The Andhra Agric. J 67 Spl: (IARD-2020): 1-6

Drymatter and Yield of Rice - Ragi Sequence as Influenced by Nutrient Management Interventions

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ABSTRACT

A field experiment entitled "Nutrient Management Interventions in Rice- Ragi Sequence" was conducted during *kharif* and *rabi* seasons of 2017-18 and 2018-19 on sandy loam soil of the Agricultural College Farm, Bapatla. The seven treatments consisted of T_1 : 100% RDF (100-60-40 kg N-P-K ha^{-1}) ; T_2: 100% RDF+ Soil application of $ZnSO_4$ @ 50 kg ha^{-1} ; T_3: 125% RDF+ Soil application of $ZnSO_4$ @ 50 kg ha^{-1}; T_4: 75% RDF+ Poultry manure @ 0.82 t ha^{-1} + Soil application of $ZnSO_4$ @ 50 kg ha^{-1}; T_5: 75% RDF+ FYM @ 5.0 t ha^{-1} + Soil application of $ZnSO_4$@ 50 kg ha^{-1}; T_6: 50% RDF+ Poultry manure @1.6 t ha^{-1}+ Soil application of $ZnSO_4$@ 50kg ha^{-1} and T_7: 50% RDF+ FYM @ 10 t ha^{-1}+ Soil application of $ZnSO_4$@ 50 kg ha^{-1}. The experiment was laid out in Randomized Block Design with seven treatments and replicated thrice during *kharif* rice and in *rabi* each *kharif* treatment was sub divided into four sub treatments (S_1:no fertilizer, S_2: 100% RDF, S_3: 75% RDF and S_4: 50% RDF) and hence, split plot design was adopted in *rabi*. Total number of plots per replication in the *rabi* was 28 (7x4= 28). Among all the *kharif* treatments, T_7 recorded the maximum drymatter (12183, 12538 and 12360 kg ha^{-1}) and grain yield (5343, 5465 and 5404 kg ha^{-1}) in rice. While during *rabi*, the treatment S_2: 100% RDF recorded the maximum drymatter (5434, 5417 and 5425 kg ha^{-1}) and grain yield (1935, 2038 and 1986 kg ha^{-1}) of ragi during both the years of study.

Keywords: *Drymatter, Grain yield, Nutrient Management Interventions, Rice- Ragi sequence.*

Rice (*Oryza sativa* L.) is the most important cereal crop in the world and is the staple food of over half the world's population. It is generally considered as semi-aquatic annual grass. Finger millet (*Eleusine coracana. L.*) is an important dryland millet crop and ranks third in importance among millets in India, after sorghum and pearlmillet. Ragi being a C_4 plant, has higher productivity among the small millets and is a supplemental food for diabetic patients instead of regular food as it can reduce sugar levels in blood and urine because it has low glycemic index. Excess use of fertilizer nutrients implies increase of cost and decrease of returns and risk of environmental pollution. Application of inadequate and unbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health. Soil organic matter is the key to soil fertility and productivity. The beneficial influence of organic matter on the physical, chemical and biological properties of the soil is well known, the full appreciation of the same remains, which is unfortunately ignored in modern agriculture. The regular recycling of organic wastes in the soil is the most efficient method of maintaining optimum levels of soil organic matter. In the conventional agriculture, which is followed over generations in India, the use of plant and animal wastes as a source of plant nutrients is a well known practice. The importance and aim of organic manures and green manure crops have failed to be recognized in modern agriculture.

MATERIAL AND METHODS

The present investigation was conducted at Agricultural College Farm, Bapatla. It is located in coastal region of Krishna Agroclimatic Zone of Andhra Pradesh. The soil was sandy loam in texture, slightly alkaline in reaction, low in organic carbon, available nitrogen and available phosphorus but medium in available potassium. The trial was laid out in a Randomized block design with seven treatments in *kharif* rice and in *rabi* it was modified to split plot design replicated thrice. The seven treatments consisted of T_1 : 100% RDF (100-60-40 kg N-P-K ha^{-1}) ; T_2: 100% RDF+ Soil application of $ZnSO_4$ @ 50 kg ha^{-1} ; T_3: 125% RDF+ Soil application of $ZnSO_4$ @ 50 kg ha^{-1}; T_4: 75% RDF+ Poultry manure @ 0.82 t ha^{-1} + Soil application of $ZnSO_4$ @ 50 kg ha^{-1}; T_5: 75% RDF+ FYM @ 5.0 t ha^{-1} + Soil application of $ZnSO_4$ @ 50 kg ha^{-1}; T_6: 50% RDF+ Poultry manure @1.6 t ha^{-1}+ Soil application of $ZnSO_4$ @ 50kg ha^{-1} and T_7: 50% RDF+ FYM @ 10 t ha^{-1}+ Soil application of $ZnSO_4$ @ 50 kg ha^{-1}. In *rabi* each *kharif* treatment was divided into four sub treatments (S_1:no fertilizer, S_2: 100% RDF, S_3: 75% RDF and S_4: 50% RDF) and the design was changed to split plot design. For drymatter accumulation, five successive plants were sampled at 30, 60, 90 DAT and at harvest in rice and 30, 60, 90 DAS and at harvest in ragi. The mean dry weight was multiplied by number of plants ha^{-1} and expressed in kg ha^{-1}. For grain yield recording, cleaning of the threshed grain was done and then dried in sun to a constant weight in order to record final yield. Grain yield from the labelled hills were also added to the corresponding plot yields before expressing the final grain yield in kg ha^{-1}. Straw yield from the net plot of each treatment was dried in Sun to a constant weight. The data was analyzed by adopting Panse and Sukhatme (1978) standard procedures.

RESULTS AND DISCUSSION

Drymatter Production

Data on drymatter production at different growth stages of rice and ragi crop are presented in table 1 & 2. At 30 DAT of rice and 30 DAS of ragi drymatter production was low, but as the crop growth advanced, it increased linearly upto maturity and thereafter exhibited with decreasing rate. However, at harvest it was maximum in both the crops during the two years of study. Application of 50 % RDF + FYM @ 10 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} recorded the highest drymatter production consistently at 30 DAT, 60 DAT, 90 DAT and at harvest stages of *kharif* rice but it was statistically on par with T_3 *i.e.*, 125% RDF. In *rabi* ragi, the residual fertility and fertiliser levels had a significant influence on the drymatter production. Among the fertilizer levels S_2 (100% RDF) recorded significantly the highest drymatter production of ragi in both the years of study and in pooled data. The increase in drymatter production under INM practices could be attributed to uninterrupted supply of available nutrients from inorganic and organic sources through mineralization and decomposition process, it implies a stimulatory effect of organic manures application in conjunction with chemical fertilizer on drymatter production capacity of rice. The increase in drymatter production in all the growth stages with T_7 treatment might be due to addition of organic manure along with inorganic fertilizers, which was responsible for slow release of nutrients. These are available for longer period throughout the life span of the crop. These also might have enhanced the photosynthetically important physiological traits *i.e.* leaf number and vegetative growth of the plant. The higher drymatter production recorded in ragi might be due to the combination of inorganic and organic sources of nutrients as residual effect which might also had synergistic and additive effect on drymatter production. However, adequate supply of chemical fertilizers in *rabi* accelerated the growth of ragi which may have increased the fertilizer use efficiency of the crop as well as soil fertility by promoting soil microbial activities in narrowing down the C: N ratio. These nutrient dynamics inturn might have resulted in longer duration of availability of the nutrients throughout the crop growth period. These results are in agreement with those findings of Pradhan and Moharana, (2015), Kandeshwari and Thavaprakash, (2016), Regar and Yadav, (2017), Neelam *et al.* (2009) and Kumar *et al.* (2017)

Grain and Straw Yield

Significantly the highest grain yield (5343 kg ha^{-1}) was recorded with 50% recommended dose of inorganic fertilizers + FYM 10 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} (T_7) over the other treatments. However, it was found statistically on par with 125 % RDF + $ZnSO_4$ @ 50 kg ha^{-1} i.e. T_3 (4881 kg ha^{-1}) which was significantly superior to the remaining treatments during the first year of study. In the second year also, significantly the highest grain yield was recorded with T_7 (50% RDF+ FYM 10 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1}) i.e., 5465 kg ha^{-1}. This treatment was followed by T_3 (125% RDF + $ZnSO_4$ @ 50 kg ha^{-1}) i.e. 5021 kg ha^{-1}. Significantly the highest straw yield (6089 kg ha^{-1}) was recorded with the application of 50% RDF+ FYM 10 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} (T_7) followed by T_3 (125% RDF + $ZnSO_4$ @ 50 kg ha^{-1}) i.e. 5696 kg ha^{-1} in the first year of study. In the second year of study also almost similar trend was noticed.

Grain yield of no till ragi under residual effect, distinctintly the highest grain yield of ragi with T_7 (1823 kg ha^{-1}), which was followed by T_6 (1735 kg ha^{-1}). The treatment T_4 and T_5 was on par with each other. The treatments $T_{1,}$ T_2 and T_3 were also on par with each other. In the second year of experimentation, the highest grain yield of ragi was recorded with T_7 (1880 kg ha^{-1}), which was statistically on par with T_6 (1857 kg ha^{-1}) and it was superior to other treatments as indicated in pooled data.

Among the different fertilizer levels tried in ragi, S_2 (1935 kg ha^{-1}) recorded significantly the highest grain yield. This was followed by S_3 (1647 kg ha^{-1}). The treatment, S_3 (1647 kg ha^{-1}) was found to be superior to S_4 (1583 kg ha^{-1}) and S_1 (1393 kg ha^{-1}) which received 50 % RDF and No fertilizer, respectively.

The data pertaining to straw yield under no till ragi maintained significantly the highest straw yield of ragi was recorded with T_7 (2760 kg ha^{-1}), which was followed by T_5 (2517 kg ha^{-1}). The treatments T_6 and T_5 remained on par with each other. Treatments T_4 (2438 kg ha^{-1}), T_3 (2426 kg ha^{-1}) and T_2 (2340 kg ha^{-1}) remained statistically identical with one another. Similar trend was noticed in the second year of experimentation. The pooled data confirmed the same trend.

Among the different fertilizer levels tried in ragi, treatment S_2 (3030 kg ha^{-1}) recorded significantly the highest straw yield and this was followed by S_3 (2385 kg ha^{-1}). The treatments S_3 and S_4 (2392 kg ha^{-1}) remained statistically on par with one another, which

Table 1. Drymatter production (kg ha^{-1}) at different stages of *kharif* rice as influenced by nutrient management interventions

Treatment	2017				2018				Pooled data			
	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest
T_1:100% RDF	1019	3024	6632	8884	1052	3143	6738	9742	1036	3083	6685	9313
T_2 : 100% RDF+ $ZnSO_4$ @ 50 kg ha^{-1}	1215	3948	6999	9277	1343	3941	7119	9886	1279	3944	7059	9581
T_3 : 125% RDF+ $ZnSO_4$ @ 50 kg ha^{-1}	1646	4789	7951	11135	1734	5005	8074	11580	1690	4897	8012	11357
T_4: 75% RDF+ PM @ 0.82 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1}	1313	4093	6916	9558	1490	4263	7172	10086	1401	4178	7044	9822
T_5: 75% RDF+ FYM @ 5.0 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1}	1402	4414	7097	9800	1594	4516	7306	10438	1498	4465	7201	10119
T_6 : 50% RDF+ PM @1.6 t ha^{-1}+ $ZnSO_4$ @ 50kg ha^{-1}	1328	4461	7042	9842	1565	4674	7296	10594	1447	4567	7169	10218
T_7: 50% RDF+ FYM @ 10 t ha^{-1}+ $ZnSO_4$ @ 50 kg ha^{-1}	1883	5074	8549	12183	2027	5332	8829	12538	1955	5203	8689	12360
S.Em ±	146.6	124.7	221.7	249.42	329.1	107	226	258.7	130.7	115.8	223.9	254
CD (P=0.05)	439.3	373.7	664.7	747.7	986.7	320.7	677.6	775.7	391.7	347.2	671.1	761.2
CV (%)	12.2	6.5	6.7	6.1	8.9	5.4	6.7	5.4	14.3	5.9	6.7	5.7

Table 2. Drymatter production (kg ha^{-1}) at different stages of no till *rabi* ragi as influenced by nutrient management interventions

Reatment	2017-18				2018-19				Pooled data			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Residual effect of nutrient interventions imposed to *kharif* rice												
T_1	775	1542	3109	4240	876	1663	3277	4796	825	1602	3193	4518
T_2	810	1636	3231	4293	894	1789	3536	4804	852	1712	3383	4548
T_3	842	1697	3382	4402	939	1872	3632	4900	890	1784	3507	4651
T_4	839	1710	3513	4513	938	1852	3629	4897	888	1781	3571	4705
T_5	849	1785	3802	4543	969	1940	3735	5003	926	1862	3768	4773
T_6	874	1794	3740	4744	964	1891	3741	5009	919	1842	3740	4876
T_7	883	1895	3846	5154	1033	2020	3877	5145	941	1957	3861	5149
SEm ±	11.1	25.8	49.95	59.145	14.14	30.11	60.07	84.648	12.61	27.95	55.01	71.89
CD (p=0.05)	34.3	79.6	153.9	182.24	43.55	92.78	185.1	260.82	38.9	86.19	169.4	221.5
CV (%)	8	7.5	7.6	8.6	6.9	8.6	9.2	10.3	7.4	8	8.4	9.4
Fertilizer doses applied to ragi												
S_1	753	1516	3081	3860	855	1675	3177	4538	804	1595	3129	4199
S_2	1001	2014	4036	5434	1084	2112	4099	5417	1042	2063	4067	5425
S_3	844	1705	3548	4500	939	1861	3693	4961	891	1783	3620	4730
S_4	814	1656	3406	4429	901	1796	3561	4829	857	1726	3483	4629
SEm ±	10.7	21.19	40.24	74.53	10.58	21.31	38.84	50.84	10.64	21.24	39.54	62.6
CD (p=0.05)	30.5	62.6	114.8	212.72	30.2	60.82	110.9	145.11	30.34	61.7	112.83	178.9
CV (%)	8	9.2	6.2	8.6	8.1	8.3	5.8	7.9	8.05	8.75	6	8.2
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note:

T_1:100% RDF
T_2: 100% RDF+ $ZnSO_4$ @ 50 kg ha^{-1}
T_3 : 125% RDF+ $ZnSO_4$ @ 50 kg ha^{-1}
T_4: 75% RDF+ PM @ 0.82 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1}
T_5: 75% RDF+ FYM @ 5.0 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1}
T_6 : 50% RDF+ PM @1.6 t ha^{-1}+ $ZnSO_4$ @ 50kg ha^{-1}
T_7: 50% RDF+ FYM @ 10 t ha^{-1}+ $ZnSO_4$ @ 50 kg ha^{-1}

S_1: No fertilizer;
S_2: 100 % RDF (30-30-20 kg NPK ha^{-1}),
S_3: 75 % RDF;
S_4: 50 % RD

Table 3. Grain and straw yields (kg ha^{-1}) of *kharif* rice as influenced by nutrient management interventions

Treatment	Grain Yield			Straw Yield		
	2017	2018	Pooled data	2017	2018	Pooled data
T_1:100% RDF (100-60-40 kg NPK ha^{-1})	4036	4165	4100	4506	5112	4809
T_2 : 100% RDF+ $ZnSO_4$ @ 50 kg ha^{-1}	4162	4299	4230	4671	5115	4893
T_3 : 125% RDF+ $ZnSO_4$ @ 50 kg ha^{-1}	4881	5021	4951	5696	6007	5851
T_4: 75% RDF+ PM @ 0.82 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1}	4253	4416	4334	4820	5190	5005
T_5: 75% RDF+ FYM @ 5.0 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1}	4319	4500	4409	4988	5441	5214
T_6 : 50% RDF+ PM @1.6 t ha^{-1}+ $ZnSO_4$ @ 50kg ha^{-1}	4360	4595	4477	4926	5494	5210
T_7: 50% RDF+ FYM @ 10 t ha^{-1}+ $ZnSO_4$ @ 50 kg ha^{-1}	5343	5465	5404	6089	6476	6282
S.Em ±	173.1	118.9	146	163.8	145.9	154.8
CD (P=0.05)	519	356.8	437.9	490.2	437.5	463.8
CV (%)	8.6	10.4	9.5	7.7	8.2	7.9

Table 4. Grain and straw yields of *rabi* ragi as influenced bynutreint management interventions

Treatment	Grain yield		Pooled data	Straw yield		Pooled data
	2017-18	2018-19		2017-18	2018-19	
Residual effect of nutrient interventions imposed to *kharif* rice						
T_1:100% RDF	1529	1594	1561	2205	2465	2335
T_2 : 100% RDF+ $ZnSO_4$ @ 50 kg ha^{-1}	1542	1684	1613	2340	2617	2478
T_3 :125% RDF+ $ZnSO_4$ @ 50 kg ha^{-1}	1573	1639	1606	2426	2571	2498
T_4: 75% RDF+ PM @ 0.82 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1}	1625	1711	1668	2438	2645	2541
T_5: 75% RDF+ FYM @ 5.0 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1}	1650	1765	1707	2517	2691	2604
T_6 : 50% RDF+ PM @1.6 t ha^{-1}+ $ZnSO_4$@ 50kg ha^{-1}	1735	1857	1796	2616	2801	2708
T_7: 50% RDF+ FYM @ 10 t ha^{-1}+ $ZnSO_4$ @ 50 kg ha^{-1}	1823	1880	1851	2760	2995	2877
S.Em ±	22.9	23.3	23.1	55.3	57.9	56.6
CD (P=0.05)	70.5	71.8	71.1	170.7	178.4	174.5
CV (%)	8.4	6.7	7.5	7.6	7.4	7.5
Fertilizer doses applied to ragi						
S_1: No Fertilizer	1393	1451	1422	2080	2236	2158
S_2 : 100 % RDF (30-30-20 Kg NPK ha^{-1})	1935	2038	1986	3030	3212	3121
S_3: 75 % RDF	1647	1751	1699	2385	2637	2511
S_4: 50 % RDF	1583	1692	1637	2392	2649	2520
S.Em ±	17.3	19.1	18.2	49.4	60.7	55.05
CD (P=0.05)	49.3	54.4	51.8	141.1	173.3	157.2
CV (%)	12.3	11.1	11.7	9.1	10.3	9.7
Interaction	NS	NS	NS	NS	NS	NS

received 75 % RDF and 50% RDF respectively. Lower straw yield was recorded with S_1 (2080 kg ha^{-1}). Similar trends were observed in the second year of experimentation as well as in pooled data as that was reflected in first year of investigation.

Combined application of organics and inorganics leads to improved overall growth of the crop interms of drymatter production, morphological and photosynthetic components along with nutrient accumulation. This shows greater availability of nutrients and metabolites for growth and development of reproductive structures, which ultimately might have led to realization of higher productivity of individual plant. The highest grain and straw yields in both crops during both the years might be due to improvement in yield attributing characters *i.e.* number of productive tillers, test weight and number of filled grains per panicle.

These results are in complete agreement with the findings of Jadhav *et al*. (2014), Parihar *et al*. (2015), Kumar *et al*. (2016), Premalatha and Angadi (2017) and Singh and Singh (2018), Apoorva *et al* (2010), Ahiwale *et al*.(2013), and Kumar *et al*. (2017) who reported similar findings.

CONCLUSION

Overall, it can be concluded that the highest drymatter, grain and straw yields of rice was recorded with the application of 50 % RDF + FYM 10 t ha^{-1} along with 50 kg zinc sulphate per hectare as soil application and in *rabi* no till ragi, the same treatment recorded maximum drymatter, grain and straw yields as residual effect and in fertilizer levels, 100 % RDF recoded significantly the highest grain and straw yields.

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