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Economics of Rice Production under Different Crop Establishment Methods with Integrated Nutrient Management in the Coastal Zone of Andhra Pradesh, India

Polagani Nagarjuna* and B. Venkateswarlu

Department of Agronomy, Agricultural College, Bapatla, Andhra Pradesh, India
*Corresponding author: pol.nag143@gmail.com

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ABSTRACT

A Field study was conducted to analyze the production economics and factors contributing to the profitability of rice production at Agricultural College Farm, Bapatla, ANGRAU, Andhra Pradesh, India during *kharif* seasons of 2019-20 and 2020-21 under different rice establishment methods with different nutrient management practices. The results showed that the highest net returns, B : C ratio and profitability were recorded in conventional tillage (T_4) (62889 and 65505 ₹ ha^{-1}, 1.39 and 1.41% and 449.21 and 467.90 ₹ ha^{-1} day^{-1} during *kharif* seasons of 2019-20 and 2020-21 respectively) and dry seeding on puddled soil (T_1) (62773 and 64708 ₹ ha^{-1}, 1.40 and 1.40% and 448.38 and 462.20 ₹ ha^{-1} day^{-1}) in different crop establishment methods. Lowest valves were observed with minimum tillage (T_3) (45603 and 48375 ₹ ha^{-1}, 1.09 and 1.12% and 325.73 and 345.53 ₹ ha^{-1} day^{-1}). Among nutrient management treatments, 50% STBN through fertilizer + 50% N through cured poultry manure (N_5) (70167 and 72706 ₹ ha^{-1}, 1.66 and 1.67% and 501.20 and 519.33 ₹ ha^{-1} day^{-1}) and 75% STBN through fertilizer + 25% N through cured poultry manure (N_4) (66385 and 69030 ₹ ha^{-1}, 1.56 and 1.57% and 474.18 and 493.07 ₹ ha^{-1} day^{-1}) were recorded with highest net returns, B : C ratio and profitability during *kharif* seasons of 2019-20 and 2020-21 respectively. The lowest net returns, B : C ratio and profitability values were observed with 50% STBN through fertilizer + 50% N through FYM (N_3) (49145 and 51766 ₹ ha^{-1}, 1.02 and 1.04% and 351.04 and 369.75 ₹ ha^{-1} day^{-1}) during *kharif* seasons of 2019-20 and 2020-21 respectively.

Keywords: Crop Establishment methods, Nutrient Management, Rice, Productivity and Profitability

In Andhra Pradesh, rice is the principal food crop cultivated throughout the state providing food for its growing population, fodder to the cattle and employment to the rural masses. Any decline in its acreage and production will have a perceivable impact on the state's economy and food security. The coastal region of Andhra Pradesh, Tamil Nadu and Karnataka form an important rice fallow ecology in peninsular India. The possibility of expanding the area under paddy in the near future is limited. When natural resources such as labour, water and capital are in short supply, it becomes less economical as these resources become extremely scarce. In this connection the following study focuses on evaluating

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the best type of establishment method and nutrient management for rice production in the Coastal Zone of Andhra Pradesh with improved resource use efficiency and increased productivity and profitability needed in the prevailing agricultural scenario.

MATERIALS AND METHODS

The experimental field was laid out in a strip-plot design with four crop establishment methods in horizontal strips and five nutrient management treatments in vertical strips and replicated three times for rice crop during *kharif* seasons of 2019-20 and 2020-21 and the treatments were randomized as per procedure given by Cochran and Cox (1952). Four different crop establishment methods *viz*., Dry seeding on puddled soil (T_1), Reduced tillage (T_2), Minimum tillage (T_3) and Conventional tillage (T_4) were taken as horizontal strip treatments and five nutrient management treatments to rice *viz*.,100% STBN through fertilizer (N_1), 75% STBN through fertilizer + 25% N through FYM (N_2), 50% STBN through fertilizer + 50% N through FYM (N_3), 75% STBN through fertilizer + 25% N through cured poultry manure (N_4) and 50% STBN through fertilizer + 50% N through cured poultry manure (N_5) as vertical strips at the Agricultural College Farm, Bapatla, ANGRAU, Lam, Guntur, Andhra Pradesh, India during *kharif* seasons of 2019-20 and 2020-21. The experimental site is situated at an altitude of 5.49 meters, 15^{0}54' North latitude, 80^o 25' East longitude and about 7 km away from the Bay of Bengal in the Coastal Zone of Andhra Pradesh. The experimental field was homogeneously fertile with even topography and uniform texture and was attached to the main irrigation channel connecting the farm tube well for irrigation. Proper drainage facility was also provided in order to remove excess water during experimental period. The average values of soil properties as well as ranges of experimental fields during the two years of study were: pH 7.9 and 7.6 EC 0.4 and 0.5 dS m^{-1}, organic carbon 0.50 and 0.49%, available nitrogen 248 and 256 kg ha^{-1}, P_2O_5 38 and 51.5 kg ha^{-1} and available K_2O 434 and 442 kg ha^{-1} .

Yield (kg ha^{-1})

Grain yield was recorded after threshing, winnowing, cleaning and after sun drying the produce. The grain yield obtained from the field was finally converted in to kilograms per hectare (kg ha^{-1}). The straw obtained after threshing the plants from field was sun dried and weighed. The weight of straw, thus obtained was converted into kg ha^{-1}.

Economics

After harvesting, data pertaining to biological and economic yield of crop were converted into per hectare. Economic produce of all the treatments were obtained manually. The gross return, net return, benefit: cost ratio and Profitability was calculated for each treatment, using the purchase price of inputs and selling of outputs prevailing in the local market. To compare the performance of different crop establishment methods and nutrient management practices, economic yield of all the treatments were converted based on the prevailing market price using following formulas;

Gross return (₹ ha^{-1}) = Selling price of yield (₹ kg^{-1}) + yield (kg ha^{-1})

Net return (₹ ha^{-1}) = Gross return (₹ ha^{-1}) – Total cost of cultivation (₹ ha^{-1})

$$\textit{Benefit cost ratio (\%)} = \frac{\text{Net return (₹ ha}^{-1}\text{)}}{\text{Cost of cultivaiton (₹ ha}^{-1}\text{)}}$$

$$\textit{Productivity (Kg.ha}^{-1}\textit{) day}^{-1}\textit{)} = \frac{\text{Total economical yield (kg. ha}^{-1}\text{)}}{\text{Total duration of crop (Days)}}$$

$$\textit{Profitability (₹ ha}^{-1}\textit{) day}^{-1}\textit{)} = \frac{\text{Net return (Rs ha}^{-1}\text{)}}{\text{Total duration of crop (Days)}}$$

Data pertaining to various characters were subjected to statistical analysis as described by Panse and Sukhatme (1989). Statistical significance was tested by applying F-test at 0.05 level of probability and critical differences were calculated for those parameters, which were found significant ($p< 0.05$) to compare the effects of different treatments. Statistical analysis for the data was done following the analysis of variance technique for strip-plot design as suggested by Gomez and Gomez (1984).

In this experiment, operational and general cost of rice production was determined in farming operations like tillage, puddling, sowing, pesticide application, fertilizer application, irrigation and harvesting. Operation cost like human labour and fuels are used. The use of fuel is for machinery for operations like tillage, puddling, sowing, harvesting, transportation, and irrigations. In agricultural activities human labours used at every step, from manual work on farm, driving agricultural machinery, maintenance, pesticides and fertilizer application, irrigation, and harvesting. Table 1, 2 & 3 shows the cost of each input and operation (₹ ha^{-1}) in rice production during the two years of study.

RESULTS AND DISCUSSION

Yield (kg ha^{-1})

Yield of a crop is the result of several morphological and physiological processes occurring at different

Table 1: Operational cost of rice cultivation under different crop establishment methods (₹ ha^{-1}) during 2019-20 & 2020-21

Input/Operation	Transplanting		Dry seeding on puddled soil		Reduced tillage		Minimum tillage	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Operational Cost								
Land Preparation 1 time (1500/-)	3000	3000	3000	3000	3000	3000	1500	1500
Puddling 1 time (1500/-)	1500	1500	1500	1500	–	–	–	–
Nursery pulling and transplanting	5000	6000	–	–	–	–	–	–
Sowing cost ha^{-1}	–	–	5000	6000	5000	6000	5000	6000
Seed cost ha^{-1}	3000	3000	2700	2700	2700	2700	2700	2700
Total	**12500**	**13500**	**12200**	**13200**	**10700**	**11700**	**9200**	**10200**

Table 2: Common cost of rice cultivation under different crop establishment methods (₹ ha^{-1}) during 2019-20 & 2020-21

Input/Operation	Transplanting		Dry seeding on puddled soil		Reduced tillage		Minimum tillage	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Common cost								
Pendimethalin	1000	1000	1000	1000	1000	1000	1000	1000
Bis-pyribac sodium application	2000	2000	2000	2000	2000	2000	2000	2000
Irrigation	7000	7000	7000	7000	7000	7000	7000	7000
Carbofuron granules 2000 ₹ ha^{-1}	2000	2000	2000	2000	2000	2000	2000	2000
Tricyclazole	1100	1100	1100	1100	1100	1100	1100	1100
Chloripyriphos + Dichlorovos	1200	1200	1200	1200	1200	1200	1200	1200
Labour charges	2000	2000	2000	2000	2000	2000	2000	2000
Spraying cost (300 day^{-1})	1200	1500	1200	1500	1200	1500	1200	1500
Harvesting	5000	5000	5000	5000	5000	5000	5000	5000
Total	**22500**	**22800**	**22500**	**22800**	**22500**	**22800**	**22500**	**22800**

Table 3: Cost of cultivation of rice under different nutrient management treatments (₹ ha^{-1}) during 2019-20 & 2020-21

Treatments	Nitrogen sources	Quantity (kg ha^{-1})					Cost (₹ ha^{-1})					Total cost
		Urea	SSP	MOP	FYM	CPM	Urea	SSP	MOP	FYM	CPM	(₹ ha^{-1})
N_1	100% STBN	271	562	100	–	–	1598	5901	1750	–	–	**9249**
N_2	75% STBN + 25% FYM	203	421	75	5000	–	1197	4420	1312	5000	–	**11929**
N_3	50% STBN + 50% FYM	135	281	50	10000	–	799	2950	875	10000	–	**14624**
N_4	75% STBN + 25% CPM	203	421	75	–	1250	1197	4420	1312	–	1850	**8779**
N_5	50% STBN + 50% CPM	135	281	60	–	2500	799	2950	875	–	3750	**8374**

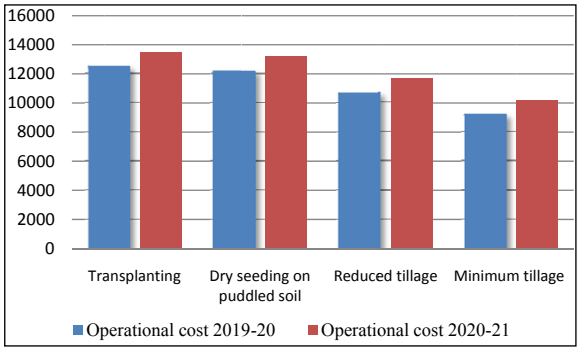

Fig. 1: Operational cost under different tillage treatments (₹ ha^{-1}) during 2019-20 & 2020-21

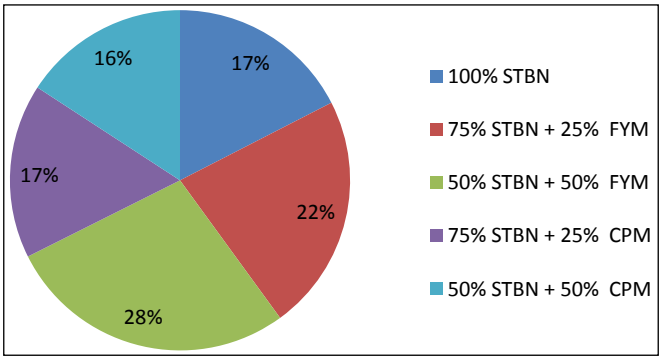

Fig. 2: Cost of cultivation of different nutrient management treatments during 2019-20 & 2020-21

growth stages during the crop growth period affecting each other. The appraisal of the ultimate produce as effected by different treatments is the primary objective of any agronomic investigation. Data pertaining to yield of different tillage treatments and nutrient management treatments during 2019-20 and 2020-21 are presented in Table 4. Highest yield was recorded with conventional tillage and found significantly superior over the other treatments except the dry seeding on puddled soil. The lowest grain yield was observed with minimum tillage during 2019-20, 2020-21. This is due to better environmental and eco-physiological conditions prevailed by less crop- weed competition for moisture and light and make better availability of nutrients for proper development of plant drymatter and yield attributing characters viz., productive tillers and filled grains per panicle which resulted in increased grain yield of rice (Kumar *et al.* 2016). Yield under dry seeding on puddled soil was also on par with conventional tillage which might be due to that fact that drilling of dry seeds was done on puddled soil and later the soil was converted into submerged conditions as the growth and development of rice plants increased similar to that of transplanting situation in conventional tillage (Singh *et al.* 2006 and Meena *et al.* 2017).

Treatments receiving both organic and inorganic sources were found to display considerable influence on yield. Significantly higher yield was recorded with the application of 50% STBN through fertilizer with 50% N through cured poultry manure, which however was on a par with 75% STBN through fertilizer with 25% N through cured poultry manure. N_3, N_2 and N_1 treatments were comparable with each other. The lowest yield was recorded with 100% STBN through fertilizer during 2019-20, 2020-21 due to higher nitrogen content in poultry manure which was readily available compared to other organic manures. Due to quick decomposition, the nutrients present in the poultry manure were readily available to the crop. Hence there was a increased growth components viz., plant height, number of tillers m^{-2} and total dry matter production and better yield components *viz.*, productive tillers, number of filled grains panicle^{-1}, 1000 grain weight that would have led to increased yield. Concentration of essential nutrients for plants in the poultry manure was higher and steadily released compared to other organic manures such as FYM could make it to perform well (Parihar, 2004). Among different combination treatments, the FYM treated plots along with chemical fertilizers gave lower yield compared to poultry manure treated plots along with chemical fertilizers due to low concentrations of nutrients in FYM than poultry manure and release of nutrients from FYM was rather slow to meet the requirements of paddy adequately. The lower yield recorded in treatments which received 100 per cent N through inorganic source due to low availability of nutrients at critical stages of crop growth period (Sarker *et al.* 2015).

Gross Return (₹ ha^{-1})

Gross return is directly related with the market value of produce including both the main and byproducts. Significantly the highest gross return (₹ 1,08,480 ha^{-1} and ₹ 1,12,396 ha^{-1} during both the years of study) was recorded by the conventional tillage (T_4) which was significantly superior to the

Table 4: Grain yield (kg ha^{-1}), straw yield (kg ha^{-1}), total yield (kg ha^{-1}) and productivity of rice as influenced by crop establishment methods and nutrient management treatments during *kharif*, 2019-20 and 2020-21

Treatments	2019-20				2020-21			
	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Total Yield (kg ha^{-1})	Productivity (Kg. ha^{-1} day^{-1})	Grain yield kg ha^{-1})	Straw yield (kg ha^{-1})	Total Yield (kg ha^{-1})	Productivity (Kg. ha^{-1} day^{-1})
Tillage practices								
T_1- Dry seeding on puddled soil	5362	7161	12522	38.30	5376	7248	12624	38.40
T_2- Reduced tillage	4980	6644	11623	35.57	4992	6784	11775	35.66
T_3- Minimum tillage	4315	6382	10697	30.82	4400	6520	10920	31.43
T_4-Conventional tillage	5370	7343	12712	38.36	5416	7484	12899	38.69
S.Em±	115.8	123.3	216.4	0.83	102.3	119.5	197.2	0.73
CD (p = 0.05)	401	427	749	2.86	354	413	682	2.53
CV (%)	8.96	6.94	7.05	8.96	7.85	6.60	6.34	7.85
Nitrogen Management								
N_1- 100% STBN	4585	5971	10555	32.75	4591	6112	10702	32.79
N_2-75% STBN +25% FYM	4728	6377	11105	33.77	4766	6524	11290	34.04
N_3-50% STBN +50% FYM	4800	6860	11660	34.29	4867	6952	11819	34.76
N_4-75% STBN +25% CPM	5400	7208	12607	38.57	5449	7317	12766	38.92
N_5-50% STBN +50% CPM	5521	7995	13515	39.43	5558	8139	13697	39.70
S.Em±	210.3	194.6	348.8	1.50	197.7	209.0	338.9	1.41
CD (p = 0.05)	686	634	1137	4.90	645	681	1105	4.61
CV (%)	14.6	9.79	10.16	14.55	13.6	10.33	9.74	13.57

Table 5: Cost of cultivation (₹ ha^{-1}), gross return (₹ ha^{-1}), net return (₹ ha^{-1}), B : C ratio (%) and Profitability (₹ ha^{-1} day^{-1}) of rice as influenced by crop establishment methods and nutrient management treatments during *kharif*, 2019-20 and 2020-21

Treatments	2019-20					2020-21				
	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio (%)	Profitability (₹ ha^{-1} day^{-1})	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio	Profitability (₹ ha^{-1} day^{-1})
Tillage practices										
T_1- Dry seeding on puddled soil	45291	108064	62773	1.40	448.38	46591	111299	64708	1.40	462.20
T_2- Reduced tillage	43791	100353	56562	1.30	404.01	45091	103425	58334	1.30	416.67
T_3- Minimum tillage	42291	87894	45603	1.09	325.73	43591	91966	48375	1.12	345.53
T_4-Conventional tillage	45591	108480	62889	1.39	449.21	46891	112396	65505	1.41	467.90
S.Em±	–	2224	2224	0.05	15.89	–	2020	2020	0.04	14.43
CD (p = 0.05)	–	7696	7696	0.17	54.97	–	6991	6991	0.15	49.94
CV (%)	–	8.51	15.12	15.08	15.12	–	7.47	13.21	13.22	13.21
Nutrient management										
N_1- 100% STBN	42899	92180	49281	1.15	352.00	44199	94919	50720	1.14	362.29
N_2-75% STBN +25% FYM	45579	95385	49806	1.09	355.76	46879	98809	51930	1.11	370.93
N_3-50% STBN +50% FYM	48274	97419	49145	1.02	351.04	49574	101340	51766	1.04	369.75
N_4-75% STBN +25% CPM	42429	108814	66385	1.56	474.18	43729	112759	69030	1.57	493.07
N_5-50% STBN +50% CPM	42024	112191	70167	1.66	501.20	43324	116030	72706	1.67	519.33
S.Em±	–	3967	3967	0.09	28.33	–	3826	3826	0.08	27.33
CD (p = 0.05)	–	12937	12937	0.29	92.41	–	12477	12477	0.27	89.12
CV (%)	–	13.58	24.13	23.44	24.13	–	12.65	22.38	21.72	22.38

remaining treatments except dry seeding on puddled soil (T_1) (₹ 1,08,064 ha^{-1} and ₹ 1,11,299 ha^{-1}). T_4 and T_1 treatments were on a par with one another. Minimum tillage (T_3) recorded significantly the lowest gross return (₹ 87,894 ha^{-1} and ₹ 91,966 ha^{-1}). This is due to higher grain and straw yields obtained under transplanted rice inturn results in increasing in gross return (Mankotia *et al*. 2009; Ashish Kumar and Jnanesha 2017 and Das *et al.* 2014). Among the nutrient management practices, the highest gross return was produced with the application 50% STBN through fertilizer with 50 % N through cured poultry manure (N_5) (₹ 1,12,191 ha^{-1} and ₹ 1,16,030 ha^{-1}) which was significantly superior to gross return obtained with the rest of the treatments, except N_4 (₹ 1,08,814 ha^{-1} and ₹ 1,12,759 ha^{-1}). N_4 treatment was followed by N_3 and these two treatments were comparable with each other. N_3, N_2 and N_1 treatments were also comparable with each other. The lowest gross return of ₹ 92,180 ha^{-1} and ₹ 94,919 ha^{-1} was reported with the 100% STBN through fertilizer (N_1). The higher grain and straw yields obtained due to the application of poultry manure along with inorganic fertilizers might have resulted in increased gross returns (Alagappan and Venkitaswamy, 2016 and Imade *et al.* 2017).

Net Return (₹ ha^{-1})

Net return was the actual profit which could be attained under particular treatments. The highest net return was recorded with conventional tillage (T_4) (₹ 62,889 ha^{-1} and ₹ 65,505 ha^{-1}) which was significantly superior to the remaining treatments except dry seeding on puddled soil (T_1) (₹ 62,773 ha^{-1} and ₹ 64,708 ha^{-1}) and these two treatments were on a par with each other. Significantly the lowest net return was recorded with T_3 treatment (₹ 45,603 ha^{-1} and ₹ 48,375 ha^{-1}). Conventional tillage (T_4) recording significantly higher net return during both the years compared to remaining treatments except dry seeding on puddled soil (T_1) could be due to savings in labour, seed cost and water inturn results in increase in net return. Lower grain and straw yields could be the reason for the lower net returns in the remaining treatment (Awan *et al.* 2007 and Ashish Kumar and Jnanesha, 2017). Within the nutrient management practices, the highest net return was recorded with N_5 treatment (₹ 70,167 ha^{-1} and ₹ 72,706 ha^{-}) which was significantly superior to rest of the treatments, except N_4 treatment. Treatment N_1 recorded the lowest net return (₹ 49,281 ha^{-1} and ₹50,720 ha^{-1}). Combined application of poultry manure and inorganic fertilizers recorded higher net returns than other treatments might be due to lower cost of production, higher grain and straw yields resulting in higher net returns (Islam *et al.* 2013 and Ashwini *et al.* 2016).

B:C ratio (%) and Profitability (₹ ha^{-1}day^{-1})

Among tillage treatments tried in the experiment T_1 and T_4 treatments recorded the higher net return resulting in higher B:C ratio and Profitability. This might be due to reasonable cost of cultivation and higher net returns. Among the nutrient management practices, N_5 treatment (1.66 and 1.67%, 501.2 and 519.3 ₹ ha^{-1}day^{-1}) which was significantly superior to rest of the treatments. Application of poultry manure along with inorganic chemical nitrogen resulted in higher gross return, net return and return per rupee investment. This might be attributed to the higher grain and straw yields recorded by the application of 50% STBN through fertilizer with 50 % N through cured poultry manure, ultimately resulting in higher economics. The application of inorganic nitrogen alone due to lower yields resulted in lower economic returns. Even though the yields in N_3 and N_2 treatments were higher cost involved in the purchase of farm yard manure reduced the net returns and B:C ratio as well (Jha *et al.* 2004, Mankotia and Shekhar 2007 and Ashwini *et al.* 2016).

CONCLUSION

The study may be concluded that conventional tillage and dry seeding on puddled soil recorded numerically higher productivity and profitability of rice during both successive years. Among Nutrient management sources, poultry manure along with inorganic nitrogen application led to productivity and profitability over recommended dose of chemical fertilizer alone. This shows the importance of poultry manure in conjunction with fertilizer under conventional tillage and dry seeding on puddled soil in improving the nutrient use efficiency of nitrogen, which would further lead to higher growth parameters, yield attributes and yield in turn resulted higher productivity and profitability.

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