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SEEDLING CHARACTERS AND HARVEST INDEX OF SOME *SALI* RICE VARIETIES AS INFLUENCED BY TYPE OF SEEDLING UNDER DELAYED DATES OF PLANTING

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ABSTRACT

Field experiment was conducted at Jorhat to study the performance of different types of rice seedling under five different dates of planting (16 and 26 August; 5, 15 and 25 September) with three replications. The study consisted of six types of seedlings with four varieties *viz.* staggered planting of Manoharsali (S_1), double planting of Manoharsali (S_2), normal planting of Manoharsali (S_3), double planting of Ranjit (S_4), normal planting of Basundhara (S_5) and normal planting of Luit (S_6). Results revealed that seedling characters, tiller and grain sterility (%) increased with delay in planting time and decreased with delay in planting date in case of harvest index (HI). Regarding type of seedling, when compared normal planting of three varieties, S_3 recorded the highest values of all parameters followed by S_5 and S_6. When we compared the three types of seedlings under same variety Manoharsali, S_2 recorded the maximum values of all parameters followed by S_1 and S_3. Under double planted condition, between two varieties, S_2 recorded the higher values of all parameters than S_4. The maximum value of per cent tiller sterility was recorded under normal planted condition and the highest value was noted by S_6. Per cent grain sterility was also recorded more under S_6 followed by S_5 and S_4 than all types of seedlings of Manoharsali. Double planting of Manoharsali (S_2) recorded the lowest values of both the yield parameters. In respect of HI, the treatments could be arranged in the order of $S_2>S_1>S_3>S_4>S_5>S_6$.

***Key words*:** Harvest Index, *sali* rice, seedling character

Introduction

Rice is the most important and major cereal crop of India. It is the single most important food crop of Assam grown in about 2.0-million-hectare area (Anon., 2023). Among the three different rice cultures in Assam, winter rice, locally known as *sali* rice is the most popular rice cultivated during rainy (*kharif*) season occupies majority of the cultivated rice area. Transplanting of seedlings is the major practice in the wetland rice cultivation system. The optimum time for transplanting of long duration photo-insensitive time-bound *sali* rice under the agro climatic conditions of Assam is from middle of July to middle of August with 30-35 days old seedlings. Both the age of seedling at planting and the planting time play a crucial role in obtaining the full yield potential of the cultivars. Timely planting of rice mainly depends on the intensity and distribution of precipitation during monsoon season (June to August). In practice, when farmers of the state can't transplant rice seedling in the optimum planting time due to late onset of monsoon, intermittent longer dry spell during monsoon season, high level of water accumulation in low lying areas and other socio-economic factors. In such situation, the farmers of the state are compelled to delay planting of their *kharif* rice with over-aged seedlings, along with a closer spacing and more number of seedlings per hill.

Rice is a photo sensitive crop; low light intensity drastically reduces its production. Transplanting of long duration photosensitive rice varieties with over aged seedling of even up to 80 days old (staggered planting) or

transplanting of medium and short duration photo-insensitive rice varieties are generally practiced in Assam even up to the end of September without much reduction in yield. The need of double transplanting of long duration photosensitive varieties also arises in situation where the main field is not conducive for planting due to early flood or delayed onset of monsoon. This practice avoids ill effects of over aged seedlings in the primary nursery and because of tillers development in secondary nursery (Ram *et al*., 2010 and Sarma *et al*., 2010) it is also useful in seedling scarcity situations as tillers can be splitted and planted. Moreover, double transplanted rice seedlings have thicker culm and better growth for early establishment in the main field as compared to the nursery raised seedling of the same age group (Ghosh, 2006 and Ashem *et al.*, 2010). This method can cover 8-10 times more area as compared to normal planting. Older seedlings obtained in this method for final transplanting are useful to cope with fluctuating water depth. Despite all these cultural manipulations, the grain yield generally remains quite low, particularly owing to the low temperature during anthesis. Under such conditions, the stable rice varieties with suitable planting method would help to minimize the yield reduction considerably. Considering these facts in view, the present investigation was carried out to study the effect of planting time, seedling type and variety on seedling growth, yield components and harvest index of transplanted *sali* rice under late planting situation during rainy (*kharif*) season in rainfed medium and lowland rice ecosystem of Assam.

Materials and Methods

The study area Instructional-Cum-Research (ICR) Farm, Assam Agricultural University, Jorhat, Assam is situated at 26°47'N latitude, 94°12'E longitude and about 86.6 m above mean sea level with average annual rainfall of 2014 mm, maximum temperature of 34 – 37°C and minimum temperature of 8-10°C respectively. The experiment was conducted in two consecutive *kharif* seasons and was laid out in a split plot design with three numbers of replication. The treatment consisted of five dates of planting *viz.* 16th August (D_1), 26th August (D_2), 5th September (D_3), 15th September (D_4) and 25th September (D_5) as main plot treatment and six types of seedling (which included method of planting, spacing and variety) *viz*. staggered planting of long duration photo sensitive variety Manoharsali with seedling age 60 days and more (S_1: STP-Manoharsali), double planting of long duration photo sensitive variety Manoharsali with 30 + 30 days and more seedling age (S_2: DP-Manoharsali), normal planting of long duration photo sensitive variety Manoharsali with 30 days old seedling (S_3: NP-Manoharsali), double planting of long duration photo insensitive variety Ranjit with 30 + 30 days and more seedling age (S_4: DP-Ranjit), normal seedling age of mid duration variety Basundhara with 25 days old seedling (S_5: NP-Basundhara) and normal seedling age of short duration variety Luit with 21 days old seedling (S_6: NP-Luit) were allotted in sub plots randomly. The soil of the experimental site was sandy loam in texture, acidic in reaction (pH 5.4), medium in available N (299.00 kg/ha), P (19.71 kg/ha) and K (164.20 kg/ha). The crop experienced favorable weather conditions in both the years of experimentation. In this experiment, there were five dates of planting for which different nursery beds were used.

In staggered planting the age of seedling increased with the advancement of dates of planting. Hence, there was only one date of sowing in the nursery (primary) for staggered planting treatment (S_1: STP-Manoharsali). There were normal seedling of three different varieties in five different dates and also Manoharsali was planted as staggered, and Manoharsali and Ranjit were planted as double planting respectively hence, there were eighteen dates of sowing in the primary nursery. Secondary nursery beds were prepared for raising double planted seedlings (S_2 and S_4) only.

Staggered planting of Manoharsali was planted in the main field at 60, 70, 80, 90 and 100 days after sowing at 5 different dates of planting. Double planted seedlings were planted in the main field on specific date with 60 (30+30), 70 (30+40), 80 (30+50), 90 (30+60) and 100 (30+70) days old seedlings where 30 days in primary nursery and 30, 40, 50, 60, 70 days in secondary nursery. In case of normal planting, 30, 25 and 21 days old seedling of Manoharsali, Basundhara and Luit respectively were planted in main field. All the agronomic practices and plant protection measures both in nursery and main field were taken as per normal recommendation for late planted condition of Assam.

Crop varieties under study with desirable features

All the four varieties were developed by Assam Agricultural University under different breeding programs.

a) Manoharsali: First high yielding variety of Assam. It is photoperiod sensitive, long duration (155–160 days) variety well fitted in double and staggered planting under delayed situation. High yielding with yield potentiality is 5.0-5.5 t/ha.

b) Ranjit : Long duration (150-155 days), photoperiod insensitive variety recommended for shallow submergence (0-30 cm water depth), medium low land areas during *sali* season in

Assam. High yielder, resistant to lodging and yield potentiality is 5.0-5.5 t/ha.

c) **Basundhara:** Medium duration (130-135 days) photoperiod insensitive variety. Yield potentiality is 4.0-4.5 t/ha.

d) **Luit:** Short duration (85-100 days), photoperiod insensitive variety suitable for both medium upland situations as pre and post flood condition in chronically flood affected areas. Sowing time of this variety can be extended up to middle of September. Yield potentiality is 3.0-4.5 t/ha.

For planting in the main field the seedlings were kept ready for 5 different planting dates. Uprooting of seedlings was done in morning hours on the day of each transplanting date in the main field and seedling samples of each variety were taken randomly from the bulk seedling and brought to the laboratory for their biometric study. The characteristics of seedlings *viz*., height of seedling, root length, root volume, dry weight of shoots and dry weight of roots were recorded with three biological replications. Seedling height was measured in centimeters from the base of the seedling to the tip of the longest leaf of 10 randomly selected seedlings for all the treatments in each planting date by using graduated meter scale at mm/cm levels. The average of 10 plants was calculated. For measuring seedling root length, seedlings were washed carefully after uprooting to remove the muds or soils adhered to the roots and the length of the roots was measured in centimeters from the base of the seedlings to the tip of the longest root of already selected 10 numbers of seedlings and the average value was taken. Root volume was determined by water displacement method used by Raja and Bishnoi (1990) and was expressed as cm^3 $seedling^{-1}$ in case of normal and staggered planted seedling and cm^3 $hill^{-1}$ in case of double planted seedling. After measuring the root length of 10 randomly selected seedlings or hills, the root of each treatment submerged in 200-500 cm^3 water taking in a 1000 cm^3 measuring cylinder, the water rised in the cylinder was noted to measure root volume of the seedling. Root-shoot ratio was calculated from the data on root and shoot dry weight at the time of transplanting**.** Dry matter weight of seedling shoots and roots from 10 randomly collected seedlings were measured separately in gram and averaged out. Before taking dry matter weight the roots and shoots from the seedlings were separated out and dried in an electric oven at 60 $\pm$ 5ºC till the constant weight was obtained.

Percent tiller sterility was calculated by counting the unproductive and total tiller number. It was calculated in 1 m^2 area at maturity of the crop and expressed in percentage. Percentage of grain (spikelet) sterility was calculated by subtracting the number of well-filled grains (spikelets) to the total number of grains (spikelets) per panicle from 10 randomly selected panicles and averaged out and expressed as percentage. Similarly, the harvest index (HI) was calculated in percentage by dividing the grain yields (q/ha) by grain + straw yield (q/ha) and multiplying by 100 (Gardener *et al*., 1985).

The data collected from field and laboratory were statistically analyzed as per the procedure prescribed for split-plot design described by Panse and Sukhatme (1985) to obtain analysis of variance (ANOVA) and differences among treatments were compared at P=0.05 level of significance.

Results and Discussion

The effect of planting time and type of seedling with variety on late planted *sali* rice were evaluated in terms of growth parameters of seedlings before transplanting in the main field, per cent tiller mortality, per cent grain sterility and harvest index of different treatments. Records of various field observations as well as those of laboratory analyses are being presented below with tables and discussed with the help of suitable reasons and evidences.

Regarding type of seedling, all treatments could not be compared to each other for all the parameters because each variety is having its own character. In that case, comparison was done either between the same or between two different varieties but same method of planting or seedling type.

Shoot length (cm)

Although the height any seedling is its varietal character, as such in this experiment three different planting methods were adopted with four different varieties to compare the performance of varietal group with different crop establishment methods and spacing under late planted condition of *kharif* rice. A perusal of data presented in Table 1 revealed that at the time of planting in the main field, the height of nursery raised seedlings was found to increase significantly with each delay of ten days in planting dates. The lowest (31.54 cm) and highest (51.29 cm) were recorded in crops planted on 16th August (D_1) and 25th September (D_5), respectively. Similar results were also reported by Ashem *et al*. (2010) and Thakuria *et al*. (2018). Significant variations were also observed in case of type of seedling also (Table 1). All the types of seedling differed significantly in their height at the time of transplanting. Maximum height (75.63 cm) was noted in double planted seedlings of Manoharsali (DP-Manoharsali) and was followed by double planting of Ranjit (DP-Ranjit), staggered planting of Manoharsali (STP-Manoharsali) and

Table 1: Seedling characters at the time of planting, per cent tiller sterility and per cent grain sterility as influenced by date of planting and type of seedling (mean data of two years).

Treatment	Seedling height (cm)	Root length (cm)	Root volume (cm^3seedling^{-1}; cm^3hill^{-1})	Root-shoot ratio	Tiller sterility (% m^{-2})	Grain sterility (% panicle^{-1})	Harvest index (%)
Date of planting (D)							
D_1: 16th August	31.54	7.59	3.54	0.28	12.57	21.58	42.89
D_2: 26th August	40.30	7.73	4.43	0.34	22.59	34.82	39.99
D_3: 5th September	44.04	8.11	5.15	0.41	32.00	52.55	34.26
D_4: 15th September	47.48	8.53	6.43	0.46	50.69	66.24	26.58
D_5: 25th September	51.29	8.98	6.79	0.49	55.28	76.13	21.86
SEm (±)	0.859	0.208	0.123	0.007	1.075	0.723	1.125
C.D. (P=0.05)	2.800	0.677	0.403	0.023	3.506	2.356	3.667
Type of seedling (S)							
S_1 : STP-Manoharsali	64.90	11.97	5.94	0.44	28.92	46.27	37.13
S_2 : DP- Manoharsali	75.63	13.69	12.80	0.55	24.90	39.39	40.09
S_3 : NP-Manoharsali	18.36	3.90	0.63	0.23	41.04	48.77	33.21
S_4 : DP-Ranjit	69.25	13.16	11.47	0.60	28.47	54.00	30.51
S_5: NP-Basundhara	15.75	3.29	0.43	0.26	41.83	54.59	29.29
S_6: NP-Luit	13.39	3.12	0.33	0.30	42.61	58.58	28.47
S. Em±	0.681	0.208	0.127	0.008	1.127	0.885	0.981
C.D. (P = 0.05)	1.934	0.591	0.361	0.023	3.119	2.513	2.785
Interaction (D × S)							
S. Em±	1.523	0.466	0.284	0.018	2.519	1.979	2.193
C.D. (P = 0.05)	**	**	**	NS	**	**	**

**= Significant, NS = non-significant

normal planting of Manoharsali (NP-Manoharsali), Basundhara (NP-Basundhara) and Luit (NP-Luit). Increase in shoot length under double planted condition over conventional planting was also reported by Ashem *et al*., (2010), Satapathy *et al*., (2015) and Thakuria *et al*., (2018). Interaction effect of date of planting and type of seedling indicated that in case of staggered and double planted crops, the height of seedlings at the time of planting increased with the advancement of seedling age or date of planting while there was an opposite trend in case normal seedlings (Table 2). The highest value (97.02 cm) was recorded in seedlings of Manoharsali double planted on 25th September (D_5S_2) which was significantly higher than all other types of seedling in all the dates. The lowest value (11.24 cm) of seedling height was recorded in normal seedlings of Luit (NP-Luit) planted on 25th September and remained at par with normal seedlings of both Luit and Basundhara planted on the last two dates (D_4S_5, D_4S_6 and D_5S_5). Manoharsali under double planted condition showed better seedling height than of Ranjit for all dates of planting. Under staggered planted condition, seedlings were raised in the same bed up to 100 days. In case of normal planted crops the growth of seedling was less due to lack of availability space for individual seedling. But in case of double planted condition, seedlings were raised in the secondary nursery and proper spacing was maintained which provided better environment for growth and development of seedlings. Also, the seedlings under double transplanted condition become more hardy and stronger than direct seeded broadcast seedlings of normal planted crops due to better shoot and root growth.

Root length of seedling (cm)

The data on root length of different types of rice seedling recorded at the time of planting in the main field at various planting dates are presented in Table 1 and their interaction effects are presented in Table 2. Root length of nursery raised seedlings also increased with the advancement of seedling age. The lowest (7.59 cm) and highest (8.98 cm) were recorded in crops planted on 16th August (D_1) and 25th September (D_5) respectively. However, both the planting dates differed significantly in this respect. Ashem *et al*., (2010) and Thakuria *et al*., (2018) also found similar results. Different types of seedlings also showed significant influence on their root length at the time of transplanting. Maximum root length (13.69 cm) was noted in double planted seedlings of Manoharsali (S_2) and was closely followed by the double planted seedlings of Ranjit (S_4). The lowest value of root length (3.12 cm) was recorded by normal planting of Luit (S_6) which remained at par with normal seedlings of Basundhara (S_5). Ashem *et al*., (2010), Satapathy *et al*.,

Table 2. Seedling height (cm) and root length (cm) of rice as influenced by different dates of planting and types of seedlings at transplanting (mean data of two years).

Date of planting (D)	Type of seedling (S)											
	Seedling height (cm)						Root length (cm)					
	S_1	S_2	S_3	S_4	S_5	S_6	S_1	S_2	S_3	S_4	S_5	S_6
16th August	42.27	47.42	21.02	45.32	18.07	15.15	10.71	11.78	4.89	11.34	3.49	3.34
26th August	58.47	68.51	20.43	62.30	17.55	14.52	11.25	12.63	4.39	11.58	3.33	3.20
5th September	66.54	78.15	18.01	71.62	16.49	13.40	11.71	13.71	3.52	13.29	3.29	3.13
15th September	74.57	87.05	16.92	78.61	15.06	12.67	12.77	14.57	3.30	14.29	3.19	3.09
25th September	82.62	97.02	15.42	88.42	13.04	11.24	13.41	15.74	3.42	15.29	3.16	2.86

	S. Em (±)	C.D. (P=0.05)	S. Em(±)	C.D. (P=0.05)
Difference of two 'S' Mean at the same level of 'D'	1.523	4.324	0.465	1.322
Difference of two 'D' Mean at the same or different levels of 'S'	1.635	4.642	0.475	1.350

S_1: STP-Manoharsali; S_2: DP- Manoharsali; S_3: NP-Manoharsali; S_4: DP- Ranjit; S_5: NP-Basundhara; S_6: NP-Luit

(2015) and Thakuria *et al*., (2018) also reported the maximum root length under double planted seedlings. Similar to height, the root length of rice seedlings was found to increase with the advancement of date of planting in case of staggered and double planted crops of both the varieties and the trend was just opposite in case normal seedlings of all the three varieties. Maximum root length (15.74 cm) was recorded by seedlings of Manoharsali double planted on 25th September (D_5S_2) which remained at par with double planting of Manoharsali planted on 15th September (D_4S_2) and also with double planting of Ranjit planted on the last planting date (D_5S_4). The lowest root length of seedlings at the time of planting (2.86 cm) was registered by normal seedlings of Luit planted on 25th September. However, the root length of normal seedlings of both Luit and Basundhara did not show any significant variation due to delay in planting date.

Root volume of seedling (cm^3 seedling^{-1}; cm^3 hill^{-1})

The data on root volume (cm^3 seedling^{-1} in case of staggered and normal planted seedlings and cm^3 hill^{-1} in case of double planted seedling) of different types of rice seedling recorded at the time of planting in the main field in different dates of planting are included in Table 1 and their interaction effects are presented in Table 3. Consistent increase in root volume of seedlings was recorded with delay in planting. The lowest (3.54 cm^3 hill^{-1}) and highest (6.79 cm^3 hill^{-1}) were recorded in crops planted on 16th August (D_1) and 25th September (D_5), respectively. There was significant difference in root volume at the time of planting in all the dates except between 15th and 25th September. Among the seedling types, double planting of Manoharsali (S_2) recorded highest root volume (12.80 cm^3 hill^{-1}) and was followed by other types of seedlings in the same order as that of seedling height. The lowest root volume (0.33 cm^3 seedling^{-1}) was noted in normal seedlings of Luit (S_6) which remained at par with those of other two normal seedlings (S_3 and S_5). Root volume of rice seedlings was also found to increase with the advancement of date of planting in case of staggered and double planted crops of both the varieties and the trend was just opposite in case normal seedlings of all the three varieties (Table 3). Maximum root volume (15.67 cm^3 hill^{-1}) was recorded by seedlings of Manoharsali double planted on 25th September (D_5S_2) which remained at par with double planting of Manoharsali planted on 15th September (D_4S_2). The root volume of normal seedlings of Manoharsali, Basundhara and Luit did not show any variation due to delay in planting date. However, the lowest root volume of seedlings at the time of planting (0.33 cm^3 seedling^{-1}) was registered by normal seedlings of Luit planted on 25th September.

Root to shoot ratio of seedling

Root-shoot ratio is the ratio of belowground biomass to aboveground biomass, which is the parameter that mostly directly reflects biomass allocation by plants (Qi *et al*., 2019). The data pertaining to root-shoot ratio of different types of rice seedling recorded at the time of planting in the main field in different dates of planting are presented in Table 1 revealed that the root-shoot ratio of different types of rice seedlings was found to decrease significantly with each delay of ten days in planting dates. Lowest value of root-shoot ratio (0.28) was recorded in the seedlings planted on 16th August (D_1) and the highest in 25th September (D_5) planted seedlings. Lower values of root to shoot ratio indicates comparatively lower inhibition of shoot growth under delayed sowing situation. Significant difference on among all the seedling types was observed in respect of root-shoot ratio at the time of transplanting (Table 1). Maximum root-shoot ratio (0.60) was noted in double planting of Ranjit (DP- Ranjit) and was followed by double planting of Manoharsali (DP-Manoharsali), staggered planting of Manoharsali (STP-Manoharsali), normal seedlings of Luit (NP-Luit), normal

Table 3. Root volume ($cm^3seedling^{-1}$; cm^3hill^{-1}) of rice seedling at transplanting and per cent tiller sterility of rice as influenced by different dates of planting and types of seedlings (mean data of two years).

Date of planting (D)	Type of seedling (S)											
	Root volume ($cm^3seedling^{-1}$; cm^3hill^{-1})						Tiller sterility (% m^{-2})					
	S_1	S_2	S_3	S_4	S_5	S_6	S_1	S_2	S_3	S_4	S_5	S_6
16th August	2.84	9.17	0.63	7.84	0.43	0.33	9.57	9.04	9.33	12.20	16.72	18.59
26th August	3.84	11.67	0.63	9.67	0.43	0.33	19.24	15.81	20.43	21.26	28.59	30.22
5th September	5.33	12.50	0.63	11.67	0.43	0.33	27.16	20.89	39.33	27.04	36.41	41.18
15th September	8.33	15.00	0.63	13.84	0.43	0.33	40.92	36.18	66.42	38.04	62.45	60.13
25th September	9.33	15.67	0.63	14.34	0.43	0.33	47.69	42.84	69.67	43.56	64.97	62.96

	S. Em (±)	C.D. (P=0.05)	S. Em(±)	C.D. (P=0.05)
Difference of two 'S' Mean at the same level of 'D'	0.284	0.806	2.519	7.153
Difference of two 'D' Mean at the same or different levels of 'S'	0.249	0.707	2.539	7.211

S_1: STP-Manoharsali; S_2: DP- Manoharsali; S_3: NP-Manoharsali; S_4: DP- Ranjit; S_5: NP-Basundhara; S_6: NP-Luit

seedlings of Basundhara (NP-Basundhara) and normal seedlings of Manoharsali (NP-Manoharsali). Increase in root and shoot weight under double planted condition was also reported by Thakuria *et al.*, (2018). However, the interaction between seedling type and dates of planting was found to be non-significant.

Tiller sterility (%)

An opposite trend was observed in case of per cent tiller sterility (Table 1). The tiller sterility was found to be lowest (12.57 %) in the crops planted on 16th August (D_1) which increased significantly with the delay in planting date reaching the highest value (55.28 %) on 25th September (D_5). It might be due to unavailability of sufficient amount of photosynthates as source of energy may result in the mortality of tillers and number of productive tillers may reduce in case of late planting. Also, the mortality of tillers might be higher due to more competition for water, nutrient, air and light in late planting. The percent tiller sterility was found to be statistically significant due to different types of seedlings (Table 1). Highest percentage of tiller sterility (42.61 %) was recorded by the normal planting of Luit (S_6) which remained statistically at par with those of normal planting of Basundhara (S_5) and normal planting of Manoharsali (S_3). Both the double planted seedlings of Manoharsali (S_2) and Ranjit (S_4) recorded comparatively lower tiller sterility. A close examination of data pertaining to percent tiller sterility presented in Table 3 reveals that the highest percentage of sterile tiller (69.67 %) was recorded in normal seedling of long duration photosensitive variety Manoharsali planted on 25th September (D_5S_3) which remained at par with same seedling of the same variety planted on 15th September (D_4S_3) and normal seedling of medium duration variety Basundhara planted on the same date (D_5S_5) and also with short duration variety Luit planted on 25th September (D_5S_6). The lowest percentage of sterile tiller (9.04%) was noted in double planting of Manoharsali on 16th August (D_1S_2) which was closely followed by normal as well as staggered planting of the same variety and also double planting of Ranjit on the same date (D_1S_3, D_1S_1 and D_1S_4). Joseph (1991), Reddy and Reddy (1992), Om *et al.*, (1997), Kumar *et al.*, (1998), Pandey *et al.*, (2001), Nayak *et al.*, (2003), Yadav (2007), Ashem *et al.*, (2010), Changmai (2015) and Thakuria *et al.*, (2018) also reported significant reduction in total tillers production with delay in planting. The higher number of effective tillers per m^2 in early planted crop might be due to availability of more time for the growth period with optimum photoperiod as well as optimum temperature for the growth of crop plant which may result in more nitrogen absorption by the roots for the synthesis of protoplasm responsible for rapid cell division which may increase plant shape and size, ultimately the production of tillers may be more. The findings had also been supported by Singh *et al.*, (1996), Singh *et al.*, (1997), Patel (1999), Yadav (2007) and Thakuria *et al.*, (2018).

Grain sterility (%)

Data on per cent grain sterility per panicle for date of planting and type of seedling are presented in Table 1 and their interaction effects are presented in Table 4. The per cent grain sterility was found to be lower in earlier dates as compared to later dates and there was significant increase with each delay of 10 days in planting from 16th August. In all the earlier dates the per cent grain sterility was significantly lower and the lowest value (21.58) was recorded in the crops planted on 16th August. The highest value (76.13) was recorded by the crops planted on 25th September (D_5) which was significantly higher than those of earlier dates. This might be due to very remarkably higher number of unfilled grains per panicle for late plantings. More number of un-filled grains per panicle due to late planting condition was also reported by Ashem *et al.* (2010). It has been reported that environmental factors more particularly lower temperature under

Table 4. Per cent grain sterility and harvest index (%) of rice as influenced by different dates of planting and types of seedlings (mean data of two years).

Date of planting (D)	Type of seedling (S)											
	Grain sterility (%)						Harvest index (%)					
	S_1	S_2	S_3	S_4	S_5	S_6	S_1	S_2	S_3	S_4	S_5	S_6
16th August	22.90	16.14	22.52	20.03	22.85	26.68	38.09	43.15	40.80	44.78	44.37	46.16
26th August	33.50	31.11	36.74	34.98	32.46	41.26	38.63	41.10	38.24	41.17	41.11	39.69
5th September	47.58	41.29	47.13	63.99	55.56	60.35	40.73	40.87	39.10	22.86	31.40	30.65
15th September	58.36	44.11	58.41	73.48	79.99	81.74	38.97	43.37	26.99	21.37	15.01	13.76
25th September	68.74	64.91	79.87	76.04	82.92	83.43	29.23	31.99	20.93	22.36	14.56	12.08

	S. Em (±)	C.D. (P=0.05)	S. Em(±)	C.D. (P=0.05)
Difference of two 'S' Mean at the same level of 'D'	1.978	5.618	2.193	6.227
Difference of two 'D' Mean at the same or different levels of 'S'	1.946	5.527	2.318	6.582

S_1: STP-Manoharsali; S_2: DP- Manoharsali; S_3: NP-Manoharsali; S_4: DP- Ranjit; S_5: NP-Basundhara; S_6: NP-Luit

delayed planting plays an important role in determining the number of unfilled grains per panicle and degree of sterility. This might be due to moisture stress, low temperature and sunshine hours during flowering to grain filling stages of the crop (Kalita, 1997). Different types of seedlings differed significantly in respect of per cent grain sterility. Significantly highest per cent grain sterility (58.58) was recorded by normal seedlings of Luit (S_6) and the lowest values of per cent grain sterility (39.39) was noted in double planted seedlings of Manoharsali (S_2). However, double planted seedlings of Ranjit (S_4) and normal seedlings of Basundhara (S_5) remained at par with each other. Staggered planted seedlings of Manoharsali (S_1) and normal seedlings of same variety (S_3) also found at par with each other in this respect. More number of filled grains per panicle under double planted conditions of photosensitive variety was also reported by Ashem *et al*., (2010). Data presented in Table 4 reveal that significantly highest percentage of sterile grain (83.43) was recorded by normal seedlings of Luit when crop was planted on 25th September (D_5S_6) which was statistically at par with the same seedling type of same variety planted on 15th September (D_4S_6), normal seedling of medium duration variety Basundhara planted on 15th and 25th September (D_4S_5 and D_5S_5) and also with long duration variety Manoharsali planted on 25th September (D_5S_3). The lowest values of number of unfilled grains per panicle was found in double planted 60 days old (30+30 days) seedlings of Manoharsali on 16th August (D_1S_2) which remained statistically at par with that of double planted seedlings of Ranjit on the same date of planting (D_1S_4). All other combinations of planting date and seedling type were found to record comparatively higher percentage of sterile grains per panicle. The higher degree of spikelet sterility in the later planting dates might be due to lower temperature during the reproductive stage as rice varieties of are thermo sensitive and their growth duration is modified depending upon the fluctuation in the atmospheric temperatures. The prolonged growth duration under low temperature might have caused higher degree of spikelet sterility in the later planting dates. These results are in agreement with the findings of Changmai (2015).

Harvest index (%)

Different dates of planting brought about significant influence on harvest index (Table 1). Harvest index (HI) was found to decrease significantly with delay in planting from the highest value of 42.89 to 21.86. The highest value of HI was recorded in the crops planted on 16th August (D_1) and the lowest on 25th September (D_5). However, the differences between 16th August (D_1) and 26th August (D_2) could not produce significance level. Changmai and Thakuria (2017) also reported similar result. The HI of rice was found to be statistically significant due to different types of seedlings (Table 1). The highest value (40.09) of HI was registered by the double planed seedlings of Manoharsali (S_2) which was significantly superior to those of other types of seedlings. While the lowest value (28.47) of HI was recorded in normal planting of Luit (D_6) which remained at par with those of normal planting of Basundhara (S_5) and double planting of Ranjit (S_4). Higher value of HI recorded by double planed seedlings of Manoharsali (S_2) indicated better vegetative growth as well as dry-matter partitioning to the reproductive part under this treatment. Similar results were also reported by Ashem *et al*., (2010) and Satapathy *et al*., (2015).

The data on interaction effect (Table 4) reveal that the HI remained more or less stable in case of staggered and double planting of Manoharsali up to 15th September (D_4S_1 and D_4S_2). Significantly lower HI was recorded beyond 15th September in these two types of seedlings (D_4S_1 and D_4S_2) while in normal planting of Manoharsali, statistical difference was noted after 5th September (D_3S_5) and for other three types of seedlings 26th August

(D_2S_4, D_2S_5 and D_2S_6) was the critical date. The significantly decreasing trend in harvest index with delay in planting might be due to higher mortality per cent of tillers in late planted crop than the early planted crop which may result reduced in grain ratio total biological yield. Nayak *et al.*, (2003), Yadav (2007), Ashem *et al*., (2010) and Thakuria *et al*., (2018) also observed reduction in harvest index due to delay in planting. The higher production of biological yield in earlier planted crop might be due to higher total tillers production more ear bearing shoot per m^2, a greater number of leaves per hill and higher fresh and dry weight per hill and better development of yield attributes than the paddy planted on later dates. Ghadekar *et al.*, (1988), Dhiman *et al.*, (1995), Singh *et al.*, (1996), Singh *et al.*, (1997), Patel (1999) Nayak *et al.*, (2003) and Yadav (2007) have also reported the same result.

Conclusion

Based on the findings from the above study it can be concluded that planting of double planted seedling increased all the seedling parameters followed by staggered planted and normal planted seedlings under delayed planting condition. The same seedling of photosensitive variety Manoharsali decreased per cent tiller sterility m^{-2} and per cent sterile grains $panicle^{-1}$ in all the planting dates. The variety Manoharsali could be grown with 90 days (30+60 days) old seedling under late planted condition up to 15th September with an average harvest index of 43.37 per cent.

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