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LONG TERM EFFECT OF INTEGRATED USE OF ORGANIC AND INORGANIC FERTILIZERS ON PRODUCTIVITY, SOIL FERTILITY AND UPTAKE OF NUTRIENTS IN RICE & MAIZE CROPPING SYSTEM

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ABSTRACT
A long term field study was initiated in 1988 at Agricultural Research Station, Kathalagere, University of Agricultural Sciences, Bangalore to study the effect of combination of organic and inorganic fertilizers on yield, fertility status and uptake pattern of nutrients in rice maize cropping system. The results of 20 years of experimentation revealed that treatments receiving both organic and inorganic fertilizers in kharif season, followed by only inorganic fertilizers during summer season has improved the soil fertility level. Higher rice grain yields were observed in kharif season in T_9 receiving 25 per cent N through paddy straw and 75 per cent NPK through inorganic fertilizers with least in control. Similarly higher maize yields were observed in T_6 receiving 50 per cent N through FYM and 50 per cent NPK through inorganic fertilizers in kharif followed by 75 per cent NPK through inorganic fertilizers with minimum yield in control. The uptake pattern also followed the yield of both the crops. Thus by following INM practices and inclusion of light irrigated crop like maize in summer season to avoid loss due to shortage of water and other constraints, yield, fertility levels and fertilizer use efficiency can be enhanced.

KEYWORDS*:* organic and inorganic fertilizers, integrated nutrient management, soil fertility and uptake of nutrients, rice maize cropping system.

INTRODUCTION

Rice is being grown on wide range of soil, climatic conditions and by following different crop establishment techniques by the farmers all over India. In command area of Karnataka it is the dominant crop which is grown both in kharif as well as summer. As per 2006-07 rice crop contribute about 36.46 lakh tones out of the total food grain production of 93.29 lakh tones in Karnataka (Anon, 2008). Maize is also equally important crop with total production of 26.42 lakh tones in Karnataka. Since most of the farmers go for rice cropping system, the tail end farmers do face shortage of water during summer season resulting in crop loss and yield reduction which can be avoided by taking a light irrigated crop in the summer season.

Both the crops respond well to fertilizer application. The current energy crisis prevailing higher prices and lack of proper supply system of fertilizer calls for more efficient use of organic manure, green manure and other crop residues with the inorganic fertilizers to sustain yield levels. These organic products besides supplying nutrients to the first crop, it also provides substantial residual effect of un utilized nutrients on the succeeding crop. The present study was initiated to find out the effect of different combination of organic sources and inorganic fertilizers on the long term basis in the most dominant crops *i.e* rice and maize, to monitor the changes in yield, fertility status and uptake pattern of nutrients.

MATERIALS AND METHODS

A long term field experiment was conducted from 1988 to 2008 at Agricultural Research Station, Kathalagere under canal irrigation from Bhadra right canal to study the effect of integrated nutrient management on soil fertility status and productivity of rice-maize sequence under permanent plot experiment in moderately shallow, dark reddish brown, sandy clay soils. The initial soil fertility levels were (pH - 6.40, EC - 0.13 dSm^{-1}, organic carbon - 0.68 % , available phosphorus - 12.3 kg/ha, available potash - 211.4 kg/ha) taken as reference. The experiment was laid out in a randomized block design with twelve treatments with different organic sources of nutrients (Treatment details are given in Table 1) and replicated four times.

The organic sources of nitrogen used were FYM (Farm yard manure), paddy straw and glyricidia with nitrogen content of 0.5 per cent, 0.4 per cent and 0.8 per cent on dry weight basis respectively. Nutrient equivalent basis of organic sources to meet the required quantity of N were incorporated in the soil 15 days before planting of kharif paddy. Entire dose of P and K and 50 per cent of inorganic N were applied at the time of planting in the form of Single Super Phosphate, Murate of Potash and Urea respectively. The remaining dose of nitrogenous fertilizer was top dressed in equal splits at 30 and 60 days after transplanting in the form of Urea. Twenty-five days old seedlings were transplanted in rows of 20 cm apart with 10cm spacing between hills. For the summer crop of maize, 50 per cent N and full dose of P and K were applied at different levels based on the treatments at the time of sowing and remaining 50 per cent N was applied at 30 days after sowing. Seeding was done in rows of 60 cm apart with 30 cm spacing between seeds. Intercultural operations were done before top dressing of nitrogen. Plant protection measures were adopted for both the crops as and when pest and diseases were noticed. Yield data on paddy crop during kharif followed by maize crop during summer has been considered for the statistical analysis. Soil samples were collected after the harvest of summer

maize crop and analyzed for different parameters like pH, electrical conductivity, organic carbon, available phosphorus and available potash content by following the standard methods to study the changes in the soil fertility levels. The plant samples (grain and straw samples separately) of both the seasons were collected after the harvest of crop and analyzed for uptake of nitrogen, phosphorus and potassium content by following standard methods and plant uptake of nutrients was calibrated using grain and straw yields data. All the results were then analyzed statistically for drawing conclusion using standard statistical analysis tools.

RESULTS AND DISCUSSION

Soil pH

The soil pH values at harvest of summer 1988 crop (first year crop) did not bring any significant variations between treatments compared (Table 1). However, summer 2008 crop (20^{th} year crop) the pH values varied significantly among the treatments. In general there was decrease in pH values over the years and fluctuations were observed within the treatments also (Basumantary and Talukdar, 1998).

Organic carbon

The data on organic carbon status at harvest of summer 1988 crop showed variation ranging from 0.63 per cent to 0.71 per cent but these values were not statistically significant in bringing variations between treatments indicating the slow nature of organic sources in releasing the nutrients (Table 2). The results at harvest of 20^{th} year crop showed significant variations among the treatments. There was an improvement (> 0.70 %) in treatments receiving both the sources of nutrients in one of the season over the years which may be attributed to higher contribution of biomass to the soil in the form of crop residues, which upon decomposition might have resulted in enhanced organic carbon content of the soil (Udayasoorian, *et al.*, 1988 and Kamlesh Kukreja *et al.*, 1991). The treatments which received only inorganic fertilizers showed lower organic carbon values when compared to initial level which could be due to no addition of organic manures as well as intensive oxidation process aided by degradation and decomposition of organic matter.

Available phosphorus

The results furnished in table 2 showed that the available P status has decreased in many treatments at harvest of 1^{st} year crop and in all treatments in the soil data of 10^{th} year crop when compared to initial level. The post harvest soil data of 1^{st} year crop showed wide fluctuations among treatments. However, during 20^{th} year crop there was improvement in available P status in all the treatments except in control and varied significantly among the treatments which is possibly due to the magnitude of yield triggered P uptake. The increase was prominent in treatments receiving both organic and inorganic fertilizers in kharif followed by only inorganic fertilizers in summer which could be attributed to the influence of organic manure which enhanced the labile P in the soil by complexing Ca, Mg and Al (Subrmanian and Kumaraswamy, 1989). The decrease in available P in control could be due to fixation of P.

Available Potassium

The available K status has decreased over the years (Table 2), it was more prominent in treatment receiving only inorganic fertilizers during both the seasons. Relatively higher available K was observed in INM treatments and lower values were noticed in control which did not receive any fertilizer over period of 20 years. This could be due to continuous cropping and non addition of organic manure in control as observed by Laxminarayana (2006).

The long term studies has clearly proved the importance of organic manuring in improving the physical and microbial conditions of soil and enhances the fertilizer use efficiency when applied in conjunction with inorganic fertilizers under rice – maize cropping sequence.

Uptake of nutrients

The data on NPK uptake by rice grain (1988 & 2006) and maize grain (1989 & 2008) crop at harvest are reported in Table 3 and 4, respectively. The treatments were statistically significant for all the three nutrients in all the three years. The results showed variations in uptake pattern corresponding to the yield fluctuations through out the experimental period. Treatments which received combination of organic and inorganic fertilizer showed higher uptake values of all the three nutrients most probably due to higher yields received in these treatments. Among two seasons, higher NPK uptake was noticed in kharif rice crop than in summer maize crop may be due to favorable effect of organic manure addition, higher biomass addition and yield. The lower NPK uptake in summer could be due to poor availability as there was no addition of organic manure.

Rice and Maize Grain yield

Among all the treatments, whenever both organic and inorganic fertilizers were used in kharif season yield of rice and maize has increased, similar trend was observed over the years which could be due to gradual decomposition of organic manure and its slow availability throughout the growing period of the crop (Kumar *et al.*, 2003 ; Gunri *et al.*, 2004 and Rajkhowa and Baroova, 1994). The similarity in yields among different organic sources indicates better utilization of nutrients from all the sources (Ahmed *et al.*, 2006). Treatment T_9 recorded significant and higher rice grain yields over the years (Table 5) when compared to control which might be due to incorporation of rice straw and supply of naturally available N derived from mineralized soil N and biological nitrogen fixation by free living and plant associated diazotrophs present in submerged rice soils. Similar results were obtained by Yaduvanshi (2003). On perusal of yield data of maize in summer season (Table 5), among various treatments T_6 recorded significantly higher grain yield from past few years, which might be due to slow release of nutrients in FYM applied treatments and lower grain yields were observed in control (Sharma *et al.*, 2001) which has not received any fertilizers. The yield data of both crops over the years indicate an improvement in the efficiency of NPK fertilizers when used in conjunction with organic manure in atleast one season (minimum of 25 % N through organic manures) for obtaining higher yield (Narain *et al.* 1990).

Hence, in order to derive maximum benefit both in terms of higher yields as well as maintaining soil fertility and fertilizer use efficiency, rice – maize cropping system has to be followed with integrated nutrient supply.

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TABLE 1: Treatment details of permanent plot experiment on integrated nutrient management in Rice- Maize cropping system

Sl. No.	Nutrient Source	
	Kharif (rice)	Summer (maize)
1	Control	Control
2	50% NPK	50% NPK
3	50% NPK	100% NPK
4	75% NPK	75% NPK
5	100% NPK	100% NPK
6	50% NPK + 50% N(FYM)	100% NPK
7	75% NPK + 25% N (FYM)	75% NPK
8	50% NPK + 50% N (Paddy Straw)	100% NPK
9	75% NPK + 25% N (Paddy Straw)	75% NPK
10	50% NPK + 50% N (Glyricidia)	100% NPK
11	75% NPK + 25% N (Glyricidia)	75% NPK
12	Farmers Practice (85:50:30 kg NPK/ha & FYM 2 t/ha)	Farmers Practice (75:37.5:38.75 kg NPK/ha)

TABLE 2: Soil properties under integrated nutrient management in rice-maize sequence (1989 & 2008)

Treatments	pH (1:2)		Organic Carbon (%)		Available Phosphorus (Kg/ha)		Available Potash (Kg/ha)	
	1989	2008	1989	2008	1989	2008	1989	2008
T_1	6.23	5.28	0.69	0.62	15.30	10.97	201.05	125.80
T_2	6.30	5.56	0.68	0.65	10.80	18.06	211.68	163.05
T_3	6.33	5.42	0.71	0.65	13.33	18.85	183.58	183.80
T_4	6.38	5.43	0.67	0.62	11.25	17.84	213.35	187.26
T_5	6.45	5.51	0.67	0.67	11.25	21.92	210.55	185.67
T_6	6.33	5.81	0.68	0.72	11.60	22.01	212.90	188.81
T_7	6.40	5.62	0.66	0.70	9.83	20.55	200.60	184.41
T_8	6.35	5.38	0.69	0.72	15.00	20.60	237.55	181.30
T_9	6.35	5.61	0.66	0.73	12.23	21.96	218.08	187.79
T_{10}	6.45	5.49	0.63	0.72	8.63	21.62	204.95	184.15
T_{11}	6.43	5.72	0.69	0.70	14.75	21.40	192.93	182.64
T_{12}	6.50	5.95	0.68	0.64	11.53	18.90	244.50	141.75
SEm±	0.101	0.015	0.025	0.014	2.284	0.13	14.02	0.84
CD @5%	NS	0.042	NS	0.040	NS	0.38	NS	2.43

TABLE 3: Uptake of NPK by rice at harvest under integrated nutrient management in rice-maize sequence (1988 & 2006)

Treatments	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	1988	2006	1988	2006	1988	2006
T_1	45.90	64.19	6.90	15.68	59.30	13.29
T_2	49.50	89.28	11.30	20.63	64.80	25.69
T_3	65.40	70.50	9.60	18.53	65.40	14.68
T_4	70.90	72.67	8.40	21.61	69.00	18.96
T_5	78.80	97.28	7.60	23.51	69.80	23.38
T_6	64.00	80.56	7.20	20.34	70.70	19.84
T_7	67.90	83.33	15.70	21.90	98.20	17.52
T_8	60.90	82.66	7.80	19.68	67.50	18.99
T_9	78.90	97.34	9.10	21.85	75.00	22.47
T_{10}	81.70	87.16	9.40	23.65	97.80	20.92
T_{11}	71.10	92.09	9.80	29.13	92.30	25.54
T_{12}	68.80	79.69	10.50	16.99	66.50	16.86
SEm±	1.111	3.82	0.263	0.95	0.644	0.96
CD @5%	3.204	11.00	0.759	2.73	1.857	2.78

Note: During 2007 kharif due to shortage of canal water crop was not established

Table 4: Uptake of NPK by maize at harvest under integrated nutrient management in rice-maize sequence(1989 & 2008)

Treatments	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	1988	2006	1988	2006	1988	2006
T_1	21.20	17.46	4.60	4.98	14.90	6.46
T_2	25.10	48.83	5.80	15.54	17.50	22.47
T_3	33.60	65.94	7.70	20.16	19.40	25.29
T_4	29.90	72.66	6.50	20.04	5.80	26.18
T_5	41.80	80.85	9.50	18.87	17.80	21.30
T_6	34.40	92.25	8.90	22.19	16.30	25.83
T_7	35.60	69.83	8.50	17.07	26.90	20.14
T_8	37.90	85.02	8.70	19.47	24.30	24.04
T_9	32.30	81.15	7.70	16.60	17.90	19.78
T_{10}	25.20	79.36	6.70	19.03	16.70	18.94
T_{11}	49.10	68.80	12.10	13.89	24.20	19.12
T_{12}	43.10	60.23	11.90	13.40	19.20	12.96
SEm±	0.660	5.15	0.253	1.46	0.403	1.72
CD @5%	1.895	14.85	0.730	2.97	1.162	4.97

TABLE 5: Rice and Maize grain yield (Kg/ha.) as influenced by integrated nutrient management in rice-maize cropping sequence (1988-89, 2006 & 2008).

Treatments	Rice (Kg/ha.)		Maize (Kg/ha.)	
	1988	2006	1989	2008
T_1	2797	2734	672	1263
T_2	4813	4327	2046	3556
T_3	4356	4547	5195	4329
T_4	4953	4927	3898	4189
T_5	5449	6177	4831	4362
T_6	5270	6279	6003	4943
T_7	5012	6367	4022	4040
T_8	5514	6287	6199	4535
T_9	5577	6542	3701	4710
T_{10}	5278	6272	4360	4223
T_{11}	5463	6461	3460	4038
T_{12}	5501	5132	2959	3775
S Em±	439	101.36	714	321.86
CD @ 5 %	892	305.44	1454	926.7

Note: During 2007 kharif due to shortage of canal water crop was not established