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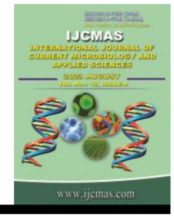

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To Assess the Effect of Different Sowing Time on the Performance of Different Local Aromatic Rice (*Oryza sativa* L.) Cultivars of Manipur

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During the 2020-21 *kharif* season, a field experiment was carried out at the Agronomy department's research farm at the College of Agriculture, Central Agricultural University, Imphal, Manipur. With 12 treatments and 3 replications, it was carried out using a factorial randomized block design. The experiment comprised of different planting dates (6th July, 21st July, 5th August and 20th August) and three cultivars of black rice aromatic rice (*Chakhao Poireiton, Makrei Kazik* and *Tangkhul Makrei/Khangamu*). With a grain yield of 1475.24 kg/ha, *Chakhao Poireiton* produced the highest growth parameters, and *Tangkhul Makrei/Khangamu* produced the lowest growth parameters with a grain yield of 1384.53 kg/ha. Dates of sowing had significant impact on growth. Early planting (6th July) resulted in the highest growth parameters and grain yield (1508.07 kg/ha), while late planting (20th August) resulted in the lowest growth parameters and grain yield (1361.58 kg/ha). Thus, the cultivar *Chakhao Poireiton* of black rice sown on July 6th was suitable for improved growth and grain yield.

Introduction

Black rice is a variety of the *Oryza sativa* L. rice species that is glutinous, rich in nutrients, and primarily grown in Asia. Other names for black rice include purple rice, prized rice, heaven rice, forbidden rice, imperial rice, and king's rice. The term "black rice" actually refers to a variety of *Oryza sativa* and it describes the grain's colour rather than any other characteristics. In addition, black rice is available in a number of glutinous, short-grain, and long-grain varieties. Due to the high anthocyanin content found in the pericarp layers, black rice has a dark purple colour (Takashi *et al.,* 2001). Black rice is the common name for rice varieties with coloured pericarps (apart from white and red). In order to improve the flavour, colour, and nutritional value of white rice before cooking, black rice is widely used in Asian nations (Yang *et al.,* 2003). Additionally, black rice is more nutritious than regular white rice in terms of proteins, vitamins, and minerals (Suzuki *et al.,* 2004). When compared to white rice, black rice has a higher concentration of minerals like Fe, Zn, Mn, and P. Its mineral content is also more variable depending on the planting area's soil types and variety (Qiu *et al.,* 1993; Zhang, 2000). The addition of black scented rice to the diet will significantly improve people's health (Asem *et al.,* 2015). Black rice has been demonstrated to lessen inflammation levels in the body in addition to being a good source of protein, fiber, and vitamin E.

The research's findings indicate that eating black rice helps manage and prevent serious conditions like cancer, arthritis, allergies, and even high cholesterol. Black rice is a native crop of the Northeast, West Bengal, Jharkhand, and Odisha in India. It is regarded as both food and traditional medicine in Manipur. In Manipur, it is consumed during communal feasts and is locally referred to as "*Chak-hao*," which means tasty rice. In order to strengthen hair, rice water is also used to wash it.

One cultural practice that has an impact on the rice crop is the method of establishment because it affects growth and development (Gopi *et al.,* 2006). In irrigated low land rice, transplanting is the most popular and traditional method of establishment. Due to a lack of labour and water, less rice is being transplanted globally. Therefore, it is necessary to investigate alternative crop establishment techniques in order to increase rice productivity (Farooq, 2011). Reduced yields of direct-sown rice are caused by early or late sowing. In order to ensure the success of direct seeded rice, the optimal sowing time must be standardized for every agro-ecological situation. Additionally, Gravois and Helms (1998) demonstrated that rice grain yields decreased as the date of sowing was postponed. Planting the crop at the ideal time, which varies from variety to variety, will result in the highest grain yield at a particular location (Reddy and Narayana, 1984).

Materials and Methods

A field experiment was conducted at the research farm of the Agronomy department at the College of Agriculture, Central Agricultural University, Imphal, Manipur during the *Kharif* season of 2020-21 which is situated at 24°81'N latitude and 93°89'E longitude with an elevation of 790 meters above mean sea level. The experiment was performed in factorial randomized block design with three replications.

The climatic condition of Imphal is sub- tropical. The rainy season usually starts by second fortnight of May and it extends up to September and retreats October onward. The winter normally starts from the mid-November and extends up to the end of February. In the year 2020, the total rainfall received was the highest in the month of June (307.4 mm) and the lowest in the month of December (0.0 mm). The maximum monthly temperature was 37.1°C in the month of October and the minimum monthly temperature was 6.5°C in the month of December.

The soil of experimental site was clayey in texture with sand 7.8% against silt 17.7% and clay 74.5%. Soil was acidic with a pH of 5.4, high organic carbon (1.25%) and medium amount of available nitrogen (292.83 kg/ha), phosphorus (16.91 kg/ha) and potassium (148.06 kg/ha). Three different cultivars (V1= *Chakhao Poireiton,* V2 = *Makrei Kazik* and V3 = *Tangkhul Makrei*/*Khangamu*) were sown with the spacing of 20 cm × 10 cm at four different sowing dates (S1 = 6th July, S2 = 21st July, S3 = 5th August and S4 = 20th August).

Comparatively higher seed rate (60 kg/ha) was put in application with the fertilizer doses of 60 kg N, 40 kg P2O5 and 30 kg K2O per ha. Weeding was carried out during the critical crop weed competition period. The whole experimental field was divided into three replications each of which contains 12 plots or treatments. Each of the 36 plots with a plot size of 4 m × 3 m was demarcated with the help of bunds. Plant height was recorded from randomly selected five hills from each plot at 30, 60, 90, 120 DAS and at harvest. For dry matter accumulation, randomly selected five plants were uprooted at 30, 60, 90, 120 DAS and at harvest. The samples were let to dry in the shade.

These plant samples were placed in brown paper bags and dried in an oven at 70°C until they reached a constant weight. After that, dry weight measurements of plant samples were made using an electronic balance, and dry matter accumulations in g/m2 for each treatment were calculated. Throughout the experiment, information was gathered regarding the plant height (cm), dry matter accumulations (g/m2), leaf area index, number of efficient tillers per hill and length of panicles (cm). Finally, grain yield (kg/ha), straw yield (kg/ha) and harvest index (%) were computed. Leaf area index was determined by using the formula (Watson, 1952)

$$\text{LAI} = \frac{\text{Area of total number of leaves}}{\text{Ground area from which leaf samples are collected}}$$

Each plot's rice grain and straw yield was used to calculate the harvest index, which was then expressed as a percentage:

$$\text{Harvest index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

All collected data were tabulated and statistically analyzed using the analysis of variance technique and, finally, Least Significance Difference (LSD at 5%) for comparing treatment means (Gomez and Gomez, 1976).

Results and Discussion

Growth parameters

Plant height (cm)

Plant height significantly varied depending on the sowing dates (Table 1). Accordingly, the earliest sowing date, July 6 (S1), had the tallest plants (178.61 cm) at harvest, which was significantly higher than the sowing dates of July 21 (S2), August 5 (S3), and August 20 (S4). The 20th of August recorded for the shortest plant height (158.10 cm).

Reduced temperatures and shorter days are likely to blame for the drop in plant height. Khade *et al.,* (1997) reported it as well. Akram *et al.,* (2007) also noted the lowered plant height with the postponed sowing. These studies support the current investigation. The height of the plants varied greatly between the varieties as well. In comparison to *Makrei Kazik* (V2) and *Tangkhul Makrei/Khangamu* (V3), *Chakhao Poireiton* (V1) had the tallest plants (174.19 cm) at the time of harvest. From *Tangkhul Makrei/Khangamu* (V3), the shortest plant height (162.05 cm) was obtained. Safdar *et al.,* (2008) also noted that early sowing produced taller heights than late sowing.

Leaf area index

An important measure of plant growth is the leaf area index (LAI), which quantifies how well plants can store solar energy for photosynthesis. With age, LAI increase steadily until it peaked at 90 DAS, after which it gradually decrease until harvest (Table 2). The highest recorded value of LAI was on July 6 (S1), and the lowest was on August 20 (S4). This could be as a result of earlier sowing dates producing more leaves per unit area. The vital organs of any plant that participate actively in photosynthesis are the leaves. The cultivar with the highest LAI among them was *Chakhao Poireiton* (V1), while *Tangkhul Makrei/Khangamu* (V3) had the lowest. *Chakhao Poireiton* might be more suitable to the soil and climatic conditions of the present location where the experiment was conducted. More tillers and leaves combined with better expansion may have contributed to improving the various growth parameters (Surekha *et al.*, 2008).

Dry matter accumulation (g/m2)

Different sowing dates and cultivars had a big impact on how much dry matter was accumulated (Table 3). Total biological yield and crop dry matter are directly proportional. Kumar *et al.*, (2009) reported similar outcomes. Interception of photosynthetically active radiation has a significant impact on the production of dry matter in rice (Kiniry *et al.*, 2001). The maximum amount of dry matter was accumulated on July 6th (1789.02 g/m2), and the least amount was accumulated on August 20th (1598.94 g/m2). This could be because increased photosynthesis, soil temperature, and soil water availability improve plant growth characteristics, resulting in higher dry matter production. Between the cultivars, *Chakhao Poireiton* accumulated the most dry matter (1741.49 g/m2) and *Tangkhul Makrei/Khangamu* accumulated the least (1624.37 g/m2).

Yield attributes

Number of effective tillers per hill

The number of effective tillers per hill was greatly influenced by sowing dates (Table 4). In comparison to the sowing dates of July 21 (S2), August 5 (S3), and August 20 (S4), the number of effective tillers per hill was significantly higher on July 6 (S1) i.e. (6.88). The fact that there were significantly more effective tillers per hill on July 6 compared to other sowing dates could be attributed to favourable environmental conditions. This outcome is consistent with the findings of Pandey *et al.*, (2001). Effective tillers per hill varied significantly between cultivars as well. In comparison to *Makrei Kazik* (V2) (6.09) and *Tangkhul Makrei/Khangamu* (V3) (5.78), *Chakhao Poireiton* (V1) had the most tillers per hill (6.43). Varietal traits may account for the variation in tiller production between cultivars (Chandrashekhar *et al.*, 2001).

Panicle length (cm)

Due to various sowing dates, the length of the panicle showed statistically significant variations (Table 4). Comparing sowing dates on July 21, August 5, and August 20, the panicle from the sowing on July 6 was found to be longer (21.46 cm). Due to incomplete photosynthesis during its growing period and roots' inability to absorb soil minerals, delayed transplanting from the early one may result in shorter panicles (Kushwaha *et al.*, 2016). Khalifa (2009) discovered that the ideal sowing date for panicle length is early in the season. Different rice cultivars caused significant statistical variation in the length of the panicles (Table 4). The shortest panicle (18.11 cm) was found in *Tangkhul Makrei/Khangamu*, while the longest panicle (19.96 cm) was seen in *Chakhao Poireiton*. Wang *et al.*, (2006) claimed that the hybrids had bigger panicles than regular cultivars.

Productivity of rice

Grain yield (kg/ha)

Different planting dates resulted in significant differences in grain yield (Table 5). The maximum grain yield (1508.07 kg/ha) was noted with the sowing on July 6 and the lowest grain yield (1361.58 kg/ha) was noted with the sowing on August 20. These findings concur with those of Iqbal *et al.*, (2008) who claimed that the rice crop produced its highest yield when it was sown earlier in the growing season. A statistically significant variation in grain yield due to various rice varieties was observed (Table 5). While *Tangkhul Makrei/Khangamu* had the lowest grain yield (1384.53 kg/ha), *Chakhao Poireiton* had the highest grain yield (1475.24 kg/ha). These findings support the findings of Wang *et al.*, (2006), according to which hybrid cultivars had larger panicles and heavier seeds than conventional cultivars, increasing yields by an average of 7.27%.

Table.1 Effect of sowing dates and cultivars on plant height (cm) of black aromatic rice

Treatment	30 DAS	60 DAS	90 DAS	120 DAS	Harvest
S1	61.29	107.66	143.64	176.43	**178.61**
S2	56.49	102.36	138.59	171.47	**174.15**
S3	47.54	93.16	129.54	162.58	**164.61**
S4	42.67	87.45	124.00	157.05	**158.10**
SE d (±)	1.81	3.06	5.17	5.05	**5.36**
CD (p=0.05)	3.76	6.35	10.73	10.48	**11.12**
V1	55.83	102.19	138.65	171.54	**174.19**
V2	53.93	99.64	135.8	168.69	**170.36**
V3	46.24	91.15	127.38	160.41	**162.05**
SE d (±)	1.57	2.65	4.48	4.37	**4.64**
CD (p=0.05)	**3.25**	**5.50**	**9.29**	**9.07**	**9.63**

Table.2 Effect of sowing dates and cultivars on leaf area index of black aromatic rice

Treatment	30 DAS	60 DAS	90 DAS	120 DAS	Harvest
S1	0.78	2.51	3.38	2.80	**2.72**
S2	0.74	2.03	2.64	2.13	**2.05**
S3	0.69	1.49	1.98	1.63	**1.65**
S4	0.67	1.26	1.70	1.40	**1.30**
SE d (±)	0.03	0.16	0.25	0.22	**0.23**
CD (p=0.05)	0.05	0.33	0.53	0.46	**0.49**
V1	0.74	2.03	2.69	2.227	**2.22**
V2	0.73	2.02	2.66	2.225	**2.15**
V3	0.68	1.43	1.92	1.51	**1.42**
SE d (±)	0.02	0.14	0.22	0.19	**0.20**
CD (p=0.05)	**0.05**	**0.29**	**0.46**	**0.40**	**0.42**

Table.3 Effect of sowing dates and cultivars on dry matter accumulation (g/m^2) of black aromatic rice

Treatment	30 DAS	60 DAS	90 DAS	120 DAS	Harvest
S1	144.17	589.42	1199.80	1779.64	**1789.02**
S2	136.45	555.86	1152.17	1713.57	**1722.59**
S3	117.83	514.95	1075.96	1637.52	**1646.87**
S4	105.57	491.85	1034.54	1590.19	**1598.94**
SE d (±)	6.38	19.19	43.24	50.89	**50.37**
CD (p=0.05)	13.23	39.79	89.66	105.54	**104.46**
V1	136.05	566.27	1159.36	1732.35	**1741.49**
V2	129.69	544.10	1125.53	1693.27	**1702.20**
V3	112.28	503.70	1061.97	1615.06	**1624.37**
SE d (±)	5.52	16.62	37.44	44.07	**43.62**
CD (p=0.05)	**11.46**	**34.46**	**77.65**	**91.40**	**90.46**

Table.4 Effect of sowing dates and cultivars on yield attributes of black aromatic rice

Treatment	No. of effective tillers per hill	Panicle length (cm)
S1	6.88	**21.46**
S2	6.27	**19.72**
S3	5.74	**18.19**
S4	5.50	**16.94**
SE d (±)	0.16	**0.44**
CD (p=0.05)	0.33	**0.92**
V1	6.43	**19.96**
V2	6.09	**19.17**
V3	5.78	**18.11**
SE d (±)	0.14	**0.38**
CD (p=0.05)	**0.28**	**0.80**

Table.5 Effect of sowing dates and cultivars on grain yield, straw yield and HI of black aromatic rice

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
S1	1508.07	3470.32	**0.355**
S2	1467.15	3431.37	**0.352**
S3	1406.02	3361.06	**0.349**
S4	1361.58	3292.16	**0.349**
SE d (±)	10.75	11.04	**0.001**
CD (p=0.05)	22.29	22.90	**0.001**
V1	1475.24	3432.37	**0.353**
V2	1447.34	3403.57	**0.352**
V3	1384.53	3330.24	**0.349**
SE d (±)	9.31	9.56	**0.001**
CD (p=0.05)	**19.30**	**19.83**	**0.001**

Straw yield (kg/ha)

The sowing dates and varieties had a significant impact on the amount of straw produced (Table 5). The sowing on July 6 produced the highest yield of straw (3470.32 kg/ha), which was significantly higher than the yields on July 21, August 5, and August 20. The straw yield from the August 20 sowing was significantly lower (3292.16 kg/ha). Similarily, *Chakhao Poireiton* recorded the highest straw yield (3432.37 kg/ha), while *Tangkhul Makrei/Khangamu* recorded the lowest (3330.24 kg/ha). The grain and straw yield from Kranti was significantly higher than that from IR36, according to Patel (2000).

Harvest index (%)

Different planting dates resulted in statistically significant differences in the harvest index (Table 5). While the minimum harvest index (0.349%) was noticed from sowing on August 20th, the maximum harvest index (0.355%) was noted from sowing on July 6th. Jalil *et al.*, (2016) discovered that the transplanting on July 30 resulted in high HI data, and the lowest data was recorded on September 15. This could be explained by a high grain yield from an earlier sowing and a low grain yield from a subsequent sowing. Due to different rice varieties, variation was noted in the harvest index (Table 5). The harvest index from *Chakhao Poireiton* had the highest value (0.353%), while *Tangkhul Makrei/Khangamu* had the lowest value (0.349%). The outcome that Karmakar *et al.*, (2002) reported was consistent with the current findings.

The cultivar of black rice, *Chakhao Poireiton* resulted in maximum growth parameters, yield attributes and grain yield on earlier sowing date (6th July). This was significantly higher than *Makrei Kazik* and *Tangkhul Makrei*/*Khangamu* cultivars and late sowing dates i.e., 21st July, 5th August and 20th August.

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