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Effect of Date of Transplanting and Spacing under Raised Bed System on the Yield of *Superamandhan*

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Conflicts of Interest
There are no conflicts to declare.

ABSTRACT

Field studies were carried out to investigate the effect of the date of transplanting and spacing on the yield and yield-related parameters of *Superamandhan*. The experimental treatments included four transplanting dates viz. 15 June, 30 June, 15 July, and 30 July 2014, and 6 spacings viz. 80 cm × 60 cm, single row (S_1); 80 cm × 60 cm, double rows (S_2); 80 cm × 50 cm, single row (S_3); 80 cm × 50 cm, double rows (S_4); 80 cm × 40 cm, single row (S_5) and 80 cm × 40 cm, double rows (S_6). The experiment was laid out in a Split-Plot Design with three replications assigning date of transplanting to the main plots and spacing to the sub plots. The size of the unit plot was 12.8 m^2 (4.0 m × 3.2 m). Results of the study showed that the effect of date of transplanting and spacing had a significant effect on all the parameters, except 1000-grain. From the analysis of the yield data, it was observed that late transplanting decreased yield. The highest grain yield of 4.28 t ha^{-1} was obtained from transplanting on 15 June, while the lowest grain yield of 2.30 t ha^{-1} was found on 30 July transplanting. The results show that due to the higher number of plant densities on narrower spacing the yield was higher than the wider spacing. The highest grain yield (3.93 t ha^{-1}) was obtained from 80 cm × 40 cm, double rows spacing, and the lowest grain yield (2.93 t ha^{-1}) was obtained from 80 cm × 60 cm, single row spacing. The interaction effect of date of transplanting and spacing was also found significant for yield and plant characters of *Superamandhan*, except 1000-grain weight. Results of the present study revealed that transplanting on 15 June with 80 cm × 40 cm double rows spacing was found to be the best for obtaining maximum grain yield of *Superamandhan*.

Keywords: RICE, TRANSPLANTING TIME, PLANT SPACING, *SUPERAMANDHAN*, YIELD

Introduction

Rice (*Oryza sativa* L.) is the most extensively cultivated staple food crop in Asia including Bangladesh. Asia-Pacific region produces and consumes more than 90 percent of the world's rice. Nowadays, Bangladesh has reached self-sufficiency in rice production [1, 2]. The geographic and agro-ecological conditions of Bangladesh are suitable for growing rice year-round. The three main rice cropping seasons of

Bangladesh are: (i) the Aus rice (March to June), (ii) the Transplant *Aman* (T. *Aman*) rice (mid-June to mid-November), and (iii) the Boro rice (January to mid-May). But the national average rice production of Bangladesh is much lower (2.94 t ha^{-1}) compared to other rice-growing countries [3]. Due to rapid population growth and urbanization, the cultivated land is gradually decreasing the cultivation land. On the other hand, the demands for food, as well as rice, have been increasing day by day. But due to increase in the cultivation of more profitable contemporary crops decreased the cultivated area of rice. Therefore, attempts should be taken to increase the yield of rice through the use of new methods and modern technologies such as different planting methods, high yielding varieties, date of sowing or transplanting according to variety, spacing, plant management and others. Thus the date of transplanting and spacing could increase the grain yield and quality of rice which might contribute a lot to the economy of Bangladesh.

The planting time of crops, which is related to temperature, day length, solar radiation, precipitation, relative humidity, nutrients, and moisture content in the soil, is the most prominent factor influencing the growth and yield of rice. Time of transplanting was identified as a key factor that influences the growth, yield, and yield-contributing parameters of rice [4]. Optimum temperature requires phenological responses such as panicle initiation, flowering, panicle exertion from flag leaf sheath, and maturity of rice which are influenced by the planting dates during the T. *Aman* season [5]. Islam 1986 reported that the time period between 15 July to 15 August was the best for transplantation time of high yielding varieties of T. *Aman* rice, especially the photosensitive varieties, in Bangladesh [6]. Due to early transplanting rice plants go through a long vegetative period than late transplanting which increases the plant height, tiller number, panicle length as well as biomass make them prone to lodging during the grain-filling period [7]. Too early or late transplanting causes the yield reduction due to shortening of the vegetative period and spikelet sterility [8, 9]. Both high and low temperatures prevailing from panicle initiation to booting stages of rice leads to spikelet sterility as well as yield [1, 10, 11].

The planting density of rice is another most important factor considering during the transplanting of rice. Plant spacing has significant effects on the growth, development, and yield of rice in field conditions. Proper spacing ensures optimum plant growth and yield of rice through adequate utilization of moisture, light, spacing, and nutrients [12]. But many farmers are not indifferent in this matter and they do not maintain proper spacing for transplanting rice. Closer spacing hinders intercultural operations which further results in increased competition among the crops for nutrients, air, light as a result in weaker crops grow and decrease the production of rice [13]. Thakur et al 2009 reported that due to fewer plants per unit area at wider spacing and less number of the tiller and shorter panicles with a low number of filled grains were the main reason for yield reduction [14]. Hence, there is a need to standardize the plant population per unit area for the higher yield of rice.

No research work has so far been conducted with *Superamandhan*, a High Yielding Variety (HYV) rice collection in the Department of Agronomy, Bangladesh Agricultural University, which has been claimed to yield up to 9.0 t ha^{-1} in *Aman* Season. Therefore, determination of optimum time of transplanting and spacing is crucial for *Superamandhan* on a raised bed with the following objectives. (i) to evaluate the effect of date of transplanting on yield and yield attributes of *Superamandhan*. (ii) to find out the suitable spacing for *Superamandhan* and (iii) to study the interaction effect of date of transplanting and spacing on yield performance of *Superamandhan*.

Materials and methods

Location

The field experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh under the Old Brahamaputra Floodplain Agro-ecological Zone (AEZ-9) of Bangladesh from June 2014 to December 2014. The site is located at 24°75' N latitude, 90°50' E longitude and at an altitude of 18 m. The land was medium-high and well-drained with a silty-loam texture with a pH value of 6.50. The fertility level of the soil was low and the percentage of organic matter was 1.29, and total Nitrogen (N) 0.09, contained available Phosphorus (P) 16.72 ppm, exchangeable K 0.12 ppm and available Sulphur (S) 14.2.

Time and plan of the study

The study was conducted with a view to evaluating the effect of the date of transplanting and spacing on the performance of *Superamandhan*. The experimental treatments included four transplanting dates viz. 15 June (T_1), 30 June(T_2), 15 July(T_3), and 30 July (T_4) in 2014, and six spacings viz. 80 cm × 60 cm, single row (S_1); 80 cm × 60 cm, double rows (S_2); 80 cm × 50 cm, single row (S_3); 80 cm × 50 cm, double rows (S_4); 80 cm × 40 cm, single row (S_5) and 80 cm × 40 cm, double rows (S_6). The experiment was laid out in a Split-Plot Design with three replications where the date of transplanting was assigned to the main plot and spacing to the subplot. The spacing between the unit plots and block were 0.75 m and 1.0 m, respectively. There were 18 unit plots for each transplanting date. The size of the unit plot was 12.8 m^2 (4.0 m × 3.2 m). There were 72 unit plots in the experiment.

Seed selection and land preparation

Superamandhan, is a High Yield Variety (HYV), collected from the Department of Agronomy, Bangladesh Agricultural University, Mymensingh. Healthy seeds were selected by a specific gravity method, then selected soaked for 24 hours and kept in gunny bags for sprouting. Firstly the land was thoroughly prepared with a power tiller and subsequently ploughing next three times with country plough followed by laddering. Finally, the transplanting plots were laid out as per experimental design on 15 June, 2014.

Fertilizer application

Both organic and inorganic fertilizers were applied in the experimental plots. The land was applied with cow dung, urea, triple super phosphate (TSP) produced by TSP Complex Limited, Chittagong, Bangladesh, muriate of potash (MoP), gypsum and zinc sulphate at the rate of 10 tons, 390 kg, 180 kg, 200 kg, 100 kg and 15 kg ha^{-1}, respectively. Cow dung was applied before land preparation and the total amount of fertilizers except urea was applied as basal dose on the top of beds for each transplanting. Urea was top-dressed for each transplanting in three equal splits at 15, 35 and 55 days after transplanting.

Seedling transplant

Fifteen-day old seedlings were transplanted on 15 June, 30 June, 15 July, and 30 July, 2014 as per experimental specification with one seedling $hill^{-1}$. In case of single row spacing, four raised bed of 40 cm width $plot^{-1}$ (12.8 m^2) was made. Seedlings were transplanted in a single row on each bed. In case of double rows spacing, three raised bed of 80 cm width $plot^{-1}$ (12.8 m^2) was made. Seedlings were transplanted in double rows on each bed maintaining distance of 40 cm between two rows. Other intercultural operations such as gap filling, weeding, irrigation and pesticide application were done as and when necessary.

Data collection

All the data on yield and plant characters were collected at maturity when 80-90 % of the crop turned golden yellow. Three hills (excluding border hills) were selected randomly and uprooted from each experimental plot to record necessary data regarding yield, yield components and plant characters. After sampling, the whole plots were harvested. Data of different plant characters were recorded from the sample plants of each plot. Grain and straw yields were recorded on a whole plot basis.
Biological yield (dry-basis) was calculated as follows:

$$\textbf{Biological yield} = \textbf{Grain yield} + \textbf{Straw yield}$$

Harvest index, denoted by the ratio of economic yield to biological yield, was calculated as follows:

$$\textbf{Harvest index (\%)} = \frac{\textbf{Grain yield}}{\textbf{Biological yield}} \times \textbf{100.}$$

Statistical analysis

The collected data was analyzed by using the split-plot design with the help of a computer package MSTAT and the mean differences among the treatments were adjudged by Duncan's Multiple Range Test (DMRT) [15].

Results and discussion

Effect of date of transplanting on the plant characters, yield components and yield of *superamandhan*

The all data from Table 2 revealed that the effect of date of transplanting was significant in respect of all the plant characters, yield components and yield, except sterile spikelets panicle^{-1} and 1000-grain weight. Among the four transplanting dates, the tallest plants (179.99 cm), the highest number of total tillers hill^{-1} (55.33), and effective tillers hill^{-1} (39.44) were obtained from transplanting on 15 June, while transplanting on 30 July showed the shortest plant height (126.73 cm), total tillers hill^{-1} (30.29), effective tillers hill^{-1} (23.90) of rice (Table 2). The growth of vegetative parts of rice is hindered due to delayed transplanting. Early sowing of rice produced taller plants than delayed sowing [16, 17] and the number of total tillers hill^{-1} reduced with delay in transplanting [18, 19]. It was also observed from data of Table 2, the longest panicle (26.52 cm), the highest number of total spikelets panicle^{-1} (223.89), grains panicle^{-1} (190.44), grain yield (4.28 t ha^{-1}), and straw yield (5.98 t ha^{-1}) were recorded from transplanting on 15 June while the lowest values of these characters were observed transplanting on 30 July. The lowest number of total spikelets panicle^{-1} (179.06), grains panicle^{-1} (142.44), grain yield (2.30 t ha^{-1}), and straw yield (3.62 t ha^{-1}) was recorded due to delay in transplanting. Late transplanting of rice reduces the yield due to the shortening of the vegetative period [8]. Actually, environmental factors like day length, light, temperature, precipitation, relative humidity, the moisture content in the soil, etc vary with planting times of crops, which have a significant effect on the growth, development, and yield of rice. Temperature is the most important factor during the reproductive stages, exactly temperature at the anthesis period of rice may lead to the spikelet sterility through producing a higher number of empty spikes [20]. The optimum temperature is 25-31^{o}C for development of tiller, 30-33^{o} C for rice anthesis, and 20-29^{o} C for ripening [21]. This experimental area was located under the sub-tropical climate which is specialized by moderately high temperature. During the vegetative to reproduction the maximum temperature was in June 30.5-33.1^{o} C and ripening period 25.1-29.6^{o} C (table 1) which showed an effect on transplanting time. On the other hand, the number of sterile spikelets panicle^{-1} (36.61) was highest on 30 July transplanting and the lowest (33.34) on 15 June transplanting (table 2). Munda et al 1994, Gangwar and Sharma 1997 and Akram et al 2007 also founded similar results [22, 23, 24]. They observed a higher yield of rice due to produce more panicles in early transplanting than in late transplanting as well as transplanting at an optimum time reduces grain sterility. Biological yield depends on grain and straw yields. Crops transplanted on 15 June produced the highest grain and straw yields which resulted in the highest biological yield (10.26 t ha^{-1}) and the lowest (5.92 t ha^{-1}) was on 30 July (Table 2). The effect of different dates of transplanting on 1000-grain weight was not significant. Saikia et al 1989 and Mejos and Pava 1980 found similar results [25, 16]. They found that 1000-grain weight was not affected by the date of transplanting. The highest harvest index (41.77%) was observed from transplanting on 15 June and the lowest one (38.85 %) was obtained from 30 July transplanting (Table 2).

Table 1. Weather data of experimental site during the period of the experiment

Year	Month	Air temperature (^{0}C)			Rainfall (mm)	Relative humidity (%)	Sunshine (hrs)
		Maximum	Minimum	Average			
2014	June	33.1	26.5	17.80	236.2	84.1	144.6
	July	31.5	26.4	29.0	338.8	86.7	120.7
	August	31.37	26.3	29.7	317.4	85.71	113.3
	September	32.4	26.3	29.388	131.6	85.3	132.0
	October	30.5	23.7	27.16	202.8	86.8	140.9
	November	29.6	16.1	22.8	0.0	81.7	118.1
	December	25.1	13.6	19.3	0.6	65.68	97.5

Monthly average weather

Source: Weather Yard, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh.

Effect of spacing on the plant characters, yield components and yield of *superamandhan*

Spacing plays an important role in enhancing rice yield. All the parameters studied were significantly influenced by spacing, except 1000-grain weight. It was observed from the data of Table 3, the widest spacing (80 cm × 60 cm, single row) produced the tallest plant (162.93 cm), the highest number of total tillers hill^{-1} (58.42), number of effective tillers hill^{-1} (43.33), the longest panicle (26.25 cm), the highest number of total spikelets panicle^{-1} (215.33), grains panicle^{-1} (185.25) and the lowest number of sterile spikelets panicle-^{1} (30.08). Miah et al 1990, Rakhasshari et al 1997, Mirza et al 2009, and Ogbodo et al 2010 found similar results [12, 26, 27, 28]. They reported that the plant height, tillers number hill^{-1}, panicle length, spikelets number panicle^{-1}, total grains panicle^{-1} were significantly affected by spacing and the widest spacing showed better results than narrower spacing. Optimum spacing supports the plants to uptake micro or macro-nutrients from the soil, influences the availability of sunlight on leaf area which leads to increased plant photosynthesis and respiration, and shows a direct effect on the yield [29]. Convenient spacing secures the proper growth of the plant with their aerial and underground parts utilizing sufficient solar radiation and nutrients [12]. But in the case of widest spacing (80 cm × 60 cm, single row) produced the lowest grain yield (2.93 t ha^{-1}), straw yield (4.37 t ha^{-1}), biological yield (7.30 t ha^{-1}), and harvest index (39.92%) because of the number of hills plot^{-1} was the lowest (32) for wider spacing. Whereas the closest spacing of 80 cm × 40 cm, double rows produced the shortest plant (157.38 cm), the number of total tillers hill^{-1} (38), effective tillers hill^{-1} (26.08), non-effective tillers hill^{-1} (12.25), grains panicle^{-1} (169.42) and the highest number of sterile spikelets

Table 2. Effect of date of transplanting on the plant characters, yield components and yield of *Superamandhan*

Date of transplanting	Plant height (cm)	Effective tillers hill^{-1} (no.)	Non effective tillers hill^{-1} (no.)	Total tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	Total spikelets panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1	179.99a	39.44a	15.94a	55.33a	26.52a	190.44a	33.44	223.89a	29.62	4.28a	5.98a	10.26a	41.77a
T_2	168.45b	33.67b	15.33a	49.44b	26.29a	186.33a	32.39	218.72a	29.38	3.55b	5.16b	8.72b	40.74ab
T_3	156.55c	33.33b	15.33a	49.28b	26.32a	185.11a	33.00	218.11a	29.32	3.50b	5.18b	8.68b	40.29ab
T_4	126.73d	23.90c	6.28b	30.29c	24.96b	142.44b	36.61	179.06b	28.77	2.30c	3.62c	5.92c	38.85b
CV (%)	5.24	7.44	6.59	6.22	5.20	7.44	6.29	6.74	6.45	4.19	4.37	5.47	4.62
Level of significance	**	**	**	**	**	**	**	**	NS	**	**	**	*

Here, in Table 2, the column, figures with same letters or without letters do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.

** = Significant at 1% level of probability

* = Significant at 5% level of probability

NS = Non significant

CV = Coefficient of variation

Table 3. Effect of spacing on the plant characters, yield components and yield of *Superamandhan*

Spacing (cm)	Plant height (cm)	Effective tillers hill^{-1} (no.)	Non effective tillers hill^{-1} (no.)	Total tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	Total spikelets panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
S_1	162.93a	43.33a	15.08a	58.42a	26.25a	185.25a	30.08c	215.33a	29.13	2.93d	4.37d	7.30d	39.92b
S_2	155.84c	36.00b	13.50b	49.58b	26.17a	178.50ab	33.67bc	212.17ab	29.05	3.35c	4.76c	8.12c	40.92a
S_3	156.04c	35.08b	12.83bc	48.17b	25.84ab	170.17c	33.08bc	203.25c	28.91	3.07d	4.54cd	7.60d	40.31ab
S_4	157.35bc	29.00c	12.25c	41.83c	25.71b	174.08bc	31.17bc	205.25bc	28.79	3.60b	5.39ab	8.99b	39.94b
S_5	158.06b	27.02cd	12.92bc	40.52c	26.11ab	173.35bc	34.33b	207.42bc	29.29	3.56b	5.20b	8.76b	40.47ab
S_6	157.38bc	26.08cd	12.05c	38.00d	26.05ab	169.42c	40.83a	210.25abc	28.95	3.93a	5.65a	9.58a	41.02a
CV (%)	5.24	7.44	6.59	6.22	5.20	7.44	6.29	6.74	6.45	4.19	4.37	5.47	4.62
Level of significance	**	**	**	**	*	**	**	*	NS	**	**	**	*

Here, in Table 3, the column, figures with same letters or without letters do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.

Spacing(S): S_1 = 80 cm × 60 cm, single row, S_2 = 80 cm × 60 cm, double rows, S_3 = 80 cm × 50 cm, single row, S_4 = 80 cm × 50 cm, double rows, S_5 = 80 cm × 40 cm, single row, S_6 = 80 cm × 40 cm, double rows

** = Significant at 1% level of probability

* = Significant at 5% level of probability

NS = Non significant

CV = Coefficient of variation

Table 4. Effect of interaction between date of transplanting and spacing on the plant characters, yield components and yield of *Superamandhan*

Interaction (T × S)	Plant height (cm)	Effective tillers $hill^{-1}$ (no.)	Non effective tillers $hill^{-1}$ (no.)	Total tillers $hill^{-1}$ (no.)	Panicle length (cm)	Grains $panicle^{-1}$ (no.)	Sterile spikelets $panicle^{-1}$ (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1S_1	189.39a	49.00a	17.67ab	66.00a	26.93a	206.00a	30.00ef	29.93	3.74fg	5.17c-f	8.90d-g	41.98ab
T_1S_2	171.90d	46.67ab	15.67cde	62.33ab	26.65abc	187.00b-f	40.33bc	29.65	4.24bcd	5.53b-e	9.77bc	43.45a
T_1S_3	176.05c	43.33b	16.33bcd	60.33b	26.64abc	186.00b-g	38.67bcd	29.64	3.82ef	5.33b-f	9.15c-f	41.76ab
T_1S_4	182.22b	38.33c	15.67cde	53.33c	25.87b-f	172.33fgh	28.67f	29.06	4.54ab	6.56a	11.10a	40.92ab
T_1S_5	179.05bc	31.33efg	14.00efg	45.67ef	26.85a	199.00ab	32.00c-f	29.85	4.51abc	6.49a	11.00a	41.06ab
T_1S_6	181.34b	28.00fgh	16.33bcd	44.33ef	26.19a-d	192.33a-d	31.00def	29.56	4.81a	6.79a	11.60a	41.46ab
T_2S_1	172.55d	47.00ab	19.33a	66.33a	26.75abc	200.33ab	29.67ef	29.75	3.31h	4.77fgh	8.08gh	40.97ab
T_2S_2	168.55e	38.33c	15.67cde	53.67c	26.24a-d	196.33abc	29.00f	29.24	3.40gh	5.03d-g	8.43fgh	40.29ab
T_2S_3	166.89e	36.33cd	15.00cde	51.67cd	25.87b-f	178.00d-h	33.00c-f	29.16	3.16h	4.84fg	8.01h	39.56ab
T_2S_4	168.00e	26.67f-i	12.67g	41.00fg	25.85c-f	171.67gh	33.67c-f	29.09	3.49fgh	5.10c-f	8.59e-h	40.61ab
T_2S_5	168.45e	27.67f-i	15.00cde	43.33efg	26.78ab	194.33abc	31.33def	29.78	3.81ef	5.55b-e	9.36b-e	40.71ab
T_2S_6	166.28e	26.00hij	14.33d-g	40.67fg	26.24a-d	177.33d-h	37.67b-e	29.24	4.16cde	5.68bcd	9.83bc	42.30ab
T_3S_1	159.33f	45.67ab	15.67cde	62.33ab	26.29a-d	187.00b-f	33.33c-f	29.29	2.71i	4.42ghi	7.13i	38.08b
T_3S_2	154.28g	36.33cd	16.33bcd	53.33c	26.78ab	191.33a-e	34.67c-f	29.78	3.74fg	5.15c-f	8.89d-g	42.03ab
T_3S_3	153.83g	34.33cde	13.00fg	47.33de	26.40a-d	187.00b-f	30.67def	29.40	3.24h	4.95efg	8.19gh	39.67ab
T_3S_4	156.78fg	29.67e-h	15.67cde	46.33e	25.92b-e	183.00c-h	33.33c-f	28.92	3.73fg	5.72bc	9.45bcd	39.45ab
T_3S_5	157.94f	28.33fgh	16.67bc	45.67ef	26.46a-d	185.67b-g	30.33def	29.46	3.47fgh	4.91efg	8.38fgh	41.38ab
T_3S_6	157.11fg	25.67hij	14.67c-f	40.67fg	26.06a-e	176.67e-h	35.67c-f	29.06	4.12de	5.92b	10.04b	41.11ab
T_4S_1	130.44h	31.67def	7.67h	39.00g	25.03fgh	147.67i	30.33def	27.55	1.98j	3.11k	5.09k	38.90ab
T_4S_2	128.61hi	22.67ijk	6.33hij	29.00hi	25.00fgh	139.33ij	30.67def	27.52	2.04j	3.34jk	5.38k	37.91b
T_4S_3	127.39hij	26.33ghi	7.00hi	33.33h	24.43gh	129.67j	30.00ef	27.45	2.04j	3.22k	5.26k	40.27ab
T_4S_4	125.39ijk	21.33jk	6.23hij	26.67i	25.21efg	137.33ij	29.00f	28.08	2.55i	4.16hi	6.71ij	38.79ab
T_4S_5	126.78ij	20.73k	6.00hij	27.40i	25.70def	137.33ij	40.67bc	28.07	2.45i	3.85ij	6.30j	38.74ab
T_4S_6	124.78jk	20.67k	5.67ij	26.33i	24.36h	131.33j	45.00a	27.92	2.64i	4.22hi	6.86ij	38.47ab
CV (%)	5.24	7.44	6.59	6.22	5.20	7.44	6.29	6.45	4.19	4.37	5.47	4.62
Level of significance	**	**	**	**	*	**	**	NS	**	*	**	*

Here, in Table 4, the column, figures with same letters or without letters do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.

Interaction of date of transplanting (T) and spacing (S): T_1S_1 = 15 June, 80 cm × 60 cm, single row, T_1S_2 = 15 June, 80 cm × 60 cm, double rows, T_1S_3=15 June, 80 cm × 50 cm, single row, T_1S_4 = 15 June, 80 cm × 50 cm, double rows, T_1S_5=15 June, 80 cm × 40 cm, single row, T_1S_6 = 15 June, 80 cm × 40 cm, double rows, T_2S_1 = 30 June, 80 cm × 60 cm, single row, T_2S_2 = 30 June, 80 cm × 60 cm, double rows, T_2S_3 = 30 June, 80 cm × 50 cm, single row, T_2S_4 = 30 June, 80 cm × 50 cm, double rows, T_2S_5 = 30 June, 80 cm × 40 cm, single row, T_2S_6 = 30 June, 80 cm × 40 cm, double rows, T_3S_1 = 15 July, 80 cm × 60 cm, single row, T_3S_2 = 15 July, 80 cm × 60 cm, double rows, T_3S_3 = 15 July, 80 cm × 50 cm, single row, T_3S_4 = 15 July,80 cm × 50 cm, double rows, T_3S_5 = 15 July, 80 cm × 40 cm, single row, T_3S_6 = 15 July, 80 cm × 40 cm, double rows, T_4S_1 = 30 July, 80 cm × 60 cm, single row, T_4S_2 = 30 July, 80 cm × 60 cm, double rows, T_4S_3 = 30 July, 80 cm × 50 cm, single row, T_4S_4 = 30 July, 80 cm × 50 cm, double rows, T_4S_5 = 30 July, 80 cm × 40 cm, single row, T_4S_6 = 30 July, 80 cm × 40 cm, double rows

** = Significant at 1% level of probability

* = Significant at 5% level of probability

NS = Non significant

CV = Coefficient of variation

panicle^{-1} (40.83) of rice (Table 3). The closest spacing increased the number of sterile spikelets [30]. But this spacing produced the highest grain yield (3.93 t ha^{-1}), straw yield (5.65 t ha^{-1}), biological yield (9.58 t ha^{-1}), and harvest index (41.02 %) because the highest number of hills plot^{-1} was the (60) for closer spacing (Table 3). Siddiqui et al 1999 also found similar results [31]. They stated that grain yield of rice under closer spacing was significantly higher than wider spacing. 1000-grain weight was not affected by spacing. Roy 2005 found similar results who stated that 1000-grain weight was unaffected by plant spacing [32]. The highest harvest index (41.02 %) was observed in closer spacing (80 cm × 40 cm, double rows) and the lowest one (39.92 %) was observed in wider spacing (80 cm × 60 cm, single row) (Table 3).

Interaction effects between date of transplanting and spacing on the plant characters, yield components and yield of *superamandhan*

The interaction between the date of transplanting and spacing had a significant effect on all studied parameters, except 1000-grain weight. From Table 4, it was observed that the vegetative growth of *Superamandhan* reduced gradually due to delaying transplanting and reducing plant spacing. Among all transplanting date and spacing interaction, the highest plant height (189.39 cm), number of total tillers hill^{-1} (66), effective tillers hill^{-1} (49), and panicle length (26.93 cm) were recorded in the combination of T_1S_1 and the lowest plants height (124.78 cm), number of total tillers hill^{-1} (26.33)), effective tillers hill^{-}

^{1} (20.67), and panicle length (24.36 cm) were was found in the combination of T_4S_6. The highest number of non-effective tillers hill^{-1} (19.33) was produced by the combination of T_2S_1 which was statistically similar to the combination of T_1S_1. The lowest number of non-effective tillers hill^{-1} (5.67) was recorded from the combination of T_4S_6 which was statistically similar to the combination of T_4S_2, T_4S_3, T_4S_4, and T_4S_5. The highest number of total spikelets panicle^{-1} (236) was obtained from the combination of T_1S_1 and the lowest number (159.67) was observed in the combination of T_4S_3 which was statistically identical with the combination of T_4S_4, T_4S_5, and T_4S_6. The maximum number of grains panicle^{-1} (206) was recorded from the combination of T_1S_1 and the minimum number of grains panicle^{-1} (129.67) was recorded from the combination of T_4S_3 which is statistically similar to the combination of T_4S_2, T_4S_4, T_4S_5, and T_4S_6 (Table 4). The highest number of sterile spikelets panicle^{-1} (45) was found in the combination of T_4S_6 and the lowest number (28.67) was observed in the combination of T_1S_4. It was observed from the date of table 4 that the weight of 1000-grain was not significantly influenced by the interaction between the date of transplanting and spacing. The interaction between the date of transplanting and spacing had a significant effect on grain yield, straw yield, and biological yield. From Table 4, the highest grain yield (4.81 t ha^{-1}) and straw yield (6.79 t ha^{-1}) were obtained from the combination of T_1S_6 which were statistically identical to the combination of T_1S_4 and T_1S_5. The lowest grain yield (1.98 t ha^{-1}) was found in the combination of T_4S_1 and the lowest straw yield (3.11 t ha^{-1}) was also observed in the combination of T_4S_1 which was similar to the combination of T_4S_2 and T_4S_3. The highest biological yield (11.60 t ha^{-1}) was observed in the combination of T_1S_6 and the lowest biological yield (5.0 t ha^{-1}) was in the combination of T_4S_1 which was statistically similar to the combination of T_4S_2 and T_4S_3 (Table 4). Harvest index was significantly influenced by the interaction of date of transplanting and spacing at a 5% level of probability. The highest harvest index (43.45%) was found in the combination of T_1S_2. The lowest harvest index (37.91%) was found in the combination of T_4S_2 (Table 4).

Conclusion

The conclusion drawn from the investigation was that, date of transplanting and plant spacing significantly affected both yield and yield components of *Superamandhan.* The result showed that *Superamandhan* should be transplanted on 15 June with 80 cm × 40 cm with double row spacing to get the highest grain yield. The highest yield was obtained in early transplanting than in late transplanting. Due to higher number of plant densities on narrower spacing the yield was higher than the wider spacing. However, further detailed studies are to be carried out to arrive at a concrete decision.

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