www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2021; 10(3): 382-387

www.thepharmajournal.com
Received: 22-12-2020
Accepted: 07-02-2021

Loyangamba Yumnam
Department of Agronomy, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur, India

Sakhen Sorokhaibam
Krishi Vigyan Kendra, Utlou, Bishnupur, Manipur, India

Bibek Laishram
Department of Agronomy, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur, India

Surajkumar Sharma Hajarimayum
Department of Agronomy, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur, India

Sanatomba Yambem
Department of Agronomy, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur, India

Zui Kadiphiubou Newmai
Department of Agronomy, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur, India

Corresponding Author:
Sakhen Sorokhaibam
Krishi Vigyan Kendra, Utlou, Bishnupur, Manipur, India

Effect of planting date and spacing on growth and yield of black aromatic rice (*Oryza sativa* L.) cultivar chakhao poireiton

Loyangamba Yumnam, Sakhen Sorokhaibam, Bibek Laishram, Surajkumar Sharma Hajarimayum, Sanatomba Yambem and Zui Kadiphiubou Newmai

Abstract
A field experiment was conducted at the Agricultural Research Farm of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Bishnupur, Utlou, Manipur to study the effect of planting date and spacing on growth and yield of black aromatic rice (*Oryza sativa* L.) cultivar chakhao poireiton. The results revealed that the growth attributes (plant height, number of tillers per hill and dry weight) were significantly enhanced by different planting date and spacing of black aromatic (chakhao poireiton). The interaction of early planting date *i.e.* (18 June, 2018) and higher planting space *i.e.* (20 cm x 25 cm) significantly increased the plant height and dry weight for all the growth stages. The individual effect of planting date, D_1 (18 June, 2018) and spacing, S_2 (20 cm x 25 cm) significantly increased the yield and yield attributes of black aromatic (chakhao poireiton). The treatment combination D_1S_2 (18 June, 2018 + 20 cm x 25 cm) gave the maximum number of effective tillers per hill *i.e.* 7.19 and number of seeds per panicle *i.e.* 92.53, grain yield (2063.66 kg/ha), stover yield (3872.41 kg/ha), biomass yield (5936.07 kg/ha) and harvest index (34.76%). The highest gross return (₹ 132863.50), net return (₹ 84492.42) and benefit-cost ratio (BCR) (2.74) was obtained from the treatment D_1S_2 (18 June, 2018) + 20 cm x 25 cm.

Keywords: Black aromatic rice, chakhao poireiton, planting date, spacing

Introduction
Rice is one of the world's major cereal crops, second to wheat only. It covers the world's largest cultivating area (28%) covering 42.3 million hectares with a total production of 80 million tonnes annually. It is grown in diversified soil, topographical and hydrological situations ranging from sloppy uplands to deep-water areas of above 1 metre depth. It is adapted to cold temperatures that exist in hilly areas and also in the adverse soil conditions such as salinity, alkalinity and acidity. It is a staple food crop of 60% of world's population which contains about starch, protein (7%) and all types of B vitamins, but devoid of vitamin A. It is also rich in minerals like calcium.

Black aromatic rice (Chak-hao) is high in nutritional value and is a source of iron, vitamin E and antioxidants. The bran hull of black aromatic rice contains one of the highest levels of anthocyanin found in food. Its grain has similar amount of fibre to brown rice. Cultivation of aromatic rice is very remunerative as it fetches higher price compared to other coarse rice indicating better income of the cultivators.

In Manipur, black aromatic rice is consumed in various ways like puddings, bread, pulao *etc.* in different festivals and during important ceremonies by different ethnic people. There is high demand of black aromatic rice not only in the state but in other parts of the country which cannot be met from the low productivity of the crop. Hence, to improve the productivity of this crop suitable nutrients and agronomic practices has to be developed. Rice cover an area of 224.50 thousand ha with a production of 255.10 thousand tonnes and productivity of 1488 kg/ha in Manipur (Anonymous, 2014-15) [1]. Manipur has the potential to grow black aromatic rice as the demand increases both locally and globally.

Beside nutritional factor, transplanting date is an important factor which affects tremendously the grain yield of transplanted rice. Late planting exposes the reproductive phase as well as phenological events of the crop to an unfavourable temperature regime, thereby causing high spikelet sterility and poor plant growth. However, optimum rice planting dates are regional and vary with location and genotypes (Bruns and Abbas, 2006) [4].

Adjustment in the time of transplanting, therefore, enables the plants to take advantage of natural conditions favourable for growth. Time of transplanting was found to have a great influence on the growth, yield and yield-contributing characters of rice (Islam *et al.*, 1999) [9].

Spacing is also one of the important parameter, which ultimately affected nutrients uptake, growth and yield of plant. Increase in spacing, the total population decrease, but with more nutrition the individual plant grow better and get more yield and vice-versa. The increase or decrease of row spacing's and plant population has definite pattern in relation to the yield. In these simultaneous opposing effects of the two components there should be a point where maximum yield is expected and that should be at the optimum spacing. Keeping the above facts in view, an investigation was carried out to find out the effect of planting date and spacing on growth and yield of black aromatic rice (*Oryza sativa* L.) cultivar chakhao poireiton.

Materials and Methods

A field experiment entitled entitled "Effect of Planting Date and Spacing on Growth and Yield of Black Aromatic Rice (*Oryza sativa* L.) Cultivar Chakhao Poireiton" was undertaken during the *kharif* season of 2018 at Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur, India. The experimental site is located at 24º43'54"N latitude and 93º51'31"S longitude with an altitude of 790 m above mean sea level. The physicochemical properties of the initial soil taken with the help of standard procedure were presented in Table 1. Soil texture was determined following (Bouyoucos, 1951**)** [2]**,** pH and EC was estimated by Jackson (1973) [11], OC was estimated by Walkley and Black (1934) [26] available N, P and K was determined by Alkaline Potassium Permanganate method (Subbiah & Asija, 1956) [25], Bray and Kurtz No. 1 Method (Bray and Kurtz, 1945) [3] and 1 N NH_4OAc (Jackson, 1973) [11] and the treatment detail of the experimental field are presented in Table 2.

Table 1: Mechanical and chemical analysis of soil

Soil characteristics	Interpretation
Textural class	Clay Soil
Sand (%)	13.6
Silt (%)	24.3
Clay (%)	62.1
pH	5.4
Electrical conductivity (EC 1:2.5) (dSm^{-1})	0.4
Organic Carbon (%)	1.31
Available N (kg N ha^{-1})	282.64
Available P (kg P_2O_5 ha^{-1})	19.52
Available K (kg K_2O ha^{-1})	208.47

Table 2: Treatment details of the experiment

Treatment	Treatment details (Planting date + Spacing)	Symbols
T_1	18 June, 2018 + 20 cm x 10 cm	D_1S_1
T_2	18 June, 2018 + 20 cm x 25 cm	D_1S_2
T_3	18 June, 2018 + 20 cm x 20 cm	D_1S_3
T_4	03 July, 2018 + 20 cm x 10 cm	D_2S_1
T_5	03 July, 2018 + 20 cm x 25 cm	D_2S_2
T_6	03 July, 2018 + 20 cm x 20 cm	D_2S_3
T_7	18 July, 2018 + 20 cm x 10 cm	D_3S_1
T_8	18 July, 2018 + 20 cm x 25 cm	D_3S_2
T_9	18 July, 2018 + 20 cm x 20 cm	D_3S_3

The experiment was laid out in a factorial randomized block design (FRBD) taking two {Factor 1 – Planting date - 3 levels: a) D_1 – 18 June, 2018, b) D_2 – 03 July, 2018 and c) D_3 – 18 July, 2018 and Factor 2- Spacing - 3 levels: a) S_1 – 20 cm x 10 cm, b) S_2 – 20 cm x 25 cm, c) S_3 – 20 cm x 20 cm} with three replications and nine treatments. Biometric parameters namely plant height, number of tillers per hill, number of leaves per plant and dry weight was recorded periodically at 30, 60, 90 DAT (days after transplanting) and at harvest and leaf area index was recorded periodically at 30, 60 and 90 DAT. Yield and yield attributing characters namely number of effective tillers per hill, number of seeds per panicle, test weight, percent chaffiness, grain yield (kg/ha), stover yield (kg/ha), biomass yield (kg/ha) and harvest index (%) were also recorded. The economics of the different planting date and spacing of black aromatic (chakhao poireiton) was also worked out. The gross return of each treatment was calculated by multiplying the yield of the crop with the prevailing local market price @ ₹ 55/kg. The data recorded for various characters were statistically analyzed by adopting the procedure of analysis of variance as per Gomez and Gomez (1984). Significance of the difference in the treatment effects were tested through "F" test and critical difference C.D.

Results and Discussion

Growth attributes

Perusal of data revealed that the growth attributes (plant height, number of tillers per hill, dry weight and leaf area index) was significantly influenced by different planting date and spacing of black aromatic rice (chakhao poireiton) for all the growth stages *i.e.* 30, 60, 90 days after transplanting (DAT) and at harvest (Table 3 and 4). Among the different planting date, D_1 (18 June, 2018) and spacing, S_2 (20 cm x 25 cm) recorded the maximum plant height. The increased in plant height might be due to fact that the higher number of plants per unit area excited competition among plants especially for light, which influenced the plant height. Similar findings were also corroborated by Muhammad *et al.* (2008) [17] and Kumari *et al*. (2000) [13] in rice. Mahato *et al*. (2007) [14] also reported that maximum plant height was obtained with wider spacing over closer spacing's in rice. The number of tillers per hill was highest for planting date, D_1 (18 June, 2018) and spacing, S_2 (20 cm x 25 cm). Such improvement in tillering may be attributed to the fact that early transplanting helps in greater translocation of photosynthates to the different parts of the plant. Mandal *et al.* (1984) [15] reported that number of tillers declined with delay in transplanting and increased with early transplanting. Kumari *et al*. (2000) [13] also reported that number of tillers m^{-2} was significantly increased with increasing plant densities. Similar findings were also corroborated by Devi and Singh (2000) [7]. The number of leaves per plant did not differ significantly with different planting date and spacing. The dry weight was highest for planting date, D_1 (18 June, 2018) and spacing, S_2 (20 cm x 25 cm). Nayak *et al.* (2003) [19] reported that early planting exhibited the maximum dry matter accumulation (DMA). The increased in vigour due to wider spacing of the plant which help in effective absorption of nutrients at critical stage enhanced the physiological activity and increase the dry matter production. This result is supported with the findings given by Kumari *et al*. (2000) [13] which observed higher dry matter accumulation in wider spacing of rice. The leaf area index (LAI) was highest for planting date, D_1 (18 June, 2018) and spacing, S_2 (20 cm x 25 cm). The increase in nutrient availability resulted in increasing leaf number and leaf

expansion. Nayak *et al.* (2003) [19] reported that early planting exhibited the maximum LAI. Similar findings were also corroborated by Mandal *et al.* (1984) [15].

The interaction effect of different planting date and spacing significantly influenced the plant height and dry weight of black aromatic rice (chakhao poireiton). The treatment combination D_1S_2 (18 June, 2018 + 20 cm x 25 cm) gave the maximum plant height, number of tillers per hill, number of leaves per plant, dry weight during 30, 60, 90 DAT and at harvest respectively and leaf area index at 30, 60 and 90 DAT respectively.

Table 3: Effect of planting date and spacing on plant height (cm), number of tillers per hill and number of leaves per plant of black aromatic rice (Chakhao Poireiton)

Treatment	Plant Height (cm)				Number of tillers per hill				Number of leaves per plant			
	30DAT	60DAT	90DAT	Harvest	30DAT	60DAT	90DAT	Harvest	30DAT	60DAT	90DAT	Harvest
Planting date												
D_1	60.77	105.44	141.04	164.34	5.09	9.11	10.92	9.73	3.97	5.03	6.21	6.22
D_2	57.89	102.05	137.65	160.36	4.67	7.64	9.34	8.31	3.91	4.94	6.09	6.13
D_3	54.35	98.37	133.97	156.68	4.16	6.46	8.16	6.96	3.7	4.76	5.94	6.08
SE (m) ±	0.306	0.141	0.142	0.223	0.074	0.104	0.149	0.161	0.088	0.081	0.074	0.049
CD (0.05)	0.925	0.426	0.430	0.674	0.224	0.313	0.451	0.486	NS	NS	NS	NS
Spacing												
S_1	56.35	100.36	135.96	158.67	4.49	7.21	8.91	7.82	3.81	4.87	6.04	6.12
S_2	58.90	103.45	139.05	162.36	4.89	8.28	10.09	6.59	3.9	4.96	6.12	6.17
S_3	57.76	102.05	137.65	160.36	4.55	7.72	9.42	7.82	3.87	4.88	6.07	6.14
SE (m) ±	0.306	0.141	0.142	0.223	0.074	0.104	0.149	0.161	0.088	0.081	0.074	0.049
CD (0.05)	0.925	0.426	0.430	0.674	0.224	0.313	0.451	0.486	NS	NS	NS	NS
Planting date × Spacing												
D_1S_1	60.02	103.45	139.05	161.76	4.96	8.57	10.27	9.15	3.97	5.00	6.20	6.21
D_1S_2	61.66	107.08	142.68	167.17	5.37	9.69	11.73	10.45	4.00	5.14	6.27	6.29
D_1S_3	60.63	105.80	141.40	164.11	4.96	9.07	10.77	9.61	3.94	4.94	6.16	6.17
D_2S_1	57.29	100.81	136.41	159.12	4.56	6.97	8.67	7.72	3.86	4.89	6.06	6.11
D_2S_2	58.58	103.13	138.73	161.44	4.76	8.21	9.91	8.92	3.96	5.01	6.12	6.15
D_2S_3	57.81	102.20	137.80	160.51	4.70	7.75	9.45	8.28	3.90	4.91	6.10	6.12
D_3S_1	51.74	96.82	132.42	155.13	3.95	6.11	7.81	6.59	3.60	4.73	5.91	6.06
D_3S_2	56.47	100.16	135.76	158.47	4.54	6.95	8.65	7.31	3.73	4.74	5.93	6.09
D_3S_3	54.84	98.15	133.75	156.46	3.98	6.34	8.04	6.98	3.76	4.81	5.98	6.08
SE (m) ±	0.530	0.244	0.246	0.386	0.128	0.179	0.259	0.278	0.152	0.141	0.128	0.084
CD (0.05)	1.602	0.738	0.745	1.168	NS	NS	NS	NS	NS	NS	NS	NS

D= Planting date, S = Spacing

Table 4: Effect of Planting Date and Spacing on Dry weight (g) and Leaf Area Index (LAI) of Black Aromatic Rice (Chakhao Poireiton)

Treatment	Dry weight (g)				Leaf Area Index (LAI)		
	30DAT	60DAT	90DAT	Harvest	30DAT	60DAT	90DAT
Planting date							
D_1	18.98	23.29	25.78	30.64	1.48	2.85	4.08
D_2	18.29	21.98	24.50	28.52	1.36	2.51	3.73
D_3	17.49	20.54	23.10	26.83	1.12	2.23	3.43
SE (m) ±	0.021	0.036	0.027	0.036	0.027	0.020	0.012
CD (0.05)	0.064	0.110	0.081	0.109	0.080	0.059	0.037
Spacing							
S_1	18	21.51	24.03	28.06	1.24	2.43	3.60
S_2	18.52	22.42	24.91	29.27	1.39	2.63	3.88
S_3	18.25	21.88	24.44	28.66	1.33	2.54	3.76
SE (m) ±	0.021	0.036	0.027	0.036	0.027	0.020	0.012
CD (0.05)	0.064	0.110	0.081	0.109	0.080	0.059	0.037
Planting date × Spacing							
D_1S_1	18.83	22.92	25.45	29.87	1.43	2.74	3.88
D_1S_2	19.14	23.76	26.19	31.41	1.51	2.96	4.23
D_1S_3	18.99	23.19	25.70	30.65	1.49	2.87	4.15
D_2S_1	18.06	21.46	24.00	27.94	1.31	2.41	3.63
D_2S_2	18.60	22.42	24.94	29.12	1.41	2.61	3.87
D_2S_3	18.21	22.05	24.58	28.51	1.35	2.53	3.71
D_3S_1	17.11	20.14	22.64	26.39	0.99	2.15	3.31
D_3S_2	17.82	21.09	23.61	27.29	1.24	2.31	3.55
D_3S_3	17.56	20.39	23.06	26.82	1.14	2.22	3.44
SE (m) ±	0.037	0.063	0.047	0.062	0.046	0.034	0.017
CD (0.05)	0.112	0.190	0.141	0.188	NS	NS	0.053

D= Planting date, S = Spacing

Yield attributes

Factors contributing yield were significantly affected by different planting date and spacing. Planting date, D_1 (18 June, 2018) and spacing, S_2 (20 cm x 25 cm) had significant effect on yield attributes (*i.e.* number of effective tillers per hill and number of seeds per panicle) of black aromatic (chakhao poireiton) (Table 5). However the test weight and percent chaffiness of black aromatic (chakhao poireiton) was found to be significantly not affected by different planting date and spacing individually. The maximum number of effective tillers per hill was recorded with planting date, D_1 (18 June, 2018) *i.e.* 6.94 and spacing, S_2 (20 cm x 25 cm) *i.e.* 6.59 and the number of seeds per panicle was highest for planting date, D_1 (18 June, 2018) *i.e.* 89.26 and spacing, S_2 (20 cm x 25 cm) *i.e.* 81.71 of black aromatic (chakhao poireiton) when their individual effect are considered. Early transplanting increased the accumulation of carbohydrates in plants which ultimately increased the yield attributes components like effective tiller, filled grain, and panicle length. Muhammad *et al.* (2008) [17] observed that the maximum number of effective tillers per hill was recorded from early transplanting. These results are in accordance with the findings given by Nayak *et al.* (2003) [19] on rice. Devi and Singh (2000) [7] reported that productive tillers hill^{-2} was significantly higher with wider spacing. The wider spacing from plant to plant accelerates the absorption of nutrients efficiently which increased in number of tiller and seeds per panicle.

The treatment combination D_1S_2 (18 June, 2018 + 20 cm x 25 cm) gave the maximum number of effective tillers per hill *i.e.* 7.33. The effective tillers per hill increased up to 42.60% over the lowest treatment. The number of seeds per panicle were highest for the treatment D_1S_2 (18 June, 2018 + 20 cm x 25 cm) *i.e.* 92.53 which is 39.16% over the lowest treatment. However the test weight and percent chaffiness of black aromatic (chakhao poireiton) was found to be significantly not affected by different planting date and spacing for the interaction effect.

Table 5: Effect of Planting Date and Spacing on Number of effective tillers per hill, Number of seeds per panicle, Test weight (g) and Percent chaffiness (%) of Black Aromatic Rice (Chakhao Poireiton)

Treatment	Number of effective tillers per hill	Number of seeds per panicle	Test weight (g)	Percent chaffiness (%)
Planting date				
D_1	6.94	89.26	27.55	25.76
D_2	6.38	77.01	27.38	24.58
D_3	5.56	68.49	27.20	21.51
SE (m) ±	0.027	0.373	0.192	1.252
CD (0.05)	0.082	1.128	NS	NS
Spacing				
S_1	5.98	74.91	27.31	23.37
S_2	6.59	81.71	27.46	24.30
S_3	6.31	78.13	27.36	24.18
SE (m) ±	0.027	0.373	0.192	1.252
CD (0.05)	0.082	1.128	NS	NS
Planting date × Spacing				
D_1S_1	6.70	85.46	27.41	25.75
D_1S_2	7.19	92.53	27.65	26.05
D_1S_3	6.94	89.78	27.59	25.49
D_2S_1	6.11	72.8	27.30	24.41
D_2S_2	6.58	82.15	27.50	24.72
D_2S_3	6.45	76.08	27.33	24.62
D_3S_1	5.14	66.49	27.21	19.97
D_3S_2	6.00	70.46	27.24	22.14
D_3S_3	5.56	68.53	27.16	22.42
SE (m) ±	0.047	0.646	0.332	2.168
CD (0.05)	0.142	1.954	NS	NS

D= Planting date, S = Spacing

Yield

The individual effect of grain yield, stover yield, biomass yield and harvest index was significantly influenced by the different planting date and spacing (Table 6). The maximum grain yield was recorded with planting date, D_1 (18 June, 2018) *i.e.* 1984.10 kg/ha and spacing, S_2 (20 cm x 25 cm) *i.e.* 1896.11 kg/ha of black aromatic (chakhao poireiton) when their individual effect are considered. This might be due to early transplanting which helped to absorb nutrients and translocate the photosynthates from source to sink. Similar findings were also corroborated by Mukesh *et al*. (2013), [18] Manoj *et al*. (2013) [16] and Islam *et al*. (2014) [10] on rice. Wider spacing help increased the nutrient uptake efficiently which results in better translocation of photosynthates to the reproductive part and improved the yield and yield attributing characters. Obulamma and Reddy (2002) [20] observed higher grain yield at wider spacing. These results are in close conformity with the findings of Patra and Nayak (2001) [22] and Mahato *et al*. (2007) [14]. The maximum stover yield was recorded with planting date, D_1 (18 June, 2018) *i.e.* 3831.04 kg/ha and spacing, S_2 (20 cm x 25 cm) *i.e.* 3691.81 kg/ha of black aromatic (chakhao poireiton) when their individual effect are considered. This might be due to the cumulative effect of early transplanting on all the growth components like plant height, leaf area index, tillers, fresh and dry weight of plant as discussed earlier. Manoj *et al*. (2013) [16] concluded that early transplanted aromatic rice performed better in terms of yield, yield attributing character. Similar findings were also corroborated by Khalifa *et al*. (2014) [12]. The increased in straw yield might be due to increased in wider spacing, resulting in increased level of yield components like effective tiller, filled grain, and panicle length and the accumulation of

carbohydrates in plants ultimately increased the yield attributes and increased the straw yield. Patra and Nayak (2001) [22] reported wider spacing gave significant straw yield. Similar findings were also corroborated by Pal *et al*. (2008) [21] and Gunri *et al*. (2004) [8]. The maximum biomass yield was recorded with planting date, D_1 (18 June, 2018) *i.e.* 5815.14 kg/ha and spacing, S_2 (20 cm x 25 cm) *i.e.* 5587.92 kg/ha of black aromatic (chakhao poireiton) when their individual effect are considered. Chopra *et al.* (2006) [6] reported the highest seed yield and straw yield due to early transplanting. Similar findings were also corroborated by Mukesh *et al*. (2013) [18], Manoj *et al*. (2013) [16] and Islam *et al*. (2014) [10] on rice. Patra and Nayak (2001) [22] reported wider spacing gave significant grain and straw yield. Similar findings were also corroborated by Pal *et al*. (2008) [21] and Gunri *et al*. (2004) [8].

Table 6: Effect of Planting Date and Spacing on Grain yield (kg/ha), Stover yield (kg/ha), Biomass yield (kg/ha) and Harvest index (%) of Black Aromatic Rice (Chakhao Poireiton)

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	Biomass yield (kg/ha)	Harvest index (%)
Planting date				
D_1	1984.10	3831.04	5815.14	34.10
D_2	1821.40	3652.51	5473.91	33.27
D_3	1648.50	3347.97	4996.47	32.96
SE (m) ±	8.256	11.042	17.276	0.077
CD (0.05)	24.964	33.388	52.239	0.232
Spacing				
S_1	1737.38	3515.56	5252.94	33.03
S_2	1896.11	3691.81	5587.92	33.90
S_3	1820.51	3624.16	5444.67	33.41
SE (m) ±	8.256	11.042	17.276	0.077
CD (0.05)	24.964	33.388	52.239	0.232
Planting date × Spacing				
D_1S_1	1903.03	3782.32	5685.35	33.47
D_1S_2	2063.66	3872.41	5936.07	34.76
D_1S_3	1985.60	3838.39	5824.00	34.09
D_2S_1	1783.53	3536.33	5319.86	33.52
D_2S_2	1861.66	3730.85	5592.52	33.28
D_2S_3	1819.00	3690.33	5509.33	33.01
D_3S_1	1525.56	3228.02	4753.59	32.09
D_3S_2	1763.00	3472.15	5235.15	33.67
D_3S_3	1656.93	3343.73	5000.67	33.13
SE (m) ±	14.300	19.125	29.923	0.133
CD (0.05)	43.240	57.829	90.481	0.403

D= Planting date, S = Spacing

The maximum harvest index was recorded with planting date, D_1 (18 June, 2018) *i.e.* 34.10% and spacing, S_2 (20 cm x 25 cm) *i.e.* 33.90% of black aromatic (chakhao poireiton) when their individual effect are considered. Gunri *et al*. (2004) [8] reported higher harvest index due to wider spacing. Similar findings were also corroborated by Mahato *et al*. (2007) [14]. Harvest index is dependent on the ability of variety or a treatment to produce more grain yield than the straw accumulation. As such, higher grain yields than the straw would account for higher harvest index. The variation in harvest index due to date of transplanting and spacing both could be explained with the variation in their grain and straw yield.

The interaction effect of grain yield, stover yield, biomass yield and harvest index of black aromatic (chakhao poireiton) was found to be significant. The treatment combination D_1S_2 (18 June, 2018 + 20 cm x 25 cm) gave the maximum grain yield (2063.66 kg/ha), stover yield (3872.41 kg/ha), biomass yield (5936.07 kg/ha) and harvest index (34.76%) which is 35.27%, 19.96%, 24.87% and 8.32% more that of the lowest treatment respectively followed by treatment D_1S_3 (18 June, 2018 + 20 cm x 20 cm).

Economics

The total cost of cultivation was found to be ₹ 48371.08 (Table 7). The highest gross return *i.e.* ₹ 132863.50 was obtained from the treatment D_1S_2 (18 June, 2018 + 20 cm x 25 cm) followed by treatment D_1S_3 (18 June, 2018 + 20 cm x 20 cm) *i.e.* ₹ 128400.30 and the lowest was for the treatment D_3S_1 (18 July, 2018 + 20 cm x 10 cm) *i.e.* ₹ 100046.30. This might be owing to higher productivity as well as efficient use of fertilizers. The highest net return *i.e.* ₹ 84492.42 was obtained from the treatment D_1S_2 (18 June, 2018 + 20 cm x 25 cm) followed by treatment D_1S_3 (18 June, 2018 + 20 cm x 20 cm) *i.e.* ₹ 80029.22 and the lowest was for the treatment D_3S_1 (18 July, 2018 + 20 cm x 10 cm) *i.e.* ₹ 51675.22. Singh *et al.* (1997) [23] reported that timely transplanted rice results in higher net return and benefit cost ratio. The results corroborate the findings of Chaudhary *et al*. (2011) [5] on rice. The increase in net return was due to increase in yield attributing character and grain yield of black aromatic rice. The benefit-cost ratio (BCR) or return per rupee investment was found to be highest (2.74) for the treatments D_1S_2 (18 June, 2018 + 20 cm x 25 cm) followed by treatment D_1S_3 (18 June, 2018 + 20 cm x 20 cm) (*i.e.* 2.55) and the lowest BCR (2.06) is obtained from the treatment D_3S_1 (18 July, 2018 + 20 cm x 10 cm). Mahato *et al*. 2007 [14] reported higher economic return due to wider spacing. The results corroborate the findings of Singh *et al*. (2012) [24].

Table 7: Effect of planting date and spacing on economics of black aromatic rice (Chakhao Poireiton)

Treatment	Cost of cultivation (₹)	Gross return (₹)	Net return (₹)	Benefit cost ratio
D_1S_1	48371.08	123578.60	75207.52	2.55
D_1S_2	48371.08	132863.50	84492.42	2.74
D_1S_3	48371.08	128400.30	80029.22	2.65
D_2S_1	48371.08	115776.00	67404.92	2.39
D_2S_2	48371.08	121045.90	72674.82	2.50
D_2S_3	48371.08	118496.70	70125.62	2.44
D_3S_1	48371.08	100046.30	51675.22	2.06
D_3S_2	48371.08	114326.00	65954.92	2.36
D_3S_3	48371.08	107850.00	59478.92	2.22

D= Planting date, S = Spacing

Conclusion

Based on the results from the experiment it can be concluded that the effect of planting date and spacing on growth and yield of black aromatic rice (*Oryza sativa* L.) cultivar chakhao poireiton significantly increases the growth attributes, yield and yield attributes of black aromatic rice (chakhao poireiton). The treatment interaction D_1S_2 (18 June, 2018 + 20 cm x 25 cm) was found most effective from all the other treatment. From this research outputs we can conclude that the planting date *i.e.* 18 June, 2018 and spacing 20 cm x 25 cm may be helpful for farmers in Manipur region and other area in the near future making black aromatic rice (chakhao poireiton) cultivation economically and viable.

References

1. Anonymous. Ministry of Agriculture and Farmers Welfare, Govt. of India 2014-15.
2. Bouyoucos GJ. The Hydrometer as a New Method for the Mechanical Analysis of Soils. Soil Science 1927;23:343-353.
3. Bray RH, Kurtz LT. Determination of total organic and available forms of phosphorus in soils. Soil Science 1945;59:39-45.
4. Bruns HA, Abbas HK. Planting date effects on Bt and Non-Bt corn in the mid-south USA. Agron J 2006;98:100-106.
5. Chaudhary SK, Singh JP, Jha A. Effect of integrated nutrient management on yield, quality and nutrient uptake of rice (*Oryza sativa*) under different dates of transplanting. Indian Journal of Agronomy 2011;56(3):228-231.
6. Chopra NX, Chopra N, Yadav RN. Effect of transplanting dates on seed yield and quality of paddy cv. Pusa-44. Seed Research 2006;94(2):288-290.
7. Devi NK, Singh LA. Influence of seedling age and plant density on the performance of rice. *Oryza* 2000;37(1):99-100.
8. Gunri SK, Pal SK, Choudhury A. Effect of integrated nitrogen application and spacings on yield of rice (*Oryza sativa*) in foot-hill soils of West Bengal. Indian Journal of Agronomy 2004;49(4):248-250.
9. Islam MR, Rahman MS, Rahman MH, Awal MA, Hossain SMG. Effect of date of transplanting of yield and yield after bytes of two advanced mutants of rice in Aman season. Bangladesh J. Nucl. Agri 1999;15:34-40.
10. Islam MS, Sarkar MAR, Alam MJ, Rafii MY, Latif MA. Effect of date of transplanting on yield and yield contributing characters of aromatic fine rice in rainfed condition. Research on Crops 2014;15(2):305-312.
11. Jackson ML. Soil chemical analysis.1st edition. Prentice Hall of India Private Limited, New Delhi 1973, pp 1- 484
12. Khalifa AA, Elkhoby W, Okasha EM. Effect of sowing dates and seed rates on some rice cultivars. African journal of Agricultural Research 2014;9(2):196-201.
13. Kumari MBGS, Subbaiah G, Vecraraghavaiah R, Rao HGV. Effect of plant density und nitrogen levels on growth and yield of rice. The Andhra Agricultural Journal 2000;47(3-4):188-190.
14. Mahato P, Gunri SK, Chanda K, Ghosh M. Effect of varying levels of fertilizer and spacing on medium duration rice (*Oryza sativa* L.) in Tarai zone of West Bengal. Karnataka Journal of Agricultural Sciences 2007;20(2):363-365.
15. Mandal BK, Sainik TR, Ray PK. Effect of age of seedlings and levels of nitrogen on the productivity of rice. *Oryza* 1984;21(2):232-252.
16. Manoj DA, Ramakrishna GI, Patel DP, Munda GC, Naropongla, Buragohain J. Effect of nutrient sources and transplanting date on aromatic rice (Oryza sativa) under mid hills of north eastern India. Indian Journal of Agronomy 2013;58(3):322-326.
17. Muhammad ES, Amjed A, Sher M, Ghularm S, Tahir HA. Effect of transplanting dates on paddy yield of fine grain rice genotypes. Pakistan Journal of Botany 2008;40:2403-2411.
18. Mukesh, Singh I, Pannu RR, Prasad D, Ram A. Effect of different transplanting dates on yield and quality of basmati rice (*Oryza sativa*) varieties. Indian Journal of Agronomy 2013;58(2):256-258.
19. Nayak BC, Dalei BB, Chodhury BK. Response f hybrid rice to date of planting, spacing and seedling rate during wet season. Indian Journal of Agronomy 2003;48(3):172-174.
20. Obulamma U, Reddy R. Effect of spacing and seedling number on growth and yield of hybrid rice. *Journal of Research*, ANGRAU 2002;30(1):76-78.
21. Pal MS, Guoping Z, Jinxin C. Nitrogen uptake and N use efficiency in hybrid and common rice as influenced by nitrogen fertilization. *Oryza* 2008;45(2):156-159.
22. Patra AK, Nayak BC. Effect of spacing on rice varieties of various duration under irrigated condition. Indian Journal of Agronomy 2001;46(3):449-452.
23. Singh MV, Tripathi HN, Tripathi HP. Effect of nitrogen and planting date on yield and quality of scented rice (*Oryza sativa*). Indian Journal of Agronomy 1997;42(41):602-606.
24. Singh N, Kumar D, Thenua OVS, Tyagi VK. Influence of spacing and weed management on rice (*Oryza sativa*) varieties under system of rice intensification. Indian Journal of Agronomy 2012;57(2):138-142.
25. Subbaiah BV, Asija GL. A rapid method for the estimation of available nitrogen in soil Current Science 1956;25:259-260
26. Walkley A, Black LA. An examination of the different methods for determining soil organic matter and a proposed modification of the chromic acid titration methods. Soil Science 1934;37:29-38.