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Effect of Varieties, Depth and Methods of Planting on Growth, Yield Attributes, Yield and Economics of Rice

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A B S T R A C T

The field experiment was carried out using split plot design with four replications during *kharif* 2009 and 2010 to investigate the effect of varieties, depth and planting methods on growth attributes, yield and economics of rice. The experiment consisted three level of varieties (V_1- Sugandha-3, V_2- JRH-5, V_3- Pro-Agro-6444), two levels of depth (D_1- 2.5, D_2- 5.0 cm) in main plot and two level of planting methods (M_1-SRI, M_2-DSSS) arranged in sub-plot. Among the different tested varieties, V_3- Pro-Agro 6444 produced significantly length of panicle, healthy grain panicle^{-1} (146.89 and 147.15), 1000- grain weight (29.25 and 29.59) and production efficiency (51.67 and 53.27) produced highest grain yield (72.86 and 75.11 qha^{-1}) than other varieties, respectively during both the years. Significantly higher value of length of panicle, healthy grain panicle^{-1}, 1000- grain weight, production efficiency and grain yield were recorded under transplanting at D_1- 2.5 cm than D_2- 5.0 cm. Further, SRI system (M_1) was find higher yield attributing characters and finally produced maximum grain yield. Based on the result variety V_1 at shallow depth of 2.5 cm under SRI system was produced highest grain yield and economically the highest B: C ration were in V_3(2.17), D_1(1.80) and M_1(1.76) by gaining highest net return during both years.

Introduction

Rice (*Oryza sativa* L.) is an important staple food crop of India, contributing 45% to the total food grain production. Hence, it is extensively grown in Eastern, Northern and Southern states of the country. In India rice is grown under diverse agro-ecological condition such as irrigated (19.6 million hectares), rainfed upland (7.1 million hectares), lowland (16.0 million hectares) and deep water (1.5 million hectares) (Moorthy and Mishra, 2004). It is widely grown in south eastern part of the country covering an area of 56.08 million hectares with an annual production of 92.6 million tonnes. India rank first in respect of area 44.50 million ha second in production 102.75 million tonne, only after China, but the productivity of rice is very low only 2.20 tonne ha^{-1} (Anonymous, 2012), which is quite low as compared to other rice growing countries like Japan (6.8 t/ha), Korea (6.1 t ha^{-1}), china (5.9 t ha^{-1}) and Indonesia (4.3t ha^{-1}). Madhya Pradesh covers 1.76 million hectares with an annual production of 1.87 million tonnes and contributes 3.26 per cent of national hectare age with an average productivity of 2.06t ha^{-1}. Among the different agronomic practices, planting management, depth of planting and planting methods play a vital role in achieving higher yield levels of hybrid and inbred rice. It is because the proper distributions of crop plant per unit area and efficient utilization of available resources as well as environment. In M.P. mostly rice is grown under direct seeding either dry broadcast after receiving first flush of shower or wet seeding of sprouted seeds in the puddle soil, which severely suffers from weeds resulting in very low yields. However, direct seeding of rice have several advantages i.e. saves labour, faster and easier planting, timely sowing, less drudgery, early crop maturity by 7 – 10 days, less water requirement, high tolerance to water deficit often high yield, low production cost and more profit, better soil physical condition for succeeding crops and less methane emission (Balasubramanian and Hill, 2002). Further looking on the intensification in limited field, the system of rice intensification (SRI) has been highly emphasized to maximize the production of rice.

Careful transplanting of young seedlings at a wider spacing under SRI cultivation, ensures more root growth. Through appropriate water management strategies under SRI the field is kept moist and not flooded. Working of rotary weeder churns the soil and provides greater aeration which helps in buildup of enormous microbial growth, thereby enhancement of nutrient supply to root which ultimately result in healthy plant growth and higher yields at lower costs. System of Rice Intensification (SRI) is a alternative practice to solve the water crisis and as a methodology for increasing the productivity of irrigated rice by changing the management of plant, soil, water and nutrients (Natarajan *et al.,* 2008). While, hybrid rice over inbred cultivation produce about 14 – 28% higher grain yield and distinct in growth and development phases particularly during the early growth stages, owing to their hybrid vigour, (Siddiq, 1993), extensive root system, greater sink size and great carbohydrate translocation from vegetative part to spikelets (Song *et al.*, 1990). Keeping these in view, the present research was under taken to varieties, depth and methods of planting on growth, yield attributes, yield and economics of rice.

Materials and Methods

The field experiment was conducted in SPD design during *kharif* 2009 and 2010 at *Krishi* Nagar Farm, Adhartal, Department of Agronomy, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh. The experiment consisted of three levels of variety (V_1: Sugandha-3, V_2: JRH-5, V_3: Pro-Agro 6444), two levels of depth (D_1: 2.5 cm, D_2: 5.0 cm) and two level of planting method (M_1: SRI, M_2: DSSS).

The soil of experimental field was sandy clay loam in texture, medium in organic carbon (0.68%), low in available nitrogen (256 kg ha^{-1}) and phosphorus (7.99 kg ha^{-1}), but high in potassium (295 kg ha^{-1}). The soil was nearly neutral in pH (7.5) and concentration of soluble salts (0.32 ds m^{-2}) had below harmful limit. In respect of biological properties, it was normal in total bacterial count (30.56 x 10^5 cfu g^{-1} soil) by Thronton's, (1930) and total fungi (20.50 x 10^3 cfu gm^{-1} soil) and total actinomycetes (65.90 x 10^3 cfu gm^{-1} soil) by adopting techniques of Rao (1988).

In preparation of experimental treatment, three separate nursery beds each of 5.0 m x 1.5 m dimension were prepared. The nursery beds were raised at height of 20 cm by spreading the loose soils on surface of bed, which were collected from the both sides of nursery beds in length direction. Uniformly spread of 25 kg FYM bed^{-1} on the surface of nursery beds and then, it's well mixed in soil.

Healthy seeds of varieties Sugandha-3, JRH-5 and Pro-Agro 6444 were treated with thirum @ 3 g kg^{-1} of seeds before sowing in nursery beds on June 29 and July 12 during 2009 and 2010, respectively sown in rows 10 cm apart by covered with mixture of dried FYM and soil to obtain desirable age of seedling for transplanting as per treatment. A basal dose of well decomposed FYM (10 t ha^{-1}) was applied before transplanting/sowing and full dose of 50kg P_2O_5 ha^{-1} and 30kg K_2O ha^{-1} was applied through single super phosphate and muriate of potash respectively at the time of puddling. As regards the nitrogen (70 kg ha^{-1}) 20% N was applied after 7 DAT/DAS, 50% N at 20-25 DAT/DAS and the remaining 30% N at 50-55 DAT/DAS to all the plots in both the years.

For planting in the method of DSSS, the healthy selected seeds of three varieties viz; 'Sugandha-3', 'JRH-5' and 'Pro-Agro 6444' soaked for 24 hours in normal water and drain the water and incubate the seed in a gunny bag for about 4-6 hours of facilitate just sprouting and easy handling. After this, water drained the sprouted seeds of three varieties were treated carefully with thirum @3g kg^{-1} seed before sowing @ two seeds $hill^{-1}$ and transplanting of 12 days old seedling @ one seedling $hill^{-1}$ in SRI method, were direct seeded/ transplanted by manually at planting geometry of 20 cm x 20 cm at depths of 2.5 and 5.0 cm in puddle field as per treatments during both year of experimentation.

Data on dry matter were recorded on 5 random places in each plot and plant biomass taken from these places to ensure the increase in biomass production overtime. Leaf area index (LAI) was recorded by using the Laser Area Metre crop growth rate (CGR) and relative growth rate (RGR) was calculated as per suggested by Watson (1952). Net assimilation rate (NAR) was also calculated as per Nichiporovich (1967). The economic parameters (gross returns, net returns and benefit: cost ratio) were worked out on the basis of prevailing market prices of inputs and outputs. Production efficiency (kg ha^{-1} day^{-1}) was worked out by dividing the total duration of crop (days). The data were analyzed by using the 'Analysis of Variance Technique' as per the procedures described by Snedecor and Cochron (1967). The treatment means were compared at 5% level of significance.

Results and Discussion

Performance of varieties

The leaf area index, dry matter of plant $hill^{-1}$, crop grow rate (except first year) and net assimilation ratio was significantly influence by the varieties of rice (Table-1) with different level of depth and methods of transplanting. The dry matter of plant $hill^{-1}$ was recorded significantly higher with variety V_3 (Pro-Agro 6444) with per cent increase of (7.9 and 9.3, 7.3 and 9.2) over V_2(JRH-5) and V_1 (Sugandha-3) at harvest, respectively during both the year.

Similarly significant record noticed in leaf area index which was (4.37 and 4.30) maximum in comparison to other two variety. While, the CGR value declined at maturity stage over their preceding stage and was significantly higher with noted variety. Where, the net assimilation ration value was higher with V_1 and lower in V_3, it may be due to all leaves of plants at early stage have sufficient expose for synthesizing the carbohydrates through the photosynthesis but over lapping the canopy of plant leaves in advanced growth stage reduced the rate (Hon'e *et al.*, 2003). Among the different tested varieties, variety V_3 (Pro-Agro-6444) produced significantly higher number of effective tiller (6.8 and 6.92), healthy grain $panicle^{-1}$ (147.89 and 147.15), test weight (29.23 and 29.59), production efficiency

(51.67 and 53.27), straw yield (16.60 and 17.27 t ha^{-1}) and grain yield (7.28 and 7.51 t ha^{-1}) than other varieties, it was also remaining at par with variety V_2 in respect of effective tiller (during second year) and straw yield with value of 15.51 and 15.56 t/ha) during both year of experimentation and thus the V_3 showed their valuing effect of gross return (69.6 Rs. ha^{-1}), net return (37.7 Rs. ha^{-1}) and B: C ratio (2:17) was maximum over remaining two varieties in experimentation. The greater LAI value of plants resulted into higher photosynthetic activity, which ultimately increased the dry matter accumulation by plants at maturity confirmed by Linguing and Aijiug (2004). The crop growth rate gradually increased with crop age and reached its peak during fifty to seventy days of crop age and thereafter decline gradually as crop proceeded towards maturity (Jayanti *et al.*, 2015). The grain yield of rice directly correlated to the number of effective tillers unit $area^{-1}$, number of grains $panicle^{-1}$, test weight and fertile grain $panicle^{-1}$ and straw yield directly related to growth parameters (Choudhary *et al.*, 2009).

Effect of planting depth

Shallow depth of planting produced significantly more dry matter accumulation $hill^{-1}$ and leaf area index (during second year) with value of (64.24 and 64.25, 3.89) for both year, respectively during investigation. However, their effect was non- significant but maximum recorded in crop growth rate, relative growth rate and lower in net assimilation rate. The effect of depth on length of panicle, healthy grain $panicle^{-1}$, test weight and grain yield in value of (27.16 and 26.8, 135.50 and 135.77, 27.15 and 27.97), respectively over D_2 (5.00 cm). production efficiency was also higher with D_1 which caused to resulted highest economics and B:C ratio. While effective tillers $hill^{-1}$ was non-significantly higher than D_2. It may be due to the increased active vegetative growth period thereby increased leaf area index which are responsible to manufacture higher food through photosynthesis for the growth and development of plants reported by Azhiri *et al.*, (2005) and Hossain *et al.*, (2003). Significantly higher values of yield attributing characters under shallow depth of planting than deeper planting depth viewed by Zhao *et al.*, (1999).

Effect of planting method

The dry matter accumulation $hill^{-1}$, leaf area index (except first year) and yield attributing character were significantly affected by methods of planting. Among the different planting methods, M_1 (System of rice intensification) had proved the most optimum and appropriate method in value of (3.0 and 2.9 per cent) higher grain yield compared to M_2 (direct seeding of sprouted seed), respectively during both the years. However, the maximum result in value of (13.61 and 12.15 g $m^{-2}day^{-1}$) in CGR, (6.52 and 6.61) in effective tiller/hill during both year, (0.01 g $g^{-1}day^{-1}$) in RGR during first year recorded in M_2 but were non- significant. Moreover, length of panicle (26.81 and 26.58), healthy grain $panicle^{-1}$ (134.64 and 135.03), 1000-grain weight (27.28 and 27.42), grain yield (5.89 and 6.10 t ha^{-1}) and straw yield (14.37 and 14.71 t ha^{-1}) were recorded under M_1 over M_2, which was showed higher in production efficiency during both of the year. In economically, M_1 effect was also higher by B: C ratio (1.76) over M_2 during investigation. There was increase in the plant height and number of tillers, when rice was grown in SRI plots compared to farmer's practice reported by Verma *et al.*, (2015). The maximum yield of grain and straw under SRI may be due to the maximum plant growth parameters by maximum translocation of photosynthates (Xu *et al.*, 2005 and Thiyagarajan, 2007).

Table.1 Growth characters of rice as influenced by varieties, depth and methods of planting (Pooled data of 2 years)

Treatment	DMA hIll^{-1} (g)		LAI		CGR (g m^{-2} day^{-1})		RGR (g g^{-1} day^{-1})		NAR (g m^{-2}day^{-1})	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Varieties										
V_1:'Sugandha-3'	59.9	60.01	2.39	2.64	14.19	11.81	0.011	0.008	0.0137	0.0109
V_2:'JRH-5'	60.98	61.07	2.84	3.25	12.85	11.56	0.009	0.009	0.0096	0.0083
V_3:'Pro-Agro 6444'	65.85	65.57	4.37	4.3	13.69	12.76	0.009	0.009	0.0072	0.0066
CD (P=0.05)	0.58	0.56	0.28	0.42	NS	0.85	NS	NS	0.0017	0.0012
Depths										
D_1: 2.5 cm	64.29	64.25	3.31	3.89	13.9	11.96	0.009	0.008	0.0101	0.0076
D_2: 5.0 cm	60.19	60.18	3.09	2.9	13.25	12.12	0.01	0.009	0.0102	0.0095
CD (P=0.05)	0.47	0.46	NS	0.34	NS	NS	NS	NS	NS	0.001
Methods										
$M_{1:}$ SRI	62.98	62.99	3.2	3.61	13.54	11.93	0.009	0.008	0.01	0.008
M_2: DSSS	61.51	61.44	3.21	3.18	13.61	12.15	0.01	0.009	0.0103	0.0091
CD (P=0.05)	0.55	0.55	NS	0.31	NS	NS	NS	0.001	NS	0.0009

SRI=System of rice intensification DSSS=Direct Seeding of sprouted seeds

Table.2 Yield and its attributes of rice as influenced by varieties, depth and methods of planting

Treatment	Effective tillers hill^{-1}		Length of panicle (cm)		Healthy grains panicle^{-1}		1000-grain weight (g)		Production efficiency (Kg ha^{-1} day^{-1})		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Varieties														
V_1:'Sugandha-3'	5.94	6.1	26.49	26.85	121.44	121.76	23.13	23.53	33.35	34.95	4.16	4.36	10.42	10.92
V_2:'JRH-5'	6.51	6.66	26.19	27.06	132.14	132.66	27.69	28.02	50.5	52.41	5.96	6.18	15.51	15.56
V_3:'Pro-Agro 6444'	6.8	6.92	25.54	24.73	146.89	147.15	29.25	29.59	51.67	53.27	7.28	7.51	16.60	17.27
CD (P=0.05)	0.27	0.31	0.51	0.4	1.43	1.13	0.38	0.49	-	-	0.81	0.81	14.4	2.14
Depths														
D_1: 2.5 cm	6.41	6.44	27.16	26.8	135.50	135.77	27.15	27.97	46.69	49.54	5.97	6.19	14.53	14.91
D_2: 5.0 cm	6.42	6.68	24.99	25.63	131.48	131.95	26.23	26.13	44.01	46.8	5.63	5.85	13.82	14.26
CD (P=0.05)	NS	NS	0.42	0.33	1.17	0.92	0.31	0.40	-	-	0.66	0.66	NS	1.75
Methods														
$M_{1:}$ SRI	6.32	6.51	26.81	26.58	134.64	135.03	27.28	27.42	44.98	47.72	5.89	6.10	14.37	14.71
M_2: DSSS	6.52	6.61	25.34	25.85	132.34	132.68	26.09	26.68	45.75	48.25	5.71	5.93	13.98	14.45
CD (P=0.05)	NS	NS	0.52	0.35	0.63	0.83	0.27	0.40	-	-	0.07	0.07	NS	0.19

SRI=System of rice intensification DSSS=Direct Seeding of sprouted seeds

Table.3 Interaction effect of planting depths x planting methods on grain yield(t ha-1) and depths x varieties on straw yield(t ha-1) during second years

Methods	Depths	
	At D_1 (2.5 cm)	At D_2 (5.0 cm)
M_1: SRI	6.29	5.92
M_2: DSSS	6.09	5.77
CD (P=0.05)	Methods x depths	1.03
Varieties		
V_1: 'Sugandha-3'	11.42	10.41
V_2: 'JRH-5'	15.71	15.40
V_3: 'Pro-Agro 6444'	17.58	16.96
CD (P=0.05)	Varieties x depths	3.03

SRI= System of rice intensification DSSS= Direct seeding of sprouted seeds

Table.4 Effect of varieties , depths and methods of planting on economics of rice (Pooled data of 2 years)

Treatment	Cost of cultivation **(X 10^3 ₹ ha^{-1})**	Gross returns (X 10^3 ₹ ha^{-1})	Net returns (X 10^3 ₹ ha^{-1})	Benefit: cost ratio
Varieties				
V_1: 'Sugandha-3'	31.9	40.5	8.6	1.27
V_2: 'JRH-5'	31.9	57.8	25.9	1.81
V_3: 'Pro-Agro 6444'	31.9	69.6	37.7	2.17
Depths				
D_1: 2.5 cm	31.9	57.6	25.7	1.80
D_2: 5.0 cm	31.9	54.4	22.5	1.70
Methods				
M_1: SRI	32.3	56.8	24.5	1.76
M_2: DSSS	31.5	55.2	23.6	1.74

SRI=System of rice intensification, DSSS =Direct seeding of sprouted seeds

Interaction effect of planting depth x planting method and varieties x depth

The data (Table-3) on combined effect of planting depth was found significant on grain yield during 2010. The grain yield in M_1 (SRI) at shallow depth of planting D_1 (2.5 cm) was found higher (1.7 %) followed by M_2. The grain yield (5.77 t/ha) was found minimum on M_2 with D_2. Another interaction between variety with planting depth was found significant on the straw yield in 2010 (Table- 3). The V_3 (Pro-Agro-6444) produced significantly higher straw yield (3.66%) with D_1 2.5 cm) and minimum straw yield was recorded under interaction with V_1 (Sugandha-3) at D_2 (5.00 cm) of planting depth.

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