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Evaluation of yield and yield attributing characteristics in upland red rice cultivars of Manipur

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Abstract
A field experiment was conducted to evaluate the yield and yield attributing characteristics of 12 upland red rice cultivars collected from various hilly districts of Manipur. The experiment was laid out in a Randomized Block Design with three replicates. The experimental field's soil was silty clay loam in texture, acidic in reaction (pH 3.9), low in available nitrogen (237.96 N kg/ha) and available phosphorus (14.80 P_2O_5 kg/ha), medium in available potassium (263.66 K_2O kg/ha) and high in organic carbon (1%). Parameters on yield contributing characters such as panicle length, panicle weight, number of filled grains/panicle, thousand grain weight and grain yield were recorded. All of the parameters of yield and yield contributing characters differed significantly at 5% level. Cultivar Tabnangsang exhibited the longest panicle (30.08 cm), while Bujaro had the shortest (23.21 cm). The heaviest panicle was observed in Taneng kahengbo (6.13 g), and the lightest in Chadae (3.08 g). Cha neng had the highest number of filled grains per panicle (110.14), while Picharo had the lowest (67.11). The highest thousand grain weight was in Angah (32.08 g), and the lowest in Shantan naphaeng (16.87 g). The cultivar Chatee had the highest grain yield (26.75 q/ha), followed by Taneng kahengbo (25.93 q/ha). According to these findings, farmers are advised to grow these particular upland red rice cultivars in order to achieve optimal yield and also benefit from the various health advantages associated with red rice consumption.

Keywords: Red rice, upland, panicle, test weight and yield

1. Introduction
Rice, the state's staple food, is abundantly grown throughout the state's hills and valleys. Rice is grown in Manipur's hill zone primarily during the kharif season. Due to limited water supplies, they may be imagined to have changeable features in order to survive a long spell of rainless weather, as well as other desired traits. The upland rice-growing regions of India have been identified as a significant focus for the conservation of indigenous rice (Gayacharan *et al.*, 2015) [5]. Manipur is endowed with many varieties of rice. Pigmented rice (red and black rice) is well-known as enriched rice with a distinct flavour and health benefits. Black and purple rice are primarily glutinous rice, and red rice is primarily indica rice. Because these forms of rice retain their bran layer, they are typically more nutritious, just as brown rice is more healthy than white rice. Red rice has significant antioxidant levels, which help minimise free radicals in the body. Regular consumption of these phytochemicals has been shown to lower the risk of several chronic illnesses, including cardiovascular disease, heart disease, diabetes, obesity, and some malignancies, as well as improve endothelial function and blood pressure (Yawadio *et al.*, 2007) [19]. Red, purple, and brown rices accounted for 17.40%, 3.44%, and 2.50% of the 20% coloured rice, respectively. A survey conducted by the National Bureau of Plant Genetic Resources (NBPGR) from 1991 to 1998 recorded about 21% of red rice varieties in Manipur (Krishnamurthy and Sharma, 1970) [9].

2. Materials and Methods
2.1 Sampling location and soil properties
The current study was conducted in Machengluang village, Tamenglong district, Manipur, during two consecutive *kharif* seasons in 2020 and 2021, laid out in randomised block design with three replications. It lies at an elevation of 1137 metres above mean sea level and is located at 25º 08' N latitude and 93º 62' E longitude. Local red rice cultivars were obtained from farmers in various hilly districts of Manipur for the study material. In 2020, the average monthly rainfall was 210.87mm, while in 2021, it was 179.83mm. The experimental field's soil was silty clay loam in texture, acidic in reaction (pH 3.9), low in available nitrogen

(237.96 N kg/ha) and available phosphorus (14.80 P_2O_5 kg/ha), medium in available potassium (263.66 K2O kg/ha) and high in organic carbon (1%).

2.2 Physical and chemical soil analysis
The pH of the experimental soil was measured using a digital pH metre and a 1:2.5 soil-water suspension, as described by Jackson, 1973 [7]. Wet oxidation was used to determine the oxidizable organic carbon (Walkley and Black, 1934) [18]. The available N content of the soil samples was determined using the alkaline potassium permanganate method, as described by Subbiah and Asija, 1956 [17]. The soil texture was determined by the Bouyoucos Hydrometer method (Chopra and Kanwar, 1976) [3]. The available phosphorus content of soil was determined using Bray and Kurtz's method, 1945 [2], and the available potassium was extracted from soil using neutral N ammonium acetate at 1:5 soil; the extract ratio and potassium concentration were determined using a flame photometer (Jackson, 1973) [7].

2.3. Statistical analysis
Important yield attributing parameters and yield were observed, including panicle length, panicle weight, number of filled grains and test weight. Data were collected from five sample plants within each replication of the cultivars under study. Statistical analysis of the replicated data was performed using Fischer's method of analysis of variance (ANOVA) and interpreted as outlined by Gomez and Gomez, 1984[6]. The interpretation of the data was, however, based on 5% probability levels.

3. Results and Discussion
3.1 Panicle length (cm)
A perusal of the data from Table 1 indicated that the mean panicle length was significantly influenced by different red rice cultivars in both the seasons. The range of panicle lengths observed among the cultivars was from 23.21 cm to 30.3 cm. The mean panicle length was maximum (30.08 cm) and significantly higher in the cultivar Tabnangsang (C10) when compared to the rest of the cultivars, followed by the cultivar Beng neng (C2) with a mean panicle length of 29.83 cm. It was observed that the minimum panicle length (23.21 cm) was recorded in the cultivar Bujaro (C3). It's worth noting that the results indicate significant differences among the cultivars, which implies that genetic factors play a significant role in determining panicle length. This result is consistent with the findings of Kumar *et al.*, 2016 [10], Chowhan *et al.*, 2017 [4], and Sharma and Hemant, 2020 [15], who reported that the variations in panicle length can be attributed to inherent variability among different genotypes.

3.2 Panicle weight (g)
The results of the study indicate that the mean panicle weight of red rice cultivars was significantly influenced by the different varieties that were examined. The maximum mean panicle weight of 6.13 g was recorded in the cultivar Taneng kahengbo (C_{11}), followed by the cultivar Cha neng (C_5) with a mean panicle weight of 5.06 g. These two cultivars produced relatively heavy panicles, indicating good grain yield potential. On the other hand, the cultivar Chadae (C_4) had a minimum panicle weight of 3.08 g, which was significantly on par with C_9-Shantan naphaeng (3.18 g) and C_8-Picharo (3.20 g). The results indicate that the mean panicle weight of red rice cultivars was significantly influenced, with notable variations between different cultivars. Similar results were also recorded by Khatun *et al.*, 2020 [8], who reported that panicle weight was influenced by variety.

Table 1: Panicle length (cm) and panicle weight (g) of upland red rice cultivars of Manipur

	Panicle length (cm)			Panicle weight (g)		
Cultivars	**2020**	**2021**	**Pooled**	**2020**	**2021**	**Pooled**
C_1- Angah	26.21	26.02	26.12	4.22	4.35	4.28
C_2- Beng Neng	30.00	29.65	29.83	4.55	4.79	4.67
C_3- Bujaro	23.36	23.06	23.21	3.41	3.29	3.35
C_4- Chadae	25.79	25.45	25.62	3.17	2.98	3.08
C_5- Cha Neng	29.48	29.16	29.32	5.13	4.99	5.06
C_6- Chatee	27.21	26.60	26.90	4.09	4.25	4.17
C_7- Mariumiu kahengbo	27.53	26.88	27.20	4.29	4.48	4.39
C_8- Picharo	24.39	23.63	24.01	3.13	3.27	3.20
C_9-Shantan naphaeng	29.23	28.60	28.91	3.27	3.08	3.18
C_{10}- Tabnangsang	30.38	30.08	30.23	4.13	3.98	4.06
C_{11}- Taneng kahengbo	29.25	28.90	29.08	6.05	6.22	6.13
C_{12}- Thanga mahra	24.92	24.59	24.75	3.59	3.71	3.65
S.Ed (±)	0.53	0.54	0.13	0.09	0.09	0.12
CD (P=0.05)	1.10	1.13	0.26	0.18	0.20	0.24
C.V (%)	2.37	2.47	2.20	2.60	2.82	3.31

3.3 Number of filled grains per panicle
The data from Table 2 indicate that the number of filled grains per panicle in red rice cultivars was significantly influenced by the specific cultivars being studied. The number of filled grains per panicle ranged from 67.11 to 110.14 among the cultivars evaluated. The cultivar Cha neng (C_5) exhibited the highest mean number of filled grains per panicle, with an average of 110.14 filled grains, which showed significant superiority over the other cultivars. Conversely, the cultivar C_8-Picharo had the lowest mean number of filled grains per panicle, with an average of 67.11. Variation in grain filling may have occurred due to genetic, environmental or cultural management practices adopted. Roy *et al.*, 2014 [13] reported that the number of spikelets per panicle in indigenous rice is generally lower. Sarkar, 2014 [14] and Navya *et al.*, 2018 [11] reported that the number of filled grains/panicle influenced by variety.

3.4 Test weight (g)
Test weight is an important parameter that measures the weight of a given volume of rice grains and is often used as an indicator of grain quality and density. A perusal of the data from Table 2 indicated that test weight was significantly influenced by different red rice cultivars. The test weight [1000 seeds] ranged from 16.87 to 32.08g among the cultivars evaluated. The test weight was maximum (32.08 g) and significantly higher in the cultivar Angah (C_1) when compared to rest of the cultivars. This was followed by the cultivar Taneng kahengbo (C_{11}) with a mean test weight of 29.95 g. It was observed that the minimum test weight (16.87 g) was recorded in the cultivar Shantan naphaeng (C_9). The reason for the difference in test weight is the variation in the genetic makeup of the variety. Variation in 1000 seed weight due to varietal characters was also supported by Pokhrel *et al.* (2020) [12] and Chowhan *et al.*, 2017 [4]. Thousand-grain weight, an important yield-determining component, is a genetic character least influenced by the environment (Bharath *et al.*, 2018) [1].

Table 2: Number of filled grains/panicle, Test weight (g) and Grain yield (q/ha) of upland red rice cultivars of Manipur

	Number of filled grains/panicle			Test weight (g)			Grain yield (q/ha)		
Cultivars	**2020**	**2021**	**Pooled**	**2020**	**2021**	**Pooled**	**2020**	**2021**	**Pooled**
C_1- Angah	71.50	68.90	70.20	32.02	32.13	32.08	22.68	21.15	21.91
C_2- Beng Neng	102.98	100.73	101.85	29.12	29.21	29.17	24.50	22.56	23.53
C_3- Bujaro	83.68	81.23	82.46	25.04	24.99	25.01	20.06	18.38	19.22
C_4- Chadae	82.52	81.28	81.90	21.81	21.65	21.73	18.86	17.40	18.13
C_5- Cha Neng	111.20	109.09	110.14	27.02	26.83	26.93	23.91	22.05	22.98
C_6- Chatee	103.74	101.49	102.62	21.50	21.41	21.45	27.66	25.85	26.75
C_7- Mariumiu kahengbo	93.46	91.87	92.66	27.77	27.96	27.86	25.62	23.99	24.80
C_8- Picharo	67.86	66.36	67.11	24.60	24.77	24.69	20.00	18.88	19.44
C_9-Shantan naphaeng	108.81	106.22	107.52	16.80	16.95	16.87	21.49	20.22	20.85
C_{10}- Tabnangsang	82.24	79.79	81.01	28.22	28.37	28.30	25.05	23.34	24.20
C_{11}- Taneng kahengbo	89.16	86.16	87.66	30.03	29.88	29.95	27.07	24.79	25.93
C_{12}- Thanga mahra	87.10	85.14	86.12	24.61	24.79	24.70	17.04	15.78	16.41
SE d (±)	0.95	1.34	0.36	0.34	0.31	0.11	0.64	0.68	0.23
CD (P=0.05)	1.97	2.78	0.73	0.70	0.64	0.21	1.34	1.41	0.46
C.V (%)	1.29	1.86	1.46	1.61	1.46	1.41	3.46	3.92	3.39

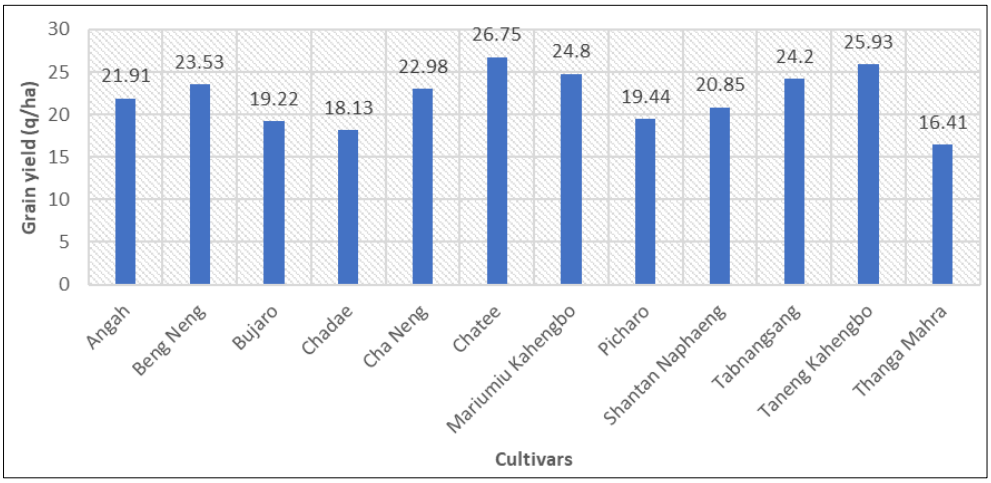

Fig 1: Graph showing variation of grain yield (q/ha) of upland red rice cultivars of Manipur

3.5 Grain yield (q/ha)

The data on grain yield as influenced by different red rice cultivars are presented in Table 2 and illustrated graphically in Fig.1. Based on the analysis of the data, it is evident that there were significant differences in grain yield among the different red rice cultivars that were investigated. The highest grain yield (26.75 q/ha) was recorded in the cultivar Chatee (C6), which was significantly superior to all the other cultivars included in the study. This indicates that Chatee (C_6) performed exceptionally well, as observed from its better yield attributes. On the other hand, the lowest grain yield of 16.41 q/ha was recorded in the cultivar Thanga mahra (C_{12}). The overall performance was found to be promising in the case of the cultivar Chatee at Tamenglong location. The number of grains per plant and test weight were positively correlated with grain yield, suggesting effective selection for improving rice grain yield under rainfed conditions (Singh *et al.*, 2018; Sharma and Hemant, 2020) [16, 15]. Varietal differences in grain yield were reported by Chowhan *et al.*, 2017 [4], and Khatun *et al.*, 2020 [8]. Though local cultivars are low-yielding and of longer duration, they are cultivated widely in the hilly areas for their quality, taste, and adaptability to the region. So, among the upland red rice cultivars, farmers can select Chatee for cultivation to acquire the highest yield possible.

4. Conclusion

The study conducted in Tamenglong district, Manipur, on local red rice cultivars found that Chatee demonstrated the highest yield, followed by Taneng Kahengbo. According to these findings, farmers are advised to grow these particular upland red rice cultivars in order to achieve optimal yield and also benefit from the various health advantages associated with red rice consumption.

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