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Growth and yield of rice under different systems of rice cultivation and organic nutrient management practices

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Abstract
A field experiment was conducted during *late* kharif season of 2021-22 and 2022-23 at S.V. Agricultural College Farm, Tirupati in split-plot design with three replications to know the effect of different organic nutrient management practices for different systems of rice cultivation. Among the different systems of rice cultivation, significantly higher growth and yield attributes of rice crop were produced under normal transplanted rice and all these parameters were at par with wet direct seeded rice. Among the organic nutrient management practices tested, higher growth and yield attributes as well as yield were obtained with application of 100% RDN through PM which was at par with 50% RDN through VC + 50% RDN through PM but both of them were significantly inferior than 100% RDN through inorganic fertilisers on sandy clay loam soils of Southern Agro-Climatic Zone of Andhra Pradesh. Application of 100% RDN through PM in transplanted rice found effective in obtaining higher grain yield as well as benefit: cost ratio than rest of systems of rice cultivation and organic nitrogen management practices.

Keywords: RDN-recommended dose of nitrogen, PM-poultry manure, VC- vermi compost, systems of rice cultivation, organic nitrogen management practices, inorganic fertilisers

Introduction
Rice is the primary staple food crop and the major source of daily calorie intake for almost one third of the global population. In India, the rice crop occupies an area of 46.28 million hectares with 129.47 million tons of production and productivity of 2798 kg ha^{-1}. (www.indiastat.com., 2021-22). Continuous use of inorganic fertilizers leads to deterioration in chemical, physical and biological properties of soil and soil health. The negative impacts of chemical fertilizers coupled with escalating prices, have led to growing interest among the farmers to use organic manures. Organic sources like farmyard manure, vermicompost, poultry manure, green manuring, neem cake and biofertilizers are important components in organic cultivation of crops to maintain the soil fertility and to produce reasonably good crop yields. Use of organic manures benefitted the sequence crops as they leave some residues in the soil. In recent years, there is a growing interest in organic foods among the consumers which warrants the use of organic manures as a source of plant nutrients for producing quality food grains and sustain the soil health for future generations.
The area under traditional method of transplanted rice in world is going to decrease due to limitation of water and labour therefore, alternate method of establishment should be promoted for enhancing the crop and water productivity (Farooq *et al.*, 2011) [2]. Wet Direct Seeded Rice (W- DSR) and Dry Direct Seeded Rice (D-DSR) are the best alternate methods of rice sowing. Nitrogen is the major essential plant nutrient and key input for rice production and increased yield in rice growing countries. An increase of 70-80% in yield of rice could be obtained by the application of nitrogen fertilizer. The application of the organic manure such as the farmyard manure and poultry manure could increase the soil organic carbon content as well as sustain the nutrient availability to crop. Nitrogen is a highly dynamic nutrient which undergoes various changes under different systems of rice cultivation *i.e.*, normal transplanted rice, wet DSR and dry DSR. The nutrient dynamics in different systems of rice cultivation has to be investigated under varied organic sources for increasing the productivity and profitability of organic rice cultivation.

Materials and Methods
A field experiment was conducted during late *kharif* season of 2021-22 and 2022-23 at the S. V. Agricultural College Farm, Tirupati.

The soil of the experimental site was a sandy clay loam with a bulk density of 1.43 g cc^{-1} having pH 7.85, EC 0.44 dsm^{-1}, low in organic carbon (0.38%), available nitrogen (187 kg ha^{-1}), medium in phosphorus (25.5 kg ha^{-1}) and potassium (218 kg ha^{-1}). Rice variety "NLR-34449" was taken as the test variety. The experiment was laid out in split-plot design with systems of rice cultivation as main plots and organic nitrogen management practices as sub-plots with three replications. The main plots comprised of three different systems of rice cultivation *viz.,* Normal transplanted rice (N-TPR), Wet Direct Seeded Rice (W-DSR) and Dry Direct Seeded Rice (D-DSR). Sub- plots comprised of seven organic nitrogen management treatments *viz.,* 100% RDN through Farm Yard Manure (FYM), 100% RDN through Vermicompost (VC), 100% RDN through Poultry Manure (PM), 50% RDN through FYM+ 50% RDN through VC, 50% RDN through FYM + 50% RDN through PM, 50% RDN through FYM + 50% RDN through PM and 100% RDN through inorganic fertilisers. The RDF for rice crop in Southern Agro-Climatic Zone of Andhra Pradesh was 120:60:40 NPK ha^{-1}.

Healthy grains of test variety were selected. Recommended seed rate for N-TPR (75 kg ha^{-1}), W-DSR (37.5 kg ha^{-1}) and D-DSR (37.5 kg ha^{-1}) was used for sowing directly or raising nursery on the same day. Twenty four days old seedlings were transplanted in well puddled field manually in transplanted rice. In W-DSR, seeds were soaked in water for 24 hours, then wrapped in jute gunny bag and kept in dark for 24 hours to induce better sprouting. These sprouted seeds were sown at 20x10 cm spacing with the help of drum seeder. In D-DSR, recommended seed rate was sown manually at spacing of 20x10 cm. In all the systems of rice cultivation, seeds were sown on 19-08-2021 and 16-08-2022 in both years of study respectively. Required quantity of organic sources as per the treatments were applied on N-equivalent basis 15 days before sowing or transplanting. The data on growth, yield parameters and yield of rice were presented.

Results and Discussion

Plant growth parameters *viz.,* plant height (cm), number of tillers m^{-2}, leaf area index, dry matter production (kg ha^{-1}), SPAD chlorophyll meter readings, root length (cm), root density (mg cm^{-3}) were significantly higher in N-TPR, which was on par with W-DSR. Significantly the lowest values above growth parameters were observed D-DSR. Continuous stagnation of water in the puddled situation in former two systems of rice cultivation lead to better growth and development and reduce the weed competition. Under these conditions, more nutrients were available to rice crop that encouraged rice crop growth thereby exposing to more light resulting in higher photosynthesis and better translocation of photosynthates in puddled plots. This could be the possible reason for the increase in growth parameters (Nahar *et al.*, 2018; Deo *et al.,* 2019) [4, 1].

Yield attributes *viz.,* number of panicles m^{-2}, total number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$, test weight and yield (grain and straw) of rice were significantly higher with N-TPR, which was on par with W-DSR might be due to better environmental and eco-physiological conditions prevailed because of less crop- weed competition resulted in increased grain yield of rice. The decrease in yield of rice in D-DSR was 53.5% compared to N-TPR.

Among nitrogen management practices, yield attributes and yield were significantly higher with the treatment 100% RDN through inorganic fertilisers. Among organic sources, 100% RDN through PM recorded significantly higher yield attributes and yield which was comparable with 50% RDN through VC+ 50% RDN through PM and significantly superior over other organic sources might be due to higher nitrogen content in poultry manure which is readily available to the crop. The poultry manure is acidic in nature which might have helped in increasing the availability of nutrients. Concentration and steady release of essential nutrients for plants in the poultry manure were higher compared to other organic manures (Meena *et al.,* 2017) [3]. Whereas, significantly lower grain and straw yield were noticed with the application of 100% RDN through FYM which might be due to less availability of nutrients at critical stages of crop growth period.

Significantly lower sterility percent was noticed in N-TPR which was comparable with W-DSR. This might be due to increased number of filled grains in transplanted rice through optimum utilization of resources which had direct effect on source-sink relation which inturn reduced sterility % (Farooq *et al.,* 2011) [2]. Among the nitrogen management practices, application of 100% RDN through inorganic fertilisers recorded lower sterility % followed by application of 100% RDN through PM. Similarly, significantly higher values of harvest index was observed with N-TPR which was comparable with W-DSR. This might be

due to more grain yield which has direct influence on the harvest index in rice crop. The higher grain and straw yield as well as harvest index were obtained with application of 100% RDN through inorganic fertilisers followed by application of 100% RDN through PM however, it was at par with 50% RDN through VC + 50% RDN through PM. Significantly higher benefit: cost ratio was registered with treatment W-DSR when compared to N-TPR and D-DSR due to decreased cost of cultivation by saving labour (Rana *et al.,* 2014) [5]. Similarly, application of 100% RDN through inorganic fertilisers recorded significantly higher benefit: cost ratio followed by application of 100% RDN through PM which might due to higher grain and straw yield.

Table 1: Growth parameters of rice at harvest as influenced by different systems of rice cultivation and organic nutrient management practices (Average of two years)

Treatments	Plant height (cm)	Number of tillers m^{-2}	Leaf area index	Dry matter production (kg ha^{-1})	SPAD readings	Root length (cm)	Root density (mg cm^{-3})
Mainplot: Systems of rice cultivation (3)							
M_1: Normal Transplanted Rice	75.0	348	3.73	11086	31.2	31.6	5.23
M_2: Wet DSR	73.2	338	3.63	10358	30.4	30.4	5.14
M_3: Dry DSR	53.8	230	1.30	5614	26.5	22.3	4.69
S.Em±	1.58	5.19	0.089	189	0.39	0.61	0.085
CD (P=0.05)	6.2	7.8	0.35	742	6.1	2.4	0.33
Subplot: Organic nitrogen management practices (7)							
S_1: 100% N-FYM	52.9	260	2.15	7110	25.0	26.1	4.82
S_2: 100% N-VC	60.0	286	2.59	8060	26.9	27.2	4.92
S_3: 100% N-PM	74.6	327	3.26	10046	31.8	28.9	5.09
S_4: 50% N-FYM + 50% N-VC	59.0	277	2.51	7902	26.8	26.5	4.87
S_5: 50% N-FYM + 50% N-PM	68.8	309	2.96	9214	29.8	28.0	4.98
S_6: 50% N-VC + 50% N-PM	72.3	318	3.11	9608	30.8	28.4	5.04
S_7: 100% N-RDF	83.7	360	3.64	11196	34.3	31.9	5.41
S.Em±	1.41	4.8	0.061	217	0.38	0.51	0.100
CD (P=0.05)	4.0	13.9	0.19	622	1.1	1.5	0.30
Interaction							
M at S							
S.Em±	2.76	9.32	0.112	396	0.73	1.01	0.201
CD (P=0.05)	8.9	29.8	0.40	1232	2.3	3.3	0.61
S at M							
S.Em±	2.44	8.34	0.073	376	0.67	0.88	0.197
CD (P=0.05)	7.0	24.0	0.21	1078	1.9	2.5	0.57

Table 2: Yield attributes and yield of rice as influenced by different systems of rice cultivation and organic nutrient management practices (Average of two years)

Treatments	Number of panicles m^{-2}	Total number of grains $panicle^{-1}$	Number of filled grains $panicle^{-1}$	Sterility (%)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index	B:C ratio
Mainplot: Systems of rice cultivation (3)									
M_1: Normal Transplanted Rice	285	143	128	14.3	13.78	4117	4461	47.8	1.72
M_2: Wet DSR	274	138	125	15.0	13.31	3922	4262	46.6	1.90
M_3: Dry DSR	211	109	97	23.2	10.17	1914	2842	39.7	0.95
S.Em±	5.1	2.8	2.4	0.28	0.28	57.1	69.3	0.41	0.031
CD (P=0.05)	20	11	10	1.1	1.1	234	271	1.6	0.12
Subplot: Organic nitrogen management practices (7)									
S_1: 100% N-FYM	217	105	95	19.7	10.74	2161	2554	43.3	1.16
S_2: 100% N-VC	237	119	107	18.5	10.83	2670	3219	44.0	0.92
S_3: 100% N-PM	278	144	128	16.1	13.17	3849	4498	44.6	1.78
S_4: 50% N-FYM + 50% N-VC	234	115	105	19.2	10.80	2486	2999	43.7	1.05
S_5: 50% N-FYM + 50% N-PM	260	132	119	16.9	13.00	3490	4070	45.5	1.73
S_6: 50% N-VC + 50% N-PM	268	138	124	16.6	13.06	3689	4289	45.2	1.46
S_7: 100% N-RDF	301	158	139	15.6	15.34	4878	5357	46.5	2.58
S.Em±	4.7	3.2	2.8	0.45	0.34	78.2	76.7	0.36	0.035
CD (P=0.05)	14	9	8	1.3	1.0	225	220	1.0	0.10
Interaction									
M at S									
S.Em±	9.1	5.9	5.1	0.78	0.61	137.9	141.1	0.71	0.063
CD (P=0.05)	29	18	16	NS	NS	420	441	2.3	0.20
S at M									
S.Em±	8.2	5.6	4.8	0.79	0.58	135.5	132.8	0.62	0.060
CD (P=0.05)	23	16	14	NS	NS	389	381	1.8	0.17

Conclusion

From the results it can be concluded that the highest growth parameters, yield attributes and yield were obtained with normal transplanted rice which was at par with wet direct seeded rice. Among the nitrogen management practices, the significantly higher growth, yield attributes and yield were recorded by 100% RDN through inorganic fertilisers. Among the organic sources tested, application of 100% RDN through PM in N-TPR resulted in higher grain yield and straw yield in sandy clay loam soils of Southern Agro-Climatic Zone of Andhra Pradesh.

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