Research Paper

ADVANCE RESEARCH JOURNAL OF
CROP IMPROVEMENT
Volume 5 | Issue 2 | Dec., 2014 | 63-68
e ISSN-2231-640X

DOI :
10.15740/HAS/ARJCI/5.2/63-68
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Effect of fertility levels, genotypes and planting pattern on yield and economics of rice under SRI during dry season in coastal Odisha

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ABSTRACT : A field experiment was conducted during the *Rabi* seasons of 2012-2013 and 2013-2014 at the Agronomy Main Research Station of Orissa University of Agriculture and Technology, Bhubaneswar in Split Plot Design with three replications. Combinations of three fertility levels and two genotypes were taken in main plots and four different methods of planting were allotted to subplots. The fertility level with 3 splits of N @ 50 per cent at planting + 25 per cent top dressing at 30 DAS+25 per cent top dressing at 60 DAS (F_2) recorded the significantly highest grain yield in the first year while F_3 (organics) recorded highest grain yield in the second year. The HI for both the years were almost same (0.44). The hybrid 'Arise gold' produced significantly higher grain yield (6.82 t ha^{-1} in the first year and 6.39 t ha^{-1} in the second year) as compared to that of conventional variety Lalat (5.51 t ha^{-1} in the first year and 4.91 t ha^{-1} in the second year). The treatment of S_2 *i.e.* 25 cm square planting with two spaced (5cm) seedlings $hill^{-1}$ recorded significantly highest grain yield which was at par with the treatment S_4-30 cm with three seedlings $hill^{-1}$ in a traingular method. With respect to economics F_2, the variety Arise gold and S_2 recorded the highest gross return, net return and B : C ratio.

Key **W**ords : SRI, Fertility levels, Organic, Genotypes, Planting pattern

How to cite this paper : Ray, Plabita and Barik, T. (2014). Effect of fertility levels, genotypes and planting pattern on yield and economics of rice under SRI during dry season in coastal Odisha. *Adv. Res. J. Crop Improv.*, **5** (2) : 63-68.

Paper **H**istory : **Received :** 20.08.2014; **Revised :** 01.10.2014; **Accepted :** 15.10.2014

Rice is an important staple food providing 66-70 per cent body calorie of millions of consumers. Barah and Pandey (2005) have very eloquently upheld the need to heighten awareness of the role of rice in alleviating poverty and malnutrition. To assure food security in the rice consuming countries of the world, rice production should be increased by 50 per cent by 2025 (Bouman *et al.,* 2007). This additional rice will have to be produced on less land with less usage of water, labour and chemicals (Zheng *et al.*, 2004). System of rice intensification is considered the methodology to increase the productivity of rice by changing the management of plants, soil, water and nutrients (Satyanarayana *et al.,* 2007). Stoop and Kassam (2005) says that SRI helps resource-poor farmers to attain higher yields despite having infertile soil, no mineral fertilizer input, reduced irrigation and fewer seeds. China, India and Indonesia are the three largest rice producing countries, where the results of SRI have been validated (Uphoff *et al.,* 2008).

The use of right dose, source and time of application of fertilizers helps to exploit the yielding ability of rice under SRI. Maintenance of right number of plant population with proper culivars are the other dimensions of SRI which needs testing under local conditions. With these ideas in view the present experiment with different fertility levels, genotypes and crop geometry was taken up.

RESEARCH PROCEDURE

A field experiment was carried out in the *Rabi* seasons of

2012-2013 and 2013-2014 at the Agronomic Main Research Station, Orissa University of Agriculture and Technology, Bhubaneswar located at a latitude and a longitude of $20^0$15' N and $85^0$52'E, respectively, with an altitude of 25.9m above the mean sea level. The station comes under the East and South Eastern Coastal Plain Agro-climatic Zone of Odisha. The texture of the soil was sandy loam with a pH of 5.90, EC 0.010 dSm^{-1}, 0.55 per cent of organic carbon, 178.25 kg ha^{-1} of available nitrogen, 49.32 kg ha^{-1} of available phosphorous and 330.40 kg ha^{-1} of potash. The experiment was conducted in Split Plot Design with three replications with the following treatments. For the main plot the combinations of fertility levels of F_1, F_2 and F_3 (100-50-50 N-P_2O_5-K_2O kg ha^{-1}-N splitted as 50% at planting + 50% top dressing at 30 DAS; 100-50-50 N-P_2O_5-K_2O kg ha^{-1} -N splitted as 50% at planting + 25% top dressing at 30 DAS+25% top dressing at 60 DAS and Organic-FYM 20 t ha^{-1} and vermicompost 2 t ha^{-1}) with variety of V_1 (Hybrid -OFD 6444 gold or 'Arise gold') and V_2 (Lalat) were taken. As far as the subplot goes, four spacing of S_1, S_2, S_3 and S_4 (25 cm with one seedling $hill^{-1}$; 25 cm with two seedlings with a gap of 5cm between 2 seedlings $hill^{-1}$; 30 cm with two seedlings with a gap of 5cm between 2 seedlings $hill^{-1}$ and 30 cm with three seedlings with a gap of 5cm between 2 seedlings in a triangular method $hill^{-1}$) were taken. Sprouted seeds were sown in wet nursery beds with the practices recommended for SRI nursery. Fourteen day old seedlings were transplanted on the main field. Crop was weeded twice *i.e.* at 30 and 60 days after transplanting with cono weeder in a crisscross manner. Experimental plots were kept at saturation up to panicle initiation stage by suitably maintaining the water level in the side channels of each bed. Thereafter, a thin film of water was allowed over the beds till 10 days before the harvest of the crop.

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under the following heads :

Table 1 : Grain yield (t ha^{-1}), straw yield (t ha^{-1}) and HI for the year 2012-2013 and 2013-2014

Treatments	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		HI	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Fertility level						
F_1	5.40	4.41	8.06	7.13	0.39	0.37
F_2	6.60	6.25	8.87	8.19	0.44	0.43
F_3	6.50	6.30	8.27	8.01	0.44	0.44
S.E. ±	0.24	0.06	0.15	0.20	0.01	0.01
C.D. (P=0.05)	0.75	0.18	0.47	0.64	0.04	0.02
Variety						
V_1	6.82	6.39	8.62	8.39	0.44	0.43
V_2	5.51	4.91	8.18	7.17	0.40	0.40
S.E. ±	0.19	0.05	0.12	0.16	0.01	0.01
C.D. (P=0.05)	0.61	0.15	0.38	0.52	0.03	0.02
Spacing						
S_1	4.64	4.43	7.82	6.81	0.37	0.39
S_2	7.12	6.51	8.42	7.67	0.45	0.45
S_3	5.95	5.36	8.77	8.60	0.40	0.38
S_4	6.96	6.32	8.59	8.02	0.45	0.43
S.E. ±	0.18	0.15	0.12	0.22	0.01	0.01
C.D. (P=0.05)	0.53	0.42	0.36	0.62	0.03	0.03
S.E.± S at same value of F	0.31	0.25	0.21	0.37	0.01	0.01
C.D. (P=0.05) S at same value of F	0.92	0.73	0.62	1.07	0.05	0.05
S.E. ± S at same value of V	0.26	0.20	0.17	0.30	0.01	0.01
C.D. (P=0.05) S at same value of V	0.75	0.60	0.50	0.88	0.04	0.04
S.E. ± S at same value of FV	0.45	0.36	0.30	0.52	0.02	0.02
C.D. (P=0.05) S at same value of FV	1.30	1.03	0.87	1.52	0.07	0.07
S.E. ± F at same or diff S	0.36	0.22	0.23	0.38	0.01	0.01
C.D. (P=0.05) F at same or diff S	1.09	0.66	0.71	1.12	0.06	0.05
S.E. ± V at same or diff S	0.29	0.18	0.19	0.31	0.01	0.01
C.D. (P=0.05) V at same or diff S	0.89	0.54	0.58	0.92	0.05	0.04
S.E. ± F*V at same or different S	0.51	0.32	0.33	0.54	0.02	0.02
C.D. (P=0.05) F*V at same or different S	1.54	0.93	1.00	1.59	0.08	0.07

Grain yield, Straw yield and HI :

The grain yield, straw yield and HI over both the years given in Table 1 revealed that the treatment of F_2 reported the highest grain and straw yield in the first year (Sikdar and Gupta, 1979; Chanrashekarppa, 1985) whereas in the second year F_3 recorded highest grain yield which may be attributed to cumulative application of organics in later (Rajput and Warsi, 1991; Mondal *et al.,* 1994). It was seen that both F_2 and F_3 recorded the same HI for both the years. These findings are in line of Kumar (2006). The hybrid rice Arise gold (V_1) was found to be significantly higher (23.77% in first year and 30.14% in the second year) in grain yield as compared to that of V_2 for both the years. Hybrid rice giving higher yield over conventional rice has been reported by Awal *et al.* (2010).As far as the spacing goes, the treatment S_2 recorded the highest grain yield (Uphoff, 2001) which was at par with the treatment of S_4. The above two planting geometry had higher plant population (100 and 106.25 %, respectively) and yield attributing characters over S_1 planting geometry which may be the reason for their grain yield to remain statistically at par. Simillar trend was noticed for the dimension of HI. However, the treatment of S_3 recorded significantly highest straw yield (8.77 t ha $^{-1}$ in the first year and 8.60 t ha $^{-1}$ in the second year).

Yield attributing characters :

The yield attributing characters like effective tillers meter square^{-1}, panicles hill^{-1}, grains panicle^{-1}, grains hill^{-1}, grain weight square metre^{-1}, length of panicle, sterility percentage,

Table 2 : Grain weight square meter^{-1} (g), grain weight hill^{-1} (g), effective tillers square meter^{-1} and panicles hill^{-1}for the year 2012-2013 and 2013-2014

Treatments	Grain weight square meter^{-1} (g)		Grain weight hill^{-1} (g)		Effective tillers square meter^{-1}		Panicles hill^{-1}	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Fertility level								
F_1	700.56	520.42	53.64	51.31	256.21	218.43	16.03	13.53
F_2	1142.84	993.70	79.32	72.93	368.42	349.56	20.78	19.07
F_3	848.23	672.95	64.91	63.75	322.34	304.82	18.64	17.84
S.E. ±	15.17	25.32	1.78	2.42	6.28	12.33	0.72	0.93
C.D. (P=0.05)	47.79	79.76	5.63	7.64	19.79	38.87	2.26	2.93
Variety								
V_1	1069.34	860.49	74.14	70.64	367.39	325.07	20.80	19.23
V_2	725.09	597.56	57.77	54.68	264.54	256.81	16.16	14.40
S.E. ±	12.39	20.67	1.45	1.98	5.12	10.07	0.59	0.75
C.D. (P=0.05)	39.02	65.13	4.59	6.24	16.16	31.74	1.84	2.39
Spacing								
S_1	715.13	538.57	73.09	70.32	257.28	225.35	20.65	18.20
S_2	1092.16	927.87	85.84	81.36	368.52	354.96	23.71	21.25
S_3	836.18	656.92	47.08	45.35	296.33	266.62	13.52	12.63
S_4	945.37	792.73	57.82	53.62	341.75	316.82	16.04	15.17
S.E. ±	25.79	31.80	1.90	2.40	6.90	12.44	0.77	0.79
C.D. (P=0.05)	73.95	91.20	5.45	6.88	19.79	35.68	2.20	2.27
S.E. ± S at same value of F	44.66	55.08	3.29	4.15	11.95	21.55	1.32	1.37
CD (P=0.05) S at same value of F	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± S at same value of V	36.47	44.97	2.68	3.39	9.76	17.59	1.08	1.12
C.D. (P=0.05) S at same value of V	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± S at same value of FV	63.16	77.89	4.65	5.87	16.90	30.48	1.87	1.94
C.D. (P=0.05) S at same value of FV	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± F at same or diff S	41.55	54.00	3.36	4.34	12.11	22.37	1.35	1.51
C.D. (P=0.05) F at same or diff S	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± V at same or diff S	33.92	44.09	2.74	3.54	9.88	18.26	1.10	1.23
C.D. (P=0.05) V at same or diff S	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± F*V at same or different S	58.76	76.37	4.76	6.14	17.12	31.64	1.91	2.13
C.D. (P=0.05) F*V at same or different S	NS	NS	NS	NS	NS	NS	NS	NS

NS=Non–significant

grain weight hill^{-1} and 1000-grain weight are given in Table 2 and 3. As far as yield contributing characters go the treatment of F_2 (Table 2) recorded the highest grain weight square meter $^{-1}$ (1142.84g in the first year and 993.70g in the second year), grain weight hill^{-1} (79.32g in the first year and 72.93g in the second year), effective tillers meter square^{-1} (368.42 in the first year and 349.56 in the second year), and panicles hill^{-1} (20.78 in the first year and 19.07 in the second year). The same F_2 (Table 3) recorded the highest grains panicle^{-1} (156.97 in the first year and 145.04 in the second year), grains hill^{-1} (2676 in the first year and 2456 in the second year), length of panicle (31.22 cm in the first year and 28.23 cm in the second year), and 1000-grain weight (30.30 g in the first year and 27.47 g in the second year) followed by rest of treatments of fertility level. Similarly the hybrid V_1 recorded the highest of the above mentioned yield contributing characters. The treatment of S_2 recorded the highest grain weight square meter^{-1}, grain weight hill^{-1}, effective tillers square meter^{-1}, panicles hill^{-1}, grains panicle^{-1}, grains hill^{-1}, length of panicle, and 1000-grain weight (Avasthe *et al.*, 2011) among the spacing dimension of the experiment, followed by S_4. The highest sterility percentage (Table 3) was recorded with the treatment of F_1. Among the varieties V_2 recorded higher sterility percentage (22.65% in the first year and 20.44% in the second year) than the hybrid. As far as the spacing goes, the treatment of S_1 recorded the highest sterility percentage followed by S_3.

Economics :

Both the treatments F_1 and F_2 (Table 4) recorded the same cost of cultivation but the treatment of F_3 was found to have

Table 3 : Grains panicle^{-1}, length of panicle (cm) , sterility (%)and1000-grain weight (g) for the year 2012-2013 and 2013-2014

Treatments	Grains panicle^{-1}		Length of panicle (cm)		Sterility (%)		1000-grain weight (g)	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Fertility level								
F_1	118.51	107.20	28.67	23.76	22.80	22.00	24.08	20.54
F_2	156.97	145.04	31.22	28.23	19.47	16.62	30.30	27.47
F_3	137.10	125.76	26.68	22.07	20.11	17.76	27.54	23.61
S.E. ±	3.49	4.83	0.78	1.03	0.56	0.64	0.63	0.95
C.D. (P=0.05)	11.02	15.22	2.47	3.26	1.79	2.02	1.99	2.99
Variety								
V_1	147.09	133.99	31.07	27.29	18.93	17.14	29.54	25.77
V_2	127.96	118.01	26.64	22.08	22.65	20.44	25.08	22.02
S.E. ±	2.85	3.94	0.64	0.84	0.46	0.52	0.51	0.77
C.D. (P=0.05)	9.00	12.43	2.02	2.66	1.46	1.65	1.62	2.44
Spacing								
S_1	120.70	110.99	25.15	20.63	23.47	22.11	26.34	21.77
S_2	153.16	142.92	33.30	29.98	19.74	17.65	28.13	24.86
S_3	128.35	116.36	26.77	21.53	21.79	19.93	27.45	23.97
S_4	147.89	133.73	30.19	26.61	18.16	15.49	27.31	24.99
S.E. ±	3.94	3.85	0.89	1.08	0.46	0.72	0.52	0.89
C.D. (P=0.05)	11.32	11.05	2.57	3.11	1.33	2.06	NS	NS
S.E. ± S at same value of F	155.32	6.68	1.55	1.87	0.81	1.25	0.90	1.55
C.D. (P=0.05)S at same value of F	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± S at same value of V	126.81	5.45	1.27	1.53	0.66	1.02	0.74	1.27
C.D. (P=0.05) S at same value of V	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± S at same value of FV	219.65	9.44	2.20	2.66	1.14	1.77	1.28	2.20
C.D. (P=0.05) S at same value of FV	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± F at same or diff S	160.40	7.54	1.56	1.93	0.90	1.26	1.01	1.65
C.D. (P=0.05) F at same or diff S	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± V at same or diff S	130.96	6.15	1.27	1.58	0.73	1.03	0.82	1.34
C.D. (P=0.05) V at same or diff S	NS	NS	NS	NS	NS	NS	NS	NS
S.E. ± F*V at same or different S	226.84	10.66	2.21	2.73	1.27	1.78	1.42	2.33
C.D. (P=0.05) F*V at same or different S	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non–significant

Table 4 : Economics for the year 2012-2013 and 2013-2014

Treatments	Cost of cultivation (Rs. ha^{-1})		Gross return (Rs. ha^{-1})		Net return (Rs. ha^{-1})		B-C ratio	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Fertility level								
F_1	30095	30745	77214	64916	47119	34171	1.52	1.08
F_2	30095	30745	93133	90065	63038	59320	2.09	1.91
F_3	56286	62936	91732	90549	35445	27613	0.62	0.43
Variety								
V_1	39991	42641	96081	92150	56090	49509	1.57	1.39
V_2	37660	40310	78638	71537	40978	31227	1.26	0.89
Spacing								
S_1	37895	40545	66864	64832	28968	24286	0.88	0.76
S_2	39308	41958	99811	92914	60503	50956	1.71	1.42
S_3	38460	41110	84855	78763	46395	37652	1.34	1.09
S_4	39638	42288	97909	90866	58270	48577	1.72	1.30

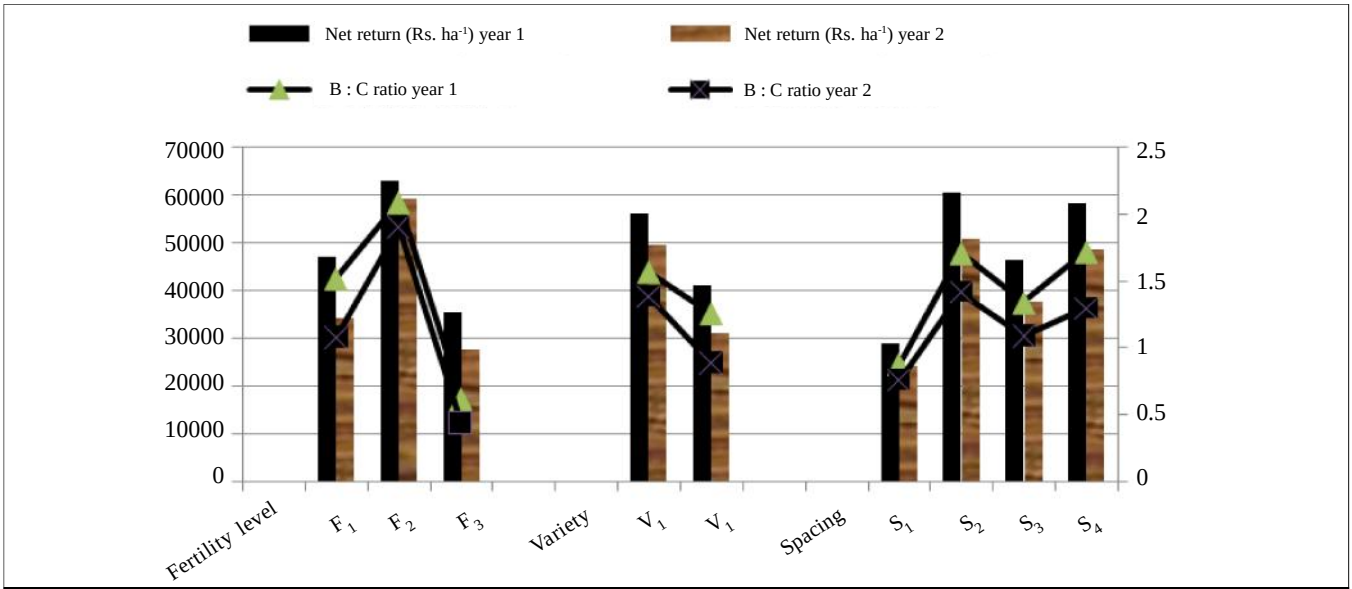

Fig. 1 : Interaction of FxVxS for the consecutive two years

exceptionally high cost of cultivation (Rs. 56286 in the first year and Rs. 62936 in the second year) due to higher quantity and cost of organic fertilizers. However, in both the years the treatment of F_2 recorded highest gross return (Rs. 93133 in the first year and Rs. 90065 in the second year), net return (Rs. 63038 in the first year and Rs. 59320 in the second year) and B:C ratio (2.09 in the first year and 1.91 in the second year). Being a hybrid V_1 recorded higher cost of cultivation, gross return, net return and B-C ratio which was significantly higher than V_2 which is same as the findings of Visalaxmi *et al.*(2014). Among the different spacing the treatment of S_4 recorded the highest cost of cultivation (Rs. 39638 in the first year and Rs. 40545 in the second year) and S_2 recorded the highest gross return (Rs. 99811 in the first year and Rs. 92914 in the second year), net return (Rs. 60503 in the first year and Rs. 50956 in the second year) and B:C ratio (1.71 in the first year and 1.42 in the second year followed by S_4.This is in line with the findings of Singh *et al.* (2012).

Interaction :

In the first year F×V×S interaction revealed that F_1 with V_1 under S_2 (9.47 t ha^{-1}) recorded highest grain yield which was at par with F_3 under V_1 and S_2 (9.03 t ha^{-1}). The lowest yield was recorded by F_1 under V_2 and S_3. The F×V shows that F_3 under V_1 (7.19 t ha^{-1}) recorded the highest yield where as F_1 under V_2 (3.91 t ha^{-1}) recorded the lowest yield. In the F×S interaction F_1 under S_1 recorded the lowest yield whereas F_2 under S_4 recorded the highest yield which was at par with F_2 under S_2. In the S×V interaction S_2 under V_1 (8.18 t ha^{-1}) recorded the highest yield

and S_1 under V_2 (4.27 t ha^{-1}) recorded the lowest yield. The second year, the F×V×S interaction shows that F_1 with V_1 under S_2 (8.38 t ha^{-1}) recorded highest yield which was at par with F_3 under V_1 and S_2 (7.38 t ha^{-1}). The lowest yield was recorded by F_1 under V_2 and S_4. The F×V interaction shows F_3 under V_1 (7.13 t ha^{-1}) recorded the highest yield whereas F_1 under V_2 (3.17 t ha^{-1}) recorded the lowest yield same as the first year. In the F×S interaction F_1 under S_1 (5.74 t ha^{-1}) recorded the lowest yield whereas F_2 under S_4 (7.54 t ha^{-1}) recorded the highest yield which was at par with F_2 under S_2 (6.87 t ha^{-1}). In the S×V interaction table S_2 under V_1 recorded the highest yield and S_1 under V_2 recorded the lowest yield.

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