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RESEARCH ARTICLE

Growth and Yield of Rice as Influenced By Methods of Establishment and Nutrient Management

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ABSTRACT

A field experiment was conducted for two consecutive years (2017 -18 and 2018-19) at the Agricultural College Farm, Naira. The experimentation was laid out in split plot design with three replications. The treatments consisted of two main plots (Wet seeded rice (Drum seeding) and transplanting method and four sub plots Viz., S1: 100% RDF (Chemical fertilizers); S2: 75% RDF+ 25% RDF through FYM; S3: 75% RDF + 25% RDF through green manure crop (Sunhemp); S4: 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (Sunhemp). Application of 75% RDF + 25% RDF through green manure crop (S3) manifested significantly superior performance in terms of growth characters of rice Viz., LAI remained on a par with the application of 100% RDF (S1). Whereas CGR, RGR and NAR was significantly highest with all three treatments S3 (2.78) 75% RDF + 25% RDF through green manure crop (sunhemp),S1 (2.61) 100% RDF (chemical fertilizers) and S2 (2.47) 75% RDF + 25% RDF through FYM. Significantly higher grain (6166 and 5586 kg ha-1) and straw yield (7157 and 7143 kg ha-1) was recorded with the application of organic sources with 25% in S3 treatment and 75 % RDF + 25% RDF through green manure crop which was at par with S1 where only (100% RDF) chemical source of fertilizers were used. The lowest grain and straw yields were recorded when nutrient applied with 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop during both the years of study.

Keywords: *Wet seeded rice, green manure crop, nutrient management.*

INTRODUCTION

Rice (*Oryza sativa* L.) an important cereal crop of India is the staple food for most of the Indians and occupies a significant position in the agricultural economy of the country. It is cultivated in an area of 43.79 M ha producing 112.91 million tons with productivity of 2.6 t ha^{-1}. Andhra Pradesh has an area of 22.6 L ha with a production of 8.18 M t and productivity of 3.8 t ha^{-1} (Directorate of economics& statistics, Ministry of Agriculture, Government of India, 2018). The productivity of rice in India is very low (2.6 t ha^{-1}) when compared to other rice growing countries.

In Andhra Pradesh, rice being one of the most important crops of coastal districts contributes 60 per cent of the state's rice production following different establishment techniques *viz*., direct dry seeding rice, transplanting, drum seeding and mechanized system of rice transplanting**.** Adoption of a particular establishment method by the farmers depends upon profitable return and labour cost. Since, high labour cost makes rice farming an unattractive enterprise, it is necessary to enhance productive performance of rice based cropping system without increasing the production cost. However, vibrant instinctiveness of cropping system results in judicious use of production

resources and nutrient management in cropping systems being more complex than individual crops. INM concept off late comprising use of dissimilar resources in the most efficient manner is gaining attention. Careful discretion in blending both organic and inorganic sources has been known to reciprocate strengthening the efficacy of both these sources resulting in higher productivity coupled with increased fertilizer use efficiency and economising the impact of costly mineral fertilizers.

Since inadequate and imbalanced fertilizers in cropping system not only results in low yields but also deteriorates soil properties, the response of rice covering 45,000 ha in North Coastal Zone of Andhra Pradesh under rain fed conditions of rice to applied fertilizers is inconsistent due to scarce moisture availability (Ramana *et al*., 2007) and number of factors have been identified as constraints for enhancing its productivity. Identifying a suitable crop stand strategy in rice based cropping system and developing a sound viable nutrient management practice was a long felt need for North Coastal Zone.

MATERIALS AND METHODS

The experiment was conducted at Agricultural College Farm, Naira with two main plot treatments with different methods of establishment in rice and four sub plot treatments comprising sources of nutrients both organic and in-organic sources. The experiment designed in Split plot with three replications during both the years of *kharif,* 2017-18 and 2018-19. The results of soil analysis indicated that the experimental soil was sandy loam in texture, slightly acidic in reaction and 0.35% in organic carbon, 229 kg ha^{-1} in available nitrogen, 29 kg ha^{-1} in available phosphorus and 268 kg ha^{-1} in potassium.

The test rice variety, Vijetha (MTU 1001) was developed at Andhra Pradesh Rice Research Institute, Maruteru of Acharya N.G. Ranga Agricultural University in the year 1995. More than 50% of area during kharif was sown with this variety in north coastal districts especially Srikakulam and Vizianagaram districts. Fresh biomass of green manure crop (sunhemp) was harvested from the adjacent field which is at 50% flowering stage. Before weighing the required quantity of sunhemp, the sunhemp samples were analysed for the percentage of N, P_2o_5 & k_2o. As per the nutrient availability the required quantity of sunhemp was weighed and chopped into pieces so as to decompose quickly in the field.

After layout of experiment and after completing the puddling operation the chopped sunhemp was spread over in the replicated plots in S_3, 75% RDF + 25% RDF through green manure crop (sunhemp) and S_4, 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp) nutrient treatments (sub plots) and trampled with the foot. Five days after trampling the green manure, rice crop was sown with drum seeder and on the same day nursery was raised for the transplanting crop in one corner of the field. 100% RDF with chemical sources was applied with 120:60: 50 kg NPK ha^{-1}, 25 % RDF was applied with 6.67 tonnes of FYM ha^{-1} and 25% of RDF was applied with 7.14 tonnes of green manure crop (sunhemp).

RESULTS AND DISCUSSION

Leaf Area Index

The data of leaf area index was not significantly influenced by crop establishment techniques during both the years of study and the same was reflected in pooled data as well. Leaf area index observed in transplanting method was on a par with wet seeded rice during both years of study and in pooled data.

LAI recorded from tillering to flowering stages, exhibited a linear and from flowering to maturity LAI it decreased due to senescence of leaves. At both the stages of crop growth the treatment supplied with 75% RDF + 25% RDF through green manure crop (sunhemp) had significant effect on LAI values which was however at par with 100% RDF (chemical fertilizers) and found significantly superior to the application of 75% RDF + 25% RDF through FYM and was the lowest LAI when 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp) was applied during both the years of study and in pooled data.

LAI varies from crop to crop and variety to variety. It also varies with the management practices besides supply of nutrients and moisture. When the crop did not suffered from any stress the LAI produced was found to be higher. Poor management practices on the other hand leads to ill growth and finally reflects on growth and yield of the crop.

LAI was significantly affected by fertilizer treatments (both organic and inorganic sources) during 2017-18. At tillering, significantly the highest values were recorded in S_1 (1.92) 100% RDF (chemical fertilizers) and S_3 (1.83) 75% RDF + 25% RDF through green

manure crop (sunhemp), which were at par and the lowest was registered in S_4 (4.30) 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp), which was again at par with S_2 (1.75) 75% RDF + 25% RDF through FYM (278.6). At flowering stage also the similar trend was observed. These results are in confirm with the findings of Sujathamma and Reddy (2004).

During the year 2018-19, the treatments S_1 and S_3 were significantly superior to S_4 and S_2, which were however at par with each other and an identical trend was reflected in pooled data. The interaction was found to be non-significant.

Crop Growth Rate (g/m2/day)

Crop growth rate was not significantly influenced by crop establishment techniques during both the years of study and the same was reflected in pooled data also. Crop growth rate observed in transplanting method was on a par with wet seeded rice during both the years of study and in pooled data. CGR recorded from tillering to PI, from PI to flowering and from flowering to harvest. From tillering to flowering the CGR was increased at increasing rate and from flowering to maturity CGR manifested a decreased trend.

CGR was significantly affected by fertilizer treatments (both organic and inorganic sources) during 2017-18. At tillering to PI, CGR was significantly highest with all three treatments S_3 (2.78) 75% RDF + 25% RDF through green manure crop (sunhemp), S_1 (2.61) 100% RDF (chemical fertilizers) and S_2 (2.47) 75% RDF + 25% RDF through FYM, which were however at par and the lowest values recorded in S_4 (2.22) 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp). Similar observations were noticed during the year 2018-19. The interaction was found to be non-significant between crop establishment techniques and fertilizer treatments.

From tillering to flowering and flowering to maturity, the nutrient requirement increased and hence, the treatment S_3 (22.4) 75% RDF + 25% RDF through green manure crop (sunhemp) and S_1 (21.13) 100% RDF (chemical fertilizers) were significantly at par however exhibited higher values over S_2 (18.7) 75% RDF + 25% RDF through FYM and S_4 (17.87) 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp). During 2018-19 similar observations were made during both the stages of crop growth and in pooled data. Negative interaction with fertilizer treatments was observed. Crop growth rate is strongly related to Leaf area index and Net assimilation ratio. Biomass production can be increased by increasing the above two crop growth parameters was also reported by Ibrahim *et al.* (2013) and Santosh Kumar et al (2021).

Relative Growth Rate (g/g/day)

Relative growth rate was not significantly influenced by crop establishment techniques during both the years of study and the same was reflected in pooled data also. Relative growth rate observed in transplanting was on a par with wet seeded rice method of establishment during both years of study and in pooled data. RGR recorded from tillering to PI and from PI to flowering displayed increasing rate, while from flowering to maturity RGR was found to decrease.

RGR was significantly affected by fertilizer treatments (both organic and inorganic sources) during 2017-18. At tillering to PI, RGR was significantly the highest with all three treatments S_1 (0.0461) 100% RDF (chemical fertilizers), S_3 (0.0460) 75% RDF + 25% RDF through green manure crop (sunhemp) and S_2 (0.0444) 75% RDF + 25% RDF through FYM, which were at par and the lowest was associated in S_4 (0.0413) 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp). Similar results were observed in the year 2018-19 and in pooled data. The interaction was found to be non-significant .

From tillering to flowering and flowering to maturity the nutrient requirement was higher and hence, treatment S_1 (0.0370) 100% RDF (chemical fertilizers) and S_3 (0.0345) 75% RDF + 25% RDF through green manure crop (sunhemp) were significantly at par displaying higher values over S_2 (0.0330) receiving 75% RDF + 25% RDF through FYM and S_4 (0.0324) 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp). During 2018-19 the similar results were revealed during both the stages of crop growth and in pooled data. Interaction with fertilizer treatments was found non- significant.

Net Assimilation Rate (g/day/m^2)

Net assimilation rate was not significantly influenced by crop establishment techniques during both the years of study and the same was reflected in pooled data also. Net assimilation rate observed in

transplanting was on a par with wet seeded rice during both years of study and in pooled data. NAR was recorded from tillering to PI, from PI to flowering and from flowering to harvest. From tillering to flowering the NAR was increased at increasing rate and from flowering to maturity NAR was decreased.

NAR was significantly affected by fertilizer treatments (both organic and inorganic sources) during 2017-18 at tillering to PI. NAR was significantly the highest with all three treatments S_1 (0.0351) 100% RDF (chemical fertilizers), S_3 (0.0343) 75% RDF + 25% RDF through green manure crop (sunhemp) and S_2 (0.0331) 75% RDF + 25% RDF through FYM which were atpar and lowest was recorded in S_4 (0.0329) 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp). During the year 2018-19 all the treatments were at par with each other and the same trend was reflected in pooled data. The interaction was found to be non-significant. From tillering to flowering the nutrient requirement is more and the nutrients from organic sources will also release at that time and hence all the four treatments were significantly at par with each other. Increase in yield was observed in the treatment where efficient utilization and conversion of resources into assimilates was also reported by Singh *et al.* (2014). During 2018-19 the trend was same in both the stages of crop growth and in pooled data. Interaction with fertilizer treatments was not observed.

Chlorophyll Content (SCMR)

SCMR at different growth stages of rice was influenced by Fertilizer treatments (Organic and in-organic sources) but not by the crop establishment methods of rice. The interaction was also found to be non significant during years of 2017-18 and 2018-19 and in pooled data.

Fertilizer treatments comprising both organic and inorganic sources applied at 30 DAS did not display any significant difference. At 60 and 90 DAS the data revealed that application of 75% RDF + 25% RDF through green manure crop (sunhemp) had significant effect on SCMR values, which was at par with 100% RDF (chemical fertilizers) and found significantly superior to application of 75% RDF + 25% RDF through FYM and the lowest SCMR was observed when 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp) was applied during both the years of study and in pooled data. At 30 DAS, similar results manifested by all the fertilizer treatments might be due to application of basal dose of fertilizers uniformly to all the treatments.

This indicated that supply of higher proportion of nitrogen at early growth stages enhanced the SCMR and also increased the size and number of green leaves associated with these timings of nitrogen application. It also revealed the fact that the SCMR based application was able to meet the real time nitrogen demand of the crop. Uniform supply of nitrogen is possible throughout the crop growth period as compared to the other timings of nitrogen application. The findings corroborate the results reported by Marquard and Tipton (1987). Besides, chlorophyll content in a leaf is closely correlated with leaf N concentration (Evans, 1983 and Blackmer and Schepers, 1994). Also observed a significant and positive relation between flag leaf N content as well as rice grain yield and SPAD values at different growth stages was in accordance with Ramesh *et al.* (2002).

Grain Yield (kg ha^{-1})

Grain yield of rice during *kharif* was unaffected by different crop establishment techniques during both the years of study and the same was reflected in pooled data also. Similar observations were also made by Ali *et al.* (2006). The grain yield of rice during *kharif* was significantly influenced by different fertilizer treatments applied to rice during both the years of study. The interaction effect of crop establishment techniques and fertilizer treatments of rice failed to influence the grain yield of rice during both the years of study.

Fertilizer treatments receiving both organic and inorganic sources were found to display considerable influence on grain yield. Significantly higher grain yield was recorded with the application of organic sources with 25% in S_3 treatment (6166) 75% RDF + 25% RDF through green manure crop (sunhemp), which was however at par with S_1 (5926) 100% RDF (chemical fertilizers), where only chemical source of fertilizers were used and S_2 (5683) 75% RDF + 25% RDF through FYM (278.6). This is in conformity with the findings of Gour *et al.* (2015) and Singh *et al.* (2019).

Both the treatments S_2 and S_3 where 25% of organic sources was used supplied sufficient amount of nutrients along with 75% chemical fertilizers, which were significantly at par with 100% RDF was also

repoted by Singh *et al*. (2009) and Aruna *et al*. (2012). The lowest grain yield were observed when applied with 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp) (5421) was applied during both the years of study and in pooled data.

Both growth and yield parameters manifested great influence on yield of the crop and in turn depended on the nutrient availability of the crop. All the above said parameters were significantly superior over S_4 treatment. But, this treatment will have immense effect on the succeeding rice fallow crops in supplying residual nutrients and moisture. The reason might be due to release of aliphatic and aromatic hydroxyl acids, humates and lignin that also act as nutrient reservoir. The absorbed ions released gradually during the entire growth period of crop resulted in higher yields. Similar results were also reported by Kumar and Yadav (2008).

Greater availability of nutrients and metabolites for growth and development of reproductive structures ultimately led to realization of higher productivity of individual plant. The increased availability of nutrients and photosynthates might have enhanced the yield attributes as reported by many workers Parihar *et al*. (2015), Kumar *et al*. (2016), Trivedi *et al*. (2016), Kandeshwari and Thavaprakash (2016), Premalatha and Angadi (2017), Singh and Singh (2018) and Ashim midya et al (2021).

Straw Yield (kg ha^{-1})

Straw yield of rice during *kharif* was unaffected by different crop establishment techniques during both the years of study and the same was reflected in pooled data also.

The straw yield of rice during *kharif* was significantly influenced by different fertilizer treatments applied to rice during both the years of study. The interaction effect of crop establishment techniques and fertilizer treatments of rice failed to influence the grain yield of rice during both the years of study.

During *kharif* 2017-18, Fertilizer treatments receiving both organic and inorganic sources were found to show considerable influence on straw yield. Significantly higher straw yield was recorded with the application of organic sources with 25% in S_3 treatment (7157) 75% RDF + 25% RDF through green manure crop (sunhemp), which was at par with S_1 (6999) 100% RDF (chemical fertilizers) where only chemical source of fertilizers were used as opined by Singh *et al*., (2009). The lowest straw yield was observed when applied with 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp) (6574) which is at par with S_2 (6688). The similar findings were observed in pooled data.

During *kharif* 2018-19 fertilizer treatments with both organic and inorganic sources were found to show considerable influence on straw yield. Significantly higher straw yield was recorded with the application of organic sources with 25% in S_3 treatment (7143) 75% RDF + 25% RDF through green manure crop (sunhemp), which was however at par with S_1 (9852) 100% RDF (chemical fertilizers) where only chemical source of fertilizers were used and S_2 (6760) 75% RDF + 25% RDF through FYM (278.6). In both these two treatments S_2 and S_3 where 25% of organic sources were used supplied sufficient amount of nutrients along with 75% chemical fertilizers but were significantly at par with 100% RDF owing to the availability of essential plant nutrients. Similar results were reported by Tamrabet *et al*. (2009). The lowest straw yield was observed when 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop sunhemp (6418).

The application of organic sources in combination with inorganic sources significantly affected the straw yields of rice due to their positive influence on growth and yield attributes. Pandey *et al.* (2009) observed an increased efficiency of inorganic N fertilizer, when it was applied along with organic manures and brought a beneficial effect on rice straw yield. These results are in conformity with the galaxy of researchers such as Sharma *et al*. (2015), Kumar *et al*. (2016), Chouhan *et al*. (2016), Malik and Singh (2016), Trivedi *et al*. (2016), Sireesha (2017), Singh and Singh (2018) and Nagrjuna et al (2021).

Harvest Index (%)

There was no significant difference observed by crop establishment methods and influence of fertilizer treatments during 2017-18 and 2018-19 and in pooled data. Interaction with fertilizer treatments was also non significant.

These results are in conformity with the findings of Murthy *et al*. (2015), Pal *et al*. (2016), Sahare and Babalad (2016) and Siddaram *et al*. (2011).

Leaf area index, Crop growth rate (g/m2/day), Relative growth rate (g/g/day), Net assimilation rate (g/day/m2) at different growth stages of rice as influenced by crop stand establishment and nutrient management

Treatments	LAI Pooled data		CGR Pooled data			RGR Pooled data			NAR Pooled data		
	Tillering	Flowering	Tillering to PI	PI to Flowering	Flowering to Maturity	Tillering to PI	PI to Flowering	Flowering to Maturity	Tillering to PI	PI to Flowering	Flowering to Maturity
***kharif* : Rice**											
M_1	1.81	4.59	2.35	19.48	8.11	0.0456	0.0338	0.0070	0.0339	0.0353	0.0086
M_2	1.76	4.51	2.67	20.65	8.51	0.0440	0.0337	0.0076	0.0337	0.0357	0.0086
SEm ±	0.039	0.090	0.08	0.34	0.16	0.001	0.001	0.0001	0.001	0.001	0.0001
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	7.52	6.83	11.91	5.81	6.57	9.89	6.79	7.66	10.37	6.61	6.54
Fertilizer treatments (Organic and in-organic sources)											
S_1	1.92	4.72	2.60	21.10	8.54	0.0464	0.0359	0.0080	0.0347	0.0363	0.0088
S_2	1.74	4.37	2.45	18.86	8.04	0.0444	0.0325	0.0069	0.0331	0.0351	0.0084
S_3	1.83	4.83	2.77	22.43	9.15	0.0465	0.0348	0.0078	0.0343	0.0360	0.0090
S_4	1.66	4.28	2.21	17.85	7.51	0.0419	0.0319	0.0066	0.0329	0.0346	0.0082
SEm ±	0.04	0.10	0.10	0.42	0.17	0.001	0.001	0.0001	0.001	0.001	0.0001
CD (P=0.05)	0.13	0.31	0.32	1.30	0.54	0.003	0.002	0.001	0.002	0.003	NS
CV (%)	5.94	5.45	10.07	5.18	5.17	5.01	5.70	9.06	5.24	5.14	3.58
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Chlorophyll content (SCMR), Grain yield (kg ha-1), straw yield (kg ha-1) and harvest index (%) at different growth stages of rice as influenced by crop stand establishment and nutrient management

Treatments	Chlorophyll content (SCMR) Polled data			Grain yield Pooled data	Straw yield Pooled data	Harvest Index Pooled data
	30 DAT	60 DAT	90 DAT			
***kharif* : Rice**						
M_1	31.20	35.97	38.54	5421	6684	45.33
M_2	32.97	35.80	39.27	5768	6964	46.01
SEm ±	0.63	0.75	1.31	173.44	202.86	0.82
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	6.86	7.24	11.66	10.73	10.21	6.22
Fertilizer treatments (Organic and in-organic sources)						
S_1	32.43	37.30	39.91	5726	6926	46.00
S_2	31.77	35.55	37.53	5521	6724	45.67
S_3	32.59	38.17	43.00	5876	7150	46.06
S_4	31.56	32.53	35.19	5256	6496	44.96
SEm ±	0.71	0.86	1.12	121.19	150.16	0.85
CD (P=0.05)	NS	2.65	3.45	373.44	458.26	NS
CV (%)	5.48	5.88	7.06	5.30	5.26	4.58
Interaction	NS	NS	NS	NS	NS	NS

CONCLUSION

Growth parameters *viz*., LAI recorded from tillering to flowering stages, exhibited a linear and from flowering to maturity LAI it decreased due to senescence of leaves. At both the stages of crop growth the treatment supplied with 75% RDF + 25% RDF through green manure crop (sunhemp) had significant effect on LAI values which was however at par with 100% RDF (chemical fertilizers) and found significantly superior to the application of 75% RDF + 25% RDF through FYM and was the lowest LAI when 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp) was applied during both the years of study and in pooled data.

CGR, RGR and NAR were significantly affected by fertilizer treatments (both organic and inorganic sources) during 2017-18. At tillering to PI, CGR was significantly highest with all three treatments S_3 (2.78) 75% RDF + 25% RDF through green manure crop (sunhemp), S_1 (2.61) 100% RDF (chemical fertilizers) and S_2 (2.47) 75% RDF + 25% RDF through FYM, which were however at par and the lowest values recorded in S_4 (2.22) 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp).

SPAD chlorophyll meter readings At 60 and 90 DAS data revealed that application of 75% RDF + 25% RDF through green manure crop (sunhemp) had significant effect on SCMR values, which was at par with 100% RDF (chemical fertilizers) and found significantly superior to application of 75% RDF + 25% RDF through FYM and the lowest SCMR was observed when 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop (sunhemp) was applied during both the years of study and in pooled data. At 30 DAS, similar results manifested by all the fertilizer treatments might be due to application of basal dose of fertilizers uniformly to all the treatments.

Significantly higher grain (6166 and 5586 kg ha^{-1}) and straw yield (7157 and 7143 kg ha^{-1}) was recorded with the application of organic sources with 25% in S_3 treatment and 75 % RDF + 25% RDF through green manure crop which was at par with S_1 where only (100% RDF) chemical source of fertilizers were used. The lowest grain and straw yields were recorded when nutrient applied with 50% RDF + 25% RDF through FYM + 25% RDF through green manure crop during both the years of study.

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