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RESEARCH PAPER

Evaluating the rice genotypes at various growth stages under agro-climatic conditions of Dera Ismail Khan

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Key Message: This study evaluated five rice genotypes (KANGNI-27, MATHRA, E-107, E-94, and IRRI-06) at various growth stages under the agro-climatic conditions of Dera Ismail Khan. Key findings include genotype MATHRA demonstrated superior seedling length and leaf length at multiple stages, while genotype E-94 showed the widest leaves, and genotype KANGNI-27 excelled in tiller number.

Abstract

This research study was conducted for evaluation of 5 genotypes of rice (KANGNI-27, MATHRA, E-107, E-94, and IRRI-06) for different traits at various growth stages. The experiment was done at the Agriculture Research Institute, Dera Ismail Khan during the kharif season of 2020. The study was designed as RCBD with three replications. Data was recorded including length of seedlings, length of leaf, width of leaf, number of tillers, and height of plant at various growth stages, at nursery stage, after 10, 20, 30 and 40 days of plantation. At the nursery stage, genotype MATHRA showed the high seedling length (48.89 cm), genotype IRRI-06 had the longest leaves (18.44 cm), and genotype E-94 had the widest leaves (6.78 mm). After 10 days of plantation, the genotype KANGNI-27 had the highest number of tillers (4.33), genotype MATHRA had the longest leaves (21.67 cm), and genotype E-94 had the widest leaves (7.22 mm). Twenty days after transplantation, genotype KANGNI-27 had the highest number of tillers (10.78), genotype MATHRA had the longest leaves (32.67 cm), and genotype IRRI-06 had the widest leaves (8.11 mm). Likewise, 30 days after transplantation, the genotype E-94 had the highest number of tillers (16.22), genotype MATHRA had the longest leaves (36.78 cm), and genotype KANGNI-27 had the widest leaves (10.11 mm). Moreover, at 40 days after transplantation, genotype MATHRA showed the tallest height of plant (36.78 cm). These findings can be used in future breeding programs to develop new rice varieties that are better adapted to Dera Ismail Khan climatic conditions.

Keywords: Dera Ismail Khan, Evaluation, Genotypes, Growth stages, Rice, Seedlings

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Introduction

Rice (*Oryza sativa* L.) falls in the list of necessary staple crops of the world, which provide nourishment for a major percentage of the population globally (Seck et al., 2012; Ibrahim et al., 2016; Ali et al., 2019). In Pakistan, rice is 2nd necessary crop and a major foreign exchange source of earning in recent years. Pakistan is also known for its major contribution to the rice trade globally. Rice commands a significant share of Pakistan's export market, ranking as the sixth-largest commodity in terms of exports (Irshad et al., 2018). Over 4.59 million tons of rice is exported, so Pakistan accounts for 8% of the total rice trade in the world, which values 2.3 billion USD approximately. These numbers create Pakistan as the 4th largest exporter in terms of value and volume of rice (International Trading Center [ITC], 2020). Cultivation of rice in Pakistan mainly focuses on 3 main types: IRRI rice, Basmati rice, and non-Basmati rice. Among these three, Basmati rice stands out as an exclusive product entirely linked with Pakistan (Bashir et al., 2007). It is known for its slender and long grains. It has a soft and fluffy texture when cooked, complemented by a distinctive aroma. Therefore, Basmati rice has increased in popularity as a premium rice variety in the international market. However, the yield of rice per unit area in Pakistan is very low than that of other nations (Bashir et al., 2007).

In Pakistan, cultivation of rice plays an important role in the economy and food security. Khyber Pakhtunkhwa province being one of the major rice-producing regions after Punjab and Sindh (Ali et al., 2022). Within Khyber Pakhtunkhwa, the district of Dera Ismail Khan has appeared as a significant contributor of rice production due to its favorable agro-ecological conditions. Efficient production of rice requires the cultivation of high-yielding genotypes which have desirable traits that can endure the various environmental challenges at different growth stages (Sandhu et al., 2019). To meet the increasing demand for rice and to ensure viable production, it is vital to identify and develop rice genotypes that show superior performance across different stages of growth (Sandhu et al., 2019). Many factors affect the growth of rice plants throughout its lifecycle, which include germination of seed, establishment of seedling, vegetative growth, flowering of plant, filling of grain, and maturity of grain (Wang et al., 2007). Each growth stage is considered by specific physiological traits, morphological traits, and agronomic traits, which include height of plant, number of tillers, length of panicle, yield of grain, quality of grain, and its resistance to biotic and abiotic stresses (Zaman et al., 2020). Enhancing breeding strategies and improving productivity of rice, it is vital to comprehend the performance of various rice genotypes at each stage of growth and by evaluating their trait expression.

Flood-irrigated rice uses 45% of water which is 2-3 times higher compared to other cereals (Alam et al., 2014). However, as we approach the end of the 21st century, diminishing water resources due to natural factors and other aspects pose challenges to flooded rice cultivation, which demands substantial water usage. To sustain rice production amidst water scarcity and meet the needs of a growing global population, it is imperative to adopt smart water-saving practices and efficient water management techniques (Verma et al., 2018). Aerobic rice cultivation techniques offer an alternative approach to traditional methods, particularly beneficial in water-scarce regions like the tropics and subtropics. In the aerobic system, rice seeds are planted in non-flooded, non-puddled fields resembling upland conditions (Waddington et al., 2010). Adequate fertilizer application and careful irrigation management, especially during drought periods, are crucial in this method. By minimizing surface runoff, seepage, evaporation, and water loss through percolation, aerobic cultivation significantly conserves water resources (Singh et al., 2011).

Lafitte et al. (2002) described numerous types of rice that flourish best in lowland conditions, growing in irrigated aerobic lands with infrequent flooding. However, in aerobic environments, highly yielding varieties of lowland rice have shown great yield losses. Thus, understanding morpho-physiological traits and yield qualities is crucial for classifying and choosing high-performing aerobic types of rice, essential for developing aerobic cultivars of rice. Research into the correlation between environmental conditions and rice yield has demonstrated enhanced grain harvests under aerobic conditions. Additionally, Agricultural China University in Beijing has developed high-yield aerobic rice cultivars known as "Han Dao," widely adopted by farmers in their regions (Castella, 2012).

This research study aims to determine the potential of rice genotypes for various traits at different growth stages in Dera Ismail Khan, Khyber Pakhtunkhwa. By evaluating a diverse range of genotypes, we sought to identify high-performing varieties that exhibit favorable characteristics at specific growth stages. This information will not only aid in the development of superior rice varieties but also assist farmers in making conversant choices regarding the cultivation of appropriate genotypes for explicit environments and growth stages.

Materials and Methods

Site of experiment and material of plant

The study is meant to assess the potential of different genotypes of rice for numerous traits at various growth stages in Dera Ismail Khan (D.I. Khan). The field experiment was performed at the Agriculture Research Institute (ARI) in Dera Ismail Khan in the season of Kharif crop 2020. The experimental material consists of five genotypes of rice, named KANGNI-27, MATHRA, E-107, E-94, and IRRI-06.

Experimental designing in field

Use of RCBD for the field experiment was done, with replicating thrice. Each replication signified a separate block. Plots were organized for experiment in random manner within each of the blocks. The length of row was maintained at 2 meters, and the distance between plants and row was set at 20 centimeters.

Preparation of nursery and plantation

The preparation of nursery began in June 2020 (12/06/2020). The selected genotypes of rice were grown in the nursery in this period. Later, on July 8, 2020 (08/07/2020), the seedlings of rice were shifted from the nursery to the experimental field.

Practices of agriculture

Suitable practices of agriculture were followed throughout the experiment to confirm uniform and optimal conditions of growth for the genotypes of rice. These practices include irrigation, fertilization, control of weed, and management of pest following standard methods

Studied parameters

Throughout the course, many key parameters were measured to evaluate the traits of genotypes of rice at different stages of growth. The parameters include:

At nursery stage

1. Length of seedlings (cm)
2. Length of leaf (cm)
3. Width of a leaf (mm)

Ten days after transplantation

1. Number of tillers
2. Length of a leaf (cm)
3. Width of a leaf (mm)

Twenty days after transplantation

1. Number of tillers
2. Length of a leaf (cm)
3. Width of a leaf (mm)

Thirty days after transplantation

1. Number of tillers
2. Length of a leaf (cm)
3. Width of a leaf (mm)

Forty days after transplantation

1. Number of tillers
2. Length of a leaf (cm)
3. Width of leaf (mm)
4. Height of a plant (cm)

Procedures of measuring

The measurements were done by randomly selecting 9 plants from each of the plot. The length (cm) from the level of the soil to the tip of each seedling was selected to be measured, and the measurement was recorded. In the 9 erratically chosen seedlings from each plot the number of tillers on each was determined, and tillers number on mean is determined. Tillers numbers on average for each plot were recorded as well. The length of nine randomly selected leaves (in centimeters) from each plot was also measured, and the average length of the leaves was calculated as well. The average length of leaf for each plot was also recorded. The 9 randomly selected leaves width (in mm) from each plot was measured, and the width measurement for each leaf was recorded as well. The height of 9 randomly selected plants (cm) from each plot was also measured, and the measurement for each plant was recorded as well.

Collection and analysis of date

The measurements taken for each parameter were recorded at the individual growth stages for all the genotypes of rice. The length of seedling, length of leaf, width of leaf, no. of tillers, and height were measured using suitable measuring tools. The data obtained from the experiment were imperiled for arithmetical study for determination of the important differences among the genotypes of rice for each trait at various growth stages. The (ANOVA) variance analysis was done, and the value of the means were taken parallel using multiple range testing of Duncan's to identify major differences between each genotype.

Results

Nursery stage performance of rice genotypes

At the nursery stage the results of the performance of genotypes of rice are summarized in Table 1. Measurements were taken for 3 different traits: Length of seedlings, length of leaf, and width of leaf. The genotype that exhibited the highest seedling length was MATHRA, measuring 48.89 cm, while the genotype with the lowest seedling length was IRRI-06, measuring 40.78 cm. In terms of leaf length, IRRI-06 had the longest leaves, measuring 18.44 cm, while E-94 had the shortest leaves, measuring 13.44 cm. When considering leaf width, E-94 had the widest leaves, measuring 6.78 mm, while MATHRA had the narrowest leaves, measuring 5.44 mm. Among all genotypes, the mean values for the three traits were as follows: mean seedling length was 45.18 cm, mean length of leaf was 15.64 cm, and mean width of leaf was 5.91 mm. These measurements were recorded at the nursery stage for the respective rice genotypes.

Table 1 Performance of different rice genotypes for various traits at nursery stage

Genotype Name	Seedling length (cm)	Leaves length (cm)	Leaves width (mm)
Kangni-27	45.11	13.78	5.56
MATHRA	48.89	16.44	5.44
E-107	44.78	16.11	5.78
E-94	46.33	13.44	6.78
IRRI-06	40.78	18.44	6.00
Mean	45.18	15.64	5.91

Performance of rice genotypes at 10 days after transplantation

Table 2 presents the performance of various rice genotypes for different traits 10 days after transplantation. The Table includes data on the number of tillers, leaf length, and leaf width for five genotypes: Kangni-27, MATHRA, E-107, E-94, and IRRI-06. For the number of tillers, Kangni-27 produced an average of 3.78 tillers, while MATHRA produced a slightly higher count at 4.33. E-107 and E-94 exhibited lower numbers with averages of 2.56 and 2.89, respectively. IRRI-06 fell in between with an average of 3.44 tillers. The mean number of tillers across all genotypes is 3.40. In terms of leaf length, Kangni-27 yielded an average of 16.28 cm, while MATHRA had a longer length at 21.67 cm. E-107 produced the longest leaf length among the genotypes, measuring 24.94 cm, while E-94 had an average of 21.11 cm. IRRI-06 produced the shortest length at 13.00 cm. Regarding leaf width, Kangni-27 yielded an average width of 6.11 mm, while MATHRA yielded a wider width at 7.78 mm. E-107 had a narrower width of 6.78 mm, while E-94 produced a slightly wider width at 7.22 mm. IRRI-06 had the same width as MATHRA at 7.78 mm.

Table 2 Performance of different rice genotypes for various traits 10 days after transplantation

Genotype name	No. of tillers	Length of leaf (cm)	Width of leaf (mm)
Kangni-27	3.78	16.28	6.11
MATHRA	4.33	21.67	7.78
E-107	2.56	24.94	6.78
E-94	2.89	21.11	7.22
IRRI-06	3.44	13.00	7.78
Mean	3.40	19.40	7.13

Performance of rice genotypes at 20 days after transplantation

The genotype "Kangni-27" exhibited the maximum number of tillers with a value of 10.78, while the genotype "IRRI-06" had the minimum number of tillers with a count of 6.56. The largest leaf length of 32.67 cm was observed in the genotype "MATHRA," whereas the shortest leaf length of 26.33 cm was measured in the genotype "IRRI-06" (Table 3). In terms of leaf width, the maximum value of 8.11 mm was recorded in the genotype "IRRI-06," while the lowest leaf width of 6.22 mm was found in the genotype "E-107." These measurements were taken 20 days after the transplantation of the rice genotypes. The mean values for the traits were 9.04 tillers, 30.50 cm leaf length, and 7.44 mm leaf width.

Table 3 Performance of different rice genotypes for various traits 20 days after transplantation

Genotype name	No. of tillers	Length of leaf (cm)	Width of leaf (mm)
Kangni-27	10.78	32.33	7.56
MATHRA	10.56	32.67	7.89
E-107	9.33	31.33	6.22
E-94	8.00	29.83	7.44
IRRI-06	6.56	26.33	8.11
Mean	9.04	30.50	7.44

Performance of rice genotypes at 30 days after transplantation

The performance of rice genotypes at 30 days after transplantation was evaluated, and the outcomes are concise in Table 4. The no. of tillers varied among the genotypes, with the highest number (16.22) observed in the E-94 genotype and the lowest number (11.67) recorded in the MATHRA genotype. Regarding leaf length, the MATHRA genotype exhibited the longest leaves, measuring 36.78 cm, while the IRRI-06 genotype had the shortest leaf length of 25.67 cm. In terms of leaf width, the KANGNI-27 genotype had the widest leaves, measuring 10.11 mm, whereas the E-107 genotype had the narrowest leaves, with a width of 6.89 mm. These measurements were taken 30 days after nursery transplantation. On average, across all genotypes, the mean values were 13.29 tillers, 30.48 cm leaf length, and 8.27 mm leaf width.

Table 4 Performance of different rice genotypes for various traits 30 days after transplantation

Genotype name	Number of tillers	Leaf length (cm)	Leaf width (mm)
Kangni-27	13.44	34.83	10.11
MATHRA	11.67	36.78	8.78
E-107	13.22	27.94	6.89
E-94	16.22	27.17	7.78
IRRI-06	11.89	25.67	7.78
Mean	13.29	30.48	8.27

Performance of rice genotypes at 40 days after transplantation

The results of the performance of rice genotypes at 40 days after transplantation are presented in Table 5 that show that the max no. of tillers (22.22) was recorded for the genotype E-94, indicating a higher degree of branching and potential for higher grain yield. In contrast, the MATHRA genotype had the low no. of tillers (11.89), signifying a moderately lower branching pattern. The genotype MATHRA showed the largest length of leaf (36.78 cm) among all, representing its potential for great photosynthesis and production of biomass. Correspondingly, the genotype IRRI-06 had a short leaf length (25.67 cm), suggesting a smaller area of leaf and potentially low capacity of photosynthesis. The IRRI-06 genotype had the max width of leaf (10.89 mm), representing broad leaves that may have a large surface area for photosynthesis and high rate of transpiration. In contrast, the MATHRA genotype exhibited the low width of leaf (6.67 mm), suggesting narrow leaves with a comparatively small surface area. The MATHRA genotype documented the max height of the plant (113.89 cm), which indicates its potential for greater biomass accumulation and tall stature. Inversely, the IRRI-06 had the min height of the plant (74.67 cm), suggesting a short and possibly more compact growth habit.

Table 5 Performance of different rice genotypes for various traits 40 days after transplantation

Genotype name	No. of tillers	Length of leaf (cm)	Width of leaf (mm)	Plant height (cm)
Kangni-27	17.67	34.83	9.44	103.22
MATHRA	11.89	36.78	6.67	113.89
E-107	12.11	27.94	9.78	81.89
E-94	22.22	27.17	7.89	84.11
IRRI-06	12.78	25.67	10.89	74.67
Mean	15.33	30.48	8.93	91.56

Discussion

This research study was conducted for evaluation of 5 genotypes of rice (KANGNI-27, MATHRA, E-107, E-94, and IRRI-06) for different traits at various growth stages. The experiment was done at the Agriculture Research Institute, Dera Ismail Khan during the kharif season of 2020. The study was designed as RCBD with three replications. Data was recorded including length of seedlings, length of leaf, width of leaf, number of tillers, and height of plant at various growth stages, at nursery stage, after 10, 20, 30 and 40 days of plantation. The findings of this research study provide valuable understandings for selecting suitable genotypes of rice for each specific trait in breeding and cultivation programs of rice. Performance of 5 genotypes of rice (KANGNI-27, MATHRA, E-107, E-94, and IRRI-06) was assessed, and numerous parameters were measured at various stages of growth. The results showed major variation among the genotypes of the rice for the trait studied.

At the nursery stage, MATHRA rice showed the highest length of seedlings, IRRI-06 genotype had the longest leaves, and E-94 type had the widest leaves. After 10 days of plantation, KANGNI-27 rice had the highest number of tillers, MATHRA rice had the longest leaves, and E-94 rice had the widest leaves. Twenty days after plantation, KANGNI-27 rice had the highest number of tillers, MATHRA rice had the longest leaves, and IRRI-6 rice had the widest leaves. Likewise, after thirty and forty days of plantation, KANGNI-27 rice had the highest number of tillers, the longest leaves were of MATHRA rice, and the widest leaves were of IRRI-06 rice. Additionally, after 40 days of uprooting, MATHRA rice presented the tallness of plant. The findings of this study are consistent with previous research in different regions. Ahad et al. (2003) stated that the collection of rice varieties significantly improved compared to other varieties, such as Gomal-7 and Gomal-6 under agro-climatic conditions of Dera Ismail Khan. Additionally, it was noted that certain genotypes of rice that are drought-tolerant produced higher grain yields under rainfed and water-stressed conditions (Gurung et al., 2016).

Our findings showed that the performance of rice genotypes can vary depending on the precise agro-climatic conditions. The evaluation of rice genotypes at numerous growing phases is vital for improving breeding plans and enhancing rice production. The parameters studied in this research comprised of length of seedlings, length of leaf, width of leaf, number of tillers, and height of plants, provide valuable information for assessing the performance of rice genotypes. These traits are important determinants of yield potential and can guide farmers in selecting suitable genotypes for specific environments and growth stages. Further investigation could focus on evaluating additional characters such as length of panicle, grain yield, grain quality, and its resistance to biotic and abiotic stresses. Evaluating these traits at different growth stages would deliver a more comprehensive understanding of the performance of rice genotypes. Moreover, conducting field trials in different locations and seasons could help determine the adaptability of genotypes to varying agro-climatic situations. Similarly, Jing et al. (2010) found that various germplasms with associations of yield, harvesting index (HI) and grain quality at eight agro-ecologically identified locations in tropical and subtropical regions in Asian continent. They considered indica and javanica familiarize to temperate climate situations, while japonica genotypes adapt to cold agro-climatic situations, so it was assumed that hybrids of indica ×

japonica may produce higher yields and better superiority of characters under an extensive series of agro-climate conditions.

Zada et al. (2014) evaluated the growth and yield performance of seven rice genotypes namely PK3445-3-2, OM5627, IR64, IR8225-9-3-2-3, CIBOGO, Fakhr e Malakand and Japanese rice under agro-climatic situations of division of Malakand. These genotypes varied significantly with days to 50% flowering, maturation days, plant height, weight of grain and paddy yield (t ha^{-1}) excluding length of penicle and number of tillers/hill. The genotype Fakhr e Malakand presented high paddy yield followed by IR64 & PK3445-3-2. In a study of Gurung et al. (2016) rice genotypes IR-87760-15-2-3-4 (5.0 t ha^{-1}) and IR-88965-39-1-6-4 (5.3 t ha^{-1}) produced significantly higher yield of grain than different genotypes tested. The effective tillers per m^2 were significantly higher in genotypes IR-88965-39-1-6-4. Chendge et al. (2017) assessed the effect of sowing time on yield and economics of different rice varieties under climatic condition of Konkan during Kharif, 2013 and 2014. The findings of this research study revealed that high yield of grain was noted with shorter time hybrid Sahyadri-4 sowed in 23rd meteorological week followed by the same hybrid sown in 24th meteorological week and medium duration variety Jaya sown during 23rd meteorological week. Conversely, in the situation of straw yield in the pooled data, the significantly higher value was recorded by medium duration variety Karjat-5 sown during 23rd meteorological week followed by same variety sown during 24th meteorological week. In respect of economics of treatment combinations, high net returns and B: C ratio was attained when rice was sowed throughout 23rd of meteorology week in shorter period hybrid Sahyadri-4 which was closely followed by the medium duration variety Jaya sown during 23rd meteorological week.

Moreover, Khan et al. (2018) studied different varieties of rice Super Kernel, Kainat, Sadeeq, Komal, HS-98 and Fakhr e Malakand. Days of panicle initiation, length of panicle (cm), number of branches $panicle^{-1}$, height of plant (cm), 1000 seeds weight (g) and yield of grain (kg ha^{-1}) was recorded. The maximum days to initiation of panicle (101.67) was recorded in Super kernel and minimum (58.67) was recorded in Fakhr e Malakand, maximum length of panicle (26.86 cm) was noted in Super kernel, while minimum length of panicle (22.92 cm) was found in Sadeeq, maximum number of branches $panicle^{-1}$ (11.42) was recorded in Komal, and minimum (9.50) number of branches $panicle^{-1}$ was observed in Kainat. Hence it was concluded those genotypes; Super Kernel, Kainat, Sadeeq, Komal, HS-98 and Fakhr e Malakand produced maximum yield and were found to be the most suitable for the agro climatic conditions of Peshawar.

Conclusion

This research study was conducted for evaluation of 5 genotypes of rice (KANGNI-27, MATHRA, E-107, E-94, and IRRI-06) for different traits at various growth stages. The experiment was done at the Agriculture Research Institute, Dera Ismail Khan during the kharif season of 2020. The study was designed as RCBD with three replications. Data was recorded including length of seedlings, length of leaf, width of leaf, number of tillers, and height of plant at various growth stages, at nursery stage, after 10, 20, 30 and 40 days of plantation. The results demonstrated important difference among the genotypes of the rice for the traits studied, including length of seedlings, length of leaf, width of leaf, no. of tillers, and height of plant constantly MATHRA showed promising features, such as elongated leaves and tall heighted plant, whereas constantly KANGNI-27 presented greater tiller figures. Wider leaves revealed by IRRI-06 at numerous growing phases. These conclusions deliver valued understandings for choosing appropriate types with preferred characters for rice upbringing and gardening plans. Planters can use this info to make well-versed choices concerning type choice and farming performs made-to-order to unambiguous surroundings and growing phases. Advance examination could discover further characters and behavior tribunals in changed sites to improve our indulgent of type adaptableness to varied agro-climate situations. By finding high-performed rice types, we can give in maintainable rice manufacture and fulfil the aggregate worldwide needs for this vital chief yield.

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