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Integrated nutrient management in rice-maize crop sequence

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ABSTRACT

The field experiment was conducted during rainy and winter seasons of 1998 and 99 at the Agronomy Farm, College of Agriculture, Dapoli, dist. Ratnagiri to study the integrated nutrient management in rice – maize crop sequence. The grain yield of rainy season rice was higher under 50% recommended NPK through fertilizers + 50% N either through glyricidia or FYM. Application of NPK at suboptimal dose *i.e.* 75 % and 50 % recommended dose of fertilizer reduced grain yield of rice significantly. The total productivity of rice – maize crop sequence was higher when 50% recommended NPK through fertilizers + 50% N through glyricidia was applied to rice and 75 % recommended dose of fertilizer to succeeding maize crop. The maize crop supplied with 100% recommended dose of fertilizer registered significantly higher cob yield. The total productivity (net return, B: C ratio) was higher when both the crops supplied with 100 % recommended dose of fertilizer. The N, P, K uptake was more when rice crop received 50 % N substitution either through glyricidia or FYM. Where as in winter season, the maximum uptake of nutrients by maize was recorded when 100 % NPK was supplied as inorganic source.

Key words : Rice-maize sequence, Integrated nutrient management, Net profit, Nutrient uptake

INTRODUCTION

In absence any significant scope for horizontal expansion and to meet the ever increasing demand for food, fuel and fodder, the vertical expansion in agriculture through increased production per unit area and per unit time is the only alternative, which involves the intensive use of resources and input. But inadequate / unbalanced use of fertilizers and organic manures are resulting in the improvement of soil health. Therefore, increasing the production and productivity on sustainable basis is a challenge before the agricultural scientists and planners.

The rice – maize is a major cropping system of the country but the average productivity of the system, which was less. Rice – maize sequential cropping is an important cropping system needs large amount of nutrients to achieve high productivity. The long term experiment at many locations have indicated that even with application of recommended dose of fertilizers (NPK), it will not be possible to sustain the productivity of rice – maize system and emphasize the importance of integrated nutrient supply system in sustaining productivity (Hedge, 1996). This involves the use of chemical fertilizers in conjunction with organic sources such as green manuring, FYM etc. This approach restores and sustains soil health and productivity in long term (Mitra *et al.*, 1992), besides meeting the nutritional deficiencies which are likely to occur due to continuous and intensive cultivation (Hegde, 1996). Therefore, the present investigation was initiated to study the effect of integrated nutrient supply of chemical fertilizers and organic sources on productivity and soil fertility in rice – maize sequence under South Konkan coastal zone of Maharashtra.

MATERIALS AND METHODS

The field experiment was conducted in the rainy (*kharif*) and winter (*rabi*) seasons of 1998 and 1999 at Agronomy farm, College of Agriculture, Dapoli, dist. Ratnagiri. The soil of experimental plot was clay loam in texture with pH 6.36, organic carbon 1.30 g kg^{-1}; and the available nitrogen 295.22 kg ha^{-1}, phosphorus 12.96 kg ha^{-1} and potassium 105.03 kg ha^{-1}. There were 11 different treatment combinations (Table 1) replicated thrice in Randomized Block Design. Rice (var. Sahyadri) and maize (var. Konkan tapora) were grown as the test crop. The recommended dose of fertilizer was 100:50:50 and 120:60:60 N, P and K kg ha^{-1} for rice and maize, respectively. In case of rice, fertilizers was applied in three slit doses, 40 % N + full P and K was applied as a basal dose *i.e.* at transplanting, 40 % N was applied 30 DAT (maximum tillering) and remaining 20 % N was applied at 60 DAT (panicle initiation) whereas in case of maize, half N and whole quantity of P and K was applied as a basal dose and half N 30 DAS. The treatment comprised application of different combinations of inorganic and organic sources of nutrients to rice and inorganic sources to maize. The grain and straw of rice, and grain, stover of maize samples were analyzed for their N content by Kjeldahl method. The samples were digested in diacid (HNO_3, $HClO_4$, 4:1) mixture. Phosphorus was estimated in diacid digest by vanadomolybdo phosphoric yellow colour method. The extract was used for determination of potassium by flame photometer. Data on grain and straw yield, total productivity/ha/year (grain and biomass), gross monetary returns, net monetary returns and benefit: cost ratio were obtained from the

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Table 1: Details of treatments and symbols use

Symbol	Treatments	
	Kharif (Rice)	*Rabi* (Maize)
T_1	No organic manures, No chemical fertilizers	No organic manures, No chemical fertilizers
T_2	50% recommended NPK through fertilizers	75% recommended NPK through fertilizers
T_3	50% recommended NPK through fertilizers	100% recommended NPK through fertilizers
T_4	75% recommended NPK through fertilizers	75% recommended NPK through fertilizers
T_5	100% recommended NPK through fertilizers	100% recommended NPK through fertilizers
T_6	100% recommended NPK through fertilizers	75% recommended NPK through fertilizers
T_7	75% recommended NPK through fertilizers	100% recommended NPK through fertilizers
T_8	50% recommended NPK through fertilizers + 50% N through FYM	75% recommended NPK through fertilizers
T_9	75% recommended NPK through fertilizers + 25% N through FYM	100% recommended NPK through fertilizers
T_{10}	50% recommended NPK through fertilizers + 50% N through Glyricidia	75% recommended NPK through fertilizers
T_{11}	75% recommended NPK through fertilizers + 25% N through Glyricidia	100% recommended NPK through fertilizers

cropping sequence during two years and its mean. Economics of fertilizer application in the cropping system was worked out.

RESULTS AND DISCUSSION

Results obtained are summarized in Table 2, 3, 4 and 5. Analysis of variance revealed that integrated nutrient managment had significant effect on yield contributing attributes.

Yield (q / ha):

The grain and straw yield of rice increased significantly due to application of different organic and inorganic sources of fertilizers compared with control (Table 2). The maximum grain (71.64 or 70.37 q/ha) and straw (73.62 or 72.37 q/ha) yield was recorded when 50 % RDF + 50 % N was applied either through glyricidia (T_{10}) or FYM (T_8), respectively followed by 75 % RDF + 25 % N through glyricidia (T_{11}) or FYM (T_9).

Application of 100 % RDF (T_5) recorded maximum grain (68.52 q/ha) and straw (70.64 q/ha) yield as compared to 75 % RDF (63.06 q/ha and 65.26 q/ha of grain and straw, respectively) as well as 50 % RDF. Unfertilized control (T_1) proved the lowest yield compared to all other treatments. The beneficial effect in respect of grain and straw yield was more prominent when 50 % N was substituted either through glyricidia or FYM which may be attributed to sustain nutrient supply or also as a result of better utilization of applied nutrients through improved micro – environmental conditions, especially the activities of soil micro-organisms involved in nutrient transformation and fixation. These results are in calibrating with findings of Powar and Mehta (1997).

During the winter season, the maize yield in general was higher when 75 and 100 % RDF (120:60:60 NPK

Table 2 : Yield of rice-maize crop sequence (mean data of two years)

Symbol	Rice			Maize		
	Treatment	Yield (q/ha)	Straw yield (q/ha)	Treatments	Yield (q/ha)	Stover yield (q/ha)
T_1	Control	37.27	37.17	Control	19.43	28.46
T_2	50 % RDF	53.89	56.13	75 % RDF	33.99	50.45
T_3	50 % RDF	55.26	57.21	100 % RDF	40.06	59.52
T_4	75 % RDF	62.30	64.56	75 % RDF	34.95	51.55
T_5	100 % RDF	68.52	70.64	100 % RDF	41.86	62.72
T_6	100 % RDF	68.14	70.28	75 % RDF	36.14	53.55
T_7	75 % RDF	63.06	65.26	100 % RDF	41.25	61.93
T_8	50% RDF+50 % N through FYM	70.37	72.37	75%RDF	43.03	64.18
T_9	75 % RDF+25 % N through FYM	69.36	71.13	100 % RDF	44.43	65.98
T_{10}	50 % RDF+50 % N through Glyricidia	71.64	73.62	75 % RDF	42.64	63.44
T_{11}	75 % RDF+25 % N through Glyricidia	70.07	72.55	100 % RDF	43.80	64.83
	'F' test	Sig.	Sig.		Sig.	Sig.
	S.E. ±	0.91	0.91		0.71	1.10
	C.D. (P=0.05)	2.51	2.52		1.97	3.05

kg/ha) was applied to maize as compared to unfertilized control. Application of 100 % RDF recorded significantly higher grain (44.43 q/ha) and stover (65.98 q/ha) yield of maize during 1998 and 1999 followed by 75 % RDF (43.03 q/ha 64.18 q/ha grain and stover yield, respectively) as the preceding crop of rice received 100 % recommended dose of fertilizers in the form of 50 % recommended NPK through fertilizer + 50 % N either through glyricidia or FYM. In short, the result clearly indicated possibility of saving 25 % RDF to succeeding maize under rice - maize sequence. This was evidently due to the residual effect of organic sources applied to *kharif* rice. While working on residual effect of organic sources on succeeding crop, Ramamurthy and Shivshankar (1996) also reported the similar findings.

System productivity:

It was observed from the data presented in Table 3 that rice – maize system required 50 % N substitution either through glyricidia or FYM to *kharif* rice and 25 % N saving to succeeding crop of maize. The total production of rice – maize crop sequence as affected by integrated nutrient management indicated that application of 50 % recommended NPK through fertilizer + 50 % N through glyricidia to rice with 75 % RDF to succeeding maize recorded the highest total productivity (114.28 q/ha) followed by 75 % recommended NPK + 25 % N through glyricidia to *kharif* rice with 100 % RDF to succeeding maize. There was considerable reduction in total productivity with reduction of fertilizer levels to 75 and 50 % of recommended dose. The lowest total productivity (56.70 q/ha) was noted in unfertilized control under rice – maize sequence. Working on similar line under rice- wheat sequence, Samui *et al.* (1998) reported possibility of substituting 50 % N through organic sources during *kharif* without any significant reduction in total grain productivity of sequence. This results gave credence to belief that about 25 to 50 % N needs of the rice should be substituted with integrated use of fertilizers, which can reduce 25 % nutrient requirement of succeeding crop without any detrimental effect on the productivity of the system.

NPK uptake:

The data regarding uptake of N, P and K by rice are presented in Table 4, which showed that substitution of 25 to 50 % N either through glyricidia or FYM registered significantly maximum uptake. This might be due to slow and continuous supply of nutrients to the rice plant, as required by the plant due to bio organic influence on chemical N as suggested by Sahrawat (1982). It was

Table 3 : Total uptake of N, P and K (kg/ha) by rice and maize crop. (mean data of two years)

Treatments		Rice						Maize					
		N		P		K		N		P		K	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Stover	Grain	Stover	Grain	Stover
T_1	Control	35.00	10.69	7.40	2.14	4.36	46.95	25.42	9.04	7.06	2.25	1.25	24.71
T_2	50 % RDF	56.89	19.45	12.86	4.37	7.30	84.59	53.82	27.10	14.35	6.35	5.82	49.69
T_3	50 % RDF	59.66	20.38	13.87	4.70	7.65	86.37	65.57	34.72	21.22	11.01	10.20	61.04
T_4	75 % RDF	75.72	27.52	18.46	7.08	10.16	101.90	55.40	28.29	15.02	6.99	6.52	50.85
T_5	100 % RDF	89.26	36.63	23.98	8.68	12.33	117.85	68.72	37.01	22.65	12.83	11.31	64.60
T_6	100 % RDF	89.79	36.48	23.57	8.61	11.79	116.15	57.71	29.40	16.06	7.45	7.25	52.89
T_7	75 % RDF	77.59	29.75	18.54	7.26	10.42	103.39	68.08	36.50	22.27	12.07	10.92	64.06
T_8	50% RDF+50 % N through FYM	93.87	39.44	23.67	8.52	12.33	117.21	71.48	38.87	23.92	13.82	11.84	68.03
T_9	75 % RDF+25 % N through FYM	91.49	37.10	22.06	8.36	12.27	116.37	73.60	40.27	24.47	14.57	12.45	69.62
T_{10}	50 % RDF+50 % N through Glyricidia	97.56	41.57	27.00	9.23	12.44	123.47	70.60	37.80	23.59	12.97	11.28	66.33
T_{11}	75 % RDF+25 % N through Glyricidia	93.53	38.89	23.70	9.05	12.31	118.76	72.75	39.53	24.07	14.30	11.94	68.42
	'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	S.E. ±	2.16	1.07	1.18	0.27	0.26	3.21	1.91	1.26	0.82	0.74	0.49	2.01
	C.D. (P=0.05)	6.41	3.18	3.64	0.80	0.76	9.51	5.68	3.74	2.43	2.18	1.45	5.94

Table 4 : Production potential of rice based crop sequences as affected by integrated nutrient management (Based on pooled mean)

Symbol	Treatments		Rice - Maize (q/ha)		
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Total*
T_1	Control	Control	37.27	19.43	56.70
T_2	50% RDF	75 % RDF	53.89	33.99	87.88
T_3	50% RDF	100 % RDF	55.26	40.06	95.32
T_4	75 % RDF	75 % RDF	62.30	34.95	97.25
T_5	100 % RDF	100 % RDF	68.52	41.86	110.38
T_6	100 % RDF	75 % RDF	68.14	36.14	104.28
T_7	75 % RDF	100 % RDF	63.06	41.25	104.31
T_8	50 % RDF + 50 % N through FYM	75 % RDF	70.37	43.03	113.40
T_9	75 % RDF + 25 % N through FYM	100 % RDF	69.36	44.43	113.79
T_{10}	50% RDF + 50 % N through Gly.	75 % RDF	71.64	42.64	114.28
T_{11}	75 % RDF + 25 % N through Gly.	100 % RDF	70.07	43.80	113.87

also evident that higher uptake of nutrients by the crop was contributed towards increased grain and straw yield of rice which was not evident in unfertilized control.

During winter season, maximum uptake of NPK nutrients by maize was recorded under the maize crop which received 100 % RDF (T_9) preceded by the treatment receiving 50 % NPK through inorganic and 50 % N through organic source. This could be due to residual effects of the nutrients applied through organic sources to preceding rice on the succeeding winter season crop of maize. Residual effect of combined application of glyricidia / FYM and inorganic source of fertilizer on maize crop supports the observation of Gill and Meelu (1989). It is evident that higher uptake of the nutrients by the crop has contributed towards the increased grain yield which was not possible in unfertilized control.

The P and K uptake by the grain and straw showed the similar trend. The additional phosphorus supplied by the organic sources (glyricidia and FYM) and their influence on solubilizing the native phosphorus might have resulted into phosphorus uptake by rice grain and straw. The enhanced potassium absorption in the same treatment may be due to increased supply of potassium by organics and increase in concentration of potassium in rice plant in the corresponding treatment.

Economics of rice – maize cropping system:

Data regarding economics of rice – maize crop sequences (Table 5) as affected by different treatments indicated that the highest net profit (Rs. 22385.32) and B:C ratio (1.49) from the rice – maize crop sequences was due to application of 100 % RDF to both the crops under sequence. The similar results of higher monitory returns from rice – wheat sequence due to application of inorganic fertilizers and organic manure was observed by Sharma *et al.* (1988). It was closely followed by 75 % recommended NPK + 25 % N through glyricidia to preceding rice with 100 % RDF to succeeding maize (Rs.

Table 5: Economics of rice - maize crop sequence as affected by different treatments (mean of two years)

Symbol	Treatments		Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B : C ratio
	Kharif (Rice)	*Rabi* (Maize)				
T_1	Control	*Control*	35345.90	33045.44	2300.46	1.07
T_2	50% RDF	75 % RDF	54485.12	40878.97	13606.15	1.33
T_3	50% RDF	100 % RDF	58687.52	42583.64	16103.88	1.38
T_4	75 % RDF	75 % RDF	60597.57	42950.72	17646.85	1.41
T_5	100 % RDF	100 % RDF	68515.05	46129.73	22385.32	1.49
T_6	100 % RDF	75 % RDF	65125.87	44627.91	20497.96	1.46
T_7	75 % RDF	100 % RDF	64560.47	44596.49	19963.98	1.45
T_8	50 % RDF + 50% N through FYM	75 % RDF	70360.47	50172.24	20187.93	1.40
T_9	75% RDF + 25% N through FYM	100 % RDF	70428.20	48725.91	21702.29	1.46
T_{10}	50% RDF + 50% N through Gly.	75 % RDF	70989.02	50329.46	20659.56	1.41
T_{11}	75% RDF + 25% N through Gly.	100 % RDF	70599.97	48768.86	21831.11	1.45

21831.11) and 75 % recommended NPK + 25 % N through FYM to preceding rice with 100 % RDF to succeeding maize (Rs. 21702.29). Thus, it showed that application of 100 % NPK through fertilizers registered highest net returns compared to 50% recommended NPK through fertilizers + 50% N either through glyricidia or FYM, but the long term benefits in respect of soil fertility on sustainable basis can not be neglected.

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