Original Research Article

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

ABSTRACT

On farm studies were conducted during kharif and rabi seasons for two consecutive years from 2017-18 to 2018-19 in 24 farmers fields each year in Vizianagaram district of Andhra Pradesh state to study and demonstrate the importance of balanced fertilization on rice-maize cropping system. The seven treatments consists of control, recommended N alone, recommended N and P, recommended N and K, recommended N, P and K, recommended NPK+ $ZnSO_4$ and farmer's practice. Balanced application of recommended dose of NPK (80-60-50 kg ha^{-1}) along with $ZnSO_4$ (50 kg ha^{-1}) to rice and recommended dose of NPK (200-80-80 kg ha^{-1}) to maize in rice-maize cropping system recorded significantly higher mean grain (5338 kg ha^{-1} and 7286 kg ha^{-1}) and straw yield (7335 kg ha^{-1} and 9065 kg ha^{-1}) during both kharif and rabi seasons. Over the years, maximum System Rice Grain Equivalent yields (8814 kg ha^{-1}), higher gross (Rs 1,13,173 ha^{-1}) and net returns (Rs 75,647 ha^{-1}). In addition to improvement in the fertility status of soil, higher sustainable yield index (0.81) and per day system productivity (55.50 kg $ha^{-1}day^{-1}$) were recorded with recommended dose of NPK+ $ZnSO_4$.

***Key words**:* Balanced fertilization, rice-maize cropping system, soil fertility, system equivalent yield, gross returns, net returns

Introduction

Rice-maize is a major cropping sequence grown in an area of 5.21 lakh ha in Andhra Pradesh state under bore well source of irrigation ecosystem. In India, grain yields have been improved for the past three decades in cereal based irrigated intensified agriculture with cultivation of high yielding varieties and enhanced usage of chemical fertilizer. The cereal production in the India increased by five times where as fertilizer consumption increased by 322 times since green revolution implies low fertilizer use efficiency (Rajendra Prasad, 2009). In cereal based cropping systems, the soil available reserves of carbon and NPK are shoveled heavily. Especially a deficit of about 10 M t of NPK is estimated in the recent past for the estimated NPK requirement of 30 M t every year. Further, subsidized availability coupled with instant response of N fertilizers prompted indiscriminate N and P applications to cereals and habituated application of DAP and low or ignoring of K resulted in nutrient imbalance. Decreasing of factor productivity or response ratio to 6 kg is another alarming situation. Further, continuous mining of secondary and micro nutrients are seldom replenished. In post green revolution era multiple nutrient deficiencies including micro nutrients is one of the important problems making systems unsustainable (Jat *et al.,* 2016). Moreover, deficiency of Zn is very frequent in rice-based cropping system with no or little application of Zn fertilizer (Saha *et al.*, 2015). In view of these facts, a participatory research was carried out in farmer's fields to quantify the productivity potential of Rice-Maize cropping systems with set of nutrient combinations treatments for continuous two years.

MATERIALS AND METHODS

On-farm experiments were conducted during *kharif* and *rabi* seasons of 2017-18 and 2018-19 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. Every year the study was conducted in 24 farmer's fields selecting four farmers in each village. The mean initial physical and chemical properties of soils indicated that soils are sandy clay loams in texture and slightly alkaline reaction with pH of 7.09 and Neutral (EC- 0.18 dS/m) in nature. Fertility status indicated that the soils were 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}).

The experiment was conducted with seven treatments *viz*., control (no fertilizer), recommended N, NP, NK, NPK, NPK+$ZnSO_4$ and farmer's practice. In farmers practice Nitrogen, Phosphorous and Potash fertilizers applying with doses of 75, 47 and 40 kg ha^{-1} in case of Rice and 157, 73 and 54 kg ha^{-1} in case of Maize . Gross and net plot areas were $10m^2 \times 10$ m^2 and $9m^2 \times 9m^2$. The data was statistically 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 as test cultures 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. Nitrogen was applied in three equal splits at basal, active tillering and panicle initiation stages. While, entire P_2O_5 was applied as basal and K_2O was applied in 2 equal splits as basal and at panicle initiation. Entire $ZnSO_4$ was applied as basal. Rice crop was transplanted after attaining sufficient age of nurseries (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.

Every season, the data on grain and straw yields were recorded at harvest. The data was analyzed statistically by the standard procedure outlined by Gomez and Gomez (1984). Initial and after harvest soil samples were analyzed for available N P and K. Soil organic carbon was determined by the Walkley–Black method (Nelson and Sommers, 1982), available N by Alkaline permanganate method (Subbaiah and Asija, 1956), available P by Olsen's extractant method (Olsen *et al*., 1954) and available K by extracting with neutral normal ammonium acetate and using Flame photometer (Jackson, 1967).

RESULTS AND DISCUSSION:

Productivity of rice during *kharif* season

During all the years of study, highest grain yields during *kharif* season (Table 1) were recorded with application of recommended dose of NPK+$ZnSO_4$ (5338 kg ha^{-1}) and lowest were recorded in control (2678 kg ha^{-1}). Mean grain yield over years was significantly higher with application of recommended dose of NPK+$ZnSO_4$ (5338 kg ha^{-1}) than NK, NP, N and control. Straw yield (Table 1) also followed similar trend as that of grain with higher straw yield (7335 kg ha^{-1}) with application of recommended dose of NPK+$ZnSO_4$. Percent 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.

Productivity of Maize during *rabi* season

During *rabi* season, maize grain yield was significantly higher in recommended dose of NPK+$ZnSO_4$ (7286 kg ha^{-1}) (Table 1) followed by recommended NPK (6775 kg ha^{-1}) and farmers practice (5967 t ha^{-1}) and found superior over rest of the treatments. Grain yield in unfertilized treatment was 2679 kg ha^{-1}. The increase in grain yield of rabi maize with recommended dose of NPK+$ZnSO_4$ was 171, 65, 39, 33, 7.5 and 22.40 percent higher over the control, N, NP, NK, NPK and farmers practice correspondingly. Straw yield (Table 1) also followed similar trend as that of grain with higher mean straw yield (9065 kg ha^{-1}) in treatments recommended dose of NPK+$ZnSO_4$ was followed by recommended dose of NPK (8533 kg ha^{-1}).

System Productivity and sustainability Yield Index :

Productivity of rice-maize system (Table 1) was higher in recommended dose of NPK+$ZnSO_4$ (14152 kg ha^{-1}) and was followed by recommended dose of NPK (13227 kg ha^{-1}) and farmers practice (11919 kg ha^{-1}). Application of recommended dose of NPK+$ZnSO_4$ increased the system productivity to the tune of 139, 56, 35, 29, 7 and 19 percentage over control, recommended N, NP, NK, NPK and farmers practice. Per day productivity was also higher with recommended dose of NPK+$ZnSO_4$ (55.50 kg ha^{-1} day^{-1}) followed by NPK (51.87 kg ha^{-1} day^{-1}) and farmers practice (46.74 kg ha^{-1} day^{-1}). Lowest per day productivity was recorded in control (23.21 kg ha^{-1} day^{-1})

Higher yields with recommended dose of NPK during both the seasons and in turn system productivity may be ascribed to improvement of P in better root development and therewith absorption of N, whereas K is involved in N hesperidins in cereals. Further, experimental soil sites were marginally deficient (0.58 PPM) in Zn, the application of this scarce nutrient helped rice-maize cropping system to record 7 to 7.5 percent higher yields over recommended NPK alone. The results are in agreement with Ravisankar *et al.* (2014), Hiremath *et al.* (2016) and shinde *et al.* (2015). Raghuveer singh *et al.* (2017) also concluded that application of recommended quantity of nitrogen, phosphorus and potassium together with supplementation of location specific deficient micronutrient is essential for realizing higher production, in major food production systems of the country.

Rice grain equivalent yield (Table 1) was higher also with recommended dose of NPK+$ZnSO_4$ (8814 kg ha^{-1}). Sustainable yield index (SYI) was higher with recommended dose of NPK+$ZnSO_4$ (0.81) followed by NPK(0.74) and farmer's practice (0.65). Control treatment registered lowest SYI (0.22).

Higher Sustainable yield index was recorded with recommended dose of NPK+$ZnSO_4$ (0.81) and was followed by recommended NPK (0.74) and farmers practice(0.65).

Profitability of rice-maize system

Recommended dose of NPK+ZnSO4 resulted in higher gross in rice and maize are Rs 101822 ha^{-1} and Rs 124523 ha^{-1} respectively (Table 2) and net return (Rs 66123 ha^{-1} & Rs 75955 ha^{-1}) with a cost of cultivation of Rs. 35699 ha^{-1} & Rs. 39352 ha^{-1} and was followed by recommended dose of NPK with Rs 94195 ha^{-1} & Rs 115185 ha^{-1} of gross returns and Rs 60405 ha^{-1} & Rs 75955 ha^{-1} of net returns. Among the different treatments tested cost of cultivation was highest (Rs 35699 ha^{-1}& Rs 39352 ha^{-1}) with NPK+ZnSO4 and was lowest in control in rice and maize crops respectively.

Benefit Cost ratio was higher in recommended dose of NPK+ZnSO4 (2.16) when compared to all other treatments. In control, though cost of cultivation was less due to no fertilizer application, this treatment recorded lesser grain yield and net benefit was also the lowest. These results are in agreement with findings of Sharma et al. (2011). Hiremath and hosamani (2015) in their study on maize-chickpea system stated that recommended dose of NPK along with $ZnSO_4$ recorded significantly higher net returns and benefit cost ratio than other treatments. Raghuveer singh *et al.* (2017) also confirmed that application of recommended quantity of nitrogen, phosphorus and potassium together with supplementation of location specific deficient micronutrient enhanced marginal returns in cereal based cropping systems.

Soil nutrient status after harvest:

Post harvest analysis indicated higher status of organic carbon and available N, P, K with application of recommended dose of NPK+$ZnSO_4$ followed by NPK over other treatments (Table 3). Balanced application of NPK results in better root and shoot growth and build up the soil fertility over a period. Gangwar *et al.* (2014) reported that the continuous use of under and less number of nutrients to soil erodes the nutrient base and effects the productivity. In higher doses of fertilizers application significant improvement in soil fertility status after harvest was reported by Hile *et al.,* (2007), Jain *et al.,* (2012), Dechassa Hirpa Dibaba (2014), Mohan Kumar and Hiremath (2016).

Conclusion

It is concluded that in rice-maize cropping systems, application of NPK+$ZnSO_4$ 80-60-50-50 kg $ha^{-1}$and 200-80-80 respectively are recommended to obtain higher grain yield, net returns and to preserve the soil fertility under East coast plains and hills of Andhra Pradesh.

REFERENCES

Dechassa Hirpa Dibaba, Hunshal, C.S., Hiremath, S.M., Awaknawar, J.S., Wali, M.C., Nadagouda, B.T. And Chandrashekar, C.P. (2014). Growth and yield of maize hybrids as influenced by application of NPK and S levels. Karnataka J. Agric.Sci.27: 454-59.

Gangwar, P., Ravisankar, N., Vijayabaskaran, S. and Vishwanath, A.P. (2014). On-farm nutrient response of crops and cropping systems (compendium). All India co-ordinated Research Project on Integarted Farming Systems, Project Directorate for Farming Systems Resarch, Modipuram, Meerut.

Gomez, K.A. and Gomez, A.A. 1976. *Statistical procedures for Agricultural Research.* IRRI. Philippines. pp 680.

Hile, R.B., Patil, H.M., Patil, Y.J. and Bhosale, S. S. 2007. Effects of N,P and K on productivity and soil fertility in maize-wheat cropping systems. Internat.J.Agric.Sci. 3: 205-07.

Hiremath, S.M. and Hosamani, M.H. 2015. Influence of balanced fertilization on productivity and nutrient use efficiency of maize (*Zea mays*)-chickpea (*Cicer arietinum*) cropping systems. *Res.on Crops* 16 (3): 479-84.

Hiremath, S.M., Mohan Kumar, R. and Gaddi, A. Kumar.2016. Influence of balanced nutrition on productivity, economics and nutrient uptake of hybrid maize (*Zea mays*)-chickpea (*Cicer arietinum*) cropping sequence under irrigated ecosystem. *Indian J. Argon*., 61 : 292-96.

Jackson, M.L. 1967. Soil Chemical Analysis. Prentis Hall of India Pvt. Ltd., New Delhi.

Jain, N.K., Hari Singh and Dashora, L.N. (2012). On-farm response of maize-wheat cropping system to fertilizer NPK input. Res.on Crop 13: 475-80.

Jat, M.L., Jat, H.S., Jat, R.K., Tetarwal, J.P., Jat, S.L.,Parihar, C.M. and Sidhu, H.S. 2016. Conservation agriculture-based sustainable intensification of cereal systems for enhancing pulse production and attaining higher resource-efficiency in India. *IndianJ. Argon*., 61 : 182-98.

Mohan Kumar, R. and Hiremath, S.M. 2016. Effect of single-cross hybrids, plant population and fertility levels on productivity and economics of maize (*Zeamays* L.). *Indian J. Argon.*, 60 : 431-35.

Nelson, D.W and Sommers, L.E. Total carbon, organic carbon and organic matter. In: Page, A.L., Miller, R.H., Keeney, D.R. (Eds.), Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. ASA, SSSA, Madison, WI 1982; pp. 539–94.

Olsen, S.R., Cole, C.V., Watanabe, F.S and Dean, L.A. 1954.Estimation of available phosphorus in soils by extraction with sodium bicarbonate, Circular U.S. Department of Agriculture.; 939.

Raghuveer Singh., Ravisankar, N. and Kamta Prasad. 2017. Improvement in productivity and economics of major food production systems of India through balanced dose of nutrients. Current Science 112, (12): 2470-74.

Rajendra Prasad. 2009. Efficient fertilizer use: The key to food security and better environment. *J. Tropic.Agric*., 47 : 1-17.

Ravisankar, N., Gangwar, B. and Prasad, K. 2014. Influence of balanced fertilization on productivity and nutrient use efficiency of cereal based cropping systems. *Indian J. Argic. Sci*., 84 : 248-54.

Ray, M., Roy, D.C. and Zaman, A. 2016. Evaluation of rice (*Oryza sativa* L.)-based cropping systems for increasing productivity, resource-use efficiency and energy productivity in costal West Bengal. *IndianJ. Argon.*, 61 : 131-37.

Saha, B., Saha, S., Hazra, G.C., Saha, S., Basak, N, Das, A. and Mandal, B. 2015. Impact of zinc application methods on zinc concentrations and zinc use efficiency of popularly grown rice (*Oryza sativa*) cultivars. *Indian J. Argon*., 60 : 391-402.

Sharma, S.K., Jain, N.K. and Upadhyay, B. 2011. Response of groundnut (*Arachis hypogeal* L.) to balanced fertilization under sub-humid Southern plain zone of Rajasthan. *Legume Res*., 4:273-77.

Shinde, R. N., Karanjikar, P. N. and D. N. Gokhale. 2015. Effect of different levels fertilizer and micronutrients on growth, yield and quality of soybean. *J CropWeed*, 11 : 213-15.

Subbaiah, B.V and Asija, G.L. A rapid procedure for the determination of available nitrogen in soils. Current Science.1956; 25: 259-60.

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 + Zn SO_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-rice cropping sequence as influenced by different NPK combinations

Treatment	Rice (Polled 2017-18 & 2018-19)				Maize (Polled 2017-18 & 2018-19)				Rice-Maize System for 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 + Zn SO_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**