding goals. Therefore, the identification and characterization of rice cultivars are essential for programs including enhancement of genetics, release, and seed production. Characterizing these types will therefore help build a genetic database that will inform breeding plans and tactics in the area. Qualitative characteristics are regarded as morphological indicators for the morphological characterization or identification of rice landraces. According to the literature, environmental changes have less impact on them (Rao et al., 2013; Kalyan et al., 2017). The majority of the morphological traits examined by the rice landraces under investigation demonstrated a broad spectrum of distinctiveness, and these findings are similar to the reports of Joshi et al. (2007); Chakrabarty et al. (2012); Tirkey et al. (2013).

The results of the present study revealed large variations amongst genotypes. Because different rice genotypes have varying yields and other morphological characteristics, genetic diversity was found in all genotypes Grain yield was used to assess the genotypic differences between rice genotypes (Hayashi et al., 2007; Hein et al., 2007). To create high-yielding varieties, Saleem et al. (2009) also investigated a few morphological features of rice. Outstanding findings have been documented by Khan et al. (2009); Vange (2009). The findings presented by Bose and Pradhan (2005); Shahidullah et al. (2009) are in good accord with these results, who reported that taller weedy rice compete more effectively with the cultivated crop for land and resourcefulness, plant height is a crucial indicator of competitive potential (Diarra et al., 1985). The taller plants would undoubtedly benefit from capturing more light than nearby plants in actual field settings (Shivrain et al., 2010; Ratnasekera et al., 2014). A rice tiller is a unique grain-bearing branch that develops on the non-elongated bottom internode and uses its adventitious roots to grow independently of the culm. According to Li et al. (2003), tillering is a crucial agronomic characteristic of rice grain production, and profuse tillering is widely known for its competitiveness in weedy rice (Sanchez-Olguin et al., 2007). The number of tillers generated by the different rice genotypes differed considerably. DR-82 appears to be growing voraciously throughout the vegetative stage, as evidenced by its tall plants and frequent tillering. The effective use of the available resources, such as sunshine and soil nitrogen (N), is closely related to these characteristics.

Joshi et al. (2007) reported that for the majority of the morphological traits in 19 different varieties of rice, their heritability and variability combined with moderate to high genetic progress indicate their usefulness in varietal characterization. Quantitative characteristics such as plant height, panicle length, panicle number per plant, days to maturity etc., were proposed by Behla & Rang (2007). Efficiently employed to group genotypes of rice, Siddiqui et al. (2007) assessed the morphological characteristics of rice grain quality in Pakistani local rice germplasm and proposed that there is a significant variance in grain size, form, and weight about the collecting site's altitude. Veasey et al. (2008) characterized the genetic heterogeneity within and between South American wild rice species and populations using a variety of morpho-agronomic parameters. Based on hulled and unhulled grain characteristics such as grain length, colour, width, and decorticated grain length, Rimpi et al. (2008) described 12 rice varieties. 1000-grain weight, grain length to breadth (L/B) ratio, decorticated grain width, and decorticated grain color. The plant morphological characters differed significantly among various rice germplasms. The plant height varied at various intervals. Similar variation was reported by Rosta (1975).

Genotype DR-82 had the greatest plant height, the maximum number of tillers that a plant can have, and genotype NUYT-RC-1951 had the smallest plant height and tillers. Genetic variability among genotypes may be the cause of the variations in growth and developmental features, including tallness of the plant, leaf length, leaf width, and number of tillers per plant. Breeding programs can use this to screen for cultivars with high yields. These factors are demonstrated to be stable and heritable at a certain growth stage for assessing rice genotypes (Peng et al., 2008). Up to a certain point, grain yield grows rapidly as one increases plant height (Fageria et al., 2004). Taller rice plants outcompete shorter plants in weed competition. Taller plants have a higher chance of lodging (Kato et al., 2019), and smaller plants have been linked to a small increase in grain output (Evans et al., 1984). Because of compensating processes, tiller number is important in both biotic and abiotic stress situations. Optimizing space and resources is linked to a high tillering capability; therefore, the overall grain yield is greatly impacted by this feature. Rice grain yields are generally greater in cultivars with higher-performing tillers per plant (Dutta et al., 2013). Breeders are always searching for morphological markers that can help them identify particular parental material for particular features. These markers are crucial. Enough genetic diversity was found in the current study for a variety of qualitative and quantitative variables. As a result, the numerous analyses that were done revealed significant variability among the different genotypes. The broad range of variability seen in the assessed traits might be ascribed to the various genetic backgrounds of the accessions under investigation, which could be utilized to choose the genotypes for crossbreeding.

Conclusion

In general, the genotypes of rice under investigation showed significant variation in the parameters associated to growth, development, and yield. According to the present research, it can be inferred that rice varietal characterization can be aided by the morphological traits of the seed, seedling, and plant. genotypes in climatic conditions of Dera Ismail Khan. Some of the distinguishing characteristics like seedling length, leaf length, leaf width, and number of tillers plant^{-1} were discovered to be more beneficial for classifying and identifying rice genotypes to preserve genetic purity during the growing of seeds. Based on data recorded, DR-82 variety performed well; hence it is recommended that DR-82 should be cultivated in this area to get a better yield of coarse rice.

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