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Establishment of Alternative Season for Cultivation of Photoperiod-Sensitive Traditional Rice Cultivars

Monish Roy[1] and Bidhan Roy[1*]

[1]Department of Seed Science and Technology, Faculty of Agriculture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar 736165, West Bengal, India.

Authors' contributions

This work was carried out in collaboration between both authors. Author BR conceptualization of research, supervised experiments, contributed to manuscript preparation and interpretation. Author MR conducted and supervised experiments, data recording, contributed to manuscript preparation and interpretation. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To find out the suitable time for cultivating the photoperiod-sensitive rice cultivars during off-season.
Study Design: Randomized Block Design.
Place and Duration of Study: University Research Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar 736165, West Bengal, India. Experiments were conducted during *Boro* 2017 and *Kharif* 2018.
Methodology: Forty nine cultivars were sown in seed beds on 28th November, 2017 for cultivation of the *Boro* crop and sowing was done on 30th June, 2018 for cultivation of *Kharif* crop. Seedlings were transplanted in randomized block design with two replications. Row to row spacing was 30 cm and plant to plant spacing was 20 cm. Standard agronomic practices compatible to the humid tropic of Terai Zone were practiced. Ten random plants from each plot were selected for recording data. Observations were recorded on yield and yield attributing parameters.
Results: High significant variation was observed for all the characters under study indicating the presence of high variability among the selected cultivars. Only the test weight between the two seasons had insignificant difference representing that there was no effect of seasons on this

**Corresponding author: E-mail: bcroy10@yahoo.com;*

character. Time of sowing was standardized for sowing of the traditional cultivars in alternative season- *Boro*. The yield ranged from 0.35 t/ha to 2.68 t/ha during *Boro* and from 2.67 t/ha to 8.48 t/ha during *Kharif*. Ronga Komal (2.68 t/ha), Kauka (2.65 t/ha), Jaldhyapa (2.54 t/ha), Chakhao Angangbi (2.07 t/ha), Kaloboichi (1.87 t/ha), Kalturey (1.85 t/ha), Chakhao-Selection-2 (1.59 t/ha), Chakhao-Selection-1 (1.46 t/ha), Chakhao Sempak (1.43 t/ha) and Chakhao-Selection-3 (1.42 t/ha) performed well during *Boro* season.

Conclusion: Ronga Komal, Kauka, Jaldhyapa, Chakhao Angangbi, Kaloboichi, Kalturey, Chakhao-Selection-2, Chakhao-Selection-1, Chakhao Sempak and Chakhao-Selection-3 performed well during *Boro* season. Consequently, those above varieties may be recommended for cultivation during *Boro* season.

Keywords: Rice (Oryza sativa L.); traditional cultivars; alternative season; yield attributes.

1. INTRODUCTION

Rice is the staple food for the people of Asian and African countries. This crop has also gained popularity in Latin America and Australian countries.The primary centre of origin of the cultivated rice is South-east Asia for *O. sativa* and Africa for *O. glaberrima*. Enormous variability is available within the sub-species of *Oryza sativa* L., such as *indica*, *japonica* and *javanica*. The *indica* sub-species characterized by tall, spreading plant types with lot of variation in the morphological characters and are cultivated all over the tropical and sub-tropical Asia. North-eastern states and Eastern states are the part of the primary centre of rice. So, a colossal of genotypic variations of traditional rice is in existence in these areas [1-3].

Traditional cultivars have immense potential of most valuable genes which can be efficiently employed in the breeding programmes to develop high yielding rice varieties with quality and resistance to biotic and abiotic stresses [4]. Most of the traditional rice cultivars are highly photoperiod-sensitive and can be cultivated only during a particular season. Rice is a *facultative short day* plant and exhibits a wide range of variation in degree to photoperiod-sensitivity, which controls its growth and flowering [5-10]. Photoperiodic mechanism on flowering of rice were further studied with molecular approaches [11,12] Experiments have also been conducted to develop early flowering and photoperiod-insensitive varieties [13].

In spite of potential advantages of traditional cultivars with nutritional values, medicinal properties, resistance to biotic stresses, tolerance to abiotic stresses and yield potential, Indian rice cultivation is limited to modern high yielding varieties. There is lack of information in respect of field data on flowering time variation within season and sensitivity to photoperiodic-season for utilizing of traditional rice cultivars for cultivation in alternative season in addition to the traditional season of cultivation. In Eastern and North-eastern states of India, traditional rice cultivars are cultivated during *Kharif* season (June-November). Identification of alternative season for cultivation of traditional rice cultivars was aimed in this endeavour.

2. MATERIAL AND METHODS

2.1 Plant Materials

Forty nine traditional rice cultivars (Table 1) collected from different parts of West Bengal and Manipur were selected from the University Rice Repository of Uttar Banga Krishi Viswavidyalaya [3,14]. Those cultivars are cultivated during *Kharif* season (June-November) and highly photoperiod-sensitive in nature. The experiment was carried out at the University Research Farm during *Boro* 2017-18 (Off-season) and *Kharif* 2018 (On-season). The geographical position of the farm was 26°19′86″ N latitude, 89°23′53″ E longitude and an elevation of 43 meter above mean sea level.

2.2 Methods

The seeds of 49 cultivars were sown in seed beds on 28^{th} November, 2017 for cultivation of the *Boro* crop and sowing was done on 30^{th} June, 2018 for cultivation of *Kharif* crop. Thirty days old seedlings were transplanted in plots measuring 3 × 1.5 m area in randomized block design with two replications. Row to row spacing was 30 cm and plant to plant spacing was 20 cm. Standard agronomic practices [14] compatible to the humid tropic of Terai Zone were practiced to obtain good crop stand. Ten random plants were selected from each cultivar of each replication for recording the data using the guidelines of IRRI [15]. Observations were recorded on days to

50% flowering, plant height (cm), number of panicles per plant, panicle length (cm), number of filled grains per panicle, number of chaffy grains per panicle, number of total grains per panicle, grain sterility (%), test weight (g) and grain yield per plant (g).

Table 1. Name of the traditional cultivars of rice used in this study and their place of collection

Sl. No.	Name of farmers' variety	Place of collection/ source of the seed
1.	A-11	Tarai Research Society, Alipurduar, West Bengal
2.	Arnnapurna	Tarai Research Society, Alipurduar, West Bengal
3.	Beto	Tarai Research Society, Alipurduar, West Bengal
4.	Binni	Tarai Research Society, AlipurDuar, West Bengal
5.	Birai	ICAR-CPRI- Kahikuchi, Kamrup, Assam
6.	Bitti	Tarai Research Society, Alipurduar West Bengal
7.	ChakhaoAngangbi	PSBSG, Sitalkuchi, Cooch Behar district, West Bengal
8.	ChakhaoPoireiton	Central Agriculture University, Imphal, Manipur
9.	Chakhao-Selection-1	Central Agriculture University, Imphal, Manipur
10.	Chakhao-Selection-2	UBKV, Pundibari, Cooch Behar, West Bengal
11.	Chakhao-Selection-3	UBKV, Pundibari, Cooch Behar, West Bengal
12.	ChakhaoSempak	UBKV, Pundibari, Cooch Behar, West Bengal
13.	ChapkaChakhao	Central Agriculture University, Imphal, Manipur
14.	DharamPhou	Central Agriculture University, Imphal, Manipur
15.	Dudheswar	Central Agriculture University, Imphal, Manipur
16.	GaruChakhua	Tarai Research Society, Alipurduar, West Bengal
17.	Harinkajali	ICAR-CPRI- Kahikuchi, Kamrup, Assam
18.	Harpi	Tarai Research Society, Alipurduar, West Bengal
19.	Jaldhyapa	Tarai Research Society, Alipurduar, West Bengal
20.	Jaldhyapa-2	Tarai Research Society, Alipurduar, West Bengal
21.	Jhagarikartik	Sitalkuchi, Cooch Behar district, West Bengal
22.	Kagey	Tarai Research Society, AlipurDuar, West Bengal
23.	Kaike	Kalimpong district, West Bengal
24.	KaloNunia	Tarai Research Society, Alipurduar, West Bengal
25.	Kaloboichi	Cooch Behar district, West Bengal
26.	Kalturey	Tarai Research Society, AlipurDuar, West Bengal
27.	KashiyaBinni	Kalimpong district, West Bengal
28.	Kataribhog	Tarai Research Society, Alipurduar, West Bengal
29.	Kauka	Alipurduar, West Bengal
30.	Khaiyamdhan	Alipurduar district, West Bengal
31.	KonkoniJoha	Tarai Research Society, Alipurduar, West Bengal
32.	Kukurjali	Alipurduar district, West Bengal
33.	Ladu	PSBSG, Sitalkuchi, Cooch Behar district, West Bengal
34.	Laldhyapa	ICAR-CPRI- Kahikuchi, Kamrup, Assam
35.	Mala	ICAR-CPRI- Kahikuchi, Kamrup, Assam
36.	Malshira	PSBSG, Sitalkuchi, Cooch Behar district, West Bengal
37.	Radhatilak	Tarai Research Society, Alipurduar, West Bengal
38.	Radhunipagal	Tarai Research Society, Alipurduar, West Bengal
39.	Ramigalee	Tarai Research Society, Alipurduar, West Bengal
40.	RongaKomal	PSBSG, Sitalkuchi, Cooch Behar district, West Bengal
41.	SadaNunia	BCKV, Mohanpur, West Bengal
42.	Satia	Tarai Research Society, Alipurduar, West Bengal
43.	Silathia Bora	ICAR-CPRI- Kahikuchi, Kamrup, Assam
44.	Sitalkuchi-3	Cooch Behar district, West Bengal
45.	Tal Mungfar	Tarai Research Society, Alipurduar, West Bengal
46.	Tarapakari	ICAR-CPRI- Kahikuchi, Kamrup, Assam
47.	Tarai Research Society -3	UBKV, Pundibari, Coch Behar, West Bengal
48.	Tulaipanji	Tarai Research Society, Alipurduar, West Bengal
49.	Uttar Banga Local -12	Tarai Research Society, Alipurduar, West Bengal

2.3 Statistical Analysis

The experimental design was RBD with 49 treatments (genotypes) with two replications. The data were subjected to standard statistical methods of analysis of variance (ANOVA), and stability test using AgRes Statistical Software, (c) 1994 Pascal Intl Software Solutions, Version 3.01.

3. RESULTS AND DISCUSSION

3.1 Analysis of Variation

High significant variation was observed for all the characters, such as 50% flowering, plant height, number of panicles per plant, panicle length (cm), number of filled grains per panicle, number of chaffy grains per panicle, number of total grains per panicle, grain sterility, test weight (g) and grain yield per plant among the cultivars (treatments), seasons and interactions of cultivars and season (Table 2).This pointed at the existence of variation in the collected traditional populations. However, test weight showed insignificant variation between two seasons indicating no influence of location on this character. The causes of differences exhibited by the cultivars could be difference in their geographical place of origin [15]. Several reports have been published on phenotypic variation among rice cultivars [16-18]. Traditional cultivars had high variability which can provide the basic information necessary to help breeding programs to plan crosses to incorporate this variability into the genetic background of elite rice lines, which in turn will generate new rice cultivars [19].

3.2 Days to 50% Flowering

Days to 50% flowering varied from 118.00 to 155.00 during *Boro* with a mean of 135.29 (Table 3). The minimum value for days to 50% flowering during *Boro* season was observed in Jaldhyapa-2 and Tarapakari followed by Chakhao-Selection-1, Radhunipagal, Laldhyapa, Chakhao-Selection-3, Chakhao Sempak and Bitti (Fig. 1).

Days to 50% flowering varied from 86.00 to 127.00 with a mean of 112.92 during *Kharif* (Table 3). The cultivars took average of 22.37 more days to attain 50% flowering during *Boro* as compared to *Kharif*. The minimum values for days to 50% flowering was recorded for Malshira, Mala and Ladu trailed by Sada Nunia, Chapka Chakhao, Dharam Phou, Chakhao Sempak, Harpi and Kauka (Fig. 1).

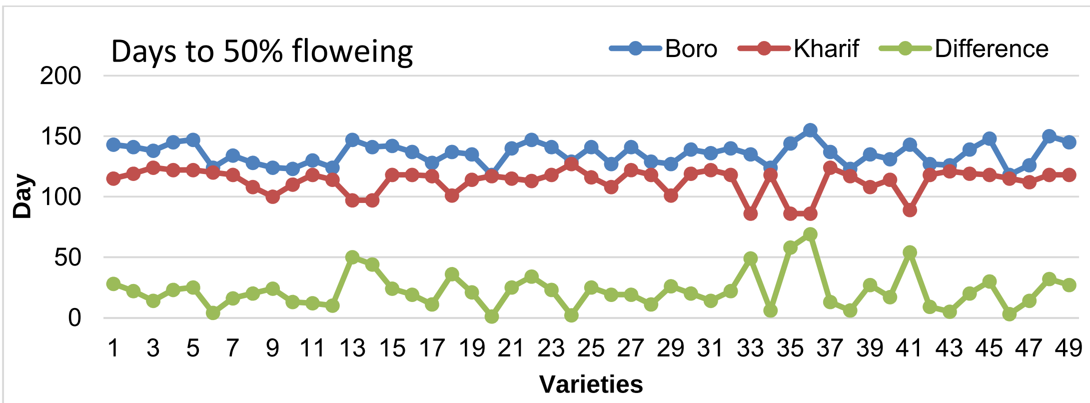
Table 2. Analysis of variance of different quantitative characters of traditional rice cultivars

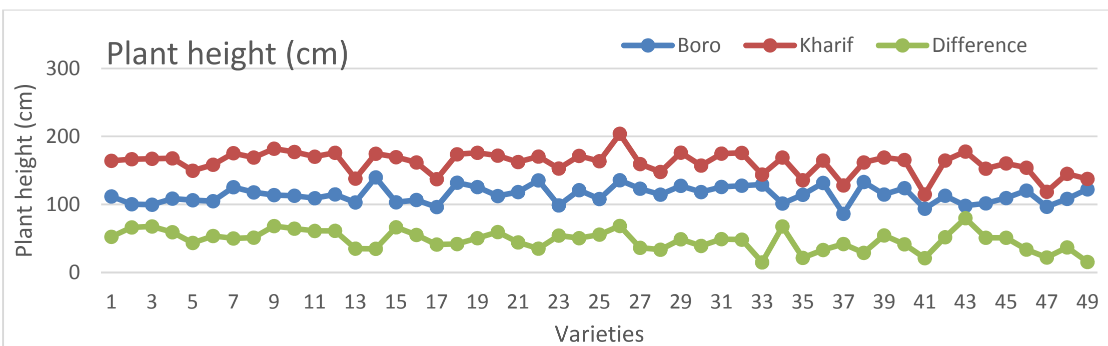
Sources	d.f.	Mean sum of square				
		Days to 50% flowering	**Plant height**	**No. of panicles per hill**	**Panicle length**	**No. of filled grains/ panicle**
Total	195	219.8869	785.9769	52.7577	9.1050	1738.1007
Replications	1	23.5918	70.8002	57.7600	1.8032	174.9951
Treatment(V)	97	439.3604**	1561.3394**	89.1155**	17.8078**	3405.8944**
Error	97	2.4371	17.9874	16.3484	0.4774	86.4214
V	48	156.3324**	661.5018**	102.6785**	28.2077**	4437.8662**
Season (S)	1	24514.6122**	108937.7175**	1377.4702**	96.8818**	63144.5102**
V × S	48	220.8205**	224.1692**	48.7118**	5.7605**	1129.3681**
Error	97	2.4371	17.9874	16.3484	0.4774	86.4214
Sources	**d.f.**	**No. of chaffy grains/panicle**	**No. of total grains/panicle**	**Sterility**	**Test weight**	**Yield**
		694.3052	2933.4269	437.81	437.8151	27.5154
Replications	1	24.8573	251.4489	10.53	10.5346	0.7298
Treatment(V)	97	1351.4068**	5796.9161**	868.08**	868.0867**	54.8703**
Error	97	44.1051	97.5871	11.94	11.9485	0.4367
V	48	1247.6229**	1978.6996**	746.86**	746.8674**	98.7948**
Season (S)	1	9795.3436**	393666.6122**	12505.62**	12505.6293**	0.1465**
V × S	48	1279.2753**	1534.5139**	746.85**	746.8571**	12.0859**
Error	97	44.1051	97.5871	11.94	11.9485	0.4367

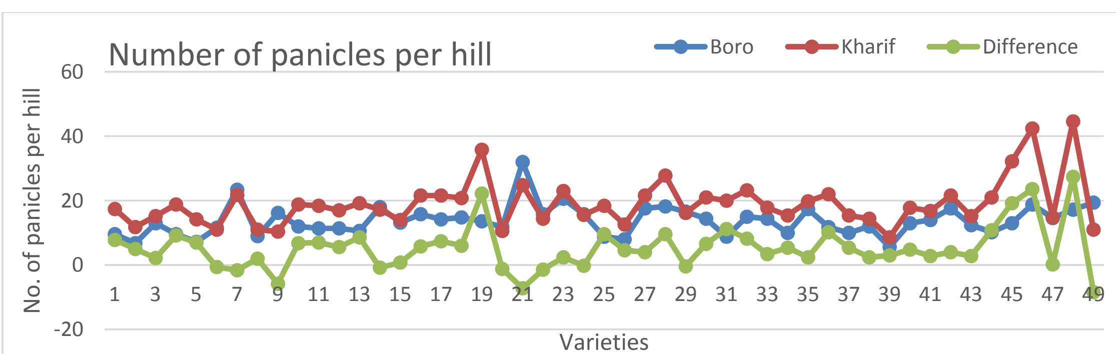
*** denote significance P = 0.01; NS: Non-significant*

Table 3. Maximum, minimum and mean values of all the yield attributing characters

Characters	*Boro*			*Kharif*		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Days to 50% flowering	118.00	155.00	135.29	86.00	127.00	112.92
Plant height (cm)	86.20	139.80	114.18	114.80	204.00	161.33
Number of panicles/ hill	5.60	32.00	13.80	8.60	44.60	19.10
Panicle length (cm)	15.80	30.60	23.24	20.60	30.20	24.66
Number of filled grains	4.60	232.00	75.49	54.20	241.60	111.39
Number of chaffy grains	-31.80	114.20	35.90	7.80	123.40	51.20
Number of total grains	50.00	266.60	126.69	66.40	291.20	148.45
Sterility (%)	8.30	93.95	41.20	8.45	54.56	25.23
Test weight (g)	8.64	32.40	21.09	10.80	32.70	21.15
Grain yield (g/hill)	2.34	17.86	7.45	17.83	56.53	33.76
Grain yield (t/ha)	0.35	2.68	1.12	2.67	8.48	5.06







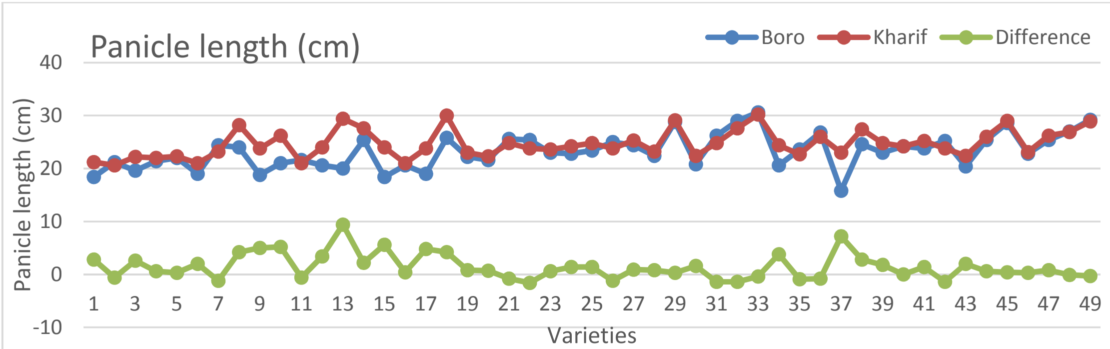


Fig. 1. Mean values of days to 50% flowering, plant height (cm), number of panicles per hill and panicle length (cm) of 49 traditional cultivars

In this endeavour, some varieties flower earlier than the others. Those that flowered earlier matured early while those that flowered late had a delay in their maturity. Early flowering indicates short lifecycle and is considered a positive character for rice improvement. Early maturing varieties are advantageous in areas with short rainfall duration because they grow faster during the vegetative phase and are thus more competitive with weeds. It is considered that drought frequently hinders production of rain-fed rice. So,the terminal drought towards the grain filling stage of traditional rice cultivars is severely affected and panicle blanking may result [20].

The difference in days to 50% flowering of rice cultivars between *Boro* and *Kharif* seasons ranged from 1.00 to 69.00 days with a mean of 22.37 days (Fig. 1). Minimum difference was recorded in Jaldhyapa-2 (1 days) followed by Kalo Nunia (2 days), Tarapakari (3 days), Bitti (4 days), Silathia Bora (5 days), Radhuni pagal (6 days), Laldhyapa (6 days) and Satia (9 days). The rice cultivars that showed very low values for the difference in days to 50% flowering were mostly long duration rice except Bitti. The reproductive phase of long duration cultivars coincided with the suitable photoperiod during normal flowering of *Boro* season (March-April), accordingly days to 50% flowering was almost same in both the seasons. Maximum difference in days to 50% flowering was observed in Malshira (89 days) followed by Mala (58 days), Sada Nunia (54 days), Chapka Chakhao (50 days), Ladu (49 days) and Dharam Phou (44 days). The cultivars with high difference all were under medium-early. This indicated that those traditional cultivars were low-temperature and photoperiod sensitive leading to delay in flowering during *Boro* season.

Seedlings are usually raised during the months of November and December during *Boro*. Temperature during seedling establishment period drops down to about 10°C and such low temperature significantly reduces seedling growth and establishment [21,22] subsequently increased the length of vegetative period. Synthesis of intracellular components, in particular of key proteins required for photosynthesis, is specifically susceptible to low temperature stress during development of rice leaves [23] leading to stunted growth of the seedlings.

Low temperature during December and January is major limiting factor for *Boro* rice cultivation in northern part of West Bengal. Low temperature about 10 ± 5°C inhibits normal growth of seedlings and cause degradation of chlorophyll. The leaves turned yellow and became *albino* at a temperature of below 10°C [22]. They also observed that after mid-February, temperature increases gradually and bright sunshine appears. Due to clear sky and raise in temperature the seedlings turn green in colour leading to normal growth of the seedlings.

3.3 Plant Height (cm)

Plant height ranged from 86.20 cm to 139.80 cm with a mean of 114.18 cm during *Boro* (Table 3). The traditional cultivar, Radhatilak was shortest plant height during *Boro* season followed by Harin Kajoli, Sada Nunia, TRS 3, Silathia Bora, Kaike, Betho and Annapurna (Fig. 1). Plant height extended114.80 cm (Sada Nunia) to 204.00 cm (Kalturey) with mean of 161.33 cm during *Kharif* (Fig. 1). Smallest plant height was observed for Sada Nunia tracked by TRS 3 and Radhatilak (Fig. 1). The difference in plant height of varieties might be due to difference in their genetic makeup. Difference in plant height with different varieties was also observed by Priyadarsini [24].

The difference in plant height of cultivars between *Boro* and *Kharif* seasons fluctuated from 14.80 cm to 79.80 cm with a mean of 47.15 cm (Fig. 1). The mean plant height during *Boro* was 114.18 cm, whereas, it was 161.33 cm during *Kharif* season. Plant height of the traditional rice cultivars were remarkably shorten during *Boro* season compared to *Kahrif* season. Dwarf and semi-dwarf rice plants are lodging resistant and lodging tolerance is an important desirable character of rice.

Highest plant height during *Boro* was 139.80 cm (Dharam Phou). Nevertheless, the plant height of 42 cultivars were > 139.80 cm (Fig. 1). Betho is a deep water (floating rice) traditional rice cultivar. It is being cultivated during *Kharif* season in the areas of 5-10′ standing water for 3-4 months. Its stem elongates along with the raise in water level and remain floating on the surface of water. Plant height of Betho was 99.60 cm during *Boro* and 167.20 cm during *Kharif* season. Surje (2016 [22]) also reported semi-dwarf nature of Betho when cultivated in normal condition. However, in the areas of 5-10′ standing water, the cultivar grow up to 250 cm. The height of this cultivar fluctuates based on the seasons and availability of standing water [25,26]. Semi-dwarf feature could be attributed to very effective assimilate partitioning at the expense of vegetative growth. So, instead of having tall plants, higher yield may came as a compensation for the vegetative deficiency. This character was also beneficial in providing lodging tolerance. The plant height is mainly governed by the genetic makeup of the cultivar, however, it was highly influenced by environmental factors [16]. Conversely, tall cultivars normally have lower yield than the short cultivars. Tallness in rice correspondingly leads to lodging susceptibility. In this experiment, the mean plant height of the traditional cultivars during *Boro* season were found to be of intermediate (114.18 cm) and it was tall (161.33 cm) during *Kharif*.

3.4 Number of Panicles per Hill

The number of panicles per hill ranged from 5.60 to 32.00 with a grand mean of 13.80 during *Boro* season (Table 3). Maximum number of panicle per hill was recorded in Jhagarikartik followed by Chakhao Angangbi, Kaike, UN 12, Tarapakri, Kataribhog and Dharam Phou. However, most of the rice cultivars showed high tillering ability (Fig. 1). The results were in conformity with the findings of Shehu et al. [27]. Number of panicles per hill fluctuated from 8.60 to 44.60 with a grand mean of 19.10 during *Kharif* season (Table 3). Maximum number of panicles per hill was recorded for Tulaipanji, followed by Tarapakari, Jaldhyapa, Tal Mungfar, Kataribhog, Jhagarikartik, Kukur Jali and Kaike (Fig. 1).

The difference in number of panicles per hill between two seasons varied from -8.40 to 27.40 with a mean of 5.30 (Table 3). Negative values indicated that some of the cultivars had more panicles per hill in off-season compared to on-season (Fig. 1). Kalo Nunia Kauka, Bitti, Dharam Phou, Jaldhyapa-2, Kagey, Chakhao Angangbi, Chakhao Sempak, Jhagarikartik and UN 12. Those cultivars may be considered as low temperature tolerant which is prevailing during *Boro*. In some of the cultivars the difference was very high and it indicted that the number of panicles per hill was highly reduced during off-season. The cultivars which showed high differences in number of panicles per hill during on-season as equated to off-season were Tulaipanji, Tarapakari, Jaldhyapa, Tal Mungfar, Sitalkuchi-3, Konkoni Joha and Malshira.

The panicle number is an important character which directly influences the yield. As a result, yield could be increased when agronomic manipulation is used to increase the number of panicles produced per unit area [16]. Number of panicles per hill is highly influenced by the environmental parameters. Thus, this character showed very high difference between off-season and on-season. Garba et al. [28] reported the influence of environmental factors in determining tillering ability of rice. Low temperature during *Boro* season reduced the initial growth of rice plants leading to reduction in number of tillers per hill [22].

3.5 Panicle Length (cm)

The panicle length varied from 15.80 cm to 30.60 cm among the cultivars with a mean of 23.24 cm during *Boro* season (Table 3). The cultivar Ladu had longest panicle (30.60 cm) during this season followed by UN 12, Kukur Jali, Kauka, Tal Mungri, Tulaipanji, Malshira and Konkoni Joha (Fig. 1). Panicle length ranged from 20.60 cm to 30.20 cm with mean of 24.66 cm during *Kharif* season (Table 3). Longest panicle was recorded in Ladu trailed by Harpi, Chapka Chakhao, Kauka, Tal Mungfar, UN 12, Chakhao Poireiton, KukurJali, Dharam Phou, Radhunipagal, Tulaipanji, TRS 3, Chakhao-Selection-1, Sitalkuchi-3 and Malshira. Among yield contributing characters, panicle length is important and this is proportional to the number of potential spikelets to be filled during grain-filling stage [16].

The difference in panicle length between two seasons varied from -1.60 cm to 9.40 cm with a grand mean of 1.42 cm (Table 3). Uppermost difference was observed in Chapka Chakhao (9.40 cm). This cultivar had 20.00 cm panicle during *Boro*, whereas panicle length was 29.40 cm during *Kharif*. The other cultivars that showed significant increase in panicle length during *Kharif* compared to *Boro* were Radhatilak, Dudheswar, Chakhao-Selection-1, Chakhao Sempak, Harin Kajoli, Harpi, Chakhao Poireiton, Laldhyapa and Chakhao-Selection-3. A long span of the initial vegetative growth (November to end of February) of those cultivars encountered low temperature leading in reduction in growth of plants and subsequently it caused reduction in panicle length as compared to panicle length during *Kharif*. Most of the Chakhao cultivars collected from Manipur were susceptible to low temperature causing the reduction in panicle length.

In contradiction, few cultivars also showed reduction in panicle length during *Kharif* as compared to *Boro*, such as, Kagey, Konkoni Joha, Satia, Kukur Jali, Kalturey, Chakhao Angangbi, Mala, Malshira, Chakhao-Selection-2, Jhagarikartik, Annapurna, Ladu, UN 12 and Tulaipanji. However, the reduction was negligible or very low.

3.6 Number of Filled Grains per Panicle

The number of filled grains per panicle during *Boro* season showed wide range of variation among the cultivars, that is, from 4.60 to 232.00 with a grand mean of 75.49 (Table 3). Maximum number of filled grains per panicle was recorded for Radhunipagal followed by Laldhyapa, TRS 3, Bitti, Kagey, Binni, Chakhao-Selection-1, Silathia Bora, Kauka and Kalturey. Number of filled grains per panicle during *Kharif* season varied from 54.20 to 241.60 with a mean of 111.39 (Table 3). The cultivars showed high number of filled grains per panicle were Radhunipagal, Malshira, TRS 3, Laldhyapa, Remigali, Jhagarikartik, Bitti, Sitalkuchi-3, Tulaipanji, Kagey and Silathia Bora (Fig. 2).

The difference between the seasons in filled grains per panicle varied widely from -31.80 to 114.20 per panicle with a grand mean of 35.90per panicle (Table 3). Less difference in filled grains per panicle between the seasons indicated their suitability to cultivate in alternative season (*Boro*). As a result, Jaldhyapa, Kaike, Harin Kajoli, Binni, UN 12, Chakhao Angangbi, Bitti, Kaloboichi, Tarapakari, Kagey, Laldhyapa, Chakhao-Selection-1 and Chakhao-Selection-3 (Fig. 2) may be recommended for cultivation in the northern part of West Bengal during *Boro* provided adjustment of sowing date, i.e. mid-November.

Maximum difference was noted in Tulaipanji followed by Malshira, Tal Mungfar, Beto, Garu Chakhua, Jhagarikartik, Kataribhog, Konkoni Joha, Khaiyamdhan, Kukur Jali, Chapka Chakhao, Dudheswar, Ladu, Remigali and Birai. Those cultivars had high differences between *Boro* and *Kharif* seasons indicated susceptible to low temperature.

Increase in number of filled grains could be attributed to efficient translocation of carbohydrates from the sources to the spikelets (sinks) which consequently leads to increase in grain yield [29]. The yield of cultivars in this venture was between moderate and low. Yield differences are genetically based, though environment has a great contribution in the manifestation of the inherent potential [16]. Thus, there was notable difference in yield performance during *Boro* and *Kharif* seasons.

3.7 Number of Chaffy Grains per Panicle

Number of chaffy grains per panicle during *Boro* season differed from 7.80 to 123.40 with a mean of 51.20 (Table 3). Least number of chaffy grains was noted in Harin Kajoli, Remigali, trailed by Kaike, Kauka, Tarapakari and Chakhao Angangbi. Maximum number of chaffy grains per panicle was noticed in Sada Nunia. Other rice cultivars which showed high number of chaffy grains per panicle were A-11, Garu Chakhua, Birai, Konkoni Joha, Dudheswar, Kataribhog, Tal Mungfar, Jhagarikartik, Satia and Annapurna (Fig. 2). The number of chaffy grains per panicle during *Kharif* season ranged from 10.60 to 74.20 with a grand mean of 37.06. Chakhao Sempak had lowest number of chaffy grains per panicle (Table 3). Other traditional cultivars exhibited less number of chaffy grains per panicle were

Kaike, Khaiyamdhan, Tal Mungfar, Binni and Sitalkuchi-3 (Fig. 2). Maximum number of chaffy grains per panicle was observed in UN 12 followed by Chakhao Poireiton, Malshira, Kashiya Binni and Jaldhyapa.

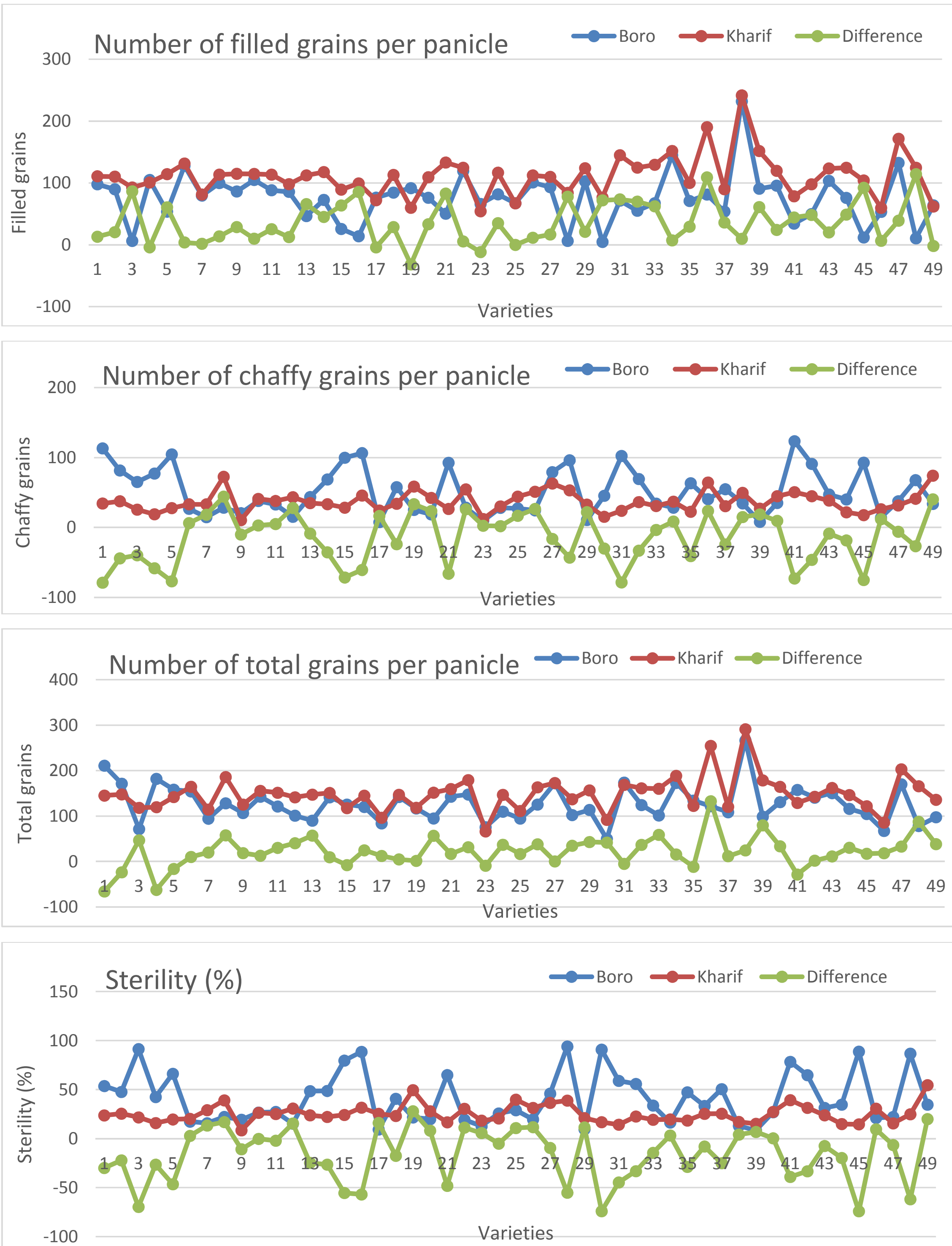


Fig. 2. Mean values of number of filled grains per panicle, number of chaffy grains per panicle, total number of grains per panicleandsterility (%) of 49 traditional cultivars

The difference between two season in number of chaffy grains per panicle -78.80 to 44.20 with a mean of -14.14 (Table 3). Negative sign indicated that chaffiness was more during *Boro* season as compared to *Kharif* season (Fig. 2). Most of the traditional cultivars displayed negative values. Bitti and Harinkajoli were the traditional rice cultivars of *Aus* (March-April sowing season), thus both of them showed positive values indicating their tolerance ability during *Boro* season.

3.8 Number of Total Grains per Panicle

The number of total grains per panicle during *Boro* season varied from 50.00 to 266.60 with a mean of 126.69 (Table 3). Radhunipagal, A-11, Binni, Konkoni Joha, Laldhyapa, Kashiya Binni, Annapurna, TRS 3, Birai, Sada Nunia, Bitti and Silathia Bora had higher number total grains per panicle (Fig. 2). The number of total grains per panicle during *Kharif* season 66.40 to 291.20 with a grand mean of 148.45 (Table 3). Three cultivars, namely Radhunipagal, Malshira and TRS 3 exhibited more than 200 total grains per panicle. Another 19 cultivars had more than 150 total grains per panicle (Fig. 2).

The difference in number of total grains per panicle between two seasons varied from -65.80 to 132.80 with a grand mean of 21.76 (Table 3). Negative values indicated less number of total grains per panicle during *Kharif* as compared to *Boro*. A-11, Binni, Sada Nunia, Annapurna, Birai, Mala), Kaike, Dudheswar and KonkoniJoha exhibited higher number of total grains per panicle during *Boro* season (Fig. 2).

3.9 Spikelet Sterility (%)

Spikelet sterility during *Boro* season varied from 8.30% to 93.95% with a mean of 41.20% (Table 3). Remigali had lowest value for sterility followed by Harin Kajoli, Kauka, Kaike, Radhunipagal, Chakhao-Selection-3 and Chakhao Angangbi. Some of the traditional cultivars showed very high spikelet sterility during *Boro* season (Fig. 2), they were Kataribhog, Beto, Khaiyamdhan, Tal Mungfar, Garu Chakhua, Tulaipanji, Dudheswar, Sada Nunia, Birai, Satia, Jhagarikartik, Konkoni Joha, Kukur Jali, A-11 and Radhatilak. Sterility during *Kharif* season ranged from 8.45% to 54.56% with a mean of 25.23% (Table 3). Lowest sterility was recorded in Chakhao Sempak. Other traditional cultivars showed low spikelet sterility (Fig. 2) were Konkoni Joha, Tal Mungfar, Sitalkuchi-3, TRS 3 and Binni. Maximum sterility was reported in UN 12 tracked by Jaldhyapa, Kaloboichi, Sada Nunia, Chakhao Poireiton, Kataribhog, Kashiya Binni, Garu Chakhua, Satia, Kalturey, Chakhao-Selection-3, Tarapakari and Kagey.

The difference in spikelet sterility of traditional cultivars between two seasons varied from -74.10% to 27.92% with a mean of -15.97% (Table 3). High negative values were the indications that the sterility was much lower during *Kharif* season (Fig. 2). Most of the traditional cultivars displayed low spikelet sterility during *Kharif* season and only few showed corresponding less sterility during *Kharif* season. Except two, all other traditional cultivars were chosen from *Kharif* season. So, those traditional cultivars adjusted and adopted for *Kharif* season.

3.10 Test Weight (g)

Test weight was found to be insignificant over the seasons (Table 2). Test weight of rice grains during *Boro* varied from 8.64 g to 32.40 g with a mean of 21.09 g (Table 3). Highest test weight was recorded in Khaiyamdhan. Other cultivars had high test weight were Jaldhyapa, Ronga Komal, Chakhao Angangbi, Remigali, Bitti, Chakhao-Selection-2, Dudheswar, Harin Kajoli, Chakhao Sempak, Kauka and Kaloboichi (Fig. 3). Minimum test weight was recorded in Birai followed by Konkoni Joha, Radhatilak, Radhunipagal, Harpi, TRS 3 and Kukur Jali. The test weight of cultivars during *Kharif* season extended from 10.80 g to 32.70 g with a mean of 21.15 g (Table 3). Maximum test weight was recorded in Remigali followed by Khaiyamdhan, Ronga Komal, Garu Chakhua, Chakhao Sempak, Dudheswar, Kaloboichi, Laldhyapa, Binni, Chakhao-Selection-2 and Bitti (Fig. 3). The result showed that the test weight ranged significantly among the traditional rice cultivars. This could also be due to their differences in origin and genetic make-up. Similar reports have been published by a BRRI [30] as well as Ashrafuzzaman et al. [31].

Some of the cultivars had low test weight during *Boro* compared to *Kharif* (Fig. 3), such as, Harpi, Silathia Bora, Remigali, Laldhyapa, Garu Chakhua, Sada Nunia, KukurJali, Birai) and Binni. This seasonal difference in test weight for a few cultivars were due to improper filling of grains during off-season.

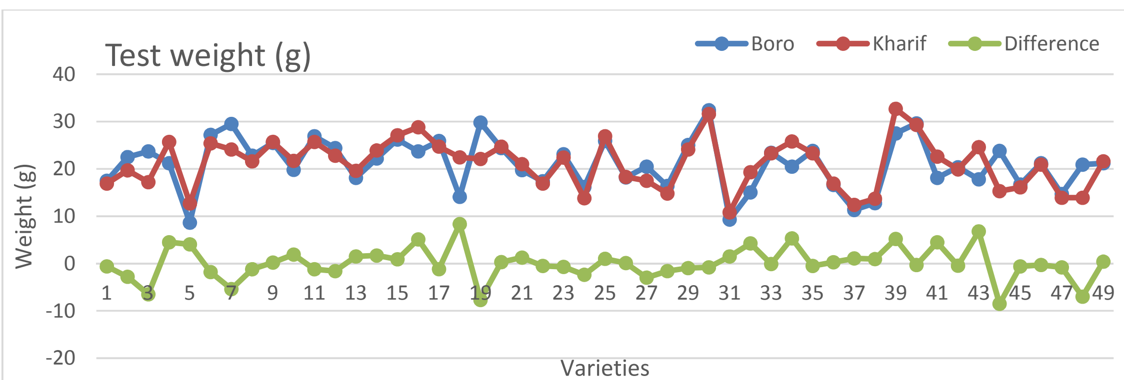
3.11 Grain Yield (g/hill)

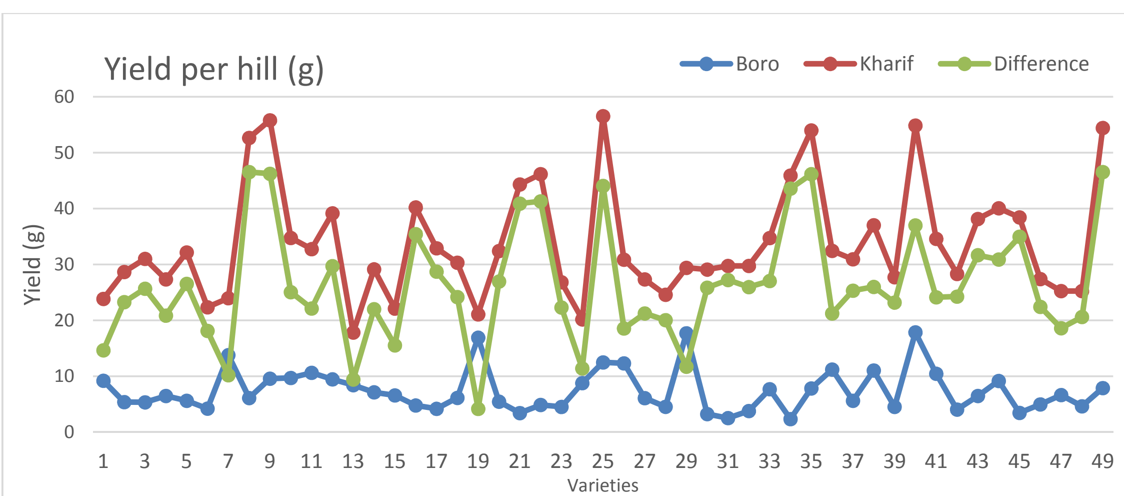
Grain yield during *Boro* season varied from 2.34 g/hill to 17.86 g/hill with a mean of 7.45 g/hill (Table 3). Whereas, the seed yield varied from

17.83 g/hill to 56.53 g/hill with a mean of 33.76 g/hill. Significant yield difference was observed between the seasons (Table 4). Yield and grain quality depends on the genetic potential of the traditional rice cultivars, prevailing environment and cultural practices. Selection of right type of rice variety is most important factors for achieving desirable production. Yield of traditional cultivars of rice changes due to seasonal fluctuations and different dates of sowing [32].

Most of those selected traditional cultivars adopted for *Kharif* season, consequently, the grain filling of those cultivars was poor leading to low yield during *Boro* season. The cause of poor grain filling and reduced yield may be due to poor vegetative growth during early vegetative stage under low temperature. However, performance of some of the cultivars during *Boro* was noticeable and can be considered for cultivation during *Boro* season (Fig. 3), such as, Ronga Komal (2.68 t/ha), Kauka (2.65 t/ha), Jaldhyapa (2.54 t/ha), Chakhao Angangbi (2.07 t/ha), Kaloboichi (1.87 t/ha), Kalturey (1.85 t/ha), Chakhao-Selection-2 (1.59 t/ha), Chakhao-Selection-1 (1.46 t/ha), Chakhao Sempak (1.43 t/ha) and Chakhao-Selection-3 (1.42 t/ha).The possible initiation of flowering time in response to seasonal change mainly determines the yield potential [5] and a positive correlation was found between grain yield and flowering time [33].

Out of those nine better performing cultivars Kataribhog, Kalo Nunia, Chakhao-Selection-1, Chakhao Sempak, Chakhao Poireiton and Chakhao-Selection-2 are aromatic [3,14,25,34,35]. In addition to the aroma, Chakhao-Selection-1, Chakhao Sempak, Chakhao Poireiton and Chakhao-Selection-2 are the black rice which have good demand in the market [14]. Roy [36] developed agronomic practices to cultivated Kalo Nunia during *Boro* season in northern part of West Bengal. Cultivation of those aromatic cultivars during off-season will additional avenue to increase the farmers' income as well as fallow lands can be efficiently utilised. Bitti is *Aus* variety with mild aroma and good cooking quality, has good demand in the market. Kaloboichi and Harpi also have consumers' preference due to its taste and cooking quality.





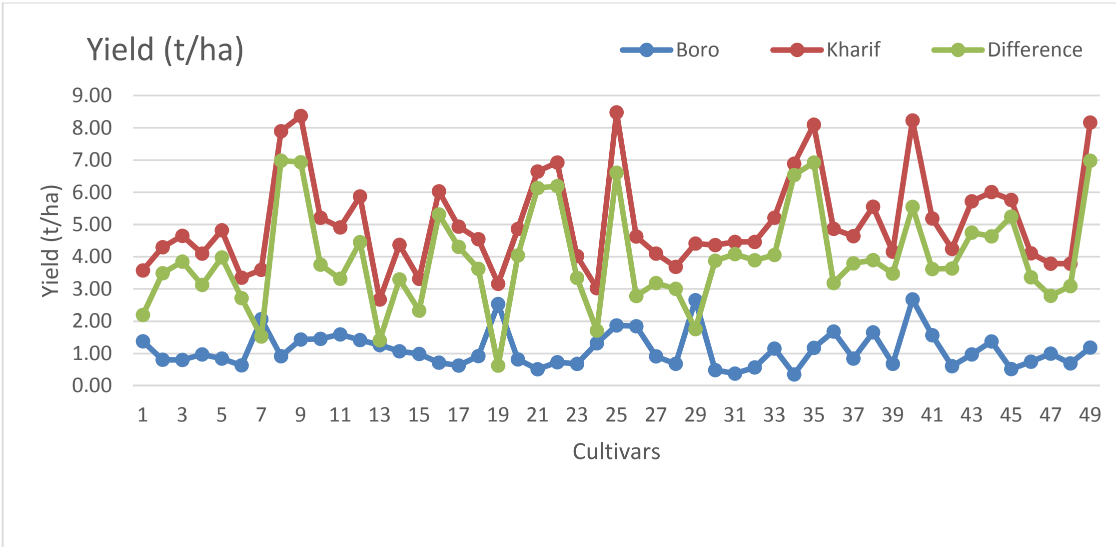


Fig. 3. Mean values of test weight (g), grain yield (g/hill) andgrain yield (t/ha) of 49 traditional cultivars

Table 4. Mean values of yield attributing characters under *Boro* and *Kharif* seasons

Character/ Seasons	*Boro*	*Kharif*
Days to 50% flowering	135.28 b	112.91 a
Plant height (cm)	114.17 b	161.32 a
Number of panicles/hill	13.80 b	19.10 a
Panicle length (cm)	23.24 b	24.64 a
Number of filled grains/panicle	75.49 b	111.39 a
Number of chaffy grains/panicle	51.19 b	37.05 a
Total number of grains per panicle	37.05 b	126.68 a
Sterility (%)	41.23 b	25.26 a
Test weight (g)	21.09 a	21.14 a
Yield/plant (g)	7.45 b	33.76 a

Values bearing same letter in the row are not significantly different at P = 0.01 of LSD

Table 5. Better performing cultivars in respect of individual character

Characters	Boro season	Kharif season
Days to 50% flowering	Jaldhyapa-2, Tarapakari, Chakhao-Selection-1, Radhunipagal, Laldhyapa, Chakhao-Selection-3, Chakhao Sempak, Bitti	Malshira, Mala, Ladu, SadaNunia, Chapka Chakhao, Dharam Phou
Plant height	Radhatilak, Harin Kajoli, Sada Nunia, TRS 3, Silathia Bora	Sada Nunia, TRS 3, Radhatilak
Number of panicles per hill	Jhagarikartik, Chakhao Angangbi, Kaike, UN 12, Tarapakri, Kataribhog, Dharam Phou	Tarapakari, Jaldhyapa, Tal Mungfar, Kataribhog, Jhagarikartik, Kukur Jali, Kaike
Panicle length	Ladu, UN 12, KukurJali, Kauka, Tal Mungri, Tulaipanji, Malshira, KonkoniJoha	Ladu, Harpi, Chapka Chakhao, Kauka, Tal Mungfar, UN 12, Chakhao Poireiton, KukurJali, Dharam Phou, Radhunipagal, Tulaipanji, TRS 3, Chakhao-Selection-1, Sitalkuchi-3, Malshira

Characters	Boro season	Kharif season
Number of filled grains per panicle	Laldhyapa, TRS 3, Bitti, Kagey, Binni, Chakhao-Selection-1, Silathia Bora, Kauka, Kalturey	Radhunipagal, Malshira, TRS 3, Laldhyapa, Remigali, Jhagarikartik, Bitti, Sitalkuchi-3, Tulaipanji, Kagey, Silathia Bora
Spikelet sterility (%)	Remigali, Harin Kajoli, Kauka, Kaike, Radhunipagal, Chakhao-Selection-3, Chakhao Angangbi	Chakhao Sempak, KonkoniJoha, Tal Mungfar, Sitalkuchi-3, TRS 3, Binni
Grain yield (g/hill)	Ronga Komal, Kauka, Jaldhyapa, Chakhao Angangbi, Kaloboichi, Kalturey, Chakhao-Selection-2, Chakhao-Selection-1, Chakhao Sempak, Chakhao-Selection-3	Kaloboichi, Chakhao Sempak, Ronga Komal, UN 12, Mala, Chakhao Poireiton, Laldhyapa, Kagey, Jhagarikartik, Garu Chakhua, Sitalkuchi-3

3.12 Comparison of Seasons

Seasonal mean values of all the characters in this endeavour given in the Table 4. Performance of the traditional cultivars in respect of yield and nine different yield attributing characters during *Kharif* season were under better side as compared to *Boro*. Test weight had not effected by seasons.

The cultivars with better yield performance during *Boro* season were Ronga Komal, Kauka, Jaldhyapa, Chakhao Angangbi, Kaloboichi, Kalturey, Chakhao-Selection-2, Chakhao-Selection-1, Chakhao Sempak and Chakhao-Selection-3 and the cultivars which perform better during *Kharif* were Kaloboichi, Chakhao Sempak, Ronga Komal, UN 12, Mala, Chakhao Poireiton, Laldhyapa, Kagey, Jhagarikartik, Garu Chakhua, Sitalkuchi-3 (Table 5).

3.13 Identification of Cultivars for Alternative Season (*Boro*)

The main objective of this endeavour was to identify the traditional cultivars for cultivation in alternative season- *Boro*. The performance of the cultivars, such as, Ronga Komal (2.68 t/ha), Kauka (2.65 t/ha), Jaldhyapa (2.54 t/ha), Chakhao Angangbi (2.07 t/ha), Kaloboichi (1.87 t/ha), Kalturey (1.85 t/ha), Chakhao-Selection-2 (1.59 t/ha), Chakhao-Selection-1 (1.46 t/ha), Chakhao Sempak (1.43 t/ha) and Chakhao-Selection-3 (1.42 t/ha) were comparatively better than the other traditional cultivars during *Boro* season (Table 5). Therefore, those cultivars may be recommended for cultivation in *Boro* season, provided sowing of the seed should be done during second fortnight of November. Roy [36] also standardized the agronomic practices for cultivation of Kalo Nunia during *Boro* season. Delay in sowing will lead only vegetative growth and the flowering and seed setting will take place only during next October-November [37].

4. CONCLUSION

Significant variation was observed for all the characters under study. This indicated the presence of variation among the traditional cultivars. Only the1000-grains weight between the two seasons exhibited insignificant difference representing that there was no effect of seasons on 1000-grains weight. The differences exhibited by the cultivars could be due to difference in their geographical place of origin. The yield ranged from 0.35 t/ha to 2.68 t/ha during *Boro* season and yield ranged from 2.67 t/ha to 8.48 t/ha during *Kharif* season. *Kharif* was much better as compared to *Boro*. The main objective of this venture was to find out alternative season for traditional cultivars. Time of sowing (27^{th}, November) was standardized for sowing the traditional cultivars in alternative season- *Boro*. Ronga Komal (2.68 t/ha), Kauka (2.65 t/ha), Jaldhyapa (2.54 t/ha), Chakhao Angangbi (2.07 t/ha), Kaloboichi (1.87 t/ha), Kalturey (1.85 t/ha), Chakhao-Selection-2 (1.59 t/ha), Chakhao-Selection-1 (1.46 t/ha), Chakhao Sempak (1.43 t/ha) and Chakhao-Selection-3 (1.42 t/ha) performed well during *Boro* season. Consequently, those above varieties may be recommended for cultivation during *Boro* season, provided the seed sowing should be done during the mid-November.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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