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Effect of planting geometry and timing and source of nitrogen application on growth attributing characters and yield of rice (*Oryza sativa* L.) under system of rice intensification (SRI)

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ABSTRACT : An experiment was conducted at Agronomy Research Station, Orissa University of Agriculture and Technology, Bhubaneswar during *Kharif* season of 2012 to study the effect of different fertility levels, planting patterns per hill and their interaction on productivity of rice variety 'Lalat' under SRI. Four fertility levels and different planting patterns affected the growth characters as well as yield significantly. F_2 {FYM @ 15 t ha^{-1} + vermicompost 2 t ha^{-1} + neem-cake 250 kg ha^{-1}} gave highest leaf m^{-2}, LAI, dry matter accumulation and CGR with highest yield (8.76 t ha^{-1}). It was found that twice or thrice splitting of N was at par (7.62 and 7.57 t ha^{-1}). Three plants per hill with wider spacing of 30×30 cm gave the highest yield among all planting patterns. Planting more than one plant per hill had not contributed much to growth attributing characters but had given increased yield due to higher plant population per m^{-2} in comparison to one plant per hill. Fertility level (F_4) with half of RDF of nitrogen, recorded the lowest yield (5.87 t ha^{-1}). Among the sub-plots the lowest yield was recorded in P_3 *i.e.*, one seedling per hill at 30×30 cm spacing (6.75 t ha^{-1}).

KEY WORDS : Planting geometry, Growth, Yield, SRI

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Rice (*Oryza sativa*), is a semi-aquatic annual grass plant and is the most important cereal and crop of Indian sub continent. As its population rises, so does the demand for rice. Rice being the staple food for 65 per cent of Indian population, it occupies about 24 per cent of gross cropped area of our country and contributes to 40 per cent of total food grains production as well as 45 per cent of total cereal production in particular. Yet, productivity of the crop is leveling out. In a state like Odisha, where agriculture is taken as foremost profession, rice is the major crop grown on about 70 per cent and 50 per cent of the gross cropped area during *Kharif* (rainy) and *Rabi* (winter), respectively. But still there is a long way to go.

The SRI is a combination of set of practices and methodology for increasing the productivity of irrigated rice by changing the management of plants, soil, water and nutrients resulting in both healthy soil and plants, supported by greater root growth and the soil microbial abundance and diversity.

SRI may be considered as the low external input sustainable agriculture (LEISA) technology (Moser and Barret, 2003). Exhaustive cropping systems involving rice are known to hasten the pace of soil deterioration because of excessive mining of inherent soil fertility. So in SRI some changes have been made regarding to nutrient supplying sources, spacing (in both plant to plant as well as in row to row) and number of seedlings per hill to be planted. In these fields various researches have been conducted and are also going on also at present to improve SRI methodology.

In this field experiment some changes in application of recommended dose of fertilizers with organics like FYM, vermicompost and neem-cake and adjustment of the timing of application with spacing of 25 cm × 25 cm and 30 cm × 30 cm and transplanting of one, two and three seedlings, in different patterns, per hill have been tested on the productivity of *Kharif* rice under system of rice intensification.

RESEARCH PROCEDURE

Field study was conducted in *Kharif* season of the year 2012 at Agronomy Research Station, Orissa University of Agriculture and Technology, Bhubaneswar. The latitude and the longitude of the research station are $21^0 15'$ N and $85^0 52'$E, respectively, with an altitude of 25.9 m above the mean sea level. The soil of the experimental field texturally was sandy loam with chemical properties like pH 5.38, EC 0.051 dS m^{-1} at 25^oC, organic carbon 0.36 per cent, available N 176.25 kg ha^{-1}, available P 48.85 kg ha^{-1} and available K 330.40 kg ha^{-1}. The experiment consisted of 24 treatments in a split-plot design with three replications. The experiment was laid out on 'Lalat' variety of rice with 4 fertility levels in main plots and 6 planting patterns in subplots. The fertility levels were F_1 {FYM @ 5 t ha^{-1} + P_2O_5 : K_2O @ 30:30 kg ha^{-1} basal + N 60 kg ha^{-1} in 3 splits (½ th basal + ½ 21 DAT + ½ th PI)}; F_2 {FYM @ 15 t ha^{-1} + vermicompost 2 t ha^{-1} + neem cake 250 kg ha^{-1}}; F_3 {FYM @ 5 t ha^{-1} + P_2O_5 : K_2O @ 30:30 kg ha^{-1} basal + N 60 kg ha^{-1} in 2 splits (½ basal+ ½ 21 DAT)} and F_4 {FYM @ 5 t ha^{-1} + N : P_2O_5 : K_2O @ 30:30:30 kg ha^{-1} basal} and planting patterns were P_1 {(25×25cm) spacing with 1 seedling $hill^{-1}$}; P_2 {(25×25cm) spacing with 2 seedlings $hill^{-1}$ at a linear distance of 5 cm from plant to plant in the same hill}; P_3 {(30×30cm) spacing with 1 seedling $hill^{-1}$}; P_4 {(30×30cm) spacing with 2 seedlings $hill^{-1}$ at a linear distance of 5 cm from plant to plant in the same hill}; P_5 {(30×30cm) spacing with 3 seedlings $hill^{-1}$ in a triangular method with 5 cm distance from plant to plant in the same hill} and P_6 {Random planting of 1 seedling $hill^{-1}$}. Incorporation of *Dhaincha* (*Sesbania aculeata*) was common for all fertility levels. The yield attributing characters like number of panicle m^{-2}, length of panicle, weight of panicle, number of grains per panicle and 1000-grain weight were studied at harvest of the rice crop. The mean data of these characters were collected replication wise and analyzed statistically.

RESEARCH ANALYSIS AND REASONING

Normally, growth refers to the permanent and irreversible increase in size and form. It is well known that growth of a plant in a community differs in many ways than the individually grown plant as the performance of a community depends upon mutual interference in resources.

Plant height :

Among the different growth parameters plant height in all the treatments increased significantly. In case of mainplots, it was found that plant height was significantly highest (123.12 cm) with the basal application of P_2O_5, K_2O and N was applied in 3 splits (¼ th basal+ ½ 21 DAT+ ¼ th PI) at different growth stages in F_1 (Table 1). It was followed by organic treatment (120.04 cm), where FYM, vermicompost and neem-cake was used and no chemical fertilizers were applied. This suggests that nitrogen was instrumental in controlling the height of plants. This finding is in accordance with Saravanakumar *et al.* (2008). In F_4 where RDF of P_2O_5 and K_2O was applied as basal and half of RDF of N was applied in 2 splits (½ + ½) as basal and at 21 DAT, plant height was minimum 111.92 cm. This indicates that there was the need of nitrogen at different stages of growth.

According to the data observed from subplots, P_2 (25×25cm spacing with 2 seedlings $hill^{-1}$ at a linear distance of 5 cm from plant to plant in the hill) recorded significantly highest plant height of 125.45 cm and lowest height recorded was 111.56 cm from P_6 (Farmers' practice, random planting with 1 seedling $hill^{-1}$). This suggests that the random plating of seedlings without any specific spacing hampered in getting more height. It was assumed that wider spacing led to more root growth which penetrated deep into the soil to exploit more nutrients and water which helped in achieving increased height. Haque (2002) found the highest plant height from wider spacing.

Number of tillers :

The number of panicles per unit area depends largely on the number of tillers. It was observed in the experiment that tillering continued till 45 DAT and then it decreased upto harvest. The decline in tiller number would have occurred due to mortality of the late formed tillers.

Among main plots, highest number of tillers recorded was 287.32 in F_3, where half doses of N was applied as basal and rest half was top-dressed at 21 DAT. The availability of higher quantity of nitrogen at the early tillering stage was probably responsible for producing more number of effective tillers.

Out of the 6 subplots, P_2 with 25x25cm spacing with 2 seedlings hill^{-1} at a linear distance of 5 cm from plant to plant in the hill (292.5 tillers m^{-2}) might have facilitated better utilization of resources by the plants resulting in production of more number of tillers (Gani *et al*., 2002; Veeraputhiran *et al.*, 2010 and Kumar *et al.*, 2011). The minimum numbers of tillers were formed in P_6 (214.86 tiller m^{-2}), the farmers' practice, with 1 seedling hill^{-1} planted randomly, indicating that irregular planting method might have hampered root growth, well penetration of sunlight into the canopy might have increased interplant competition to some extent in comparison to other treatments.

Number of leaves :

The number of leaves per square meter was highest (6491.30 m^{-2}) at 45 DAT commensurate with the number of tillers. Then the number gradually reduced and became minimum at harvest (1796 m^{-2}). It was found that among the mainplots number of leaves m^{-2} was significantly highest (515.45) in F_2 (FYM+ vermicompost + neem-cake). This would have resulted because of slow release of nitrogen from FYM and availability of plant-growth regulators and mineral nutrients into more plant-available forms due to the application of vermicompost. Similar observation was also found by Canellas *et al.* (2002); Meena *et al.* (2010) and Arun Kumar *et al.* (2011).

According to the result obtained from subplots, farmer's practice with random planting of one seedling hill^{-1} *i.e.*, P_6 had 529.08 leaves m^{-2} which was the highest.

Table 1 : Growth attributing characters and yield of rice variety Lalat during *Kharif* 2012

Treatments	Plant height (cm)	Number of tillers	Number of leaves	Leaf are index (LAI)	Dry matter accumulation (g)	Crop growth rate (CGR) g day^{-1} m^{-2})	Relative growth rate (RGR) g g^{-1} day^{-1})	Net assimilation rate (NAR) g g^{-1} day^{-1})	Grain yield (t ha^{-1})
	At harvest					90-harvest			At harvest
F_1	123.12	219.50	461.91	3.15	1291.49	6.09	0.0021	0.0045	7.57
F_2	120.04	240.32	515.45	3.45	1521.66	6.83	0.0020	0.0046	8.76
F_3	118.41	287.32	439.46	3.11	1678.33	7.50	0.0020	0.0057	7.62
F_4	111.92	210.06	379.28	3.04	1269.32	5.27	0.0019	0.0047	5.87
S.E. ±	2.12	4.28	13.57	0.028	22.26	0.71	0.0031	0.0006	0.36
C.D. (P=0.05)	7.32	14.79	46.97	0.096	77.02	2.46	0.0106	0.0022	1.26
P_1	122.46	201.21	407.87	2.86	1439.08	6.49	0.0020	0.0058	7.58
P_2	125.45	292.57	505.33	3.12	1535.77	7.77	0.0023	0.0051	7.62
P_3	115.48	228.21	372.13	2.62	1268.75	6.29	0.0022	0.0053	6.75
P_4	121.64	235.28	430.56	3.10	1250.87	4.27	0.0015	0.0033	7.33
P_5	115.64	210.73	449.19	3.19	1796.34	8.34	0.0021	0.0062	8.55
P_6	111.56	214.86	529.08	2.22	1350.11	5.34	0.0018	0.0041	6.97
S.E. ±	0.93	3.74	11.69	0.023	10.21	0.66	0.0038	0.0006	0.23
C.D. (P=0.05)	2.64	10.68	33.41	0.065	29.18	1.87	0.0108	0.0017	0.67
F within PP S.E. ±	0.6999	2.2143	6.9419	0.0138	7.5156	0.3860	0.0021	0.0003	0.553
F within PP C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
PP within F S.E. ±	0.5369	2.1592	6.7492	0.0132	5.8947	0.3811	0.0007	0.0011	0.46
PP within F C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS=Non-significant

In other plots because of more rapid senescence and death of leaves there was lower number of leaves. This shows that leaf number m^{-2} was significantly influenced by the spacing as well as number of plants per hill.

LAI (Leaf area index) :

The higher productivity of a crop depends on the persistence of high LAI over a greater part of its vegetative phase. The rate of crop photosynthesis depends on the LAI. After germination LAI increases and reaches the peak levels and then declines due to increased senescence (Katiya, 1980). The leaf area index was highest in F_2 mainplot (FYM+ vermicompost + neem-cake) and lowest in F_4 (half of RDF OF N+ P_2O_5, K_2O all as basal). Split application of N produced the better LAI.

According to the result obtained from subplots, P_5 (30×30 cm spacing with 3 seedlings $hill^{-1}$ in a triangular method with 5 cm distance from plant to plant in the hill) has given highest LAI *i.e.,* 3.19. Three seedlings per hill with 30 × 30 cm spacing gave more LAI above 2 plants per hill with 25 × 25 cm spacing. This shows that more number of plants per hill might had positive effect on increased value of LAI because of increase in leaf area per hill as well as per m^{-2}. Obtained data also revealed that wider spacing had significantly higher LAI. This was also reported by Shrirame *et al*. (2000). Lowest LAI obtained from P_6 (2.22) with 30×30cm spacing with 1 seedling $hill^{-1}$.

Dry matter accumulation :

Rate of crop dry matter accumulation is the product of total incident solar radiation, the absorption of incident solar radiation by the crop canopy, and the efficiency of conversion of absorbed solar radiation into plant dry matter.

Results on dry matter production indicated that it increased as the crop growth advanced. F_3 {N (½ basal + ½ 21 DAT) + full dose of P_2O_5 and K_2O as basal} produced 1678.33 g/m^2 which was highest and F_4 (half of RDF OF N, P_2O_5, K_2O all as basal) produced 1269.32 g/m^2 which was lowest among the mainplots. This clearly indicates that N has a direct relation with dry matter accumulation. Nitrogen imparts vigorous vegetative growth resulting in high dry matter. Significant increase in total dry matter production with successive increase in levels of nitrogen was also reported by Devasenamma *et al*. (1999).

Shrirame *et al*. (2000) reported that the number of functional leaves, leaf area and total number of tillers $hill^{-1}$ were higher at wider spacing which increased the photosynthetic rate leading to higher dry matter accumulation. P_5 (1796.34 g/m^2) was the significantly higher performer among subplots, this might be due to more (three) number of plants per hill with wider spacing of 30×30 cm due to obvious reasons of better land area and availability of nutrients, water and energy and heavier root system. As suggested by Krishna *et al*. (2008) P_5 might have resulted in the development of efficient photosynthetic structure which enabled the plants to intercept higher quantity of radiant energy resulting in higher dry matter production. At the time of harvest P_6 was the lowest performer with 1350.11 g (24.84% lower than P_5) with the reason of random planting without any specific plant spacing. P_3 and P_4 were at par at harvest.

Crop growth rate :

CGR measures the efficiency of production of a total field of plants over a given soil area. There was progressive decrease in CGR (g $day^{-1}m^{-2}$) from 15 DAT till maturity. It was highest in F_3 (7.50 g $day^{-1}m^{-2}$), where ½ N, full P_2O_5 and K_2O were given as basal and rest ½ N was topdressed at 21 DAT. There was no effect on CGR by the different fertility levels and their application in splits or as basal.

P_5 with 30×30cm spacing and 3 seedlings $hill^{-1}$ in a triangular method with 5 cm distance from plant to plant in the hill recorded highest value of 8.34 g $day^{-1}m^{-2}$. On the basis of this result we can say that more the number of plants per hill more will be the CGR value. More number of tiller m^{-2} in this plot perhaps also helped in increasing CGR value (Dewangan *et al.*, 2013).

Relative growth rate :

It is measured as the mass increase per aboveground biomass per day. The relative growth rate declined gradually from 15 DAT to the harvest stage. Among mainplots a significant variation was not found among the values during any of the growth stages which indicated that there was no significant effect of different fertility level on RGR of the crop. From 30-45 DAT to 90 DAT to harvest F_1 with full P_2O_5, K_2O + N in splits of ¼ th basal+ ½ 21 DAT+ ¼ th PI, recorded the highest values (0.013, 0.008, 0.006, 0.004 and 0.002 g g^{-1} day^{-1}). The minimum was in F_4 (0.0019 g g^{-1} day^{-1}), where full dose of P_2O_5, K_2O and half dose of N were applied as basal.

Among subplots there was no significant variation due to the effect of planting pattern. P_2 with 30×30cm spacing with 3 seedlings hill^{-1} in a triangular method with 5 cm distance from plant to plant in the hill, recorded highest value among all subplots (0.0023 g g^{-1} day^{-1}) and lowest was 0.0015 g g^{-1} day^{-1} of P_4 {(30×30cm) spacing with 2 seedlings hill^{-1} at a linear distance of 5 cm from plant to plant in the same hill}.

Net assimilation rate :

NAR measures the accumulation of plant dry weight per unit leaf area per unit time. The increase in LAI, and, consequently, the increase in rate of dry matter accumulation, is proportional to rate of dry matter accumulation per unit leaf area (NAR). An increase in leaf area leads to an increase in rate of dry matter accumulation (because light interception is directly related to leaf area) and an increase in dry matter accumulation leads to an increase in leaf area (because proportion of dry matter allocated to leaves remain fairly constant).

Net assimilation rate was markedly influenced at all stages of growth by the treatments imposed. All four mainplots were at par. P_5 with 30×30cm spacing and 3 seedlings hill^{-1} in a triangular method at 5 cm distance from plant to plant in the hill, recorded highest (0.0062) and P_4 with 30×30cm spacing and 2 seedlings hill^{-1} at a linear distance of 5 cm from plant to plant in the hill, (0.0033) recorded lowest NAR values. Thakur and Patel (1998) stated that NAR is one of the factors responsible for higher paddy yield (Ray and Barik, 2014).

Grain yield :

Among the fertility levels significantly highest yield obtained was 8.76 t ha^{-1} in plot treated with FYM+ vermicompost + neem-cake. The lowest value was recorded in FYM @ 5 t ha^{-1} + N : P_2O_5 : K_2O @ 30:30:30 kg ha^{-1} basal that was 5.87. Increasing nitrogen efficiency through the use of optimum nitrogen fertilizer level is very important factor to obtain high yield of rice. In organic mainplot sufficient amount of FYM had already been applied and there was constant release of nitrogen due to favourable soil conditions maintained due to SRI type of management which led to production of highest grain yield.

Among different planting patterns 8.55 t ha^{-1} was the significantly higher grain yield obtained from plot with 30×30cm spacing with 3 seedlings hill^{-1}, this shows that grain yield responded more to spacing and more number of plants per hill. Lowest grain yield was recorded (6.75 t ha^{-1}) treatment plot with 30×30cm spacing with 1 seedling hill^{-1}. Instead of producing higher number of effective tillers this subplot produced lowest yield because of low 1000-grain weight and lower dry matter accumulation.

Conclusion :

From the above experiment it is concluded that under system of rice intensification method of cultivation, fertilizer and nutrient management with organic manures only gave significantly highest yield. Splitting of nitrogen either in two or three splits was found equally beneficial. Triangular method of planting with 30×30 cm spacing gave the significantly highest yield over one and two seedlings.

Literature Cited

Arun Kumar, J.S., Dawson, Joy, Kumar, Akhilesh and Haricharan Reddy, K. (2011). Effect of rice (*Oryza sativa* L.) to integrated nutrient management on yield attributes, yield and microbial population under system of rice intensification. *Adv. Res. J. Crop Improv.,* **2** (1) : 108-111.

Canellas, L.P., Olivares, F.L., Okorokova-Facanha, A.L. and Facanha, A.R. (2002). Humic acids isolated from earthworm compost enhance root elongation, lateral root emergence, and plasma membrane Ht + ATPase activity in maize roots. *Plant Physiol.,* **130** (4) : 1951-1957.

Devasenamma, V., Reddy, M.R. and Rajan, M.S.S. (1999). Effect of varying levels of nitrogen on growth and nitrogen uptake of rice hybrids. *Andhra Agril. J.,* **46**(1&2): 124-125.

Dewangan, Devendra Kumar, Singh, Anu Shri, Sahu, Eshu and Toppo, A.R. (2013). Effect of integrated weed management on weed flora distribution, weed dynamics and performance of rice (O*ryza sativa* L.) under system of rice intensification (SRI) in Chhattisgarh. *Adv. Res. J. Crop Improv.,* **4** (1) : 79-84.

Gani, A., Rahman, A., Dahono Rustam and Hengsdijk, H. (2002). Water management experiments in Indonesia. Paper presented in International Symposium on Water Wise Rice Production, IARI, New Delhi, November, 2-3. pp. 29-37.

Haque, D.E. (2002). Effect of Madagascar technique of younger seedling and wider spacing on growth and yield of boro rice. M.S. Thesis, Department of Agronomy, BAU, Mymensingh. pp. 50-80.

Katiya, R.P. (1980). Development changes in LAI and growth parameters in chickpea. *Indian J. Agril. Sci.,* **50** : 684-691.

Krishna, A., Biradarpatil, N.K. and Channappagoudar, B.B. (2008). Influence of system of rice intensification (SRI) cultivation on seed yield and quality. *Karnataka J. Agril. Sci.,* **21**(3) : 369-372.

Kumar, J.S. Arun, Dawson, Joy, Kumar, Akhilesh and Reddy, K. Haricharan (2011). Effect of rice (*Oryza sativa* L.) to integrated nutrient management on growth attributes, dry matter production and nutrient status under system of rice intensification. *Internat. J. Forestry & Crop Improv.*, **2** (2) : 190-193.

Meena, Mamta, Patel, M.V. and Mevada, K.D. (2010). Integrated nutrient management in the system of rice intensification techniques (SRI) for *Kharif* rice (*Oryza sativa* L.) under middle Gujarat conditions. *Adv. Res. J. Crop Improv.,* **1** (2) : 194-197.

Moser, C.M. and Barrett, C.B. (2003). The disappointing adoption dynamics of a yield increasing, low external input technology: the case of SRI in Madagascar. In: *Agricultural systems*, Oxford, U. K. pp. 1085- 1100.

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.

Saravanakumar, S., Panneerselvam, S. and Bhaskaran, A. (2008). Nitrogen management for rice under SRI technique in alkali soil. 3rd National Symposium on SRI held at Tamil Nadu Agricultural University, India from December 1-3, 2008. pp. 117-118.

Shrirame, M.D., Rajgire, H.J. and Rajgire, A.H. (2000). Effect of spacing and seedling number per hill on growth attributes and yield of rice hybrids under lowland condition. *J. Soils & Crops,* **10** (1) : 109-113.

Thakur, D.S. and Patel, S.R. (1998). Growth and sink potential of rice as influenced by the split application of potassium with FYM in inceptisols of eastern central India. *J. Potassium Res.,* **14**(1-4) : 73-77.

Veeraputhiran, R., Balasubramanian, R., Pandian, B.J., Kalidasan, G., Chelladurai, M. and Ganesaraja, V. (2010). Productivity, water use efficiency and economics of system of rice intensification in farmers field of Southern Tamil Nadu. *Internat. J. Forestry & Crop Improv.,* **1** (2) : 139-142.