

Research Article

Evaluation of rice genotypes for growth, yield and yield components

Jiban Shrestha^{1*}, Sudeep Subedi¹, Ujjawal Kumar Singh Kushwaha¹ and Bidhya Maharjan¹

¹Nepal Agricultural Research Council, National Plant Breeding and Genetics Research Centre, Khumaltar, Lalitpur, Nepal

*Correspondence: jibshrestha@gmail.com

*ORCID: <https://orcid.org/0000-0002-3755-8812>

Received: June 15, 2020; Revised: October 15, 2020;

Accepted: December 25, 2020; Available online: January 01, 2021

© Copyright: Shrestha *et al.* (2021).



This work is licensed under a [Creative Commons Attribution-NonCommercial 4.0 International License](https://creativecommons.org/licenses/by-nc/4.0/).

ABSTRACT

Twelve rice genotypes were evaluated under irrigated lowland and upland rainfed conditions in a randomized complete block design with three replications at Khumaltar, Lalitpur, Nepal in 2019. Data on plant height, panicle length, effective tillers per plant, fertile grain number per panicle and grain yield were taken. The variation was observed for plant height, panicle length, effective tillers per plant, fertile grain number per panicle among the evaluated rice genotypes. The rice genotype NR 11375-B-B-21 produced the highest grain yield (3974.75 kg/ha) followed by NR 11374-B-B-23 (3615.26 kg/ha) and NR 11145-B-B-B-6 (3597.56 kg/ha) under irrigated low land condition. Similarly, the rice genotypes, NR 11375-B-B-21 produced the highest grain yield (3837.15 kg/ha) followed by NR 11321-B-B-7-3 (3588.71 kg/ha) and NR 11305-B-B-1-3 (3292.36 kg/ha) under upland rainfed condition. The combined analysis showed that rice genotype NR 11375-B-B-21 produced the highest grain yield (3905.95 kg/ha) followed by NR 11374-B-B-23 (3494.63 kg/ha), and NR 11321-B-B-7-3 (3409.89 kg/ha) respectively. Thus, after evaluation of yield, two genotypes namely NR 11375-B-B-21, NR 11374-B-B-23, were selected as outstanding genotypes, which can be used as potential breeding materials for upland and low land environments of mid hills of Nepal.

Keywords: Evaluation, growth, low land, rice, upland, yield

Correct citation: Shrestha, J., Subedi, S., Kushwaha, U.K.S., & Maharjan, B. (2021). Evaluation of rice genotypes for growth, yield and yield components. *Journal of Agriculture and Natural Resources*, 4(2), 339-346. DOI: <https://doi.org/10.3126/janr.v4i2.33967>

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops and serves as the primary source of staple food for more than half of the global population (Ricepedia, 2020; USDA, 2020). Approximately, 90% of the world's rice is grown in the Asia (Paranthaman *et al.*, 2009). Rice is the number one staple food crop in Nepal and contributed significantly to livelihood of majority of people and also to national economy. The total area, production and productivity of rice is 1.49 million ha, 5.61 million ton and 3.76 t/ha in Nepal (CBS, 2018). In Nepal rice self- sufficiency ratio is below 100, which means domestic rice production is not sufficient to meet the domestic consumption (Tripathi *et al.*, 2019). Nepal Agricultural Research Council (NARC) has been playing a significant role to improve the rice productivity in the country. The

current production is not sufficient to meet the demand of growing population and ensure food security in the country.

Rice can be grown in different soil environments. Upland rice is grown in rainfed, naturally well-drained soils with bunded or unbunded fields without surface water accumulation. The general perception about the upland environment is that it is drought-prone, usually sloping land with erosion problems, and has soils with poor physical and chemical properties (Rice Knowledge Bank, 2020). Upland rice varieties are drought tolerant, but have a low yield potential and tend to lodge under high levels of external inputs such as fertilizer and supplemental irrigation (Rice Knowledge Bank, 2020). The high water use efficiency is one of the most important attributes of upland rice (Price *et al.*, 2002), and the main criteria for its selection in upland areas with low rainfall. Furthermore, upland rice genotype is useful as a donor for breeding improved root systems and improved adaptation to water stress growing environments (Bernier *et al.*, 2008). Lowland rice is grown in fields that can be flooded and they are either rain-fed or irrigated. The lowland conditions have puddled and saturated soils with a continuous layer of ponded water. Nepal's production ecosystems have been broadly classified into two major ecosystems, namely, irrigated and rainfed, which comprise 49% and 51%, respectively (Tiwari *et al.*, 2019).

Yield component traits such as plant height, tillers per hill, panicles per hills, panicle length, numbers of filled and unfilled grains per panicle, 100-grain weight, and total grain weight per panicle are important and also essential fundamental task before making any successful breeding program (Oladosu *et al.*, 2018). Yoshida (1983) reported that the major yield components in rice are number of panicles per unit area, spikelet numbers per panicle, spikelet fertility percentage and grain weight normally expressed as 1,000 grain weight. International Rice Research Institute (IRRI) (1997) stated that traits contributing to yield potential in rice include tillering ability, leaf length, leaf width, number of leaves, number of panicle length of grain and number of grains on the panicle. Rice yield might be increased by selecting for the component of yield and that parental varieties should be selected on the basis of component attributes (Tsehaye *et al.*, 2018). Yield is a complex quantitative character and is greatly influenced by environmental fluctuations; hence, the selection for superior genotypes based on yield is important. The objective of the study was to evaluate and compare the yield and yield components of rice genotypes.

MATERIALS AND METHODS

The experiments were conducted at National Plant Breeding and Genetics Research Centre, Khumaltar, Lalitpur, Nepal. It is located at 85°02'E longitude, 27°04' N latitude and 1350 m altitude (NARC, 2018). The soil of the research area is clayey loam (NARC, 2018). Twelve rice genotypes were evaluated in randomized complete block design with three replications with two conditions; lowland irrigated and upland rainfed condition. The rice was transplanted on 2 July, 2019 for lowland irrigated and 16 July 2019 for upland rainfed condition. The plot size was maintained of 6 m². The planting geometry was maintained as 20 cm × 15 cm. Fertilizer and farmyard manure (FYM) were applied at the rate of 100:40:40 NPK kg/ha and 10 t/ha respectively as per the recommendation. The full dose of P₂O₅ and K₂O and half dose of N was applied as basal dose and the remaining 50% nitrogenous fertilizer was further split into two parts. The first part was applied at the tillering stage and the second part was applied at the booting stage. The genotypes were evaluated based on the measurement of grain yield. The grain yield was calculated using the formula adopted by Shrestha *et al.* (2020).

$$\text{Grain yield } \left(\frac{\text{kg}}{\text{ha}}\right) \text{ at 12\% moisture} = \frac{(100 - M) \times \text{Plot yield (kg)} \times 10000 \text{ m}^2}{(100 - 12) \times \text{Net plot area, m}^2}$$

The analysis of variance was performed using RCBD design to derive variance components derived using GenStat statistical package (12th edition) (Payne *et al.*, 2009). The mean comparisons among treatment means were estimated by the least significant difference (LSD) test at 5% levels of significance (Gomez & Gomez, 1984).

Table 1. Climate data of the experimental location (2019)

Months	Max. Temp. (°C)	Min. Temp. (°C)	Rainfall (mm)
July	27.9	20.6	446.1
August	29.2	20.9	172.8
September	27.0	19.5	239.9
October	26.0	14.4	3.0
November	24.1	10.1	0
December	18.2	3.5	29.2

(NARC, 2020)

RESULTS AND DISCUSSION

High variations were observed among the evaluated rice genotypes for all the yield and its attributing traits (Table 2, 3, and 4). Similar results was reported by Tahir *et al.* (2002) who also observed highly significant variation among different traits and reported that these traits were under the control of genotypic difference among the genotypes. For other parameters, significant differences were also recorded among the tested genotypes. Significant variation for grain yield was also found among the twelve genotypes of coarse rice (Zahid *et al.*, 2005). This variation in grains yield might be due to environment (Mahapatra, 1993).

In low land irrigated condition, the rice genotypes NR 11375-B-B-21 (3974.75 kg/ha) had higher grain yield followed by NR 11374-B-B-23 (3615.26 kg/ha) and NR 11145-B-B-B-6 (3597.56 kg/ha), NR 11361-B-B-7 (3235.99 kg/ha) and NR 11321-B-B-7-3 (3231.05 kg/ha) (Table 2). Olaleye *et al.* (2008) observed genotypic variation among the upland rice cultivars for growth and yield parameters in southwestern Nigeria. In upland rainfed condition, the rice genotypes NR 11375-B-B-21 produced the highest grain yield (3837.15 kg/ha) followed by NR 11321-B-B-7-3 (3588.71 kg/ha) and NR 11305-B-B-1-3 (3292.36 kg/ha) (Table 3). Jaruchai *et al.* (2018) found genotypic variation among the upland rice cultivars for growth and yield parameters in North and Northeast Thailand. In combined analysis over locations, the rice genotype NR 11375-B-B-21 (3905.95 kg/ha) followed by NR 11374-B-B-23 (3494.63 kg/ha), NR 11321-B-B-7-3 (3409.89 kg/ha) respectively (Table 4).

Plant height is one of the important growth parameters of any crop as it determines or modifies yield contributing characteristics and finally shapes the grain yield (Reddy and Redd, 1997). It is a complex character and is the end product of several genetically controlled factors mostly governed by the genetic make-up of the genotypes, generally depends on their number of internodes and length of internodes (Rahman *et al.*, 2018). In low land irrigated condition, the mean range of plant height was 129.87 cm (NR 11391-B-B-1) to 165.47 cm (NR 11301-B-B-15-4) (Table 2). The mean range of plant height was 118.27cm (NR 11375-B-B-21) to 145.93 cm (NR 11361-B-B-7) in upland rainfed condition (Table 3).

Table 2: Performance of rice genotypes under lowland irrigated condition at Khumaltar, Lalitpur, Nepal, 2019

SN	Rice Genotypes	DTM	PHT (cm)	PL (cm)	ET	FGP	GYLD (kg/ha)
1	NR 11361-B-B-7	145	164.40	25.33	10	93	3236.00
2	NR 11301-B-B-15-4	153	165.47	26.80	10	123	2792.49
3	NR 11305-B-B-1-3	146	156.53	26.13	11	118	2894.26
4	NR 11319-B-B-5	145	159.33	24.20	11	91	1944.69
5	NR 11375-B-B-21	148	137.33	26.40	12	109	3974.75
6	NR 11391-B-B-1	139	129.87	21.53	15	93	2716.45
7	NR 11303-B-B-5-1	139	156.80	26.40	13	85	2570.16
8	NR 11374-B-B-23	152	147.87	27.33	12	104	3615.26
9	NR 11372-B-B-11	139	159.20	27.53	9	42	2713.43
10	NR 11321-B-B-7-3	139	154.27	25.60	13	96	3231.06
11	NR 11145-B-B-B-6	155	149.13	26.07	13	136	3597.56
12	Khumal-4	146	156.53	26.07	13	125	2331.67
	Mean	146	153.06	25.78	12	101	2968.15
	SEM	1.66	3.05	0.464	0.490	7.09	168.00
	CV(%)	2.54	2.95	5.92	18.67	0.020	22.12
	F test	**	**	**	NS	NS	*

**= Significant at 1% level, *=Significant at 5% level, NS: Not Significant at 5% level, DTM: Days to maturity, PHT: Plant height (cm), PL: Panicle length (cm), ET: Effective tillers per plant, FGP: Fertile grain number per panicle, GYLD: Grain yield (kg/ha), CV(%):Coefficient variation in %.

In combined analysis over locations, the mean range of plant height was 127.64 cm (NR 11375-B-B-21) to 155.17 cm (NR11361-B-B-7) (Table 4). This result was in consistent to those of Khatun (2001) and Das *et al.* (2012) who observed variable plant height among the rice varieties. The difference in plant height could be attributed to the varietal characteristics of the crops planted. Shorter plant height is an important character of the varieties to withstand lodging (Malini *et al.*, 2006). Similar findings were reported by Rasheed *et al.* (2002) for plant height differences in rice genotypes.

The number of days to maturity plays a significant role in the cropping system. Early maturing crops are timely handled, evacuate the land early for the next crops and escape from insect pest attack. The mean range of maturity days was 139 days (NR 11391-B-B-1, NR 11303-B-B-5-1 and NR 11321-B-B-7-3) t 155 days (NR 11145-B-B-B-6) under lowland irrigated condition (Table 2). The mean range of maturity days was 158.67 days (NR 11301-B-B-15-4) to 166.67 days (NR 11361-B-B-7) under upland rainfed condition (Table 3). The combined analysis over locations showed that the mean range of maturity days was 153 days (Khumal-4) to 157.50 days (NR 11145-B-B-B-6) under low land irrigated and upland rainfed condition (Table 4).

In low land irrigated condition, the mean range of panicle length was 21.53 cm (NR 11391-B-B-1) to 27.53 cm (NR 11372-B-B-11) (Table 2). In upland rainfed condition, the mean range of panicle length was 22.47 cm (NR 11145-B-B-B-6) to 25.93 cm (NR 11372-B-B-11) (Table 3). In combined analysis over locations showed that the mean range of panicle length was 22.13 cm (NR 11391-B-B-1) to 26.73 cm (NR 11372-B-B-11) (Table 4). Idris and Matin (1990) reported that panicle length influenced by variety.

Table 3: Performance of rice genotypes under upland rainfed condition at Khumaltar, Lalitpur, Nepal, 2019

SN	Rice Genotypes	DTM	PHT (cm)	PL (cm)	ET	FGP	GYLD (kg/ha)
1	NR 11361-B-B-7	166.67	145.93	22.93	8.80	123.13	3119.25
2	NR 11301-B-B-15-4	158.67	140.33	25.00	9.53	115.00	2566.79
3	NR 11305-B-B-1-3	162.00	132.33	23.73	10.47	121.60	3292.36
4	NR 11319-B-B-5	162.00	145.73	23.87	11.33	150.47	3071.96
5	NR 11375-B-B-21	160.00	118.27	23.80	11.00	114.73	3837.15
6	NR 11391-B-B-1	160.67	125.40	22.73	12.60	80.60	1713.14
7	NR 11303-B-B-5-1	163.67	139.60	25.47	12.53	121.87	3165.02
8	NR 11374-B-B-23	158.67	122.93	24.00	10.07	95.40	3374.00
9	NR 11372-B-B-11	159.67	140.00	25.93	9.87	83.27	1672.01
10	NR 11321-B-B-7-3	160.00	139.40	25.73	12.53	125.20	3588.71
11	NR 11145-B-B-B-6	160.00	122.40	22.47	12.07	93.00	3153.51
12	Khumal-4	160.00	137.40	23.53	12.20	115.80	2746.99
	Mean	160.00	134.14	24.10	11.08	111.67	2941.74
	SEM	0.663	2.76	0.339	0.382	5.80	194.00
	CV(%)	1.32	4.91	5.43	14.2	25.34	21
	F test	**	**	*	NS	NS	**

**= Significant at 1% level, *= Significant at 5% level, NS: Not Significant at 5% level, DTM: Days to maturity, PHT: Plant height (cm), PL: Panicle length (cm), ET: Effective tillers per plant, FGP: Fertile grain number per panicle, GYLD: Grain yield (kg/ha), CV(%): Coefficient variation in %.

The mean range of number of effective tillers per plant was 9 (NR 11372-B-B-11) to 15 (NR 11391-B-B-1) under low land irrigated condition (Table 2). The mean range of number of effective tillers per plant was 8.80 (NR 11361-B-B-7) to 12.60 (NR 11391-B-B-1) in upland rainfed condition (Table 3). The mean range of number of effective tillers per plant was 9.40 (NR 11361-B-B-7) to 13.80 (NR 11391-B-B-1) in combined analysis over both locations (Table 4).

Table 4. Combined performance of rice genotypes under lowland irrigated and upland rainfed conditions at Khumaltar, Lalitpur, Nepal, 2019

SN	Rice Genotypes	DTM	PHT (cm)	PL (cm)	ET	FGP	GYLD (kg/ha)
1	NR 11361-B-B-7	155.84	155.17	24.13	9.40	62.64	3177.62
2	NR 11301-B-B-15-4	155.84	152.90	25.90	9.77	119.00	2679.64
3	NR 11305-B-B-1-3	154.00	144.43	24.93	10.73	119.80	3093.31
4	NR 11319-B-B-5	153.50	152.53	24.04	11.16	120.74	2508.32
5	NR 11375-B-B-21	154.00	127.80	25.10	11.50	86.80	3905.95
6	NR 11391-B-B-1	149.84	127.64	22.13	13.80	106.46	2214.80
7	NR 11303-B-B-5-1	151.34	148.20	25.93	12.77	103.44	2867.59
8	NR 11374-B-B-23	155.34	135.40	25.66	11.04	111.87	3494.63
9	NR 11372-B-B-11	149.34	149.60	26.73	9.43	99.70	2192.72
10	NR 11321-B-B-7-3	149.50	146.84	25.67	12.77	110.60	3409.89
11	NR 11145-B-B-B-6	157.50	135.76	24.27	12.54	114.50	3375.53
12	Khumal-4	153.00	146.97	24.80	12.60	120.40	2539.33
	Mean	153.25	143.60	24.94	11.46	106.46	2954.94
	SEM	4.86	4.37	1.02	0.62	20.59	452.53
	CV(%)	3.17	3.04	4.10	5.42	19.34	15.31
	F test	NS	**	NS	**	NS	**

**= Significant at 1% level, NS: Not Significant at 5% level, DTM: Days to maturity, PHT: Plant height (cm), PL: Panicle length (cm), ET: Effective tillers per plant, FGP: Fertile grain number per panicle, GYLD: Grain yield (kg/ha), CV(%): Coefficient variation in %.

The reason of difference in number of effective tillers per plant is the variation in the genetic makeup of the variety. Similar result was also reported by Ramasamy *et al.* (1987) who stated

that number of tillers differed due to varietal variation. Tillering ability plays a vital role in determining rice grain yield. Too few tillers result fewer panicle, but excessive tillers enhance high tiller mortality, small panicle, poor grain filling and consequent reduction in grain yield (Peng *et al.*, 1994). Among the various yield components, productive tillers are very important as the final yield is mainly a function of the number of panicles bearing tillers per unit area (Roy *et al.*, 2014). Zahid *et al.* (2005) also found highly significant variation among twelve genotypes of coarse rice in number of tillers per plant.

In low land irrigated condition, the mean range of fertile grain number per panicle was 42 (NR 11372-B-B-11) to 136 (NR 11145-B-B-B-6) (Table 2). In upland rainfed condition, the mean range of fertile grain number per panicle was 80.60 (NR 11391-B-B-1) to 150.47 (NR 11319-B-B-5) (Table 3). The combined analysis over locations showed that the mean range of fertile grain number per panicle was 62.64 (NR 11361-B-B-7) to 120.74 (NR 11319-B-B-5) (Table 4). The variation was observed in fertile grain number per panicle in various rice experiments in Khumaltar, Lalitpur, Nepal (NPBGRC, 2020). The fertile grain number per panicle is one of the important yield attributing traits. Grevois and Helms (1992) also observed positive direct effects for filled fertile grains per panicle on rice yield.

CONCLUSION

The variation for growth, yield and yield components were observed among rice genotypes. The rice genotypes namely, NR 11375-B-B-21 and NR 11374-B-B-23 produced higher yield and better growth traits in both lowland irrigated and upland rainfed conditions. Growing high yielding varieties is crucial for successful crop production; therefore, it is advisable to grow NR 11375-B-B-21 and NR 11374-B-B-23 in Khumaltar areas and similar agro-ecological conditions.

ACKNOWLEDGEMENTS

The authors acknowledge the Nepal Agricultural Research Council for financial support for conducting this experiment.

Authors' contributions

J. Shrestha, S. Subedi and U.K.S. Kushwaha designed and performed the experiment, recorded data and analyzed data. B. Maharjan helped for collecting data. J. Shrestha wrote the paper, S. Subedi and U.K.S. Kushwaha helped to finalize initial draft of this manuscript. All authors approved the final revised version of manuscript for publication.

Conflict of Interest

The authors declare no conflict of interest regarding the publication of this manuscript.

REFERENCES

- Bernier, J., Atlin, G. N., Serraj, R., Kumar, A., & Spaner, D. (2008). Breeding upland rice for drought resistance. *Journal of the Science of Food and Agriculture*, 88, 927-939.
- CBS (Central Bureau of Statistics). 2018. National Population and Housing Census. Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics (CBS), Kathmandu, Nepal

- Das, B., Mannan, M.A., & Das, P.K. (2012). Performance study of three high yielding varieties of Bangladesh and one exotic rice variety. B.Sc.Ag. Thesis. Agrotechnology Discipline, Khulna University, Khulna.; pp.19-27.
- Gomez, K.A., & Gomez, A.A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). Int. Rice Res. Inst. and Willey, New York pp. 28-192.
- Grevois, K.A., & McNew, R.W. (1993). Genetic relationship among and selection for rice yield and yield components. *Crop Science*, 33, 249-252.
- Idris, M., & Matin, M.A. (1990). Response of four exotic strains of aman rice to urea. *Bangladesh Journal of Agricultural Science*, 17(2), 271-275.
- IRRI (International Rice Research Institute), (1997). Evaluating local germplasm for the upland rice ecosystem in Western Nepal. *Inter Rice Res. Notes.*, 22(1),31-32.
- Jaruchai, W., Monkham, T., Chankaew, S., Suriharn, B., & Sanitchon, J. (2018). Evaluation of stability and yield potential of upland rice genotypes in North and Northeast Thailand. *Journal of Integrative Agriculture*, 17(1), 28-36.
- Khatun, R. (2001). Effect of variety and nitrogen on the performance of fine rice. M. Sc. Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh; pp 93.
- Mahapatra, K.C. (1993). Relative usefulness of stability parameters in assessing adaptability in rice. *Indian Journal of Genetics and Plant Breeding*, 53(4), 435-441.
- Malini, N., Sundaram, T., Ramakrishnan, S.H., & Saravanan, S. (2006). Prediction of hybrid vigour for yield attributes among synthesized hybrids in rice (*Oryza sativa* L.). *Research Journal of Agriculture and Biological Sciences*, 2, 166-170.
- NARC (Nepal Agricultural Research Council). (2020). Nepal Agricultural Research Council (NARC), National Agricultural Environment Research Centre, Khumaltar, Lalitpur, Nepal.
- NARC. (2018). Annual Report (2017/18) of Nepal Agricultural Research Council (NARC), Agronomy Botany Division, Khumaltar, Lalitpur, Nepal
- NPBGRC (National Plant Breeding and Genetics Research Center).2020. Annual Report. 2076/77 (2019/20). National Plant Breeding and Genetics Research Center (NPBGRC), NARC, Khumaltar, Lalitpur, Nepal.
- Oladosu, Y., Rafii, M.Y., Magaji, U., Abdullah, N., Miah, G., Chukwu, S.C., Hussin, G., Ramli, A., & Kareem, I. (2018). Genotypic and phenotypic relationship among yield components in rice under tropical conditions. *BioMed research international*, 1-10. DOI: <https://doi.org/10.1155/2018/8936767>
- Olaleye, A. O., Akinbola, G. E., Marake, V. M., Molete, S. F., & Mapheshoane, B. (2008). Soil in suitability evaluation for irrigated lowland rice culture in southwestern Nigeria: Management implications for sustainability. *Communications in soil Science and plant analysis*, 39(19-20), 2920-2938.
- Paranthaman, R., Alagusundaram, K., & Indhumathi, J. (2009). Production of protease from rice mill wastes by *Aspergillus niger* in solid state fermentation. *World Journal of Agricultural Sciences*, 5(3), 308-312.
- Payne, R., Murray, D.A, Harding, S.A., Baird, D.B., & Soutar, D.M. (2009). Genstat for Windows (12th Edition) Introduction, VSN International, Hemel Hempstead, UK, 2009.
- Peng, S., Khush, G.S., & Cassman, K.G. (1994). Evaluation of a new plant ideotype for increased yield potential. P.5-20. In Cassman, K.G. (ed.). Breaking the yield barrier: Proceedings of a workshop on rice yield potential in favorable environments, Los Banos, Philippines. 29 Nov-4 Dec. 1994. International Rice Research Institute, Los Banos, Philippines.

- Price, A. H., Steele, K. A., Gorham, J., Bridges, J. M., Moore, B. J., Evans, J. L., Richardson, P., & Jones, R. G. W. (2002). Upland rice grown in soil-filled chambers and exposed to contrasting water-deficit regimes I. Root distribution, water use and plant water status. *Field Crops Research*, 76, 11–24.
- Rahman, S., Jahan, T., Rahman, S. Md. M., Rahman, M., Haque, M.M., & Khan, Md. A.A. (2018). Evaluation of Some Transplanted AUS Rice Genotypes for Morphology, Yield and Disease Incidence. *European Academic Research*. Bangladesh. P. 295.
- Ramasamy, S., Chandrasekaran, B., & Sankaran, S. (1987). Effect of spacing and seedlings hill-1 on rice yield. *International Rice Research Newsletter, IRRI, Philippines*, 12(4), 49.
- Rasheed, M.S., Sadaqat, H.A., & Babar, M. (2002). Correlation and path coefficient analysis for yield and its components in rice. *Asian Journal of Plant Sciences*, 1(3), 241-244. <https://doi.org/10.3923/ajps.2002.241.244>
- Reddy, T.Y., & Redd, G.H. (1997). Principle of Agronomy. Kalyani Publication, New Delhi, India.; p. 515.
- Rice Knowledge Bank. (2020). What is the difference between aerobic rice and upland rice?. Retrieved from <http://www.knowledgebank.irri.org/step-by-step-production/growth/water-management/faqs-about-water-management/item/what-is-the-difference-between-aerobic-rice-and-upland-rice>
- Ricepedia. (2020). Rice as food. Retrieved from <http://ricepedia.org/rice-as-food>
- Roy, S.K., Ali, M.Y., Jahan, M.S., Saha, U.K., Ahmad- Hamdani, M.S., Hasan, M.M., & Alam, M.A. (2014). Evaluation of growth and yield attributing characteristics of indigenous Boro rice varieties. *Life Science Journal*, 11(4), 122-126.
- Shrestha, J., Kushwaha, U. K. S., Maharjan, B., Subedi, S. R., Kandel, M., Poudel, A. P., & Yadav, R. P. (2020). Genotype × environment interaction and grain yield stability in Chinese hybrid rice. *Ruhuna Journal of Science*, 11(1), 47–58. DOI: <http://doi.org/10.4038/rjs.v11i1.86>
- Tahir, M., Waden, D., & Zada, A. (2002). Genetic variability of different plant yield attributes in rice. *Sarhad Journal of Agriculture*, 18(2), 13-17.
- Tiwari, D. N., Tripathi, S. R., Tripathi, M. P., Khatri, N., & Bastola, B. R. (2019). Genetic variability and correlation coefficients of major traits in early maturing rice under rainfed lowland environments of Nepal. *Advances in Agriculture*, 1-9 DOI: <https://doi.org/10.1155/2019/5975901>
- Tripathi, B.P., Bhandari, H.N., & Ladha, J.K. (2019). Rice Strategy for Nepal. *Acta Scientific Agriculture*, 3(2), 171-180.
- Tsehaye, Y., Kinfe, H., Reda, A., Welegebriyal, R., Geretsadkan, G., Yalaw, D., Gebrelibanos, W., Gebremikael, Y., Abebe, E., Asgele, K., Girmay, A. (2018). Evaluation of performance for yield and yield components of upland rice under rain-fed condition. *Asian Journal of Biological Sciences*, 11, 78-82. DOI: 10.3923/ajbs.2018.78.82
- USDA (The United States Department of Agriculture). (2020). Rice Sector at a Glance. Retrieved from <https://www.ers.usda.gov/topics/crops/rice/rice-sector-at-a-glance/>
- Yoshida, S. (1983). Rice. In: Potential Productivity of field crops under different Environments. IRRI (ed). Los Banos, Philippines, pp. 103-127.
- Zahid, A.M., Akhtar, M., Sabrar, M., Anwar, M., & Mushtaq, A. (2005). Interrelation-ship among Yield and Economic Traits in Fine Grain Rice. Proceedings of the International Seminar on Rice Crop. October 2-3. Rice Res. Inst. Kala Shah Kaku, Pak. pp. 21-24.