

## Performance of Candidate Varieties of Basmati Rice in Uniform Yield Trials

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### ABSTRACT

The primary focus of rice breeding research is now on developing high-yielding rice varieties with early maturing and physio-chemical features, such as improved cooking quality, aroma, and extra-long grain. This shift in focus is driven by the growing global demand for high-quality rice. Using traditional breeding methods to trait pyramid these extremely important traits while maintaining yield and quality is a challenging task. Good grain quality (aromatic), fertilizer responsiveness, and high-yielding varieties can help the farmers in Pakistan to increase their revenue despite global population growth and changing international market patterns. At the Rice Research Institute, Kala Shah Kaku (RRI KSK), new, improved, high-yielding, extra-long grain lines with the qualities of early maturity, small stature, and good cooking with aroma are being developed through traditional breeding methods. The present study aimed to assess the genetic variability of these lines in terms of paddy yield and to discover superior high-yielding cultivars suitable for widespread cultivation. There were notable variations in paddy yield among the different entries in the pooled analysis. The highest average paddy yield (5010 Kg/ha) was seen in entry 10640-10-1-1-1, followed by entry 10684-3-1-2 (4990 Kg/ha) and PK 10434-6-2-1 (4550 Kg/ha) and suggested for general cultivation based on their mean paddy yield. A strong positive correlation was seen between the grain thickness grading of over 2.2 mm and the number of panicles per plant. Overall quality of the Uniform Yield Trials of Fine rice samples can be reported as excellent for PK 10306-15-5, PK PB-8 and PK 10678-2-1-1 over check Basmati-515. here will be a simultaneous increase in grain yield with improvements in these qualities.

**Keywords:** aroma, fertilizer responsiveness, pooled analysis, traditional breeding, trait pyramid.

### INTRODUCTION

Rice, scientifically known as *Oryza sativa* L., is of utmost importance for human sustenance as it serves as a staple meal for over two billion individuals, which accounts for approximately 60% of the global population, as reported by the United States Department of Agriculture [1]. It has a higher caloric content compared to any other food crop [2]. Rice plays a significant part in Pakistan's economy as it is the second most important food crop after wheat and

the largest agricultural product that earns foreign cash. It represents 3% of the value added in agriculture and 0.6% of the gross domestic product [3]. Asia accounts for 90% of global rice production and consumption. India, Thailand, Vietnam, and Pakistan dominate international rice exports, collectively accounting for approximately 60-70% of the total global export [4]. Pakistan ranks fifth among the top 10 countries in terms of rice exports. During the 2023-2024 year, a total of 6.850 million metric tonnes (P) were produced. Out of this, 4.20 million metric tonnes were exported, resulting in substantial foreign exchange earnings of US\$ 1.860 billion [3].

The amylose content is determined by a single gene. The amylose concentration can vary at several levels, such as 0 (waxy), very low, low, intermediate, and high. These variations are determined by numerous alleles at the waxy locus, which is situated on chromosome 6 [5]. Therefore, breeding for and improving these features is not difficult. However, aroma appears to be a quantitative trait, as segregants with varying levels of aroma are observed in the crosses between aromatic and non-aromatic rice. The

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presence of aroma has been reported to have a monogenic [6] or digenic [7] character and a gene associated with fragrance has been identified using molecular markers [8]. It is possible that there is a single dominant gene responsible for fragrance, along with many modifiers or quantitative trait loci (QTL). There is a lack of knowledge regarding the heritability of longitudinal grain elongation. The expression of these features is significantly influenced by a strong gene-environment interaction [9]. The highest quality Basmati rice is cultivated in the northwestern region of India and the northern region of Pakistan, where the rice matures in the cool temperature conditions of October. The expression of Basmati quality is thought to be influenced by different soil types.

Pakistan has been able to meet the increasing local and worldwide needs for rice through continuous advancements in rice breeding, production, and technology. The lack of fresh or high-quality seed, the slow pace of research, and a shortage of water are the main reasons for the country's significant annual variance in rice production. In 2023, there was a decrease of approximately 14% in rice exports compared to the previous year. This decline can be attributed to high input costs, low output, and increased local consumption [5, 6]. Therefore, substituting low-yielding rice genotypes with potentially input-efficient and higher-yielding basmati cultivars can be a realistic strategy to obtain premium benefits.

The conventional basmati varieties are prone to lodging, diseases, photoperiod, and temperature, but have high yields compared to non-basmati varieties with aroma and quality parameters [10]. In the 1920s, the basmati rice development effort was started at the Rice Research Institute KalaShah Kaku (RRI, KSK) in Pakistan [11]. We have been eagerly anticipating the development of new basmati cultivars with increased genetic yield potential, improved grain

quality characteristics, resistance to lodging, and protection against several diseases. The previous endeavors encountered limited achievements because of insufficient infrastructure for assessing grain quality and clearly defined criteria for selection. The pure line selections resulted in cultivars that exhibited favorable cooking quality attributes but were vulnerable to lodging, diseases, and insects, and had a decreased potential for high yields [12, 13]. The primary challenge in the Basmati enhancement program is the combining of aroma and grain quality along with high yield.

#### Material and Methods

A total of forty-seven potential varieties of high-quality rice, in addition to one standard variety, were evaluated in the uniform yield trials. The nursery of high-quality rice genotypes, namely, were planted in June. The nursery, which was thirty days old, was transplanted in the field with a plant spacing of 20 cm×20 cm. The experiment was conducted using a Randomized Complete Block Design (RCBD) with three replications. Upon reaching maturity, data were collected for both the quantity and quality of the paddy crop. The data received were subjected to Analysis of variance [14]. The trials included measurements of various agronomic traits such as yield, maturity days, height, panicle, grain shape (length, width, thickness of both grain and paddy), as well as cooking quality parameters such as boiled kernel length, cooked grain length, and elongation ratios. Additionally, milling parameters including husk %, bran %, total recovery %, head rice recovery %, and broken % were measured. Nutritional parameters such as amylose contents, alkaline spread value, and aroma were also evaluated to assess the consistency and uniformity of these traits in successive generations. A quality index has been calculated to evaluate and compare the overall quality of the newly developed rice variety with that of the existing rice types used as standards.

**Table 1. Description of varieties used in the study**

Sr. No.	Genotypes	Sr. No.	Genotypes
1	11369-8-1	26	PK 10434-6-2-1
2	10975-25-1-1	27	PK 10683-12-1
3	10680-3-6-2-1	28	PK 9832-4-1
4	10640-10-1-1-1-1	29	PK 10350-7-2-1
5	10684-3-1-2	30	PK 10419-2-1-1
6	10686-2-1-1	31	PK 9847-10-1
7	PK 10938-3-1-1	32	PK 10437-14-2-1
8	PK 10358-7-2-1-1	33	PK 10436-2-1-1
9	PK 10461-7-2-1-2	34	PK 10324-1-1

10	PK 10424-4-2-1-2	35	PK 10029-13-2-1
11	PK 10677-3-1-1	36	PK 9966-10-1
12	PK 10678-2-1-1	37	PK 10306-15-5
13	PK 10684-6-1-1	38	PK PB-8
14	PK 10816-5-3-1	39	PK 9444-8-1-2
15	PK 10824-9-1-3	40	PK 10161-1-5-1
16	PK 10824-9-1-5	41	PK 10969-39-1
17	PK 10825-5-1-4	42	PK 9533-9-6-1-1
18	PK 10825-13-1-1	43	PK 10967-30-1
19	PK 10835-9-1-1	44	PK 10101
20	PK 10843-7-2-2	45	PK 10198-7-2
21	PK 10845-6-2-2	46	PK 10749-18-1-1
22	PK 10663-6-1-2-1	47	Super basmati
23	PK 10436-4-2-2-1	48	PS2
24	PK 10495-7-3-1	49	Basmati-515
25	PK 10355-13-2-1		

## RESULTS AND DISCUSSION

The entries had a substantial impact ( $p < 0.05$ ) on the paddy yield of aromatic rice (Table 3). The highest average paddy yield (5010 Kg/ha) was seen in entry 10640-10-1-1-1, followed by entry 10684-3-1-2 (4990 Kg/ha) and PK 10434-6-2-1 (4550 Kg/ha). The lowest average paddy yield (2650 Kg/ha) was noticed in PK 9533-9-6-1-1. All candidate varieties exhibited higher paddy yield compared to the check Basmati-515. Based on the pooled analysis of paddy yield conducted at Rice Research Institute, Kala Shah Kaku, it is suggested that the following entries should be considered for extensive cultivation: 10686-2-1-1, PK 10436-4-2-2-1, PK 10434-6-2-1, and PK 10663-6-1-2-1.

Among all samples, six samples had shown maximum quality index for the studied traits due to good, cooked kernel length, elongation ratio, zero bursting and well separated cooked kernels. Regarding cooking quality

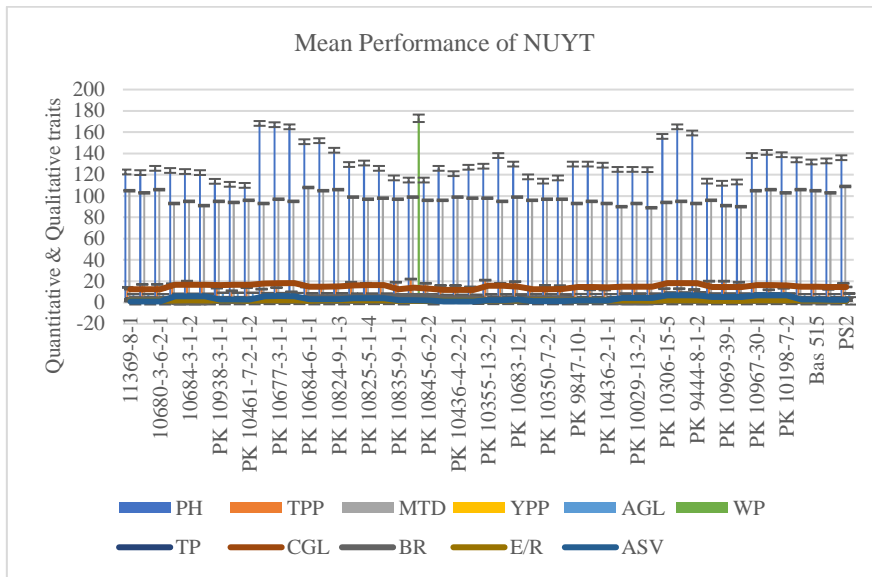
of all samples is O.K. ( $L/I = > 1.5$ ). However, overall quality of the Uniform Yield Trials of Fine samples can be reported as excellent for PK 10306-15-5, PK PB-8 and PK 10678-2-1-1 over check Basmati-515 as control. Brusting ratio was least for 10640-10-1-1-1 followed by 10684-3-1-2, PK 10324-1-1, PK 10029-13-2-1 and PK 9966-10-1.

Rice with a lower gelatinisation temperature tends to have a softer texture and undergoes less retrogradation compared to rice with a higher gelatinisation temperature. The alkali spreading method is commonly used to quantify gelatinisation. Nevertheless, advancements in technology have enhanced the ability to assess this characteristic as well. The entry 10640-10-1-1-1, 10684-3-1-2 and 10686-2-1-1 had shown best elongation ratio along with alkali spread ratio.

**Table 3 Mean Performance of the entries of Fine Rice samples in uniform yield trials**

SOV	D. F	PH	TPP	MTD	YPP	AGL	WP	TP	CGL	BR	ASV
Block	2	27.6	2.475 9	2.475 9	0.09327	0.04	202	0.003	0.433 9	0.0212	0.0313
Treatment	48	692.7 ***	27.6* **	27.6* **	1.90318 ***	0.628 ***	199.00 ***	0.024 ***	7.423 ***	0.1046 ***	11.625 ***
Residuals	96	21.17	2.31	1 2.31	0.036	2 0.06	199.7	8 0.00	0.038	6 0.00	0.008

**Sov**= Sources of Variation, **D.F**= degrees of freedom, **PH**= plant height, **MTD**= 50% days to maturity, **YPP**= yield per plant, **AGL**= Average grain length, **WP**= Average grain width, **TP**= average grain thickness, **CGL**= cooked grain length, **BR**= Brusting ratio, **ASV**= Alkali spreading value



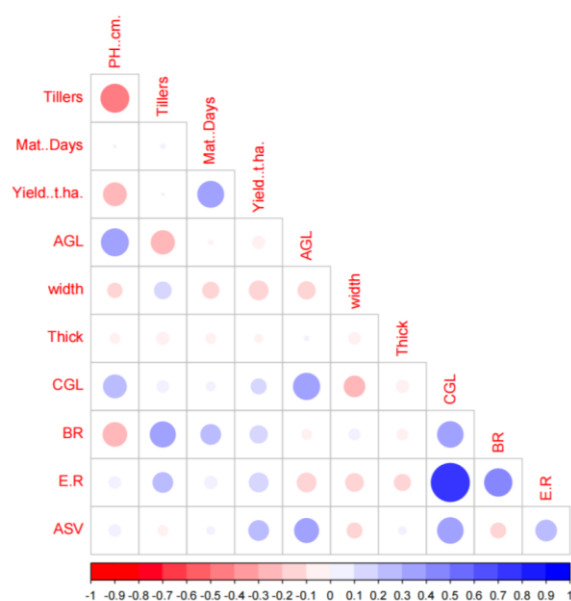
**Correlation Coefficient Analysis of Fine Rice samples in uniform yield trials**

A strong positive correlation was seen between the grain thickness grading of over 2.2 mm and the number of panicles per plant, with a correlation coefficient of 0.722 (Fig.2). In addition, there were substantial negative correlations between the thickness of the grains (ranging from 1.8-2.0 mm, 1.6-1.8 mm, and less than 1.6 mm) and the number of panicles per plant. The correlation coefficients for these relationships were -0.806, -0.828, and -0.796, respectively. Except for a single positive link observed between grain thickness grading exceeding 2.2 mm and yield per plant, all other grain thickness exhibited a negative correlation. The correlation coefficients between the yield per plant and grain thickness are greater than 2.2 mm and range from 1.8 to 2.0 mm. The findings indicated a strong and statistically significant correlation between grain yield and number of panicles per plant.

Similar results were shown by Zahid *et al.*, 2020; Wattoo *et al.*, 2010; Minnie *et al.*, 2016 and Tahir, 2014 [15, 16, 17, 18]. Furthermore, findings of Buckley *et al.*, 2020 and Keith, 1980 also supported it [19, 20]. In contrast to Bordolui *et al.*, 2006, this data demonstrates a negative correlation with yield per plant [21]. The results indicate a positive and substantial link between grain yield and average grain length. This suggests that an increase in grain length leads to an increase in grain yield. The experiment conducted by Islam *et al.*, 2016, Fahliani *et al.*, 2011, Yousafzai *et al.*, 2010, Arminian *et al.*, 2019 and Limochi and Eskandari, 2013 revealed similar results

[22, 23, 24, 25, 26]. The same results were also supported by the findings of Abarshahr *et al.*, 2011, Blackmer *et al.*, 1995, Maiti *et al.*, 2006, Warren *et al.*, 2021, Kishore *et al.*, 2015 and Yadav *et al.*, 2015 [27-32]. The findings were additionally supported by Panwar and Mathur, 2007, Divya *et al.*, 2015 and Wattoo *et al.*, 2010 [33, 34, 35]. The correlation coefficient analysis revealed that there is a positive association between grain yield and average grain length, however this correlation is not statistically significant. Experiments carried out by Kishore *et al.*, 2015, Roy *et al.*, 2014, Saif *et al.*, 2003 and Das Saif *et al.*, 2005 provided comparable findings [36-39]. The report was provided by Bishwas, and the result was supported by a study conducted in 1993.

According to Madhavilatha and Suneetha, (2005), there was a positive but non-significant correlation between days to maturity and grain yield [40]. The number of panicles per plant was found to positive correlation with grain yield per plant. Comparable findings were discovered in the study conducted by Hairmansis *et al.*, 2017 [41]. The study revealed a positive correlation between the number of panicles per plant and grain yield, however, this correlation was not statistically significant Limbani *et al.*, 2017, Bhadru *et al.*, 2012, Kalyan *et al.*, 2017 and Nayak *et al.*, 2003 [42, 45] all had similar results. The investigation revealed a negative and statistically insignificant correlation between plant height and grain yield. The same result was discovered by Eidi-Kohnaki *et al.*, 2015 [46]. However, Steel *et al.*, 1997 discovered a correlation between plant height and grain yield that contradicts this finding [47].



**Fig. 2 Correlation Coefficient analysis**

## CONCLUSION

The results indicated that there was a positive correlation and positive direct effect between average grain length, number of panicles per plant, maturity days on yield. Thus, in rice breeding programs, these features can be directly selected for. There will be a simultaneous increase in grain yield with improvements in these qualities.

## REFERENCES

- 1) Chauhan, B. S., & Johnson, D. E. (2011). Growth response of direct-seeded rice to oxadiazon and bispyribac-sodium in aerobic and saturated soils. *Weed Science*, 59(1), 119-122.
- 2) Rofiat, A. S., Fanelli, F., Atanda, O., Sulyok, M., Cozzi, G., Bavaro, S., ... & Ezekiel, C. N. (2015). Fungal and bacterial metabolites associated with natural contamination of locally processed rice (*Oryza sativa* L.) in Nigeria. *Food Additives & Contaminants: Part A*, 32(6), 950-959.
- 3) Fischer, K. S., Barton, J., Khush, G. S., Leung, H., & Cantrell, R. (2000). Collaborations in rice. *Science*, 290(5490), 279-280.
- 4) Maclean, J., Dawe, D., Hardy, B., & Hettel, G. P. (2002). *Rice Almanac*. Los Baños, Philippines, International Rice Research Institute (IRRI); Bouaké, Côte d'Ivoire, West Africa Rice Development Association; Cali, Colombia. International Center for Tropical Agriculture.
- 5) Kumar, I., & Khush, G. S. (1988). Inheritance of amylose content in rice (*Oryza sativa* L.). *Euphytica*, 38, 261-269.
- 6) Cruz, N. D., & Khush, G. S. (2000). Rice grain quality evaluation procedures. *Aromatic rices*, 3, 15-28.
- 7) Prasad, B., Patwary, A. K., & Biswas, P. S. (2001). Genetic variability and selection criteria in fine rice (*Oryza sativa* L.). *Pakistan J. Biol. Sci*, 4(10), 1188-1190.
- 8) Sasaki, T., & Burr, B. (2000). International Rice Genome Sequencing Project: the effort to completely sequence the rice genome. *Current opinion in plant biology*, 3(2), 138-142.
- 9) Ahn, W. K., Kalish, C. W., Medin, D. L., & Gelman, S. A. (1995). The role of covariation versus mechanism information in causal attribution. *Cognition*, 54(3), 299-352.
- 10) Rani, N. S. (2001). Current status and future prospects for improvement of aromatic rices in India. *Speciality rices of the world. Breeding, production and marketing*.
- 11) Ashraf, M. (2001). Basmati the heritage of Pakistan. *Farming outlook*, 17-22.
- 12) Shrestha, N., Poudel, A., Sharma, S., Parajuli, A., Budhathoki, S., & Shrestha, K. (2018). Correlation coefficient and path analysis of advance rice genotypes in central mid-hills of Nepal. *International Journal of Research in Agricultural Sciences*, 5(3), 150-154.
- 13) Madhavalatha, L., & Suneetha, Y. (2005). Studies on genetic divergence in rice germplasm lines. *Madras Agricultural Journal*, 92(1-3), 12-16.
- 14) Abarshahr, M., Rabiei, B., & Lahigi, H. S. (2011). Assessing genetic diversity of rice varieties under drought stress conditions. *Notulae Scientia Biologicae*, 3(1), 114-123.
- 15) Zahid, A., Ali, S., Ahmed, M., & Iqbal, N. (2020). Improvement of soil health through residue management and conservation tillage in

- rice-wheat cropping system of Punjab, Pakistan. *Agronomy*, 10(12), 1844.
- 16) Wattoo, J. I., Khan, A. S., Ali, Z., Babar, M., Naeem, M., Ullah, M. A., & Hussain, N. (2010). Study of correlation among yield related traits and path coefficient analysis in rice (*Oryza sativa* L.). *African Journal of Biotechnology*, 9(46), 7853-7856.
  - 17) Minnie, L., Gaylard, A., & Kerley, G. I. (2016). Compensatory life-history responses of a mesopredator may undermine carnivore management efforts. *Journal of Applied Ecology*, 53(2), 379-387.
  - 18) Tahir, N. A. R. (2014). Genetic variability evaluation among Iraqi rice (*Oryza sativa* L) varieties using RAPD markers and protein profiling. *Jordan Journal of Biological Sciences*, 7(1), 13-18.
  - 19) Keith, M. (1980). Effect of plant spacing on the competitive ability of rice growing in association with various weed communities at different nitrogen levels. *KOREAN JOURNAL OF CROP SCIENCE*, 25(4), 17-27.
  - 20) Buckley, C. R., Caine, R. S., & Gray, J. E. (2020). Pores for thought: can genetic manipulation of stomatal density protect future rice yields?. *Frontiers in plant science*, 10, 1783.
  - 21) Bordolui, S. K., Chattopadhyay, P., & Chandra, P. R. A. D. Y. U. T. (2006). Comparative performance of low land indigenous rice genotypes in Gangetic Alluvial Zone. *Journal of crop and weed*, 2(1), 33-36.
  - 22) Islam, S., Rahman, M. M., Islam, M. R., & Naidu, R. (2016). Arsenic accumulation in rice: consequences of rice genotypes and management practices to reduce human health risk. *Environment international*, 96, 139-155.
  - 23) Fahlani, R. A., Khodambashi, M., Houshmand, S., Arzani, A., & Sorkheh, K. (2011). Heritability for some agronomic characters of rice (*Oryza sativa* L.) and their linked microsatellites identification. *Turkish Journal of Agriculture and Forestry*, 35(5), 481-490.
  - 24) Yousafzai, F. K., Al-Kaff, N., & Moore, G. (2010). The molecular features of chromosome pairing at meiosis: the polyploid challenge using wheat as a reference. *Functional & integrative genomics*, 10, 147-156.
  - 25) Arminian, A., Karimi, Z., Rodrigues, P. C., & Ozgur, C. (2019). Novel MINITAB macros for advanced statistical and plant genetic analyzes: A case study with maize. In *Proceedings of the 2019 DSI Annual Conference in New Orleans, Louisiana, USA*.
  - 26) Limochi, K., & Eskandari, H. (2013). Effect of planting date on the performance of flag leaf stomata and grain yield of rice cultivars.
  - 27) Abarshahr, M., Rabiei, B., & Lahigi, H. S. (2011). Assessing genetic diversity of rice varieties under drought stress conditions. *Notulae Scientia Biologicae*, 3(1), 114-123.
  - 28) Blackmer, T. M., Schepers, J. S., & Meyer, G. E. (1995, September). Remote sensing to detect nitrogen deficiency in corn. In *Site-specific management for agricultural systems* (pp. 505-512). Madison, WI, USA: American Society of Agronomy, Crop Science Society of America, Soil Science Society of America.
  - 29) Maiti, S., Saha, M., Banerjee, H., & Pal, S. (2006). Integrated nutrient management under hybrid rice- (*Oryza sativa*) hybrid rice cropping sequence. *Indian Journal of Agronomy*, 51(3), 157-159.
  - 30) Warren, W. C., Boggs, T. E., Borowsky, R., Carlson, B. M., Ferrufino, E., Gross, J. B., ... & Rohner, N. (2021). A chromosome-level genome of *Astyanax mexicanus* surface fish for comparing population-specific genetic differences contributing to trait evolution. *Nature communications*, 12(1), 1447.
  - 31) Kishore, N. S., Srinivas, T., Nagabhushanam, U., Pallavi, M., & Sameera, S. K. (2015). Genetic variability, correlation and path analysis for yield and yield components in promising rice (*Oryza sativa* L.) genotypes. *SAARC Journal of Agriculture*, 13(1), 99-108.
  - 32) Yadav, S., Anuradha, G., Kumar, R. R., Vemireddy, L. R., Sudhakar, R., Donempudi, K., ... & Siddiq, E. A. (2015). Identification of QTLs and possible candidate genes conferring sheath blight resistance in rice (*Oryza sativa* L.). *SpringerPlus*, 4, 1-12.
  - 33) Panwar, L. L., & Mathur, S. S. (2007). Variability studies in segregating populations of Rice (*Oryza sativa* L.). *Annals of Agricultural Research*, 28(1).
  - 34) Divya, B., Robin, S., & Biswas, A. (2015). Genetics of association among yield and blast resistance traits in rice (*Oryza sativa*). *The Indian Journal of Agricultural Sciences*, 85(3), 354-360.
  - 35) Wattoo, J. I., Khan, A. S., Ali, Z., Babar, M., Naeem, M., Ullah, M. A., & Hussain, N. (2010). Study of correlation among yield related traits and path coefficient analysis in rice (*Oryza sativa* L.). *African Journal of Biotechnology*, 9(46), 7853-7856.
  - 36) Kishore, N. S., Srinivas, T., Nagabhushanam, U., Pallavi, M., & Sameera, S. K. (2015). Genetic variability, correlation and path analysis for yield and yield components in promising rice (*Oryza*

- sativa L.) genotypes. SAARC Journal of Agriculture, 13(1), 99-108.
- 37) Roy, S. K., Ali, M. Y., Hakim, M. A., Hanafi, M. M., Juraimi, A. S., Jahan, M. S., ... & Kashem, M. A. (2014). Evaluation of growth and yield potentialities of local boro rice varieties in south-west region of Bangladesh. Life Sci. J, 11(10), 277-281.
- 38) Saif, S. M. H., Lan, Y., & Sweat, V. E. (2003). Gelatinization properties of rice flour. International Journal of Food Properties, 6(3), 531-542.
- 39) Das, R., Borbora, T. K., Sarma, M. K., & Sarma, N. K. (2005). Genotypic variability for grain yield and flood tolerance in semi deep water rice (*Oryza sativa* L.) of Assam. *Oryza*, 42(4), 313.
- 40) Madhavilatha, L., & Suneetha, Y. (2005). Studies on genetic divergence in rice germplasm lines. Madras Agricultural Journal, 92(1-3), 12-16.
- 41) Hairmansis, A., Yullianida, Y., Supartopo, S., JAMIL, A., & Suwarno, S. (2017). Variability of upland rice genotypes response to low light intensity. Biodiversitas Journal of Biological Diversity, 18(3), 1122-1129.
- 42) Limbani, P. L., Gangani, M. K., & Pandya, M. M. (2017). Genetic variability, heritability and genetic advance in rice (*Oryza sativa* L.). Int. J. Pure App. Biosci, 5(6), 1364-1371.
- 43) Bhadru, D., Reddy, D. L., & Ramesha, M. S. (2012). Studies on combining ability for development of new hybrids in Rice. Indian Journal of Agricultural Research, 46(2), 97-109.
- 44) Kalyan, B., Krishna, K. R., & Rao, L. S. (2017). Correlation coefficient analysis for yield and its components in rice (*Oryza sativa* L.) genotypes. International Journal of Current Microbiology and Applied Sciences, 6(7), 2425-2430.
- 45) Nayak, B. C., DALE, B., & CHOUDHLIRY, B. (2003). Response of hybrid rice (*Oryza sativa*) to date of planting, spacing and seedling rate during wet season. Indian Journal of Agronomy, 48(3), 48\_3-48\_3.
- 46) Eidi-Kohnaki, M., Kiani, G., & Nematzadeh, G. (2015). Selection of restorer lines in segregating populations of rice. Jordan Journal of Agricultural Sciences, 11(4).
- 47) Steel R. G. D., J. H. Torrie and D. A. Dickey. 1997. Principles and Procedures of Statistics: A Biometric Approach. 3<sup>rd</sup> Ed. New York: McGraw-Hill Book Co.