Int.J.Curr.Microbiol.App.Sci (2018) 7(2): 2247-2261

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 02 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.702.271

Comparative Economics of Rice-Ratoon-Green gram Production System in East and South East Coastal Plain Zone of Odisha, India

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Keywords

Modifies system of rice intensification, Best management practice, Ratoon, Green gram, Production economics

Article Info

Accepted:
20 January 2018
Available Online:
10 February 2018

A B S T R A C T

Early sowing of rice by 20 June produced significantly the highest grain yield followed by normal (5 July) and late sowings (20 July) and the yield of its stubble crop also followed the similar trend. The combined grain yields of early sown rice-ratoon and the rice equivalent yield (REY) of early sown green gram was significantly higher by 8.64% and 23.74% than normal and late sowings, respectively in rice-ratoon-green gram system. The combined REY in modified system of rice intensification (MSRI)-ratoon-green gram system was 7.33% and 33.22% higher than system of rice intensification (SRI)-ratoon-green gram and best management practice (BMP)-ratoon-green gram system, respectively. The system with hybrid rice Ajay had significantly higher REY than the system with high yielding rice cv. Tapaswini. The system productivity under early sowing of rice and green gram was significantly higher by 8.64% and 23.76% than normal and late sowings of such crops. To get maximum dividend in terms of net return, benefit-cost ratio and system profitability with minimum cost of production, early sowing of hybrid Ajay under MSRI followed by its ratoon and early sown green gram in sequence should be given first priority in east and south east coastal plain zone of Odisha, India having dwindling hybrid rice area.

Introduction

In India, rice occupies about 44.6 million hectares (Mha) with an annual production of about 86 million tonnes (Mt) and it continues to hold the key to sustain food production by contributing to 20-25% of agricultural gross domestic product (GDP) and assures food security for more than half of the total population (Balamurugan and Sudhakar, 2012). 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. Planting young seedlings singly in wider square geometry, use of organics, alternate wetting and drying instead of flooding and mechanical weeding as followed in SRI compared with the continuous flooded traditional farmers' practices 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; Dwibedi *et al.*, 2016a; Dwibedi *et al.*, 2016b), 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 needed careful evaluation. MSRI is the system of growing rice as in SRI with similar nursery, nutrient, water, weed and pest management practices but with the plant geometry and seedling numbers per hill like in BMP. Earlier efforts have been made to assess the profitability of SRI compared to continuous flooded BMP/ farmers' practice in rice crop only. But, the studies on the economics of rice-ratoon-green gram as influenced by time of sowing of rice and green gram and, systems of cultivation and genotypes of rice are still lacking.

The Department of Agriculture in the state of Odisha had promoted SRI in 21,000 ha during 2014-15 (Outcome Budget 2015-16, Agriculture Department, Government of Odisha). In coastal irrigated Odisha, summer crops are sometimes harvested late in May or June, which restricts the farmers for timely preparation of land for *Kharif* rice. Ultimately, the farmers are oriented towards delayed planting in more than 60 per cent of rice area. Moreover, as early period may leave the field in swampy condition which compels the farmers to keep the field fallow for a month or two, planting is also very often delayed keeping in view the suitability of plot for its preparation for the subsequent crop of green gram, However, no such work has yet been undertaken to study the relative performance of delayed planting under SRI and BMP in coastal plains. So also studies on the feasibility of a third crop of ratoon rice by utilizing the gap period between rice and green gram effectively and efficiently was still awaited.

Hence, efforts have been made here to elucidate the production economics of rice-ratoon-green gram cropping system under varying dates of sowing and water saving approaches.

Materials and Methods

Experimental site

The field experiments were conducted from 2009 to 2011 in the village Nimakana of Tirtol block, Jagatsinghpur district in east and south east coastal plain zone of Odisha, India at 25.6 km air distance from the Bay of Bengal at east. The experiment site in particular was located at 86^0 22' E longitude, 20^0 17' N latitude and 14.0 m above the mean sea level. The experimental soil was clay loam in texture, moderately acidic in reaction (pH 5.6 to 5.5), high in soil organic carbon (0.79 to 0.87) and electrical conductivity (0.96 to 0.98 ds m^{-1}) so also the available primary plant nutrients were medium in N, P_2O_5 (Bray, 1945) and K_2O.

Climate and weather parameters

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 (Lenka, 1976). 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 1,333.9 mm and nearly 62% 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 daily mean sunshine hours during the period of investigation was more or less the same with the long term average and ranged from 1.82 to 7.84 hours. The crops enjoyed 5.57, 5.53 and 6.03 hours of average daily bright light during the first, second and third years, respectively. The total annual rainfall received during the period of investigation was within the range of normal (-16.37% to -9.89%) of the long term average (1,333.9 mm). The irrigation water requirements of rice and ratoon as depicted in the Table 1 varied due to difference in the sowing date and systems of cultivation. However, in green gram irrigation water of 1,500 m^3 ha^{-1} was applied during crop growth.

Experimental design and treatments

The treatments consisted of three dates of sowing (D_1, D_2 and D_3), three systems of cultivation (S_1, S_2 and S_3) and two medium duration rice genotypes (G_1 and G_2). Three dates of sowing were D_1-20 June (rice)/ 2 January (green gram), D_2-5 July (rice)/ 17 January (green gram) and D_3- 20 July (rice)/ 1 February (green gram). Three systems of cultivation of rice-ratoon-green gram were BMP-ratoon-green gram (S_1), SRI-ratoon-green gram (S_2) and MSRI-ratoon-green gram (S_3). Two medium duration rice genotypes released from National Rice Research Institute, Cuttack were G_1-high yielding variety (HYV) 'Tapaswini' (IET 12168) and G_2-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 three dates of sowing were assigned to the main plots. The second treatment of three systems of cultivation was allotted to three sub-plots and the two rice genotypes were grown in sub sub-plots. The treatments were allotted at random by the help of two digit random number table (Cochran and Cox, 1977). The subsequent *mung* bean (green gram) crop was grown with HYV Samrat (PDM-139), released in 2001 from the Indian Institute Pulses Research, Kanpur.

Agronomic practices of ratoon rice

Immediate after harvesting of plant rice at 10 cm above ground surface (Oad and Cruz, 2002) so as to facilitate ratooning through retillering process (Mobasser *et al.*, 2009 and Daliri *et al.*, 2009) the nitrogenous fertilizer at the rate of 60 kg ha^{-1} was applied to the sub sub-plots. Subsequently, the field was irrigated for suppressing the fallen seeds from sprouting and acting as weeds. 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 cm above the ground level (Table 2).

Agronomic practices of green gram crop

After harvesting of the ratoon rice crop, the field was ploughed thoroughly and deeply and cross ploughed according to dates of sowing of green gram at 15 days intervals i.e. 2 January, 17 January and 1 February each year. Green gram seeds of cv. Samrat (PDM 139) after seed treatment with Vitavax power at the rate 1.5 g kg^{-1} were sown at 5 cm deep furrows and in paired rows with 15 cm intra paired row spacing and 35 cm inter paired row spacing. The crop was grown with residual soil fertility to study the effect of each treatment combination on the growth and yield attributes of the third crop of green gram after preceding plant and ratoon rice crops. However, the seeds were inoculated with strains of *Rhizobium sps* and P solublising bacteria (PSB) each at the rate of 20 g kg^{-1} of seeds just before sowing. The plots were irrigated with 5 cm depth of water just after sowing for early and uniform germination of the seeds. The weeds thus emerged were effectively managed with pre-emergence application of herbicide like Pendimethalin at the rate of 0.5 kg a.i. ha^{-1}. Subsequently, two irrigations were applied at 20 and 40 DAS for mitigating the water requirement of green gram crop. The plants were thinned in the rows leaving 10 vigorous plants per running meter (m) or 40 plants m^{-2} at about two weeks stage. Earthing up was carried out at 20 DAS and weeds remaining after herbicide application were thus incorporated. The crops were well protected from the attack of insect-pests like white fly by using yellow sticky traps at the rate of 50 traps ha^{-1}. That apart, neem oil at the rate of 5 mL L^{-1} of water was sprayed as prophylactic measures. Harvesting dates ranged from the month of March to April for the crop under different sowing dates of the green gram. The matured pods were plucked manually from the plants in net plot area for recording the economic yield plot-wise. The pods were sun-dried for 3-4 days and threshed manually. The seed and haulm yield were recorded plot-wise after reduction of moisture content to 8%.

Methods of recording observations

Rice equivalent yield (REY)

The yield from different crop components in the rice-ratoon-green gram cropping system was calculated in a single commodity term i.e. rice grain. Yields and prices of all the component crops were considered to determine the equivalency in yield.

Yields and prices of economic part like grains of both plant and ratoon rice and seeds of green gram were taken into consideration for evaluation. The equivalent yield was calculated using the following formula.

$$REY = \frac{Y(g).P(g)}{P(r)}$$

Where,

REY denotes rice equivalent yield
Y(g) = Yield of green gram seeds
P(g) = Price of green gram seeds
P(r) = Price of rice grains

Economics

Independent calculations on the economics of production of different crops in all the three systems were carried out to analyse and interpreted the experimental output with their financial implications.

Cost of cultivation

The cost of cultivation of plant rice, ratoon rice and green gram taking account all the expenditure incurred in purchase of physical inputs like seeds, plant protection chemicals, nutrients, *etc.* and labour charges like bullocks, human and farm machineries, *etc.* were meticulously calculated as per prevailing market price in the locality and noted down for interpretation. The gross and net profit/ return from grains or seeds and straw were calculated as per the minimum support price for sale in the locality.

Benefit-cost ratio (BCR)

BCR was calculated by dividing gross return by the cost of cultivation in economist point of view. Higher or wider the ratio, more benefit or return on investment was reflected thereby.

Cost of production (COP)

The COP of individual crop was calculated by dividing the total cost incurred in cultivation of that crop by the grain yield of respective crop. It is expressed in term of Rs. t^{-1}.

Lower the cost of production of any crop better is its adoptability and *vice versa*.

Crop profitability and system profitability

The crop profitability was calculated by dividing the net return ha^{-1} by number of days (d) the field was occupied with that crop. Similarly, it was calculated by dividing the net return ha^{-1} $year^{-1}$ by 365 days. The crops and systems with higher profitability were economical and advisable. For calculating the profitability the pre-requisites *viz.* crop wise cost of cultivation, sale price of produce, gross return and duration of crop were required.

$$\text{Crop profitability (Rs. } ha^{-1} d^{-1}) = \frac{\text{Net return } ha^{-1}}{\text{No. of days the field was occupied}} \quad (1)$$

$$\text{System profitability (Rs. } ha^{-1} d^{-1}) = \frac{\text{Net return } ha^{-1} \text{ } year^{-1}}{365} \quad (2)$$

Statistical analysis

The entire gamut of data from the observations recorded at progressive stages of crop growth has been processed for statistical analysis to assess the essence of each treatment using F–test as per the procedure suggested by Gomez and Gomez (1984). Least significance difference (LSD) values at P = 0.05 were used to determine the significant differences between treatment means. The interaction effects of different treatment combinations have been elaborated when they are significant.

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 this experiment on SRI take on special significance as the effects of sets of recommended components have been evaluated.

Studies on plant rice crop

Grain yield

Early sowing (20 June) i.e. 15 days ahead of normal sowing was the most promising in recording significantly the highest grain yield of 5.811 t ha^{-1} that provided an additional yield of 0.333 t ha^{-1} (6.08% more) over 5 July sowing (Table 3). Sowing by 5 July had the advantage of producing significantly higher grain yield (5.478 t ha^{-1}) than that of delayed sowing by 15 days causing saving of 0.663 t ha^{-1} i.e. 13.77% yield. Thus there was reduction of grain yield to the tune of 0.0442 t ha^{-1} d^{-1} due to delay in sowing time beyond 5 July. The lowest yield of 4.509 t ha^{-1} was in BMP on the contrary the highest yield of 6.108 t ha^{-1} was in MSRI while SRI produced moderate yield of 5.487 t ha^{-1} i.e. 0.621 t ha^{-1} (10.17%) less than that of MSRI but 0.978 t ha^{-1} (21.69%) more than in BMP. The hybrid rice Ajay produced 0.466 t ha^{-1} (9.07%) significantly higher grains than the high yielding variety Tapaswini.

Economics of production

An in-depth study on the economics of production of plant rice (Table 4) at varying dates of sowing indicated the highest gross return of Rs.86,854 and net return of Rs.41,510 ha^{-1} with BCR of 1.92 and the lowest cost of production of Rs.6,822 t^{-1} of grain under early sowing by 20 June of hybrid rice Ajay in MSRI. The same genotype under same system of cultivation but under normal sowing on 5 July was second in order in recording gross return of Rs.86,335, net return of Rs.40,897 and BCR of 1.90. The variety Tapaswini under early sowing in MSRI was however third in rank to record net return of Rs.37,466 ha^{-1} and BCR of 1.85. The performance of rice variety Tapaswini under late sowing condition in BMP recorded the lowest gross return of Rs.46,423 and net return of only Rs.5,964 with BCR of 1.15 from the highest cost of production of Rs.11,529 t^{-1} of grains. The profitability of plant rice Ajay sown by 5 July under MSRI (Table 4) was of the highest with Rs.334 ha^{-1} d^{-1}. The profitability of the same genotype under same system of cultivation sown early by 20 June ranked second (Rs.316 ha^{-1} d^{-1}) and cv. Tapaswini sown timely under MSRI (Rs.272 ha^{-1} d^{-1}) followed the sequence.

However, the performance of cv. Tapaswini sown late by 20 July under BMP was poorest in the crop profitability (Rs.48 ha^{-1} d^{-1}).

Studies on ratoon rice crop

Grain yield

The ratoon crop of 20 June sown rice produced significantly promising grain yield (0.569 t ha^{-1}) compared to that of the grain yield in ratoon crop of 5 and 20 July sown rice which had grain yield within the limits of critical difference (Table 3). All three systems of cultivation i.e. BMP-ratoon, SRI-ratoon and MSRI-ratoon were significantly different in terms of their ratoon grain yield. The lowest yield of 0.463 t ha^{-1} was recorded in ratoon of BMP, whereas the highest yield of 0.603 t ha^{-1} was obtained in ratoon of MSRI and the moderate ratoon grain yield of 0.533 t ha^{-1} was recorded in SRI-ratoon. Hybrid rice Ajay (0.542 t ha^{-1}) significantly out yielded Tapaswini (0.524 t ha^{-1}) with statistical difference.

Economics of production

The economics of production of ratoon rice (Table 5) of plant rice sown at varying dates resulted in the highest gross return of Rs.8,794 ha^{-1} and net return of Rs.3,980 ha^{-1} with BCR of 1.83 under early sowing of Ajay in MSRI system with the lowest cost of production of Rs.7,453 t^{-1}. Whereas it was interesting to find that ratoon crop of cv. Tapaswini under similar treatment combination was second in order in recording gross return of Rs.8,560. However, the net return (Rs.3,762) and BCR (1.82) were of second order in ratoon crop of plant rice Ajay sown by 5 July under MSRI. The performance of the stubble crop of cv. Tapaswini under late sown condition in the system of BMP-ratoon recorded the lowest gross return of Rs.5,522 and net return of Rs.1,066 with BCR of 1.24. The cost of production was the highest (Rs.11,043 t^{-1}) in this combination.

The data on the profitability of ratoon rice (Table 5) revealed that hybrid rice Ajay sown timely by 5 July under MSRI system was the best with value of Rs.69 ha^{-1} d^{-1} and same genotype under MSRI system sown early by 20 June ranked second (Rs.68 ha^{-1} d^{-1}). This was followed by the ratoon crop of plant rice cv. Tapaswini sown timely under MSRI system (Rs.66 ha^{-1} d^{-1}) with respect to crop profitability. The performance of ratoon crop of plant rice cv. Tapaswini sown late by 20 July under BMP system was the lowest in order with crop profitability of only Rs.22 ha^{-1} d^{-1}.

Studies on green gram crop

Grain yield

Early sowing of green gram by 2 January recorded significantly the highest seed yield of 0.703 t ha^{-1} and this was ensued by seeding by 17 January and 1 February, respectively with significant difference and in descending order (Table 3). Among the three systems of cultivation of rice, SRI-ratoon rice-green gram with significant difference had the advantage of recording the highest seed yield of green gram (0.711 t ha^{-1}).

Table.1 Irrigation water applied to rice-ratoon-green gram system as influenced by different treatments (pooled over 2009-10 and 2010-11)

Treatments	Plant rice (m^3 ha^{-1})	Ratoon (m^3 ha^{-1})	Green gram (m^3 ha^{-1})	System (m^3 ha^{-1})
Dates of sowing				
20 June (Pr) / 2	1501.3c	1955.4a	1500.0	4956.8b*
5 July (Pr) / 17	1808.9b	1699.0c	1500.0	5008.0b
20 July (Pr) /1	2226.2a	1750.9b	1500.0	5477.1a
C.D. (0.05)	173.7	12.6	0	170.3
Systems of cultivation				
BMP-ratoon-green	3207.7a	1753.3	1500.0	6461.0a
SRI-ratoon-green	931.4c	1834.1	1500.0	4265.4c
MSRI-ratoon-green	1397.4b	1818.0	1500.0	4715.4b
C.D. (0.05)	307.1	32.9	0	309.3
Genotypes				
Tapaswini	2023.0	1805.7	1500.0	5328.7a
Ajay	1668.0	1797.9	1500.0	4965.8b
C.D. (0.05)	40.8	9.1	0	42.5

* Means followed by common letters did not differ significantly up to 5% level.

Table.2 Agronomic practices of plant rice

Practices	Best management practice (BMP)	System of Rice Intensification (SRI)	Modified System of Rice Intensification (MSRI)
Seedling age at transplanting	25 days old seedlings from raised dry bed nursery	10 days old seedlings from raised dry bed nursery	10 days old seedlings from raised dry bed nursery
Plant spacing and density	Two seedlings per hill at 25 cm x 12.5 cm spacing quickly after uprooting	One seedling per hill at 25 cm x 25 cm spacing quickly after uprooting	Two seedlings per hill at 25 cm x 12.5 cm spacing quickly after uprooting
Nutrient management	FYM at the rate of 5 t ha^{-1} along with total phosphorous (P) and 1/3rd of the total recommended dose (100:50:50 kg ha^{-1} of $N:P_2O_5:K_2O$) of the nitrogenous (N) and potassic (K) fertilizers were applied before	FYM at the rate of 15 t ha^{-1} along with total P and 1/4th of the total (50:50:50 kg ha^{-1} of $N:P_2O_5:K_2O$) nitrogenous and potassic fertilizers were applied before final puddling. Rest of the N and K fertilizers were applied in three equal splits i.e. 1/4th 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 t extra FYM applied to	

	final puddling. Rest of the N and K fertilizers were applied in two equal halves i.e.1/3rd at maximum tillering i.e. 40 days after sowing (DAS) and 1/3rd at panicle initiation (PI) stage (70 DAS).	the field at the time of final land preparation.	
Weed management	Three hand weedings at 40, 55 and 70 DAS incorporating the weeds *in situ*.	Four weedings at 20, 30, 40 and 50 DAS by cono-weeder in criss-cross manner.	Four weedings at 20, 30, 40 and 50 DAS by conoweeder in east west direction only.
Water management	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.	Water was not allowed to stand in the plots and special care was taken to avoid submergence of 10 days' old seedlings just after planting in the field. The soil was kept moist above the field capacity by irrigating the sub sub-plots as per requirement till PI. 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 to 5 cm and the next morning first weeding was performed by using cono-weeder. Thereafter alternate wetting and drying irrigation method was practiced and subsequent irrigations were applied three 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 cm height up to two weeks before harvest.	
Plant protection	Prophylactic sprays of neem oil at the rate of 5 mL L^{-1} 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^{-1} were released at 15 days intervals i.e. at 40, 55 and 70 DAS for preventing the infestation by stem borers in all three systems of planting. Sex pheromone traps at the rate of 20 traps ha^{-1} 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).		

Table.3 Effect of treatments on grain yield of plant rice, ratoon rice, green gram, rice equivalent yield (REY) green gram and rice-rtoon-green gram sytem and system productivity

Treatments	Grain yield (t ha^{-1})			REY (t ha^{-1})		System productivity (kg ha^{-1}day^{-1})
	Rice		Green gram	Green gram	System	
	Plant	Ratoon				
Dates of sowing						
2 January	5.811a	0.569a	0.703a	2.933a	9.314a	25.52a
17 January	5.478b	0.524b*	0.643b	2.571b	8.573b	23.49b
1 February	4.815c	0.505b	0.552c	2.207c	7.527c	20.62c
C.D. (0.05)	0.267	0.020	0.036	0.228	0.291	0.80
Systems of cultivation						
BMP-ratoon-green gram	4.509c	0.463c	0.516c	2.065b	7.036c	19.28c
SRI-ratoon-green gram	5.487b	0.533b	0.711a	2.844a	8.864b	24.28b
MSRI-ratoon-green gram	6.108a	0.603a	0.670b	2.803a	9.514a	26.07a
C.D. (0.05)	0.232	0.021	0.031	0.257	0.319	0.87
Genotypes						
Tapaswini	5.135b	0.524b	0.641a	2.645	8.304b	22.75b
Ajay	5.601a	0.542a	0.624b	2.496	8.639a	23.67a
C.D. (0.05)	0.141	0.015	0.014	NS	0.230	0.63

* Means followed by common letters did not differ significantly up to 5% level.

Table.4 Effect of treatments on economics of production of plant rice (Pooled over 2009 and 2010)

Treatments	Cost of cultivation (Rs. ha^{-1})	Return from grains (Rs. ha^{-1})	Return from straw (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit : cost (BCR)	Cost of production (Rs. t^{-1})	Crop profitability (Rs. ha^{-1} day^{-1})	Cost of Irrigation (Rs.)
[1]Pr ($D_1S_1G_1$)	40286	61508	2730	64238	23952	1.59	8187	170	1259
Pr ($D_1S_1G_2$)	42967	70029	3456	73486	30518	1.71	7669	227	1212
Pr ($D_1S_2G_1$)	43237	70742	2992	73733	30496	1.71	7640	224	303
Pr ($D_1S_2G_2$)	43786	72121	3247	75368	31581	1.72	7589	244	291
Pr ($D_1S_3G_1$)	44230	78371	3325	81696	37466	1.85	7055	272	499
Pr ($D_1S_3G_2$)	45344	83079	3775	86854	41510	1.92	6822	316	489
Pr ($D_2S_1G_1$)	40324	53454	2563	56017	15693	1.39	9430	117	1359
Pr ($D_2S_1G_2$)	42979	58981	3108	62089	19110	1.44	9109	150	1286
Pr ($D_2S_2G_1$)	43380	66675	2832	69507	26127	1.60	8133	205	507
Pr ($D_2S_2G_2$)	43938	73656	3196	76852	32914	1.75	7457	271	502
Pr ($D_2S_3G_1$)	44339	75413	3690	79103	34763	1.78	7349	269	669
Pr ($D_2S_3G_2$)	45438	82683	3652	86335	40897	1.90	6869	334	644
Pr ($D_3S_1G_1$)	40459	43867	2556	46423	5964	1.15	11529	48	1870
Pr ($D_3S_1G_2$)	43222	50317	2667	52983	9761	1.23	10737	81	1903
Pr ($D_3S_2G_1$)	42857	60875	2687	63562	20704	1.48	8800	173	435
Pr ($D_3S_2G_2$)	43471	67471	2798	70269	26798	1.62	8054	234	423
Pr ($D_3S_3G_1$)	43995	66783	2985	69768	25774	1.59	8235	215	709
Pr ($D_3S_3G_2$)	45132	71788	3412	75199	30067	1.67	7859	261	723

[1]Pr-plant rice

Table.5 Effect of treatments on economics of production of ratoon rice (Pooled over 2009 and 2010)

Treatments	Cost of cultivation (Rs. ha^{-1})	Return from grains (Rs. ha^{-1})	Return from straw (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit : cost (BCR)	Cost of production (Rs. t^{-1})	Crop profitability (Rs. ha^{-1} d^{-1})	Cost of Irrigation (Rs.)
[1]Pr($D_1S_1G_1$)-Rr	4703	6263	635	6898	2196	1.47	9385	37	988
Pr ($D_1S_1G_2$)-Rr	4676	6542	643	7185	2509	1.54	8934	44	961
Pr ($D_1S_2G_1$)-Rr	4768	6949	584	7533	2766	1.58	8576	47	989
Pr ($D_1S_2G_2$)-Rr	4745	7024	629	7653	2907	1.61	8445	50	967
Pr ($D_1S_3G_1$)-Rr	4833	7858	702	8560	3726	1.77	7689	63	991
Pr ($D_1S_3G_2$)-Rr	4814	8073	720	8794	3980	1.83	7453	68	972
Pr ($D_2S_1G_1$)-Rr	4449	5561	527	6088	1640	1.37	10000	31	831
Pr ($D_2S_1G_2$)-Rr	4395	5327	509	5836	1441	1.33	10314	29	778
Pr ($D_2S_2G_1$)-Rr	4579	6475	612	7087	2508	1.55	8840	45	897
Pr ($D_2S_2G_2$)-Rr	4556	6835	601	7435	2879	1.63	8333	53	874
Pr ($D_2S_3G_1$)-Rr	4596	7457	644	8101	3505	1.76	7704	66	851
Pr ($D_2S_3G_2$)-Rr	4614	7640	735	8376	3762	1.82	7548	69	868
Pr ($D_3S_1G_1$)-Rr	4456	5044	477	5522	1066	1.24	11043	22	838
Pr ($D_3S_1G_2$)-Rr	4483	5957	573	6529	2046	1.46	9409	41	865
Pr ($D_3S_2G_1$)-Rr	4550	6319	588	6907	2356	1.52	9001	47	868
Pr ($D_3S_2G_2$)-Rr	4590	6360	586	6946	2356	1.51	9021	46	908
Pr ($D_3S_3G_1$)-Rr	4620	7015	646	7661	3041	1.66	8233	61	874
Pr ($D_3S_3G_2$)-Rr	4645	7161	678	7839	3194	1.69	8108	62	899

[1] Pr-plant rice and Rr-ratoon rice

Table.6 Effect of treatments on economics of production of green gram (Pooled over 2010 and 2011)

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit : cost (BCR)	Cost of production (Rs. t^{-1})[2]	Crop profitability (Rs. ha^{-1} d^{-1})	Cost of Irrigation (Rs.)
[1]Pr($D_1S_1G_1$)-Rr-Gg	14581	28067	13485	1.92	25976	187	750
Pr ($D_1S_1G_2$)-Rr-Gg	14581	28933	14352	1.98	25198	202	750
Pr ($D_1S_2G_1$)-Rr-Gg	15027	40183	25157	2.67	18698	348	750
Pr ($D_1S_2G_2$)-Rr-Gg	15027	38833	23807	2.58	19348	332	750
Pr ($D_1S_3G_1$)-Rr-Gg	14963	37567	22603	2.51	19916	311	750
Pr ($D_1S_3G_2$)-Rr-Gg	14963	37183	22220	2.48	20121	309	750
Pr ($D_2S_1G_1$)-Rr-Gg	14263	26200	11937	1.84	27220	171	750
Pr ($D_2S_1G_2$)-Rr-Gg	14263	24885	10621	1.74	28659	157	750
Pr ($D_2S_2G_1$)-Rr-Gg	14709	38058	23349	2.59	19324	327	750
Pr ($D_2S_2G_2$)-Rr-Gg	14709	36767	22058	2.50	20003	315	750
Pr ($D_2S_3G_1$)-Rr-Gg	14645	33950	19305	2.32	21569	277	750
Pr ($D_2S_3G_2$)-Rr-Gg	14645	32933	18288	2.25	22234	261	750
Pr ($D_3S_1G_1$)-Rr-Gg	14009	25167	11158	1.80	27832	177	750
Pr ($D_3S_1G_2$)-Rr-Gg	14009	21600	7591	1.54	32428	120	750
Pr ($D_3S_2G_1$)-Rr-Gg	14454	28617	14163	1.98	25255	220	750
Pr ($D_3S_2G_2$)-Rr-Gg	14454	30817	16363	2.13	23452	257	750
Pr ($D_3S_3G_1$)-Rr-Gg	14391	30483	16093	2.12	23604	257	750
Pr ($D_3S_3G_2$)-Rr-Gg	14391	28850	14459	2.00	24940	226	750

[1] Pr-plant rice, Rr-ratoon rice and Gr-green gram

[2] Cost of production was estimated by taking REY of rice-ratoon-green gram system

Table.7 Effect of treatments on economics of production of plant rice (Pr)-ratoon rice (Rr)-green gram (Gg) system gram (pooled over 2009-10 and 2010-11)

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross profit (Rs. ha^{-1})	Net Profit (Rs. ha^{-1})	Benefit : cost (BCR)	Cost of production	System profitability	Cost of Irrigation
[1]Pr($D_1S_1G_1$)-Rr-Gg	59570	99203	39633	1.67	7770	109	2997
Pr ($D_1S_1G_2$)-Rr-Gg	62224	109604	47380	1.76	7372	130	2923
Pr ($D_1S_2G_1$)-Rr-Gg	63032	121449	58417	1.93	6684	160	2042
Pr ($D_1S_2G_2$)-Rr-Gg	63558	121854	58296	1.92	6734	160	2008
Pr ($D_1S_3G_1$)-Rr-Gg	64026	127823	63797	2.00	6016	175	2240
Pr ($D_1S_3G_2$)-Rr-Gg	65121	132831	67710	2.04	6343	186	2211
Pr ($D_2S_1G_1$)-Rr-Gg	59036	88305	29269	1.50	8660	80	2940
Pr ($D_2S_1G_2$)-Rr-Gg	61637	92810	31173	1.51	8638	85	2814
Pr($D_2S_2G_1$)-Rr-Gg	62668	114652	51984	1.83	7044	142	2154
Pr ($D_2S_2G_2$)-Rr-Gg	63203	121054	57851	1.92	6738	158	2126
Pr ($D_2S_3G_1$)-Rr-Gg	63580	121154	57574	1.91	6803	158	2270
Pr ($D_2S_3G_2$)-Rr-Gg	64697	127644	62947	1.97	6561	172	2262
Pr ($D_3S_1G_1$)-Rr-Gg	58924	77112	18188	1.31	9943	50	3458
Pr ($D_3S_1G_2$)-Rr-Gg	61714	81112	19398	1.31	9906	53	3518
Pr ($D_3S_2G_1$)-Rr-Gg	61861	99086	37225	1.60	8071	102	2053
Pr ($D_3S_2G_2$)-Rr-Gg	62515	108032	45517	1.73	7467	125	2081
Pr ($D_3S_3G_1$)-Rr-Gg	63006	107912	44906	1.71	7552	123	2333
Pr ($D_3S_3G_2$)-Rr-Gg	64168	111888	47720	1.74	7441	131	2372

[1] Pr-plant rice, Rr-ratoon rice and Gr-green gram
[2] Cost of production was estimated by taking REY of rice-ratoon-green gram system

The effect of MSRI-ratoon rice-green gram on yield of green gram was moderate while BMP-ratoon rice-green gram significantly the lowest in green gram seed production. Both the genotypes of rice had significant effect on the seed yield of succeeding green gram crop. The yield of green gram grown in rice-ratoon sequence with Tapaswini out yielded Ajay with significant difference.

Rice Equivalent Yield (REY)

The seed yields of green gram were expressed as equivalent yields of rice grain yield (Table 3). The REY of green gram under early sowing by 2 January was significantly superior over the REY of 17 January and 1 February sown crops. REY of green gram grown after SRI-ratoon rice (2.844 t ha^{-1}) was statistically at par with MSRI-ratoon (2.803 t ha^{-1}) but both were significantly higher than in green gram in BMP-ratoon (2.065 t ha^{-1}) sequence. However, the REYs of green gram after rice-ratoon with both genotypes were statistically at par with each other.

Economics of production

The economics of production of green gram (Table 6) at varying dates of sowing resulted in the highest gross return of Rs.40,183 ha^{-1} and net return of Rs.25,157 ha^{-1} with BCR of 2.67 in the field where early sowing of cv. Tapaswini by 20 June in SRI was carried out. The gross return (Rs.38,833 ha^{-1}) and net return (Rs.23,807 ha^{-1}) of green gram crop under same condition but with change in genotype of the preceding rice by hybrid Ajay was second in order. However, the cost of production (Rs.19,916) was of higher degree in such a combination. The economics of production of green gram after cultivation of cv. Tapaswini under SRI-ratoon with timely sowing however was third in rank to record gross return of Rs.38,058 ha^{-1} and net return of Rs.23,349 ha^{-1} but the BCR of 2.59 was of second order. The performance of green gram sown after Ajay cultivated under late sown condition in BMP-ratoon recorded the lowest gross return of Rs. 21,600 ha^{-1} and net return of Rs.7,591 ha^{-1} with BCR of 1.54. However, the cost of production was the highest (Rs.32,428 t^{-1}) in this combination.

The scrutiny of data on the profitability of green gram (Table 6) revealed that the green gram grown after ratoon crop of plant rice cv. Tapaswini sown early by 20 June under SRI recorded the highest crop profitability with Rs.348 ha^{-1} d^{-1}. The profitability of the green gram after rice-ratoon with Ajay sown early under SRI was of second order (Rs.332 ha^{-1} d^{-1}) followed by the profitability of green gram grown after rice-ratoon with variety Tapaswini sown timely under SRI (Rs.327 ha^{-1} d^{-1}). The performance of green gram after rice-ratoon of hybrid Ajay sown late by 20 July under BMP was the lowest in crop profitability of Rs.120 ha^{-1} d^{-1}.

Studies on rice-ratoon-green gram system

Rice Equivalent Yield (REY)

The REY from different crop components in the rice-ratoon-green gram system was calculated in a single commodity term i.e. rice grains (Table 3). Sowing of rice by 20 June followed by its ratooning and subsequently green gram sown by 2 January had significantly the highest REY of 9.314 t ha^{-1} followed by 5 July (8.573 t ha^{-1}) and 20 July sowings (7.527 t ha^{-1}) with statistical differences. The REY of MSRI-ratoon-green gram had top ranking (9.514 t ha^{-1}) followed by SRI-ratoon-green gram (8.864 t ha^{-1}) with statistical difference from BMP-ratoon-green gram (7.036 t ha^{-1}). The hybrid rice Ajay-ratoon-green gram had significantly higher REY (8.639 t ha^{-1}) than with rice genotype Tapaswini-ratoon-green gram (8.304 t ha^{-1}).

The system productivity (SP) calculated by dividing the REY of plant rice-ratoon-green gram by 365 clearly revealed that under early sown condition it was significantly superior (25.52 kg ha^{-1} d^{-1}) over both timely (23.49 kg ha^{-1} d^{-1}) and late (20.62 kg ha^{-1} d^{-1}) sown conditions with significant difference between them. The SP of MSRI-ratoon-green gram was significantly superior (26.07 kg ha^{-1} d^{-1}) over both SRI-ratoon-green gram (24.28 kg ha^{-1} d^{-1}) and BMP-ratoon-green gram (19.28 kg ha^{-1} d^{-1}) with statistical difference between them. The SP of rice-ratoon-green gram with hybrid rice Ajay (23.67 kg ha^{-1} d^{-1}) was significantly superior over the system with rice cv. Tapaswini (22.75 kg ha^{-1} d^{-1}).

Economics of production

The economics of production of rice-ratoon-green gram system (Table 7) at early sowing of Ajay in MSRI-ratoon-green gram resulted in the highest gross return of Rs.1,32,831 and net return of Rs.67,710 ha^{-1} with BCR of 2.04 from the second lowest cost of production of Rs.6,343 t^{-1} of paddy grains (REY) whereas cv. Tapaswini under same condition was of second order resulting in Rs.1,27,832 of gross profitability and cost of production of Rs.6,016 t^{-1} was the lowest (Table 5). However, it was interesting to note that the Ajay under MSRI-ratoon-green gram in normal sowing recorded gross return (Rs.1,27,644), net return (Rs.62,947) and BCR (1.97) of third order. In contrast, delayed sown condition of cv. Tapaswini in

BMP-ratoon-green green recorded the lowest gross return of Rs.77,112, net return of Rs.18,188 and BCR of 1.31 but the highest cost of production of Rs. 9,943 t^{-1} in term of paddy grains due to substantial reduction in yield of rice and ratoon crop.

The system profitability of plant rice-ratoon-green gram as measured by summing up the net profits from plant rice, ratoon and green gram and divided by 365 days indicated that the highest profit (Rs.186 ha^{-1} d^{-1}) was accrued from sowing of hybrid Ajay early by 20 June and green gram by 2 January under MSRI-ratoon-green gram system. Under similar treatment combinations the plant rice variety Tapaswini ranked second in this regard (Rs.175 ha^{-1} d^{-1}). The hybrid rice Ajay under MSRI followed by its ratoon and succeeding green gram crop when sown in time recorded system profitability of third order (Rs.172 ha^{-1} d^{-1}). However, the profitability was the least (Rs.50 ha^{-1} d^{-1}) in the rice-ratoon-green gram system with cv. Tapaswini under BMP sown late by 20 July and green gram by 1 February.

Under the dwindling acreage of hybrid rice in Odisha early sowing of hybrid Ajay by 20 June under MSRI followed by ratoon and early sowing (2 January) of green gram in sequence should be given first priority so as to get maximum dividend in terms of net return, BCR and system profitability with minimum cost of production. The next best system giving all such benefits should be by taking HYV Tapaswini instead of hybrid Ajay under similar treatment combinations. However, preference for HYV Tapaswini under BMP sown late by 20 July and green gram by 1 February should be the least in rice-ratoon-green gram system in coastal plains of Odisha. These could be the recommendations to the farming communities of coastal Odisha as the better option for rice based cropping.

Acknowledgements

The technical and informative support of Visva Bharati, Santiniketan, West Bengal; National Rice Research Institute, Cuttack; Krishi Vigyan Kendra, Jagatsinghpur and College of Agriculture, Chiplima for conducting such Doctoral research of the first author are highly acknowledged.

References

Agriculture Department, Government of Odisha. Outcome Budget 2015-16, Pp.77.

Balamurugan, R. and Sudhakar, P. 2012. Influence of planting methods and different vermicompostis on yield and nitrogen use efficiency in rice. *Iternational Journal of Current Agricultural Sciences*, 2(6).

Bray, R. H., and Kurtz, L. T. 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Science*, 59: 39-45.

Chapagain, T., Riseman, A. and Yamaji, E. 2011. Achieving more with less water: Alternate wet and dry irrigation (AWDI) as an alternative to the conventional water management practices in rice farming. *Journal of Agricultural Science*, 3(3): 3-13.

Choudhury, B. U., Singh, A. K., Bouma, B. A. M. and Prasad, J. 2007. System of Rice Intensification and irrigated transplanted rice: Effect on crop water productivity. *Journal of the Indian Society of Soil Science*, 55(4): 464-470.

Cochran, G. and Cox, G. M. 1977. *Experimental designs*, P. S. Jaysingh, *New York Asia publishing House*, Ed; 218-219.

Daliri, M. S., Eftekhari, A., Mobasser, H. R., Ztari, D. B. and Porkalhor, H. 2009. Effect of cutting time and cutting height on yield and yield components of ratoon rice. (Tarom Langrodi Variety). *Asian Journal of Plant Sciences*, 8(1): 89-91.

Dass, A. and Chandra, S. 2012. Effect of different components of SRI on yield, quality, nutrient accumulation and economics of rice (*Oryza sativa*) in *tarai* belt of northern India. *Indian Journal of Agronomy*, 57(3): 250-254.

Dwibedi, S. K., De, G. C. and Dhua, S. R. 2016a. Energetics of rice-ratoon-green gram production system in coastal Odisha. *International Journal of Agriculture Sciences*, 8(9):1096-1099.

Dwibedi, S. K., De, G. C. and Dhua, S. R. 2016b. Influence of sowing time and system of cultivation of kharif (wet season) rice (Oryza sativa L.) genotypes on nutrient and water use efficiency in eastern coastal alluvial soil of India. *International Journal of Agriculture Sciences*, 8(51):2335-2340.

Gomez, K. A. and Gomez, A. A. 1984. *Statistical procedures for agricultural research. Second edition. Wiley India*, pp. 200-206.

Krupnik, T. J., Shennan, C. and Rodenburg, J. 2012. Yield, water productivity and nutrient balance under the system of rice intensification and recommended management practices in the Sahet. *Field Crop Research*, 130: 155-197.

Kumar, D. D. and Singh, A. P. 2013. Effect of integrated weed management on weed flora distribution, weed dynamics and performance of rice (*Oryza sativa* L.) under system of rice intensification (SRI) in Chhattisgarh. *Journal of Progressive Agriculture*, 4(1): 96-101.

Lenka, D. 1976. Classification of rainfall zones and drought prone areas, (*In*) water management of crops in Orissa. Directorate of Agriculture, Government of Orissa, pp. 4-5.

Mobasser Hamid Reza; Siavoshi Morteza; Taari Davood Barari; Eftekhari Ali and Pourkalhor Hamid 2009. Determination of rice ratooning characteristics and yield as influenced by different agronomic practices. *Indian Journal of Crop Science*, 4(1 & 2).

Oad, F. C. and Cruz, Pompe Sta. 2002. Rice varietal screening for ratoonability. *Journal of Applied Sciences*, 2(1).

Sato, S. and Uphoff, N. 2007. A review of on-farm evaluations of system of rice intensification methods in Eastern Indonesia. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources*, 2(54): 1-12.

Shekhar, J., Mankotia, B. S. and Dev, S. P. 2009. Productivity and economics of rice *(Oryza sativa)* in system of rice intensification in North-Western Himalayas. *Indian Journal of Agronomy*, 54(4): 423-427.

Stoop, W. A., Adam, A., Kassam, A. 2009. Comparing rice production systems: a Challenge for agronomic research and for the dissemination of knowledge intensive farming practices. *Agricultural Water Management*, 96: 1491-1501.

How to cite this article:

Sanat Kumar Dwibedi, Gopal Chandra De, Sudhi Ranjan Dhua, Biswa Ranjan Pattanaik, Bijaya Kumar Sethy and Sasmita Priyadarshini. 2018. Comparative Economics of Rice-Ratoon-Green gram Production System in East and South East Coastal Plain Zone of Odisha, India. *Int.J.Curr.Microbiol.App.Sci.* 7(02): 2247-2261.
doi: https://doi.org/10.20546/ijcmas.2018.702.271