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Balanced Fertilization in Rice-maize Cropping System to Enhance Productivity, Economics and Soil Fertility Status in North Coastal Zone, Andhra Pradesh

M. M. V. Srinivasa Rao [a*], D. Nagarjuna [a], K. Tejeswar Rao [a], M. Srinivas [b], T. S. S. K. Patro [a] and N. Ravisankar [c]

[a] *AICRP on Integrated Farming Systems, Acharya N. G. Ranga Agricultural University, Agricultural Research Station, Vizianagram-535 001, Andhra Pradesh, India.*
[b] *Regional Agricultural Research Station, Maruteru, Andhra Pradesh, India.*
[c] *ICAR-Indian Institute of Farming System Research, Modipuram, Meerut-250 110, Uttar Pradesh, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted in 24 farmers fields during both kharif, rabi seasons in two successive years i.e., 2017-18 and 2018-19 in Vizianagaram district, Andhra Pradesh to demonstrate the importance of optimal fertilizers schedule in rice-maize cropping system. The seven treatments consist of control, N, NP, NK, NPK, NPK+ $ZnSO_4$ and farmer practice. The results revealed that yield and yield components showing significantly higher with optimal fertilizers schedule of NPK (80-60-50 kg ha^{-1}) along with $ZnSO_4$ (50 $kgha^{-1}$) to rice and recommended dose of NPK (200-80-80 kg ha^{-1}) to maize. NPK+Zn combination in Rice-Maize cropping sequence noticed statistically superior higher mean grain yield (5338kg ha^{-1} and 7286kg ha^{-1}) and straw yield (7335kg ha^{-1} and 9065kg ha^{-1}) during both kharif and rabi seasons. Highest Rice equivalent yield(8814kg ha^{-1}), higher gross returns (Rs 1,13,173 ha^{-1}) and net returns (Rs 75,647 ha^{-1}) is fallowed same trend with balanced nutrition during both the years of study. Higher sustainable yield index (0.81) and system productivity per day (55.50 kg $ha^{-1}day^{-1}$) were noticed with recommended dose of NPK+ $ZnSO_4$ besides enhanced soil fertility.

**Corresponding author: E-mail: drsamuelpatro@gmail.com, mmv.sinivasarao@angrau.ac.in, mmvsrangrau@gmail.com;*

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1. INTRODUCTION

Rice-maize is a predominant cropping sequence cultivating in an extent of 5.21 lakh hectares in Andhra Pradesh state under irrigating under bore wells situation. In earlier decades grain yields are being improved in rice and maize with the introduction of new plant genotypes and synthetic fertilizer use. Since green revolution, Indian cereal production increased by 5 folds where as fertilizer consumption increased by 322 folds, it indicates low fertilizer use efficiency [1]. In cereal-based cropping systems, soil carbon and NPK stocks are lost in substantial amounts. An estimated 10Mt of NPK deficit in the soils is required to meet the annual need of 30Mt.

Significant response of N fertilizers coupled with subsidized availability forced to over exploitation of N in cereals and meager application of P, K and Zn leads to imbalanced usage of nutrients. This imbalance fertilization resulted in decreasing factor productivity with 6 kg response ratio is another alarming situation. Further, over draft of secondary and micro nutrients from soil are not redepositing to the soil system back. In post green revolution era continuous cultivation of crops resulted in micro and macro nutrient deficiencies is the major problem poses system unsustainable [2]. “In rice-based cropping systems, deficiency of Zn is very common due to no or less quantity use of Zn fertilizer” [3]. In view of the above, an on farm study was carried out in farmer’s fields to quantify the productivity and profitability in Rice-Maize cropping system with set of nutrient combination treatments in two consecutive years.

2. MATERIALS AND METHODS

During *kharif* and *rabi* seasons of 2017-18 and 2018-19 farmers participatory experiments were carried out in farmers fields of Saluru (Mettavalasa, Regapuvalasa and Gangannadoravalasa Villages) and Makkuva (Chimidivalaasa, Kodipeddavalasa and Yerrasamanthalavalasa Villages) mandals of the Vizianagaram district, situated in North Coastal Zone of East Coast Planis and Hills of Andhra Pradesh. To execute the experiment in each village four farmers were identified likewise 24 farmer’s fields identified in six villages. The soils are sandy clay loams and slightly alkaline reaction with pH of 7.09 and Neutral (EC-0.18dS/m) in nature. Soils are medium in organic carbon (0.54%), low in available N (175 kg ha^{-1}), high in available P (25.25 kg ha^{-1}) and high in available K (322.77 kg ha^{-1}).

Seven treatments were designed for the experiment *viz*., control (no fertilizer), recommended N, NP, NK, NPK, NPK+$ZnSO_4$ and farmer’s practice. On an average farmers applying NPK at 75:47:40 kg ha^{-1} in case of Rice and 157:73:54 kg ha^{-1} in case of Maize .Gross and net plot areas were $10m^2$× 10 m^2 and $9m^2$ × $9m^2$. The data analyzed in RBD with each village as one replication consists of average four farmers in that village. In rice popular variety MTU-1121 (Medium duration) and in maize popular hybrid Kaveri Bumper (Medium Duration) were grown during *kharif* and *rabi* respectively. Recommended dose of fertilizer to rice crop was 80:60:50:50 of NPK and 200:80:80:00 of NPK and Zn SO_4 for *kharif* and *rabi* seasons respectively. Urea, SSP, MOP and Zn SO_4 were used as source for NPK and Zn. At the basal, active tillering, and panicle initiation stages, nitrogen was supplied in three equal splits. P2O5 was applied in its entirety as a basal layer, and K2O was administered in two equal splits as a basal layer and at panicle start. As a base, the entire ZnSO4 was used. After the nurseries had reached a proper age, the rice harvest was transplanted (25-30 days during *kharif*). In case of Maize, Nitrogen was applied in four equal splits at basal, 20DAS, 40 DAS and 60 DAS. While, entire P_2O_5 was applied as basal and K_2O was applied in 2 equal splits as basal and at 60 DAS initiation along with nitrogenous fertilizer. The $ZnSO_4$ was applied as basal in rice is sufficient for Maize crop. Irrigation, weed, pest and disease management was done as per recommendations of Acharya N.G.Ranga Agricultural University. Mean total of 6 and 8 irrigations were given to *kharif* and *rabi* respectively.

“The data on grain and straw yields were recorded at harvest in every season. The data was analyzed in the standard procedure” outlined by Gomez and Gomez [4]. “Soil samples were analyzed initial and after harvest for available NP and K. Soil organic carbon was analysed by the Walkley–Black method [5], available N with the procedure of Alkaline permanganate method [6], available P with the procedure of Olsen’s extractant method [7] and available K with the procedure of extracting with neutral normal ammonium acetate and using Flame photometer" [8]. The rainfall received in 2017-18 536mm, 233mm and 114mm in 42, 11 and 9 Days respectively in Kharif, Rabi and summer. The rainfall received in 2018-19 549mm, 137mm and 1mm in 39, 5 and 1 Days respectively in Kharif, Rabi and summer.

3. RESULTS AND DISCUSSION

3.1 Productivity of Rice during *Kharif* Season

During both years of study (Table 1), with application of recommended dose of NPK+$ZnSO_4$ (5338kg ha^{-1}) were recorded significantly higher grain yield during *kharif* season and significantly lowest were recorded in control (2678kg ha^{-1}). Mean grain yield in both the years were significantly higher with application of recommended dose of NPK+$ZnSO_4$ (5338 kg ha^{-1}) than NK, NP, N and control. Similar trend was observed in straw yield and significantly higher straw yield (7335 kg ha^{-1}) was recorded with the application of recommended dose of NPK+$ZnSO_4$ (Table 1). The percentage increase in grain yield with the application of recommended dose of NPK+$ZnSO_4$ was 101, 43, 28, 24, 7 and 14 over control, N, NP, NK, NPK and farmers practice respectively. Balance nutrition helped in more effective photosynthetic area and reflected in more sink resulted in more grain yield.

3.2 Productivity of Maize during *Rabi* Season

Significantly highest maize grain yield during *rabi* season was recorded in recommended NPK+$ZnSO_4$ (7286 kg ha^{-1}) (Table 1) followed by recommended NPK (6775kg ha^{-1}) and farmers practice (5967 t ha^{-1}) and superior over rest of the treatments. The grain yield in control treatment was 2679kg ha^{-1}. The percentage of increase in grain yield of rabi maize with recommended NPK+$ZnSO_4$ was 171, 65, 39, 33, 7.5 and 22.40 higher over the control, N, NP, NK, NPK and farmers practice correspondingly. In case of straw yield (Table 1), same happened with recommended NPK+$ZnSO_4$ treatment, higher mean straw yield (9065kg ha^{-1}) was noticed which is closely followed by recommended dose of NPK(8533kg ha^{-1}).

System Productivity and sustainability Yield Index: The system productivity of rice-maize cropping system (Table 1) was highest in RDF treatment *i.e.,* NPK+$ZnSO_4$ (14152kg ha^{-1}) and followed by recommended NPK(13227kg ha^{-1}) and farmers practice (11919 kg ha^{-1}). Treatment NPK+$ZnSO_4$ combination has 139, 56, 35, 29, 7 and 19 percentage increase in system productivity over control, recommended N, NP, NK, NPK and farmers practice. The per day productivity highest with RDF of NPK+$ZnSO_4$ (55.50 kg ha^{-1} day^{-1}) was closely followed by NPK (51.87 kg ha^{-1} day^{-1}) and farmers practice (46.74 kg ha^{-1} day^{-1}). Least per day productivity was with control (23.21 kg ha^{-1} day^{-1})

Balanced application of fertilizers during both the seasons favored for better root development and in-turn facilitated optimum absorption of N and K resulted in higher system productivity. The outcome of this experiment was in concurrence with Ravisankar et al*.,* [9], Hiremath et al*.,* [10] and Shinde et al*.,* [11], Raghuveer Singh et al*.* [12].

Grain equivalent yields of rice (Table 1) were highest with recommended NPK+$ZnSO_4$ (8814 kg ha^{-1}). The Sustainable yield index (SYI) was highest with recommended NPK+$ZnSO_4$ (0.81) followed by NPK (0.74) and farmer's practice (0.65). Control treatment registered lowest SYI (0.22).

3.3 Profitability of Rice-maize System

In treatment NPK+ZnSO4 recorded higher gross returns in rice and maize are Rs101822 ha^{-1} and Rs 124523ha^{-1} respectively (Table 2) and similar trend is followed win case of net return (Rs.66123 per ha & Rs.75955 per ha). The treatment recommended dose of NPK was closely followed after NPK+ZnSO4 with Rs.94195 ha^{-1}& Rs.115185 $ha^{-1}$of gross returns and Rs60405 ha^{-1} & Rs75955 ha^{-1} of net returns. Across the different treatments, highest cost of cultivation was associated (Rs.35699 ha^{-1}& Rs.39352 ha^{-1}) with NPK+ZnSO4 and lowest with control in rice and maize crops respectively.

B:C Ratio was highest in treatment NPK+ZnSO4 (2.16) when compared to all other treatments. The results in this study are in accordance to the studies of Sharma et al*.* [13], Hiremath and Hosamani [14]. The location specific recommended quantity of NPK along with Zinc enhanced the significantly more marginal returns in cereal based cropping systems [12] in the north coastal zone.

Table 1. Grain and straw yield of Rice and Maize in Rice-Maize Cropping System as influenced by different NPK combinations

Treatment	Pooled (2017-18 & 2018-19) grain yield (t ha^{-1})		Straw yield (t ha^{-1})		System Rice Grain Equivalent Yield (t ha^{-1})	System Productivity (t ha^{-1})	Production efficiency (kg ha^{-1} day^{-1})	Sustainable Yield Index (SYI)
	Paddy	**Maize**	**Paddy**	**Maize**				
Control	2678	2679	3890	3357	3241	5919	23.21	0.22
N	3759	4390	5408	5895	5310	9069	35.56	0.45
NP	4179	5210	5876	6844	6302	10481	41.10	0.55
NK	4334	5451	6074	7012	6594	10928	42.85	0.58
NPK	5031	6775	6900	8533	8196	13227	51.87	0.74
NPK + $ZnSO_4$	5338	7286	7335	9065	8814	14152	55.50	0.81
Farmers practice	4701	5967	6723	7827	7218	11919	46.74	0.65
SEm(±)	50.93	52.01	87.66	46.42				
CD(0.05)	147.12	150.24	253.20	134.07				
CV	2.90	2.36	3.56	1.64				

Table 2. Productivity and profitability of rice-maize cropping system as influenced by different npk combinations

Treatment	Rice (Polled 2017-18 & 2018-19)				Maize (Polled 2017-18 & 2018-19)				Rice-Maize Systemfor both the years			
	Gross Returns	**COC**	**Net Returns**	**BC Ratio**	**Gross Returns**	**COC**	**Net Returns**	**BC Ratio**	**Gross Returns**	**COC**	**Net Returns**	**BC Ratio**
Control	42423	28196	14227	0.50	46140	30194	15946	0.53	44282	29195	15087	0.52
N	63533	29177	34356	1.18	74429	32681	41748	1.28	68981	30929	38052	1.23
NP	72971	32334	40637	1.26	88186	36858	51328	1.39	80579	34596	45983	1.33
NK	78594	30667	47927	1.56	93532	35102	58430	1.66	86063	32885	53179	1.61
NPK	94195	33790	60405	1.79	115185	39230	75955	1.94	104690	36510	68180	1.87
NPK + $ZnSO_4$	101822	35699	66123	1.85	124523	39352	85171	2.16	113173	37526	75647	2.01
Farmers practice	86921	32755	54166	1.65	102295	37529	64766	1.73	94608	35142	59466	1.69

Table 3. Post harvest soil nutrient status as influenced by NPK combinations (Pooled data of 2 years-2017-18 & 2018-19)

Treatment	pH	Organic carbon (%)	Avail N (kg ha^{-1})	Avail P (kg ha^{-1})	Avail K (kg ha^{-1})	E C (ds/m)
Before	**7.09**	**0.54**	**175.18**	**25.25**	**322.77**	**0.18**
Control	6.53	0.51	187.50	67.24	256.83	0.15
N	6.32	0.47	210.33	62.87	246.00	0.16
NP	6.64	0.47	199.33	103.35	241.17	0.16
NK	6.59	0.46	198.00	60.56	276.00	0.17
NPK	6.63	0.50	195.17	95.38	269.33	0.17
NPK+Zn SO_4	6.59	0.54	193.67	89.40	268.33	0.17
Farmers practice	6.68	0.54	202.00	88.71	266.33	0.16
SEm(±)	**0.04**	**0.011**	**1.52**	**0.29**	**1.60**	**0.004**
CD(0.05)	**0.11**	**0.032**	**4.41**	**0.85**	**4.63**	**0.012**
CV	**1.52**	**5.48**	**1.89**	**5.34**	**1.50**	**6.28**

Post harvest soil nutrient status: "Analysis of post harvest of soil data indicated higher status of organic carbon and available NPK with application of recommended NPK+$ZnSO_4$ followed by NPK over other all treatments (Table 3). Better root and shoot growth was associated with balanced application of NPK and also helped in buildup of soil fertility over a period. The application of under and fewer amounts of nutrients drains the soil nutrient base and affect the productivity" [15]. "The significant improvement in soil fertility status after harvest was due to balanced application of fertilizers" [16-19].

4. CONCLUSION

Application of recommended NPK+$ZnSO_4$ @ 80-60-50-50 kg ha^{-1} for Rice and 200-80-80 for maize respectively are to get higher grain yield and to realize more net returns besides to augment the soil fertility in East coast plains and hills of Andhra Pradesh in Rice-Maize cropping system. It was inferred that application of recommended NPK along with micronutrients is necessary to realize higher productivity in major cropping systems in the country.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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