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Research Paper

Relative performance of rice (*Oryza sativa*)–ratoon production system as influenced by date of sowing and system of cultivation of plant rice genotypes

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ABSTRACT

Field experiments were conducted in coastal Odisha, India during 2009 to 2011 in split split-plot design to investigate whether modified system of rice (*Oryza sativa* L.) intensification (MSRI) mimicking all the production principles of system of rice intensification (SRI), except planting geometry and seedling number that were in accordance to the best management practice (BMP), could improve the performance of plant rice genotypes compared to the latter two different water using systems under varying dates of sowing during the wet season. Attempts were also made to ascertain their relative impacts on the succeeding ratoon crop. Grain yield in plant rice sown by 20 June (early) was significantly the highest followed by 5 and 20 July sowing with 5.73% and 17.14% reduction in yield. MSRI was superior over SRI and BMP with 11.32% and 35.46% increase in yield and Hybrid 'Ajay' yielded higher (9.07%) than HYV 'Tapaswini'. The performance of ratoons followed the similar trend as in plant rice. Early sown hybrid 'Ajay' in MSRI produced significantly the highest and 20 July sown 'Tapaswini' in BMP had the lowest grain yield in plant rice. Superiority of early sown rice, MSRI and hybrid 'Ajay' could be attributed to the synergistic effects of their yield attributes. The root volume of plant rice at 100 DAS had strong correlation with the plant height, straw and grain yield of plant rice as well as the grain yield of subsequent ratoon.

Key words: Correlation, Date of sowing, Genotype, Hybrid, Ratoon, Rice, System of rice intensification

A set of water-saving rice cultivation management practices popularly known as system of rice intensification (SRI) has been introduced from Madagascar to many countries including India. Its changes in management practices include: transplanting of very young seedlings singly in a square pattern, maintaining non-flooded soil rhizosphere up to panicle initiation through alternate wetting and drying, much stress to organic nutrient and plant protection measures and mechanical weeding. The benefits of SRI with the entire set of recommended management practices compared to the continuous flooded traditional farmers' practices in terms of water saving and productivity are well established in rice growing countries including India (Choudhury *et al*., 2007; Sato and Uphoff, 2007; Shekhar *et al*., 2009; Chapagain *et al*., 2011; Krupnik *et al*., 2012; Dass *et al*., 2012; Kumar and Singh, 2013), but research findings on the relative production efficiencies of subsequent ratoon or stubble crop of rice genotypes involving the recommended "Best Management Practices (BMP)", SRI and "Modified SRI (MSRI)" under assured irrigation system during wet season needed careful evaluation. The MSRI is the system of growing rice as in SRI with all similar nursery, nutrient, water, weed and pest management practices but with the plant geometry and seedling numbers/hill like in BMP.

Ratoon crops are usually considered as the bonus to the main crop as lesser external inputs are required for its successful production. Moreover, it can suitably be fitted in to the lag or idle or fallow period between the harvesting of the plant rice and sowing of the succeeding green gram crop in the areas of rice-greengram system of production in India. Similarly, no such work to study the effect of time of sowing of the plant rice on its stubble crop had been done before.

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MATERIALS AND METHODS

The field experiments were conducted during 2009 and 2011 in east and south east coastal plain of Odisha at 25.6 km air distance from the Bay of Bengal at east. The experimental site in particular was located at 86< 22' E, 20< 17' N and 14.0 m above the mean sea-level. The physico-chemical properties of the experimental soil indicated clay loam texture, moderately acidic in soil reaction (*p*H 5.6–5.5), high organic carbon (0.79–0.87) and electrical conductivity (0.96–0.98 dS/m). Available primary plant nutrients analysed were to have medium in N, P_2O_5 (Brays') and K_2O. The climate of the experimental location is characterized as warm and moist, with a hot and humid summer and normal cold winter, which broadly falls in the moist hot group. The range of maximum and minimum temperatures during the experimental cropping years was more or less similar as the long term average. The mean annual rainfall is 1,334 mm and nearly 62.0% of rainfall was being received between June and October (827 mm). The monsoon usually sets in around mid June and recedes by first week of October. July and August are wettest months, while December is the driest one.

The treatments consisted of 3 dates of sowing, viz. 20 June, 5 July and 20 July; 3 systems of cultivation of rice–ratoon, viz. Best management practices (BMP)-ratoon, system of rice intensification (SRI)-ratoon and modified system of rice intensification (MSRI)–ratoon; and 2 medium duration rice genotypes released from National Rice Research Institute, Cuttack, viz. high yielding variety (HYV) 'Tapaswini' (IET 12168) and hybrid 'Ajay' (CRHR-7, IET 18166). The experiment was carried out in a split-split plot design with 18 treatment combinations replicated thrice. The first treatment involving 3 dates of sowing were assigned to the main-plots. The second treatment of 3 systems of cultivation was allotted to 3 sub-plots and the 2 rice genotypes were grown in sub-sub-plots.

For each date of sowing under BMP 3 beds of 5.0 m × 1.0 m were prepared by raising the nursery bed 15.0 cm above the ground level and the beds were separated by channels in-between. In each bed, 15 kg of FYM, 50 g of muriate of potash (MOP) and 100 g of single super phosphate (SSP) were applied at the time of final land preparation. In each bed 0.75 kg of sprouted seeds of 'Tapaswini' and 'Ajay' were sown separately and duly labeled for easy identification. Chemical seed treatment was done with carbendazim powder @ 1.5 g/kg of seeds before soaking with water. After 15 days of sowing, 50 g of urea was applied to each bed.

For each date of sowing under SRI and MSRI cultivation, 3 beds of 2.5m × 1.0m for each genotype were prepared through mixing of one part sand, one part well decomposed FYM and 2 parts of top soil in between 2 parallel bamboos separated at 1.0 m width. In each bed, 50 g of MOP and 100 g of SSP were applied at the time of final bed preparation before sowing. The bed top was leveled and 0.25 kg of sprouted seeds of 'Tapaswini' and 'Ajay' were sown separately and duly labeled for easy identification. The seeds were covered with soil mixture of 1.0cm thickness and irrigated by sprinkling water over it.

Seedlings from the raised nursery beds were uprooted at 25-days old stage for transplanting under BMP. The beds were irrigated before uprooting for smooth lifting of the seedlings. Two seedlings/hills were transplanted in the main field at 25.0cm × 12.5cm spacing in lines.

The main field was puddled and measured quantities of fertilizers were added to the field before final puddling. For transplanting under SRI and MSRI, seedlings from the raised bamboo beds were uprooted at 10 days by scooping the seedlings in bulk at 2cm to 3cm below the nursery bed surface along with the moist mother soil. Due care was taken up to reduce damage to the root system of the seedlings during uprooting. The seedlings were then carried away to the main field by trays without much delay and the transplanting was carried out preferably within half an hour of uprooting. Single seedling/hill in SRI and 2 seedlings/hill in MSRI were then transplanted in the main field at 25.0cm × 25.0cm and 25.0cm × 12.5cm spacing respectively in lines. In SRI, 25.0cm spacing was maintained in both the directions. However, in MSRI, 12.5cm spacing was maintained in east-west direction and 25.0cm spacing was maintained in north-south direction so as to facilitate easy penetration of solar radiation throughout the entire day.

In BMP sub plots, FYM @ 5.0 t/ha along with total phosphorous (P) and one-third of the total recommended dose (100–21.8–41.5 kg/ha of N-P-K) of N and K were applied before final puddling. Rest of the N and K fertilizers were applied in two equal halves i.e. one-third at maximum tillering (40 DAS) and one-third at panicle initiation (PI) stage (70 DAS). In SRI and MSRI, FYM @ 15.0 t/ha along with total P and one-fourth of the total (50–10.9–20.8 kg/ha of N-P-K) N and K fertilizers were applied before final puddling. Rest of the N and K fertilizers were applied in three equal splits i.e. one-fourth each at 25, 40 and 70 DAS. The share of the N fertilizer from chemical source has been reduced to half of the recommended dose keeping in view its availability from the 10.0 t extra FYM applied to the field at the time of final land preparation.

In SRI and MSRI systems of cultivation, 4-weedings at 20, 30, 40 and 50 DAS were carried out by using conoweeder. In SRI, the weeder was operated in criss-cross manner and the weeds were incorporated into the soil. In MSRI, the weeder was run in east-west direction only.

In BMP, 3 hand weedings at 40, 55 and 70 DAS were carried out incorporating the weeds *in- situ*. In BMP, water was allowed to stand in the plots since planting of the seedlings by irrigating at alternate days so as to maintain a layer of 5 to 8 cm depth of water during the entire crop period till 15 days before harvest.

In SRI and MSRI, water was not allowed to stand in the plots and special care was taken to avoid submergence of 10-days old seedlings just after transplanting in the main field. The soil was kept moist above the field capacity by irrigating the sub-sub-plots as per requirement till panicle initiation (PI) stage was attained. These plots were first irrigated 5 days after transplanting to moisten the field without ponding. A second irrigation was given on the evening of 9th day after planting at a ponding depth of 2.0 to 5.0cm and the next morning first weeding was performed by using cono-weeder. Thereafter, alternate wetting and drying method of irrigation was practiced and subsequent irrigation were applied 3 days after disappearance of the ponded water or immediately after the development of hair cracks on the soil surface. However, after PI stage, the plots were allowed to hold standing water of 5.0cm height up to 2 weeks before harvest.

Prophylactic sprays of neem oil @ 5.0 ml/liter of water at 15 days intervals were carried out to avoid any possible damage by insects and diseases. In addition, Trichocards with 1,00,000 viable eggs of *Trichogramma japonicum/*ha were released at 15 days intervals i.e. at 40, 55 and 70 DAS for preventing the infestation by stem borers in all 3 systems of planting. Sex pheromone traps @ 20 traps/ha were installed and lures were regularly changed at 15 days intervals. However, necessary and adequate plant protection measures were adopted depending upon the possibility and incidence of the disease and pest infestation reached at economic threshold limit (ETL).

Immediate after harvesting of plant rice, the nitrogenous fertilizer @ 60.0 kg/ha was applied to the sub-sub-plots and subsequently irrigated for suppressing the fallen seeds from sprouting and acting as weeds and for promising emergence of ratoon tillers. After retillering, sufficient water was maintained in the field to control weeds. As the maturity in ratoon rice was irregular, the field was drained out at 80% maturity stage and crop was then harvested leaving the residue at 5.0 cm above the ground level.

The data collected were arranged in appropriate tables and analysed statistically by applying analysis of variance technique (AVNOVA) mentioned by Gomez and Gomez (1984). Standard error of means i.e. SEm± were used in all cases. The significance of variance was tested by 'Error mean square' method of Fisher Snedecor's F-test at the probability level of 0.05 for appropriate degrees of freedom (P=0.05). The relationships between yield and yield attributing characters were studied by simple correlation coefficient formula as stated below.

$$r = \frac{\text{Cov (xy)}}{\sqrt{V(x).V(y)}}$$

Where,
Cov (xy) = Covariance xy
V(y) = Variance y
V(x) = Variance x

RESULTS AND DISCUSSION

As elaborated by Stoop *et al.* (2009), any comparison between two systems made up of several different crop management components is subject to compounding effects that will complicate and/or interfere with the subsequent interpretation of the data. In this context, the results obtained in the current studies on SRI are having special significance as the effects of sets of components were evaluated rather than just any one component.

Studies on plant rice

Effect of date of sowing: Early sowing of rice by 20 June had the advantage of recording the highest grain yield of 5.81 t/ha and subsequent fortnightly delay in sowing beyond this time reduced grain yield (Table 1). Rice sown on 20 July lagged behind (4.82 t/ha) in this regard compared to other earlier sowing dates. The root volume at 100 DAS and days to physiological maturity followed the similar trend, whereas, the spikelet sterility was in the reverse direction. Such reduction in growth duration in late sown rice might be due to progressive decrease in soil and air temperature and decline in bright sunshine hours when sown beyond 20 June. Early sown rice received favourable solar radiation levels and temperature regime (Halder *et al*., 2004). Diminishing root configuration in latter dates of sowing could also be due to the reasons ascribed above resulting in reduced crop duration. Yield attributing characters like effective tillers, panicle length and weight, grains/panicle and test weight were in the lowest order in 20 July sown rice compared to other 2 earlier dates.

Effect of system of cultivation: MSRI had the advantage of recording significantly the highest grain yield (6.11 t/ha) in rice followed by SRI (5.49 t/ha) and BMP (4.51 t/ha). Higher productivity in MSRI might be due to the synergistic effect of all the yield attributes, however, BMP lagged behind possibly due to poor production of such components. Wider spacing in SRI resulting in reduced effective tiller/m^2 might have moderated the productivity inspite of its superiority in recording yield contributing components in its panicle.

Root volume/m^2 was significantly more in MSRI compared to both SRI and BMP. The root volume/hill, however was the highest in SRI. Higher volume and deeper roots in the hills of SRI probably be due to favourable soil physic-chemical properties, balanced soil air and moisture, availability of adequate soil volume and greater light interception by open rice canopy. Such result in SRI was the cumulative effects and thus reflected in enhanced root proliferation/hill. However, the present trend of superiority of MSRI in recording higher root morphology/m^2 could be due to crop geometry accommodating more plants/unit area.

BMP, MSRI and SRI were in diminishing order in recording days to physiological maturity. Reduction in phenological duration of rice in SRI and MSRI might be due to favourable growth factors in soil and better light interception by open canopy enhanced growth cycle to complete life earlier. However, rice in BMP having been deprived of such conditions might have toiled hard to complete its growth cycle with delayed growth stages. Little delay in attaining growth stages of rice in MSRI could be attributed to availability of relatively less favourable factors compared to SRI.

Effect of genotypes: Hybrid rice 'Ajay' had the advantage of recording significantly higher grain yield (5.60 t/ha) which could be due to the synergistic effect of good number of yield attributes. Genotype 'Tapaswini' lagged behind in this aspect possibly due to poor performance of such yield contributing characters. Superior genetic character of hybrid 'Ajay' could keep it in frontier line. Longer and heavier panicles and vigorous root configuration in 'Ajay' could be due to its inherent quality and better utilization of nutrients. 'Ajay' was relatively faster in achieving the physiological maturity probably due to its intrinsic genetic character.

The interaction effect of system of cultivation of plant rice at varying dates of sowing (Table 1a) on grain yield indicated significantly superior performance of MSRI under early sowing by 20 June that produced the highest grain yield of 6.46 t/ha but this was at par with the performance of 5 July sown rice by producing grain yield of 6.32 t/ha under same system of cultivation. However, the grain yield of rice under BMP sown by 20 July was not acceptable since producing the lowest i.e. 3.77 t/ha grain yield.

Studies on ratoon rice

Effect of date of sowing: Early sowing of rice by 20 June had the advantage of recording the highest ratoon-grain yield (0.569 t/ha) and subsequent fortnight delay in sowing beyond this time reduced grain yield in their ratoons (Table 2). Such decline in ratoon-grain yield could be due to poor production of yield attributes of ratoon in late sown rice. Ratoon of early sown rice had the benefit of producing heavier grains, more number of panicles/m^2

Table 1. Effect of treatments on agronomic traits of plant rice during *kharif* of 2009 and 2010 (pooled data of 2 years)

Treatment	Root volume at 100 DAS (cm^3/m^2)	At harvest: Days to physiological maturity	Plant height (cm)	Panicle Nos./m^2	Panicle Length (cm)	Panicle Weight (g)	Grains/ panicle	1,000-grain weight (g)	Spikelet sterility (%)	Yield (t/ha) Straw	Yield (t/ha) Grain
Dates of sowing											
20 June	1166	135.1	121.2	220.4	26.0	4.03	202.7	22.3*	9.67 (3.11)	6.50	5.81
5 July	1040	127.1	118.8	209.3	26.6	3.9	197.8	22.1	12.04 (3.47)	6.34	5.47
20 July	899	119.3	114.1	192.8	23.8	3.7	190.6	21.6	16.73 (4.09)	5.70	4.81
SEm±	9	0.22	1.5	2.9	0.16	0.05	2.29	0.11	0.07	0.077	0.08
CD (P=0.05)	31	0.71	5.1	9.7	0.52	0.15	7.45	0.34	0.23	0.252	0.26
Systems of cultivation											
BMP	850	130.7	113.5	201.3	24.4	3.5	172.2	21.5	16.40 (4.05)	5.69	4.50
SRI	1045	124.8	122.5	193.2	26.5	4.2	217.4	22.5	9.80 (3.13)	5.91	5.48
MSRI	1209	125.9	118.1	228.0	25.5	4.0	201.5	22.0	12.18 (3.49)	6.94	6.10
SEm±	14	0.25	1.4	3.3	0.27	0.05	2.58	0.18	0.07	0.079	0.08
CD (P=0.05)	42	0.74	4.2	9.7	0.78	0.16	7.53	0.54	0.20	0.229	0.23
Genotypes											
'Tapaswini'	946	130.0	107.5	209.7	22.2	3.7	202.6	19.3	11.70 (3.42)	5.85	5.13
'Ajay'	1124	124.3	128.5	205.3	28.7	4.1	191.4	24.7	13.62 (3.69)	6.51	5.60
SEm±	7	0.18	0.9	1.4	0.17	0.03	2.36	0.13	0.05	0.054	0.05
CD (P=0.05)	20	0.50	2.5	4.0	0.48	0.08	6.79	0.37	0.15	0.154	0.14

**Figures in parentheses indicate the square root values and grains/panicle, which might have positive influence on its final grain yield.

Early sowing of plant rice by 20 June had the advantage of recording significantly taller crop of ratoon rice at harvest (62.9cm) and subsequent delay in sowing time of plant rice could produce shorter ratoon crops. Height of ratoons of late sown rice was the shortest (54.2cm). The reason behind such diminishing trend with delay in sowing time of plant rice beyond 20 June could primarily be attributed to reduction in duration of ratoon from cutting to harvesting. Furthermore, decrease in mean atmospheric temperature could have reduced the ratoon height so also the crop duration.

Probably due to less number of tillers/m^2 at harvest of plant rice sown beyond 20 June, the number of panicles/m^2 in its ratoons might have significantly reduced. Other yield attributes like panicle length and weight of ratoon of plant rice sown late were also significantly reduced compared to earlier two dates of sowing. However, spikelet sterility per cent of grains followed the reverse trend. Reduction of growth duration and less nutrient extraction in ratoon crop of 5 and 20 July sown rice could not have effectively and efficiently traslocated assimilates from source to sink and thus would have affected such attributes. This corroborated the findings of Yazdpour *et al*. (2007).

Table 1a. Grain yield (t/ha) of plant rice as affected by dates of sowing and systems of cultivation during rainy season (*kharif*) of 2009 and 2010 (pooled data of 2 years)

Dates of sowing	Systems of cultivation			
	BMP	SRI	MSRI	Mean
20 June	5.26	5.715	6.46	5.81
5 July	4.49	5.613	6.32	5.47
20 July	3.76	5.134	5.54	4.81
Mean	4.50	5.48	6.10	

SEm± for systems of cultivation at same or different dates of sowing	=	0.138
CD (P=0.05) for systems of cultivation at same or different dates of sowing	=	0.403
SEm± for dates of sowing at same or different systems of cultivation	=	0.173
CD (P=0.05) for dates of sowing at same or different systems of cultivation	=	0.525

Table 2. Effect of treatments of plant rice on agronomic traits of its ratoon during 2009–10 and 2010–11 (pooled data of 2 years)

Treatment	At harvest									
	Days to maturity	Crop height (cm)	Panicle Nos./m^2	Panicle Length (cm)	Panicle Weight (g)	Grains/ panicle	1,000 grain weight (g)	Spikelet sterility (%)	Yield (t/ha) Straw	Yield (t/ha) Grain
Dates of sowing										
20 June	58.51	62.94	56.14	16.83	1.36	64.21	20.09	12.11 (3.48)	1.30	0.56
5 July	53.35	57.79	53.71	17.13	1.28	62.58	19.92	13.47 (3.67)	1.21	0.52
20 July	50.02	54.17	48.88	14.99	1.21	60.89	19.31	16.40 (4.05)	1.18	0.50
SEm±	0.10	0.98	0.91	0.30	0.02	0.67	0.12	0.08	0.024	0.006
CD (P=0.05)	0.31	3.20	2.97	0.97	0.08	2.19	0.37	0.26	0.077	0.020
Systems of cultivation										
BMP-ratoon	52.75b	55.79	48.51	15.90	1.19	58.47	19.31	17.56 (4.19)	1.12	0.46
SRI-ratoon	54.77a*	60.51	51.53	16.92	1.37	66.89	20.34	11.36 (3.37)	1.20	0.53
MSRI-ratoon	54.37a	58.61	58.69	16.12	1.29	62.32	19.67	13.25 (3.64)	1.37	0.60
SEm±	0.28	0.79	0.77	0.30	0.03	0.92	0.15	0.09	0.024	0.007
CD (P=0.05)	0.82	2.31	2.26	NS	0.08	2.68	0.44	0.27	0.069	0.021
'Genotypes'										
'Tapaswini'	54.06	52.52	53.50a	15.58	1.21	64.41	17.49	13.18 (3.63)	1.20	0.52
'Ajay'	53.86	64.08	52.32b	17.04	1.36	60.71	22.06	14.75 (3.84)	1.26	0.54
SEm±	0.08	0.59	0.34	0.25	0.02	0.51	0.10	0.06	0.011	0.005
CD (P=0.05)	NS	1.68	0.97	0.70	0.05	1.47	0.27	0.17	0.033	0.015

Figures in parentheses indicate the square root values

Effect of system of cultivation: Grain (0.60 t/ha) and straw yield (1.38 t/ha) of ratoon from MSRI rice were significantly higher than that of ratoon of rice crops from SRI and BMP (Table 2). Ratoon rice yields from BMP were the lowest. Superiority of ratoon rice in MSRI rice could be due to the synergistic effect of all yield attributes. Prolonged growth duration and larger root volume/hill of ratoon of rice in SRI could have effectively and efficiently traslocated assimilates from source to sink and thus would have influenced such attributes as compared to such conditions in ratoon of rice from BMP and MSRI.

Height of ratoon rice crop at harvest in BMP-ratoon was significantly the lowest (55.8 cm) compared to ratoon of rice from SRI and MSRI. The shorter ratoon in BMP-ratoon could be due to its reduced growth duration and also owing to lesser translocation of carbohydrates in individual hills with inferior roots. Taller ratoons in SRI-ratoon and MSRI-ratoon could be due to positive contribution of such characters.

Ratoon from BMP rice matured earlier than that of ratoon from SRI and MSRI, probably because of relatively inferior growth attributes of the ratoon of rice from BMP and thus might have matured earlier.

Effect of genotypes: Ratoon of hybrid 'Ajay' inspite of having fewer grains/panicle and higher per cent of floret sterility could out yield (0.54 t/ha) ratoon of cv. 'Tapaswini' (0.52 t/ha) possibly due to more number of tillers/m^2 and higher test weight. Cumulative effect of taller plants with more number of tillers/m^2 might have reflected in higher straw yield in ratoon of hybrid 'Ajay' (1.26 t/ha). Higher tillering per cent in ratoon of 'Tapaswini' might have increased number of panicles/m^2 compared to 'Ajay'. More number of grains/panicle in ratoon of 'Tapaswini' and higher panicle length and test-weight of grains in ratoon of 'Ajay' might be because of their biological character. Low spikelet sterility per cent (13.2) in ratoon of 'Tapaswini' might have favoured for recording more grains/m^2. Ratoon rice of hybrid 'Ajay' was significantly taller (64.1 cm) than high yielding variety 'Tapaswini' (52.5cm) and number of tillers/m^2 followed the same trend (Table 2). This could be due to inherent capability of genotypes. Larger root volume and higher assimilation of carbohydrates in tillers of 'Ajay' could influence plant height and tillering behavior of its ratoon positively. However, 'Ajay' was little faster in attaining maturity of its ratoon. This might be due to its genetic character.

Correlation studies

In plant rice (table 3), significant positive correlation was observed between plant height and root volume at 100 DAS (r = 0.55). Panicles/m^2 (r = 0.59), length (r = 0.55) and weight (r = 0.64) of panicles and yield of straw (r = 0.75) and grain (r = 0.8) were positively influenced by the root volume of plant rice. Days to physiological maturity had no such alluring statistical effects on such parameters in plant rice. However, the sterility percent in plant rice was significantly but negatively correlated with the root volume (r = -0.54), days to physiological maturity (r=-0.44), grains/ panicle (r=-0.59) and grain yield (r=-0.61).

Days to maturity in ratoon had significant positive influence on its straw (r=0.51) and grain yield (r = 0.55), height (r=0.45), panicles/m^2 and all other panicle characters except sterility where it had significant but negative effect (r=-0.49) (table 4). Ratoon height had significant influence on its panicle weight (r=0.53) and test weight (r =0.71). Moreover, like days required for maturity, ratoon height was also positively and significantly correlated with

Table 3. Correlation coefficients of agronomic traits of plant rice

Treatment	Root volume at 100 DAS	Days to physiological maturity	Plant height	Panicles/m^2	Grains/ panicle	1,000-grain weight	Panicle length	Panicle weight	Spikelet sterility	Straw yield
Days to physiological maturity	0.173									
Plant height	0.545**	-0.128*								
Panicles/m^2	0.593**	0.470**	0.098*							
Grains/panicle	0.355**	0.082	0.146	0.096						
1,000-grain weight	0.525**	-0.194	0.807**	0.081	-0.010					
Panicle length	-0.551**	-0.112	0.742**	0.095	0.056	0.878**				
Panicle weight	0.636**	-0.079	0.580**	0.156**	0.454**	0.648**	0.697**			
Spikelet sterility	-0.544**	-0.441**	-0.194	-0.298*	-0.586**	-0.038	-0.167	-0.446**		
Straw yield	0.752**	0.093	0.451**	0.523**	0.097	0.431**	-0.428**	0.463**	-0.363**	
Grain yield	0.804**	0.110	0.478**	0.510**	0.352*	0.373**	0.409**	0.558**	-0.606**	0.861**

* Means significant at 5% level; ** Means significant at 1% level

Table 4. Correlation coefficients of agronomic traits of ratoon rice

Treatment	Days to maturity	Crop height	Panicles/m²	Grains/panicle	1,000-grain weight	Panicle length	Panicle weight	Spikelet sterility	Straw yield
Crop height	0.453**								
Panicles/m²	0.389**	0.080							
Grains/panicle	0.341*	0.087	0.142						
1,000-grain weight	0.180	0.713**	0.117	0.020					
Panicle length	0.383**	0.314*	0.149	0.212	0.447**				
Panicle weight	0.393**	0.530**	0.296*	0.330*	0.557**	0.410**			
Spikelet sterility	-0.485**	-0.214	-0.172	-0.325*	0.028	-0.205	-0.367**		
Straw yield	0.507**	0.325*	0.339**	0.025	0.227	0.253*	0.238	-0.337*	
Grain yield	0.550**	0.361**	0.356**	0.203	0.223	0.201	0.327*	-0.473**	0.893**

* Means significant at 5% level,** Means significant at 1% level

Table 5. Correlation coefficients of agronomic traits of plant and ratoon rice interaction

Treatment		Plant rice					
		Root volume at 100 DAS	At harvest				
			Days to physiological maturity	Plant height	Panicles/m²	Straw yield	Grain yield
Ratoon rice	Days to maturity	0.553**	0.726**	0.294*	0.500**	0.361**	0.549**
	Crop height	0.606**	0.066	0.794**	0.107	0.459**	0.521**
	Panicles/m²	0.393**	0.192	-0.023	0.498**	0.274**	0.321**
	Straw yield	0.608**	0.126	0.299*	0.543**	0.584**	0.679**
	Grain yield	0.693**	0.131	0.286*	0.502**	0.653**	0.791**

*Means significant at 5% level; **means significant at 1% level

root volume, plant height and yield of straw and grain, except with the days to physiological maturity and panicles/m² in plant rice (table 5). Straw and grain yield of ratoon were significantly and positively correlated with root volume (r = 0.61 and 0.69), plant height (r = 0.3 and 0.29), panicles/ m² (r = 0.54 and 0.5) and yield of straw (r = 0.58 and 0.65) and grain (r = 0.68 and 0.79) in plant rice except days to its physiological maturity.

Based on the study it is concluded that early sowing on 20 June significantly superior over 5 and 20 July sowing with 5.73 and 17.14% reduction in yield. MSRI was superior over SRI and BMP with 11.32 and 35.46% increase in yield. Among the genotypes, Hybrid 'Ajay' was superior to HYV 'Tapaswini' with 9.07 and 11.18% higher grain and straw yield. The performance of ratoons followed the similar trend as in plant rice. Early sown hybrid 'Ajay' in MSRI produced significantly the highest grain yield and 20 July sown 'Tapaswini' in BMP had the lowest in plant rice.

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