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Effect of Slow - Release Fertilizers and Mahua Oil Cake on the Growth of Chakhao Black Rice (*Oryza sativa* L.)

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A B S T R A C T

A field experiment was conducted during the kharif season of 2025 at the Agricultural Farm of Himalayan University, Jollang, Itanagar, to evaluate the synergistic effects of slow-release fertilizers and Mahua oil cake on the growth of Chakhao black rice (*Oryza sativa* L.). The experiment was laid out in a Randomized Block Design (RBD) with three replications and eight treatments, viz., T_1 (control), T_2 (100% Recommended Dose of Nitrogen (RDN) through Neem Coated Urea (NCU) +25% Mahua oil cake), T_3 (75% RDN through NCU + 25% Mahua oil cake), T_4 (50% Recommended Dose of Nitrogen (RDN) through Neem Coated Urea (NCU) +25% Mahua oil cake), T_5 (100% Recommended Dose of Nitrogen through rock phosphate + 25% Mahua oil cake), T_6 (75% Recommended Dose of Nitrogen through rock phosphste +25% of mahua oil cake), T_7 (50% Recommended Dose of Nitrogen through rock phosphate +25 % mahua oil cake), T_8 (100% Recommended Dose of Nitrogen through neem coated urea +100% RDN through rock phosphate + 25% of mahua oil cake). The study recorded Significant differences among treatments were observed in plant height, leaf length, number of tillers, dry weight and leaf width of plant at 30, 60 and 90 days after transplanting (DAT). The results revealed that treatment T_4 (50% RDN through Neem coated urea + 25% of Mahua oil cake) recorded the highest values for all growth parameters. This was followed by treatment T_5, which received (100% RDN through rock phosphate + 25% Mahua oil cake).The lowest values were observed in the control (T1), which did not receive any additional nutrient inputs.

Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops, supporting more than half of the global population, particularly in Asia, where glutinous types are commonly grown and consumed (Kong *et al.,* 2008). Compared to many other rice varieties, it is valued for its relatively higher nutritional content.In recent years, there has been a growing shift in consumer preference toward nutrient – rich and health-promoting foods. However, malnutrition remains a major global concern, affecting nearly three billion people due to insufficient intake of essential nutrient (Welch, 2005).

Black rice, commonly known as “Chakhao” in the local dialect, meaning “delicious rice,” is mostly grown by Meitei farmers in Manipur. There are four major landraces of black rice in Manipur which includes

Chakhao amubi, Chakhao angouba, Chakhao poireiton and Chakhao pungdol amubi. Compared to commonly consumed rice varieties, black rice exhibits comparatively higher antioxidant activity due to its bioactive compounds, has high protein content (8.16%) and low fat content (0.07%) (Thomas *et al., 2013*) as compared with other rice varieties, is gluten- free, gut - friendly and a natural cleaner with many medicinal values (Jha *et al.,* 2017).

Chak-hao is highly associated with socio-cultural value of people of Manipur. It plays a unique role in festival and cultural ceremonies of the state as it uses for namesake on the occasion like birth and death ceremonies of domicile of Manipur (Borah, 2018).The uniqueness of the black aromatic rice of Manipur is its pleasant aroma and color coupled with stickiness which is not common in other black rice grown in other parts of the world. The local name of this black rice is Chak-hao.

The characteristic dark coloration of black rice is mainly attributed to the presence of anthocyanin pigments located in the outer grain layers. It also contains γ - oryzanol and other pharmacological compounds, such as phenolics and flavonoids compounds (Balasubramaniam *et al.,* 2019).

Due to its nutritional and cultural importance, Chakhao received the Geographical Indication (GI) tag in 2020 (Chanu *et al.,* 2022). It is cultivated during the kharif season under warm climatic condition Black rice is grown during the kharif season**.**

Mahua oil cake is a nutrient – rich organic fertilizer containing nitrogen, phosphorus, potassium, and organic matter. It improves soil structure, enhances microbial activity, and increases water- holding capacity, thereby promoting crop growth.

The application of neem coated urea significantly enhances grain yield of rice by improving nitrogen use efficiency and minimizing nitrogen losses, which ensures a sustained nitrogen supply during critical growth stages and ultimately increases productivity.

Neem coated urea application resulted in higher grain and straw yield compared to conventional urea due to improved nitrogen retention in soil and better synchronization between nutrient release and crop demand (Verma and Yadav., 2018).

The application of rock phosphate improves phosphorus availability in acidic soil, which enhances root growth and grain formation, thereby leading to increased yield in rice crops (Khan *et al.,* 2016)

Materials and Methods

The experiment was conducted at the Agricultural field, College of Agriculture, Himalayan University, Jollang, Itanagar, Arunachal Pradesh during the period of kharif season starting 26 June 2025. The experimental farm is situated at 27.074684 °, N latitude and 93.652878 ° E longitude with an average elevation of 320 meters. It was undertaken with the objective to analyze the different rice varieties and to assess their performance in kharif season.

The treatment include, T_1-control, T_2- 100% RDN through NCU +25% Mahua oil cake,T_3-75% RDn through NCU + 25% Mahua oil cake,T_4- 50% RDN through NCU +25% Mahua oil cake,T_5- 100% RDN through rock phosphate + 25% Mahua oil cake,T_6- 75% RDN through rock phosphate +25% of mahua oil cake, T_7-50% RDN through rock phosphate +25 % mahua oil cake, T_8- 100% RDN through neem coated urea +100% RDN through rock phosphate + 25% of mahua oil cake. The experiment was carried out in Randomized Block Design (RBD) in the year 2025-2026.

The climate of Itanagar is humid subtropical, with a distinct season. The rainy season usually starts from May and it extends up to September and from October onwards. The meteorological data of weather parameter. Temperature, rainfall, relative humidity and sunshine hours recorded during the period of the experimentation have been presented in the table. The mean minimum and maximum temperature recorded during the cropping season was 22.9 °C and 25.5 °c, respectively, with an average relative humidity of 80%

Crop Growth Attributes

Plant height was measured in centimeters from the base to the tip of the plant on 5 randomly selected plants in each plot. These plants were tagged so the same ones could be observed again later, measurements were taken three times - at 30. 60, and 90 days after sowing (DAT).The average height of the plants in each treatment was calculated for each observation time. Leaf length was measured from the base to the tip of the leaf on 5 randomly selected plants in each plot. These plants were tagged and measured again later. Observation were taken

at 30, 60 and 90 days after sowing (DAT), and the average leaf length for each treatment was calculated at each time point. The number of tillers per treatment was calculated for each time point. The dry weight of a plant is the weight remaining after all the water has been eliminated. This is usually achieved by heating the plant material at a temperature above normal room temperature untill all the moisture has been dried out.

Results and Discussion

The growth and development parameters of Chakhao Black rice were recorded under a Randomized Block Design (RBD) with three replications. Observations were taken for various traits such as plant height (cm), leaf length, number of tillers, and leaf width. The data were statistically analyzed to compute the general mean, standard error (Sed), and critical difference (CD) for each trait.

Plant height

Plant height of Chakhao black rice recorded at 30, 60 and 90 DAT was stastistically analyzed and presented in table 1.

At 30 days after sowing (DAT), the maximum plant height was observed in treatment T_4, which included 50% RDN through NCU along with 25% Mahua oil cake resulting in an average height of 64.1cm, Treatment T_5, consisting of 100% RDN through Rock phosphate and 25% Mahua oil cake, produced a height of 63.3 cm, with no significant difference compared to T_4. The shortest plants, measuring 58.3 cm, were recorded in the control treatment (T1), which did not receive any additional inputs.

At 60 DAT, the maximum plant height was observed to be statistically significant in treatment T4 which included 50% recommended dose of Nitrogen (RDN) through Neem Coated Urea (NCU) along with 25% Mahua oil cake, resulting in average height of 111.5 cm and T5 consisting of 100% RDN through Rock Phosphate and 25% Mahua oil cake, produced a height of 109.2 cm, with no significant difference compared to T_4 cm. The shortest plants, measuring 93.1 cm, were recorded in the control treatment (T_1), which did not receive any additional inputs.

At 90 DAT, the maximum plant height was observed in treatment T_4, which included 50% recommended dose of nitrogen (RDN) through Neem Coated Urea (NCU) along with 25% Mahua Oil Cake, resulting in average height of 149.5 cm. and T_5 consisting of 100% RDN through Rock Phosphate and 25% Mahua oil cake, produced a height of 146.3 cm, with no significant difference compared to T_4.The shortest plants, measuring 130.5 cm, were recorded in the control treatment (T_1), which did not receive any additional inputs.

The maximum plant height recorded under treatment T_4 may be due to the combined application of 50% neem - coated urea and 25% mahua oil cake. Neem coated urea which provides nitrogen in a more controlled and sustained manner, facilitating gradual release and improving nitrogen use efficiency by reducing losses (Fageria *et al.,* 2008). At the same time, Mahua oil cake enhances soil health, microbial activity, and the availability of essential nutrients. (Mahapatra *et al.,* 2012). This combined supply of nutrients provides a more balanced and continuous supply of nutrients to the crop, which supported important growth processes such as cell division and elongation, ultimately resulting in taller plants. The combined use of efficient nitrogen sources and organic amendments improves nutrient use efficiency, yield and plant growth have also been reported by (Singh *et al.,* 2012).

Leaf length

Leaf length of Chakhao black rice recorded at 30, 60, and 90 DAT was statistically analyzed and presented in tables.2 and graphs 2.

At 30 days after transplanting (DAT), the greatest leaf length was observed in treatment T_4, which included 50% recommended dose of Nitrogen (RDN) through Neem Coated Urea (NCU) along with 25% Mahua Oil Cake, resulting in an average height of 47.1 cm. Treatment T_5, consisting of 100% RDN through Rock Phosphate and 25% Mahua oil cake, produced a leaf length of 46.8cm, with no significant difference compared to T_4.The shortest leaf length, measuring 41.8 cm, were recorded in the control treatment (T_1), which did not receive any additional inputs.

At 60 DAT, the greatest leaf length was observed to be statistically significant in treatment T_4, which included 50% recommended dose of nitrogen (RDN) through Neem Coated Urea (NCU) along with 25% Mahua Oil Cake, resulting in an average height of 81.97 cm. Treatment T_5, consisting of 100% RDN through Rock

Phosphate and 25% Mahua oil cake, produced a leaf length of 80.7 cm, with no significant difference compared to T_4.The shortest leaf length measuring 74.6 cm, were recorded in the control treatment (T_1), which did not receive any additional inputs.

At 90 DAT, the greatest leaf length was observed to be statistically significant in treatment T_4, which included 50% recommended dose of Nitrogen (RDN) through Neem Coated Urea (NCU) along with 25% Mahua Oil Cake, resulting in an average height of 93.6 cm. Treatment T_5, consisting of 100% RDN through Rock Phosphate and 25% Mahua oil cake, produced a leaf length of 92.9 cm, with no significant difference compared to T_4. The shortest leaf length measuring 84.96 cm, were recorded in the control treatment (T_1), which did not receive any additional inputs.

The greater leaf length observed under the treatment T4 (50% RDN through NCU + 25% Mahua oil cake) compared to the shortest leaf length in treatment T1 (Control) may be attributed to the continuous and control supply of nitrogen through the crop growth period. Adequate nitrogen availability supports key physiological processes such as cell division and cell elongation, which ultimately result in increased leaf expansion.

Nitrogen plays a key role in determining leaf size and vegetative growth (Fageria N.K. *et al.,* 2011). In addition, organic sources such as Mahua oil cake improve soil fertility and microbial activity, further supporting leaf development.

T5 recorded moderate leaf length may be due to the application of rock phosphate, which supplies phosphorus essential for root development and energy transfer; however, its slow solubility and lack of sufficient nitrogen limited leaf growth compared to T4 (Chien *et al.,* 2010).

The lowest leaf length in T1(control) was due to nutrient deficiency, particularly nitrogen, resulting in reduced cell division and elongation, thereby restricting leaf development (Prasad *et al.,* 2014).

Dry Weight

Dry weight of Chakhao black rice recorded after 90 DAT and this was statistically analyzed and presented in tables 4.1.5 and graphs 4.1.5.

At 30 days after transplanting (DAT), Treatment T_4 which received (50% recommended dose of nitrogen (RDN) through Neem Coated Urea (NCU) along with 25% Mahua Oil Cake), exhibited the highest dry weight of 1.92333g, a statistically significant result. This was closely followed by treatment T_5 (100% RDN through Rock Phosphate and 25% Mahua oil cake), recording an average dry weight of 1.86333g. The lowest dry weight was observed in control group (T_1), which received no additional nutrient supplementation, showed the lowest dry weight at 0.9g.

At 60 days after transplanting (DAT), Treatment T_4 which received (50% recommended dose of nitrogen (RDN) through Neem Coated Urea (NCU) along with 25% Mahua Oil Cake), exhibited the highest dry weight of 3.66333g, a statistically significant result.

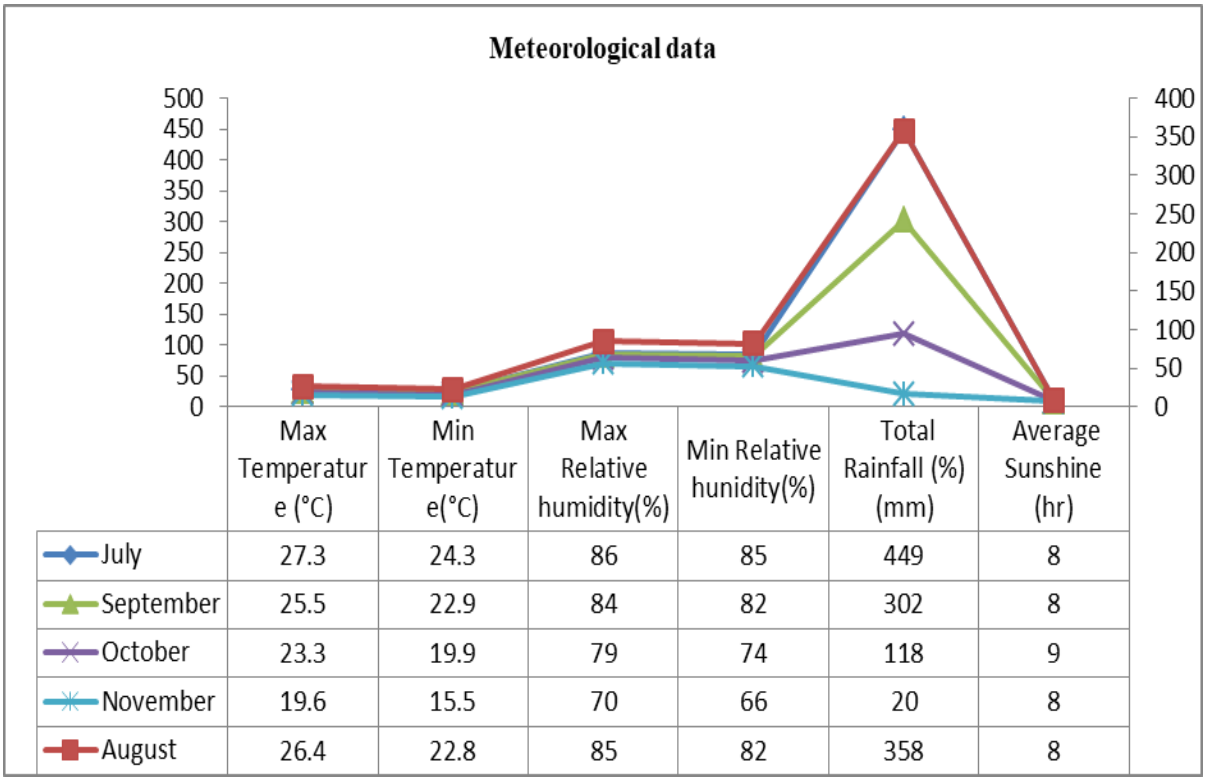
This was closely followed by treatment T_5 (100% RDN through Rock Phosphate and 25% Mahua oil cake), recording an average dry weight of 3.4g. The lowest dry weight was observed in control group (T_1), which received no additional nutrient supplementation, showed the lowest dry weight at 2.89g.

At 90 days after transplanting (DAT), Treatment T_4 which received (50% recommended dose of nitrogen (RDN) through Neem Coated Urea (NCU) along with 25% Mahua Oil Cake), exhibited the highest dry weight of 8.326g, a statistically significant result. This was closely followed by treatment T_5 (100% RDN through Rock Phosphate and 25% Mahua oil cake), recording an average dry weight of 7.356g. The lowest dry weight was observed in control group (T_1), which received no additional nutrient supplementation, showed the lowest dry weight at 5.873g.

The likely reason for the observed increase in dry matter production can be attributed to the elevated levels of nitrogen (Neem coated urea) application, which tend to stimulate vegetative growth by enhancing plant height and promoting the development of a greater number of tillers per square meter. This cumulative effect of increased structural biomass and tillering capacity consequently leads to a substantial rise in the overall accumulation of dry matter within the plant system (Wani *et al.,* 2016)

In conclusion, this improvement is mainly attributed to better nutrient availability, enhanced nitrogen use efficiency, and improved soil health.

Table.1 Meteorological data of weather parameters and total rainfall during the cropping season (Kharif 2025-2026)



	Max Temperature (°C)	Min Temperature(°C)	Max Relative humidity(%)	Min Relative hunidity(%)	Total Rainfall (%) (mm)	Average Sunshine (hr)
July	27.3	24.3	86	85	449	8
September	25.5	22.9	84	82	302	8
October	23.3	19.9	79	74	118	9
November	19.6	15.5	70	66	20	8
August	26.4	22.8	85	82	358	8

Table.1 Effect of different Slow Release Fertilizers and Mahua Oil Cake on Plant Height of Chakhao Black Rice

Treatment	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
T_1- Control	58.5	93.1	130.5
T_2: 100% RDN Through NCU + 25% Mahua oil cake	59.9	101.7	132.3
T_3: 75% RDN Through NCU + 25% Mahua oil cake	60.5	102.3	136.9
T_4: 50% RDN Through NCU + 25% Mahua oil cake	64.1	111.5	149.5
T_5: 100% RDN Through Rock Phosphate (RP) +25% Mahua oil cake	63.3	109.2	146.3
T_6: 75% RDN Through Rock phosphate (RP) +25% Mahua oil cake	62.7	106.2	144.6
T_7: 50% RDN Through Rock Phosphate (RP) + 25% Mahua oil cake	62.0	104.5	142.4
T_8: 100% RDN Through Neem Coated Urea + 100% RDN Through Rock phosphate + 25% Mahua oil cakes	61.3	103.1	138.2
F test	S	S	S
S.Ed±	0.333333	0.719069	0.361435
CD (P=0.05)	0.714929	1.54225	0.7752

Table.1 Effect of different Slow Release Fertilizers and Mahua Oil Cake on Plant Height of Chakhao Black Rice

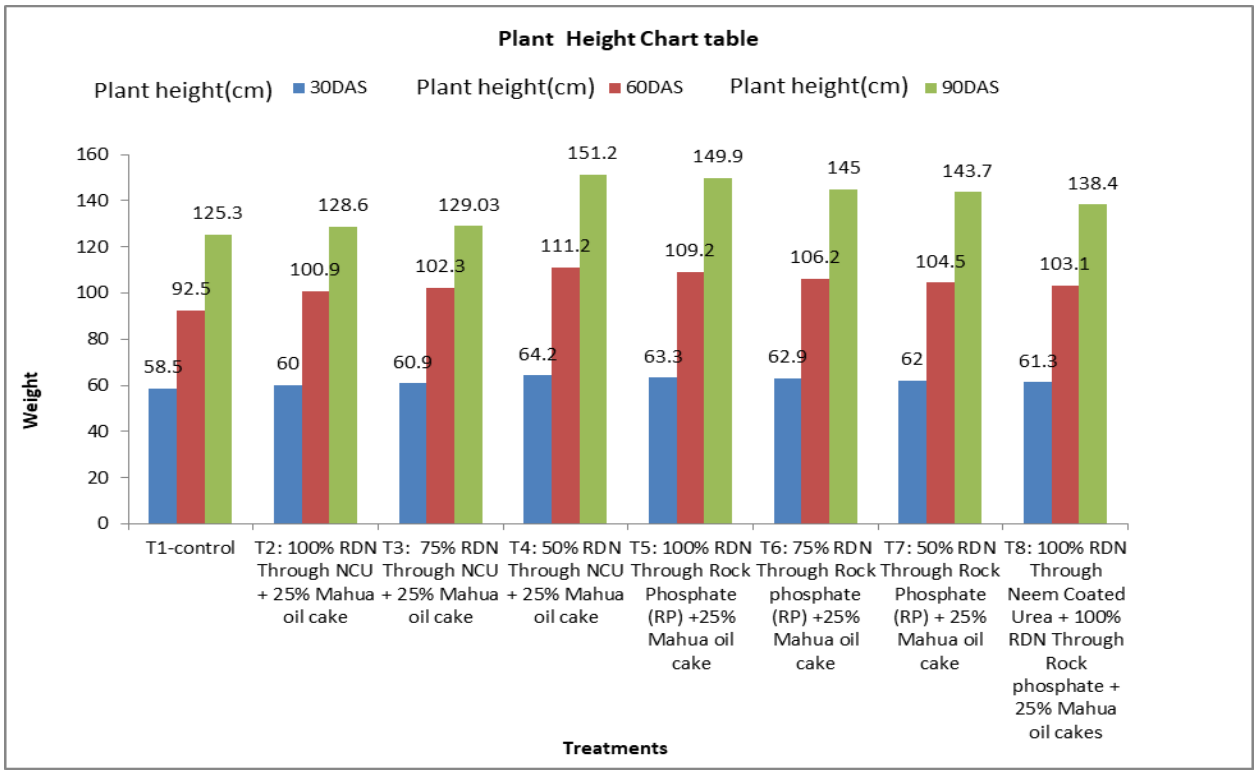


Table.2 Effect of different Slow Release Fertilizers and Mahua oil cake on leaf length of Chakhao Black Rice

Treatments	Leaf length (cm)		
	30DAS	60DAS	90DAS
T_1- Control	41.8	74.6	84.96
T_2: 100% RDN Through NCU + 25% Mahua oil cake	42.9	75.6	85.4
T_3: 75% RDN Through NCU + 25% Mahua oil cake	44.5	77.7	86.06
T_4: 50% RDN Through NCU + 25% Mahua oil cake	47.1	81.97	93.6
T_5: 100% RDN Through Rock Phosphate (RP) +25% Mahua oil cake	46.8	80.7	92.9
T_6: 75% RDN Through Rock phosphate (RP) +25% Mahua oil cake	45.7	79.4	91.4
T_7: 50% RDN Through Rock Phosphate (RP) + 25% Mahua oil cake	45.5	79.2	90.8
T_8: 100% RDN Through Neem Coated Urea + 100% RDN Through Rock phosphate + 25% Mahua oil cakes	44.97	78.5	86.5
F test	NS	S	S
S.Ed±	0.978641	1.918405	1.255132
CD (P=0.05)	2.098976	4.11457	2.691991

Table.2 Effect of different Slow Release Fertilizers and Mahua oil cake on leaf length of Chakhao Black Rice

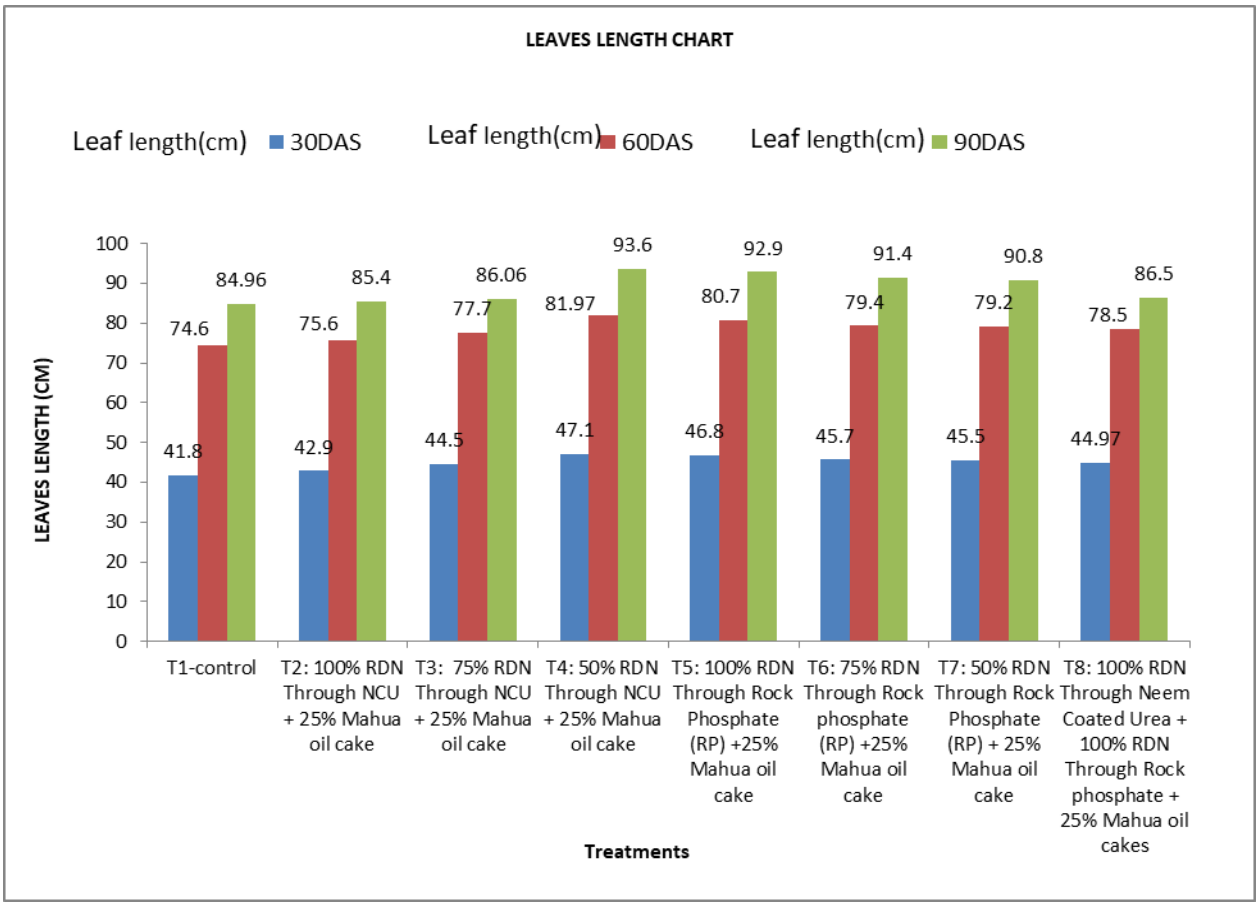
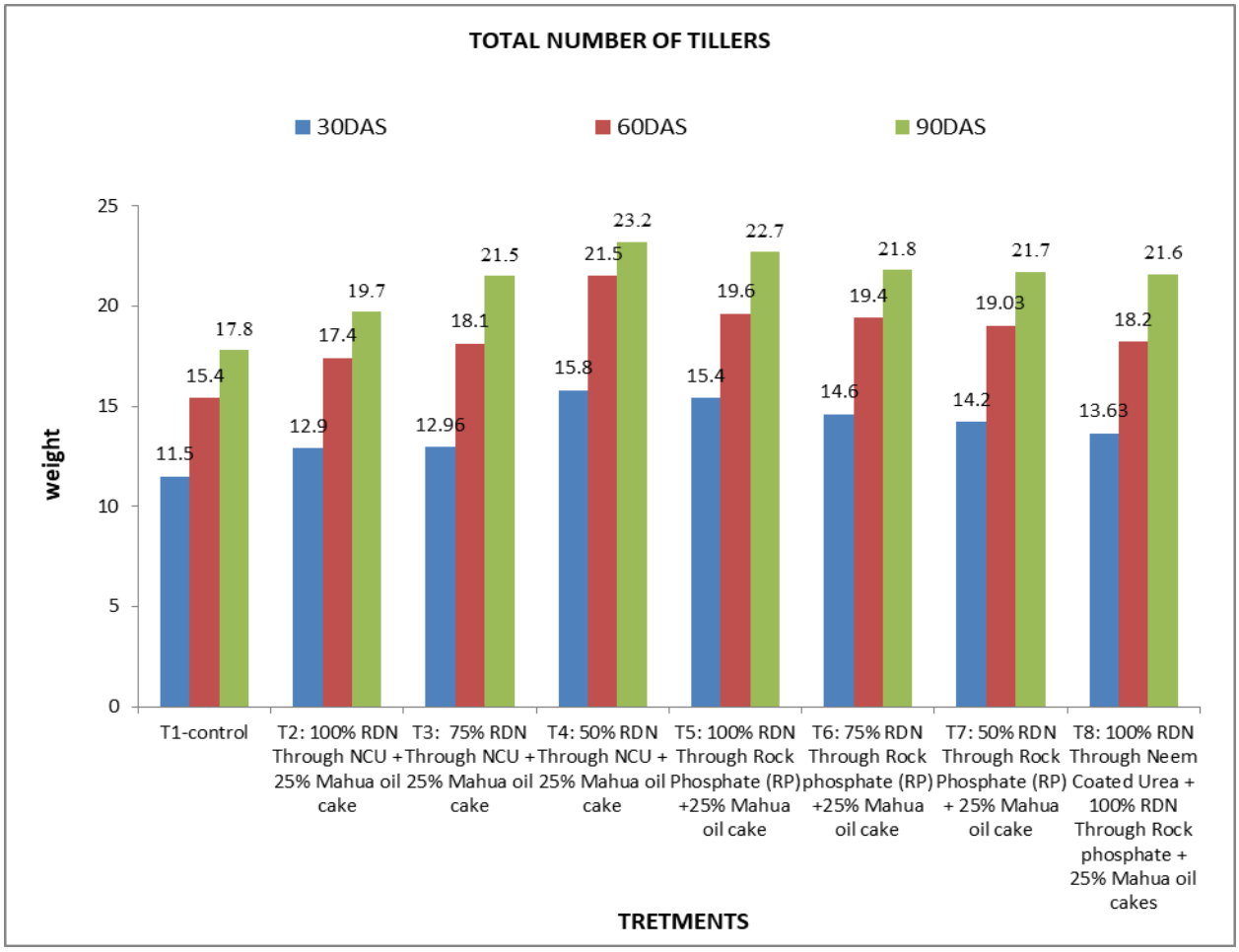


Table.3 Effect of different Slow Release Fertilizers and Mahua oil cake on tillers of Chakhao Black Rice

Treatments	Total number of tillers		
	30 DAS	60 DAS	90DAS
T_1- Control	11.5	15.4	17.8
T_2: 100% RDN Through NCU + 25% Mahua oil cake	12.9	17.4	19.7
T_3: 75% RDN Through NCU + 25% Mahua oil cake	12.97	18.1	21.5
T_4: 50% RDN Through NCU + 25% Mahua oil cake	15.8	21.5	23.2
T_5: 100% RDN Through Rock Phosphate (RP) +25% Mahua oil cake	15.4	19.6	22.7
T_6: 75% RDN Through Rock phosphate (RP) +25% Mahua oil cake	14.6	19.4	21.8
T_7: 50% RDN Through Rock Phosphate (RP) + 25% Mahua oil cake	14.2	19.03	21.7
T_8: 100% RDN Through Neem Coated Urea + 100% RDN Through Rock phosphate + 25% Mahua oil cakes	13.6	18.2	21.6
F test	S	S	S
S.Ed±	0.822332	0.747987	0.571652
CD (P=0.05)	1.763727	1.604272	1.226071

Table.3 Effect of different Slow Release Fertilizers and Mahua oil cake on tillers of Chakhao Black Rice



Therefore, the integration of neem coated urea with Mahua oil cake can be recommended as an effective and sustainable nutrient management practice for increasing the productivity of Chakhao black rice.

On the basis of the results obtained from the present investigation, it is concluded that the combined application of slow- release fertilizers and Mahua oil cake significantly improves the growth parameters of Ckhakhao black rice. Shows the most favourable outcomes across the growth parameters i.e Maximum plant height (149.5 cm), highest leaf length (93.6 cm), and highest dry weight (8.33g) at 90 DAS and moreover, it is seen that under T4 (50% RDN through Neem coated urea +25% mahua oil cake).This improvement is mainly attributed to better nutrient availability, enhanced nitrogen use efficiency, and improved soil health. Therefore, the integration of neem coated urea with Mahua oil cake can be recommended as an effective and sustainable nutrient management practice for increasing the productivity of Chakhao black rice.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as larger Language Models (ChatGpt, COPILOT, etc) and text-to- image generators have been used during writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

Author Contributions

Dorjee Gyachen Jairy: Investigation, formal analysis, writing—original draft. Kasinam Doruk: Validation, methodology, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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