

Original Research Article

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## Effect of Economic Evaluation of *Oryza sativa* under different Planting Methods and Nutrient Management Practices

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### ABSTRACT

A field experiment was conducted at Annamalai University Experimental Farm, Annamalainagar, during *Samba* season 2017 (August-November) to evaluate different methods of rice cultivation along with certain levels of nutrients and sources, on its growth, yield parameter and economics of rice. The experiment was laid out in Split Plot Design. The planting methods was assigned to main plots while, different levels and sources of nutrients to the sub plots. Two planting methods viz., (M<sub>1</sub>) wet seeded method and (M<sub>2</sub>) transplanting method were tried. The sub treatments were, Control (No manure) (S<sub>1</sub>), Recommended dose of fertilizer (120:38:38 N, P and K kg ha<sup>-1</sup>) (S<sub>2</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + Pressmud (5 tonns ha<sup>-1</sup>) + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>3</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>4</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + pressmud (5 tonns ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>5</sub>). The results of the study revealed that, among the main plot treatments, i.e., various levels of crop establishments, transplanting method recorded significantly highest grain 4421 kg ha<sup>-1</sup> and straw yield 5058 kg ha<sup>-1</sup> rate than compare to direct seeded method of planting. Among different sources and levels, i.e., five sub plot treatments, large variation were noticed RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + pressmud (5 tonns ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>5</sub>) recorded highest grain 5244 kg ha<sup>-1</sup> and straw yield 5927 kg ha<sup>-1</sup> compared to the rest of the treatments, yet, it was found on par with (S<sub>3</sub>). Gross monetary returns (Rs. 82868), net monetary returns (Rs. 50173) and B:C ratio (Rs. 2.53) were recorded significantly higher in transplanting method compare to direct seeded method of planting. Among different sources and levels, i.e., five sub plot treatments, large variation were observed RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + pressmud (5 tonns ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>5</sub>) was better for realizing higher grain yield, straw yield and economic returns apart from sustainable better soil nutrient status.

#### Keywords

Planting methods,  
Soil health, Crop  
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## Introduction

Rice (*Oryza sativa*) is the most vital food crop and a major food grain for more than one third of the world's population (Zhao *et al.*, 2011). Global demand for food is rising because of population growth, increasing affluence and changing dietary habits.

The UN/FAO forecasts that global food production will need to increase by over 40 per cent by 2030 and 70 per cent by 2050 (FAO, 2009).

Direct seeding of rice is the process of establishing the crop from seeds sown in the field rather than by transplanting seedling from the nursery. Direct seeding avoids three basic operations namely puddling (process of soil is compacted to reduce water seepage), transplanting and maintain standing water (Farooq *et al.*, 2011).

It requires less labour and direct seeded plants mature 7 to 10 days earlier than transplanted rice. The other way of establishment is not by sowing seeds but by transplanting seedlings that are grown in nursery first. Transplanting requires less seeds but much more labour, and the crop takes longer to mature because of transplant shock. Manual transplanting of seedlings is very labour intensive. Planting in straight rows will make it easier to weed or apply fertilizers, herbicides, or insecticides.

The concept of integrated nutrient management through the judicious mixing of organic as well as inorganic sources of nutrients is an appropriate, which will not only economize the use of chemical fertilizers but also improve the physio-chemical status of the soil (Goud and Konde, 2009).

Under these circumstances, more emphasis is now being given on integration of inorganic and organics including crop residues, agro-

based industrial wastes and by-products to improve the soil productivity.

Besides improving nutrient status of soil, it also helps in improving physical, chemical and biological properties of soil towards betterment of soil quality, and permeability which increases fertilizer use efficiency due to higher addition of humus (Mankotia *et al.*, 2008).

Zinc deficiency is the wide spread micronutrient disorder in lowland rice and application of zinc along with nitrogenous fertilizers increased the grain yield dramatically in most cases (Chaudhary *et al.*, 2007). Zinc deficiency in rice appears right from seedling stage in nursery and three weeks after transplanting in main field. Zinc deficiency is considered the most widespread disorder in lowland rice (Fageria *et al.*, 2002).

## Materials and Methods

A Field experiment was conducted in the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalainagar to study the response of rice variety CO 47 to varied levels of RDF (Recommended dose of fertilizer) with organic sources (Pressmud and *Azospirillum brasilense*) and inorganic sources (Recommended dose of fertilizers and Zinc sulphate) viz., wet seeded rice and transplanted rice. The study was conducted during 2017 (August – November). The experiment was laid out in Split Plot Design.

The planting methods was assigned to main plots while, different levels and sources of nutrients to the sub plots. Two planting methods viz., (M<sub>1</sub>) wet seeded method and (M<sub>2</sub>) transplanting method were tried. The sub treatments were, Control (No manure) (S<sub>1</sub>), Recommended dose of fertilizer (120:38:38 N, P and K kg ha<sup>-1</sup>) (S<sub>2</sub>), RDF (120:38:38 N, P

and K kg ha<sup>-1</sup>) + Pressmud (5 tonns ha<sup>-1</sup>) + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>3</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>4</sub>), RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + pressmud (5 tonns ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>) (S<sub>5</sub>).

Pressmud with N - 0.12 %, P<sub>2</sub>O<sub>5</sub> - 2.41 %, K<sub>2</sub>O - 0.64 % @ 5 tonnes ha<sup>-1</sup> was applied in last puddling at basal as per the treatment schedule or two days before sowing or transplanting based on the treatments.

*Azospirillum brasilense* @ 2 kg/ha as a soil application was applied at basal as per the treatment schedule two days last puddling before sowing or transplanting based on the treatments.

The fertilizers were applied to the experimental field as per the recommended manurial schedule of 120:38:38 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O ha<sup>-1</sup>. Urea (46 % N), Single super phosphate (16 % P<sub>2</sub>O<sub>5</sub>) and Muriate of potash (60 % K<sub>2</sub>O) fertilizers were used to supply N, P and K nutrients, respectively.

Zinc sulphate @ 25 kg ha<sup>-1</sup> was applied in last puddling at basal as per the treatment schedule or two days before sowing or transplanting based on the treatments.

Biometric observations on plant height, number of tillers m<sup>-2</sup>, leaf area index (LAI), yield parameters were recorded at harvest. The data was subjected to statistical scrutiny to arrive at meaningful for the effect of treatments on rice crop.

### **Biometric and yield observation**

Five sample per hills in each plot were peg marked randomly for recording biometric observation. The observations were recorded

at different stages of crop growth as given blow.

### **Plant height (cm)**

Plant height was recorded at tillering, flowering and at harvesting stage by measuring the height of the sample plant from the surface of the soil to the tip of the top leaf. The mean value of all the five sample hills was computed and expressed in cm.

### **Number of tillers m<sup>-2</sup>**

The number of tillers m<sup>-2</sup> was recorded by counting the tillers at maximum tillering stage of the crop (35 - 40 DAT).

### **Leaf area index (LAI)**

Leaf area was estimated at flowering stage (60 DAT) of the crop by using the following formula (Yoshida *et al.*, 1976).

$$LA = L \times W \times K$$

Where,

LA = leaf area in cm<sup>2</sup>

L = length of leaf in cm (3<sup>rd</sup> leaf from top)

W = maximum width of leaf in cm (3<sup>rd</sup> leaf)

K = Adjustment factor (0.75)

The total leaf area of the mother tiller of sample hill was calculated and was multiplied by the number of tillers in each hill. The total area was arrived by multiplying the leaf area hill<sup>-1</sup> with number of hill m<sup>-2</sup>. The leaf area index was computed by using the formula given below.

$$LAI = \frac{\text{Total leaf area per unit area (m}^2\text{)}}{\text{Unit land area (m}^2\text{)}}$$

## **Yield**

### **Grain yield**

The matured crop was harvested from the net plot area and the grains separated, cleaned and dried to 14 per cent moisture content. The total yield was computed and recorded in kg ha<sup>-1</sup>.

### **Straw yield**

The straw yield obtained from each net plot area after threshing was sun dried and weighed and expressed in kg ha<sup>-1</sup>.

### **Economics**

The cost of cultivation for each treatment was worked out. Similarly, gross returns were calculated based on current market price of the produce. The net returns were obtained after deducting the cost of cultivation from gross returns. Later, the benefit-cost ratio was worked out by using the formula:

$$\text{Return per rupee invested} = \frac{\text{Gross return (Rs.ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs.ha}^{-1}\text{)}}$$

### **Statistical Analysis**

The data on various characters studied during the course of investigation were statistically analysed for split plot design. Wherever treatment differences were significant (“F” test), critical differences were worked out at five per cent probability level. Treatment differences that were not significant were denoted as “NS”.

### **Results and Discussion**

The present investigation showed significant difference in main as well as sub treatments. All the growth components viz., plant height,

number of tillers m<sup>-2</sup>, LAI, yield and economics showed superior performance with transplanting method, compared to wet seeded method of rice cultivation.

### **Growth components**

#### **Plant height**

The data on plant height showed significant difference among main as well as sub treatments at all the stages of observation viz, flowering and harvesting stages are presented in Table 1.

Among the main treatments, wet seeded method gave the highest mean plant height of 77.4 cm followed by transplanting method with a plant height of 73.6 cm at flowering stages and transplanting method gave the highest mean plant height of 85.3 cm followed by wet seeded method with a plant height of 81.6 cm at harvesting stage respectively. The least plant height was recorded in flowering stage by transplanting method and harvesting stage by wet seeded method.

Regarding sub treatments, i.e., certain levels and sources of nutrients, RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (S<sub>5</sub>) recorded the highest plants height of 84.9 and 92.8 cm which was on par with RDF + Pressmud + zinc sulphate (S<sub>3</sub>) at flowering and harvesting stages respectively. The least plant height was obtained with no fertilizer plot (S<sub>1</sub>), the plant height being 63.0 cm and 71.2 cm at flowering stage and harvesting stages respectively.

There was significant interaction between the planting methods and application of different nutrients on rice for plant height. The treatment combination of wet seeded method + RDF + pressmud + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>1</sub>S<sub>5</sub>) recorded the highest plant height of 87.6 cm at

flowering stage of crop. The least plant height was recorded by the treatment transplant method + control (No manure) ( $M_2S_1$ ).

The treatment combination of transplanting method + RDF + pressmud + *Azospirillum brasilense*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate ( $M_2S_5$ ) recorded the highest plant height of 95.5 cm at harvesting stage of crop. The least plant height of 71.2 cm was recorded by the treatment wet seeded method + control (No manure) ( $M_1S_1$ ).

This might be due to the fact that, younger seedlings in transplanting method had higher vigour, more root growth and transplantation shock occur during the initial growth stages after which stimulated plant height. Transplanting plants had more open architecture, with tillers spread wide more widely covering more ground area and more erect leaves that avoid mutual shading of leaves, resulted in optimum LAI due to significant increase in leaf size. The above results are in accordance with earlier findings of Ehsanullah *et al.*, (2000).

### **Number of tillers m<sup>-2</sup>**

The data on number of tillers m<sup>-2</sup> are presented in Table 2. The main and sub treatments significantly influenced the tiller number transplanting method ( $M_2$ ) produced the largest number of tillers with 443.2 m<sup>-2</sup>, followed by wet seeded method ( $M_1$ ) with 408 tillers m<sup>-2</sup>.

Among various sub treatments tried, RDF + pressmud + *Azospirillum brasilense*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate ( $S_5$ ) recorded the highest tillers with 509 m<sup>-2</sup> and 494 m<sup>-2</sup> which was on par with RDF + Pressmud + zinc sulphate ( $S_3$ ) respectively. Recommended dose of fertilizer (RDF) ( $S_2$ ) could produce 374.5 tillers m<sup>-2</sup> which was significantly lower to rest of the treatments

except Control ( $S_1$ ). There was significant interaction between the planting methods and application of different nutrients on rice for number of tillers m<sup>-2</sup>. The treatment combination of transplant method + RDF + pressmud + *Azospirillum brasilense*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate ( $M_2S_5$ ) recorded the highest tillers of 532 m<sup>-2</sup> and least tillers was recorded by the treatment wet seeded method + control (No manure) ( $M_1S_1$ ).

Improvement in growth components as a result of application of organic fertilizers might be due to the enhanced metabolic activities which lead to increase in various plant metabolites responsible for cell division and cell elongation (Hatwar *et al.*, 2003). The increment in plant height may be brought about by the presence of boron (B) which acts as a constituent of cell walls and membranes (Krikby and Romheld, 2004).

### **Leaf area Index (LAI)**

Noteworthy difference among main and sub treatments was observed on leaf area index at flowering stages are presented in Table 2. Between certain main treatments, the largest LAI of 6.0 was obtained with transplanting method ( $M_2$ ) which was significantly higher than that of the rest of the treatments. Wet seeded method ( $M_1$ ) produced the least LAI of 5.6.

Within sub plot treatments, RDF + pressmud + *Azospirillum brasilense*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate ( $S_5$ ) produced the largest LAI of 6.7 and was followed by on par with RDF + Pressmud + zinc sulphate ( $S_3$ ) with 6.6. The least LAI (4.6) was with control ( $S_1$ ).

There was significant interaction between the planting methods and application different nutrients on rice for leaf area index. The

treatment combination of transplanting method + RDF + pressmud + *Azospirillum brasilense*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) recorded the highest LAI of 6.9 and least LAI was recorded by the treatment wet seeded method + control (No manure) (M<sub>1</sub>S<sub>1</sub>).

INM increased leaf area index, as proper decomposition of organic matter supply available plant nutrient directly to plants and created favourable soil environment, ultimately increased nutrient supplying capacity of soil for long time, which resulted in better growth of the crop. The present findings are in line with observation made by kumar *et al.*, (2010).

**Yield**

Among the main plot treatments, transplant method (M<sub>2</sub>) showed a significant influence on grain and straw yield are given in table 4. This might due to transplant method of planting of crops better utilized space, light, nutrients and air.

These reflects on higher grain and straw yield. Also the highest grain yield and straw yield was obtained by the effective utilization of resources which increased the performance of crop. This result is conformity with the reports of (Sarker *et al.*, 2012).

With respect to subplot treatments, RDF + pressmud + *Azospirillum brasilense*@ 2 kg/ha as a soil application + zinc sulphate (S<sub>5</sub>) has significantly increased grain and straw yield.

The application of organic sources and fertility levels significantly affected the grain and straw yield of rice due to their positive influence on growth and yield attributes especially number of panicle hill<sup>-1</sup>, total number of grains panicle<sup>-1</sup> and number of filled grains panicle<sup>-1</sup>. The increased in grain and straw yield of rice with combined application of inorganic, organic and biofertilizers sources of plant nutrient was attributed to significant improvement in growth and yield characters.

**Table.1** Effect of planting methods and INM on Plant height of rice

Treatments	Flowering stage (cm)		Mean	Harvesting stage (cm)		Mean
	M <sub>1</sub>	M <sub>2</sub>		M <sub>1</sub>	M <sub>2</sub>	
S <sub>1</sub>	65.8	63.0	<b>64.4</b>	71.2	74.0	<b>72.6</b>
S <sub>2</sub>	71.5	68.7	<b>70.1</b>	76.7	79.4	<b>78.0</b>
S <sub>3</sub>	85.1	79.8	<b>82.5</b>	87.6	92.9	<b>90.3</b>
S <sub>4</sub>	77.0	74.3	<b>75.7</b>	82.1	84.9	<b>83.5</b>
S <sub>5</sub>	87.6	82.3	<b>84.9</b>	90.2	95.5	<b>92.8</b>
<b>Mean</b>	<b>77.4</b>	<b>73.6</b>		<b>81.6</b>	<b>85.3</b>	
	<b>S.Ed</b>	<b>CD</b>		<b>S.Ed</b>	<b>CD</b>	
<b>Main</b>	1.5	<b>3.2</b>		1.6	<b>3.5</b>	
<b>Sub</b>	2.1	<b>4.5</b>		2.0	<b>4.3</b>	
<b>M at S</b>	1.2	<b>2.6</b>		1.2	<b>2.6</b>	
<b>S at M</b>	1.1	<b>2.4</b>		1.0	<b>2.3</b>	

**Table.2** Effect of planting methods and INM on tiller number m<sup>-2</sup> at tiller stage, and LAI at flowering stage of rice

Treatments	Tiller number m <sup>-2</sup> at tiller stage		Mean	LAI of rice at flowering stage		Mean
	M <sub>1</sub>	M <sub>2</sub>		M <sub>1</sub>	M <sub>2</sub>	
S <sub>1</sub>	304	332	<b>318</b>	4.5	4.8	<b>4.6</b>
S <sub>2</sub>	360	389	<b>374.5</b>	5.1	5.4	<b>5.3</b>
S <sub>3</sub>	472	516	<b>494</b>	6.4	6.8	<b>6.6</b>
S <sub>4</sub>	418	447	<b>432.5</b>	5.7	6.0	<b>5.9</b>
S <sub>5</sub>	486	532	<b>509</b>	6.5	6.9	<b>6.7</b>
<b>Mean</b>	<b>408</b>	<b>443.2</b>		<b>5.6</b>	<b>6.0</b>	
	<b>S.Ed</b>	<b>CD</b>		<b>S.Ed</b>	<b>CD</b>	
<b>Main</b>	12.73	27		0.1	0.3	
<b>Sub</b>	16.50	35		0.2	0.5	
<b>M at S</b>	10.37	22		0.1	0.2	
<b>S at M</b>	8.49	18		0.08	0.1	

**Table.3** Effect of planting methods and INM of rice at grain yield and straw yield (Kg ha<sup>-1</sup>)

Treatments	Grain yield (Kg ha <sup>-1</sup> )		Mean	Straw yield (Kg ha <sup>-1</sup> )		Mean
	M <sub>1</sub>	M <sub>2</sub>		M <sub>1</sub>	M <sub>2</sub>	
S <sub>1</sub>	2235	2800	<b>2517.5</b>	3017	3394	<b>3205.5</b>
S <sub>2</sub>	3458	3881	<b>3669.5</b>	4311	4602	<b>4456.5</b>
S <sub>3</sub>	4796	5366	<b>5081</b>	5429	5947	<b>5688</b>
S <sub>4</sub>	4106	4572	<b>4339</b>	4873	5165	<b>5019</b>
S <sub>5</sub>	5002	5486	<b>5244</b>	5672	6182	<b>5927</b>
<b>Mean</b>	<b>3919.4</b>	<b>4421</b>		<b>4660.4</b>	<b>5058</b>	
	<b>S.Ed</b>	<b>CD</b>		<b>S.Ed</b>	<b>CD</b>	
<b>Main</b>	213.6	<b>453</b>		180.1	<b>382</b>	
<b>Sub</b>	249.5	<b>529</b>		225	<b>477</b>	
<b>M at S</b>	102.8	<b>218</b>		121.6	<b>258</b>	
<b>S at M</b>	90.5	<b>192</b>		100.4	<b>213</b>	

M<sub>1</sub> - wet seeded method

M<sub>2</sub> -Transplanting method

S<sub>1</sub>- Control (No manure)

S<sub>2</sub>-Recommended dose of fertilizer (120:38:38 N, P and K kg ha<sup>-1</sup>)

S<sub>3</sub> -RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + Pressmud (5 tonns ha<sup>-1</sup>) + zinc sulphate (25 kg ha<sup>-1</sup>)

S<sub>4</sub>- RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + *Azospirillum brasilense* @ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>)

S<sub>5</sub> - RDF (120:38:38 N, P and K kg ha<sup>-1</sup>) + pressmud (5 tonns ha<sup>-1</sup>) + *Azospirillum brasilense*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (25 kg ha<sup>-1</sup>)

**Table.4** Effect of planting methods and INM of rice at economics of various treatments

Treatments	Grain yield (kg ha <sup>-1</sup> )	Straw yield (kg ha <sup>-1</sup> )	Cost of cultivation (ha <sup>-1</sup> )	Gross return (ha <sup>-1</sup> )	Net return (ha <sup>-1</sup> )	B:C Ratio
M <sub>1</sub> S <sub>1</sub>	2235	3017	20780.00	37268.50	16488.50	1.79
M <sub>1</sub> S <sub>2</sub>	3458	4311	26645.00	57483.50	30838.50	2.16
M <sub>1</sub> S <sub>3</sub>	4796	5429	32645.00	79450.50	46805.50	2.43
M <sub>1</sub> S <sub>4</sub>	4106	4873	27695.00	68132.50	40437.50	2.46
M <sub>1</sub> S <sub>5</sub>	5002	5672	32695.00	82868.00	50173.00	2.53
M <sub>2</sub> S <sub>1</sub>	2800	3394	23780.00	46497.00	22717.00	1.96
M <sub>2</sub> S <sub>2</sub>	3881	4602	29645.00	64397.00	34752.00	2.17
M <sub>2</sub> S <sub>3</sub>	5366	5947	35645.00	88829.50	53184.50	2.49
M <sub>2</sub> S <sub>4</sub>	4572	5165	30695.00	75734.50	45039.50	2.47
M <sub>2</sub> S <sub>5</sub>	5486	6182	35695.00	90867.00	55172.00	2.55

The efficient supply of nutrient delayed the senescence and increased the life cycle of the plant, which resulted in higher economic yield.

Judicious use of organic and inorganic fertilizer enabled rice plant to assimilate sufficient photosynthates resulting in increased dry matter production and these together produced more productive tillers, panicle and number of filled grains leading to higher grain yield Hossaen *et al.*, (2011).

Among the various treatment combinations, transplant method and RDF + pressmud + *Azospirillum brasilance*@ 2 kg/ha as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) exerted significant result on grain yield of crop, over other treatments combinations the better establishment of crops in transplant method resulted in favourable physical, chemical and biological condition of soil along with balanced application of nutrient by RDF + pressmud + *Azospirillum brasilance*@ 2 kg/ha as a soil application + zinc sulphate which efficiently increased the grain yield compared to other treatment combinations. The recorded higher straw yield due to higher LAI and dry matter production.

### Grain yield

The data on grain yield showed significant variance among main and sub treatments are presented in Table 3.

Among the main treatments, transplanting method (M<sub>2</sub>) gave the highest mean yield of 4421 kg ha<sup>-1</sup> after that followed by wet seeded rice method (M<sub>1</sub>) with a yield of 3919.4 kg ha<sup>-1</sup>. The treatments were significantly different from each other.

Among various sub treatments, *i.e.*, certain levels and sources of nutrients, RDF + pressmud + *Azospirillum brasilance*@ 2 kg

ha<sup>-1</sup> as a soil application + zinc sulphate (S<sub>5</sub>) recorded the highest grain yield of 5244 kg ha<sup>-1</sup> which was on par with RDF + Pressmud + zinc sulphate (S<sub>3</sub>) with 5081 kg ha<sup>-1</sup>. The smallest grain yield was obtained with no fertilizer plot (S<sub>1</sub>), the yield being 2517.5 kg ha<sup>-1</sup>.

There was significant interaction between the planting methods and application of different nutrients on rice for grain yield. The treatment combination of transplanting method + RDF + pressmud + *Azospirillum brasilance*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) recorded the highest grain yield of 5486 kg ha<sup>-1</sup> and least grain yield was recorded by the treatment wet seeded method + control (No manure) (M<sub>1</sub>S<sub>1</sub>).

### Straw yield

The data on straw yield exhibited significant alteration among main as well as sub treatments are presented in Table 3.

Among the main treatment, transplanting method (M<sub>2</sub>) gave the peak straw yield of 5058 kg ha<sup>-1</sup> and followed by wet seeded rice method with a straw yield of 4660.4 kg ha<sup>-1</sup>. The treatments were expressively different from each other.

Among various sub treatments, *i.e.*, certain levels and sources of nutrients, RDF + pressmud + *Azospirillum brasilance*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (S<sub>5</sub>) recorded the largest straw yield of 5927 kg ha<sup>-1</sup> which was on par with RDF + Pressmud + zinc sulphate (S<sub>3</sub>) with 5688 kg ha<sup>-1</sup>. The smallest straw yield was obtained with no fertilizer plot (S<sub>1</sub>), the yield being 3205.5 kg ha<sup>-1</sup>. There was significant interaction between the planting methods and application of different nutrients on rice for straw yield. The treatment combination of transplanting method + RDF + pressmud + *Azospirillum*

*bracilance*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>) recorded the highest straw yield of 6182 kg ha<sup>-1</sup> and least straw yield was recorded by the treatment wet seeded method + control (No manure) (M<sub>1</sub>S<sub>1</sub>).

### Economics

The data on cost of cultivation, gross returns, net return and benefit cost ratio are presented in Table 4.

Between different methods of planting and different levels and sources of nutrients, the gross return and net return varied to a considerable extent. Higher gross return (Rs. 90867) and net return (Rs. 55172) and B:C ratio (Rs. 2.55) were realized in the rice crop raised from transplanting method with the application of RDF + pressmud + *Azospirillum bracilance*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>2</sub>S<sub>5</sub>).

Next promising treatment combination is transplanting method with the application of RDF + pressmud + *Azospirillum bracilance*@ 2kg ha<sup>-1</sup> as a soil application + zinc sulphate (M<sub>1</sub>S<sub>5</sub>) which gave the gross return (Rs. 82868) and net return (Rs. 50173) and B:C ratio (Rs. 2.53). The lower gross return (Rs. 37268.50) and net return (Rs. 16488.50) and B:C ratio (Rs. 1.79) was obtained wet seeded method with no fertilizer plot (M<sub>1</sub>S<sub>1</sub>).

Transplanting method of rice cultivation showed the maximum performance when combined with RDF + pressmud + *Azospirillum bracilance*@ 2 kg ha<sup>-1</sup> as a soil application + zinc sulphate returned the maximum growth parameter its leads to increase the yield of the rice crop. Hence, the above treatment can be suggested to the rice farmers to augment the rice productivity with sizeable economic gains and without any significant loss on soil health.

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