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Original Research Article

Effect of organic, inorganic and integrated nutrient management on crop productivity, water productivity and soil properties under various rice-based cropping systems in Madhya Pradesh, India

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Keywords

Cropping systems; crop productivity; Rice equivalent yield; organic carbon, Integrated nutrient management

A B S T R A C T

A field experiment was conducted at Krishi Nagar Research Farm, Jawaharlal Nehru Krishi Viswa Vidyalaya, Jabalpur with an aim to find out the effect of various nutrient management on crop productivity, water productivity and soil-properties under different rice-based cropping systems during 2004-05 to 2007-08. Total 12 treatments consisted with 3 nutrient management practices (100% organics, 100% inorganics and INM as 50% organics + 50% inorganics) and 4 crop-sequences (Green- manuring-Rice cv. Pusa Basmati-Wheat cv. HD 4672; Rice cv. Pusa Basmati-Potato cv. K. Sinduri-Okra cv. Parbhani Kranti; Rice cv. Pusa Basmati-Berseem cv. JB-1 for fodder and seed and Rice cv. Pusa Basmati-Vegetable Pea cv. Arkel-Sorghum fodder cv. MP Chari) were tested in an unreplicated strip plot design. The result revealed that the Rice cv. Pusa Basmati-Potato cv. K. Sinduri-Okra cv. Parbhani Kranti cropping sequence excelled among all the 4 crop-sequences with regard to crop productivity (187.16 q/ ha) and water productivity (86.5 kg/ha/cm) under all nutrient management practices. The crop productivity of all cropping systems was maximum (127.44 q/ ha) with 100% inorganic nutrient management followed by integrated nutrient management (122.44q/ ha). The 100% organic nutrient management although produced minimum system productivity (110.62q/ ha) under all cropping systems in terms of rice equivalent yield and it showed improving trend in the productivity with each advancement in the crop-cycle every year. The improvement in organic carbon and nitrogen contents as well as maintenance of phosphorus and potash contents was noticed over their initial status under 100% organic nutrient management with all cropping systems till the completion of fourth crop cycle. The organic carbon and nitrogen content were almost maintained and phosphorus and potash contents showed a little declining trend over their initial status with 100 % inorganic nutrient management.

Introduction

The high input agriculture has led to self-sufficiency in food-grains but it has posed several new challenges. The conversion of modern agriculture into organic agriculture is now widely debated. Growing of high yielding varieties with indiscriminate use of fertilizers, poor water management practices and

inefficient plant-protection measures in modern chemical intensive agriculture has resulted into degradation of lands owing to low crop yields with poor quality of produce (Pradhan and Mondal, 1997). The productivity of most of the crops is declining. Hence, conversion of modern chemically intensive agriculture to a more sustainable form of agriculture like organic farming appears to be an option for maintaining the desirable agricultural production in future (Modgal *et al.*, 1995).

Therefore, the use of locally available agro-inputs in agriculture by avoiding or minimizing the use of synthetically compounded agro-chemicals appears to be one of the probable options to sustain the agricultural productivity. In Madhya Pradesh, by virtue of using less quantity of chemical fertilizers and pesticides and dependency upon naturally available sources of nutrients, organic food could provide better vistas towards high remuneration with premium price in market with inherent lesser cost advantage.

Diversification of rice-wheat system towards other cropping systems involving vegetables, and fodder crops under organic farming system may be another option to improve the monetary gain of the farmers along with improvement in the soil-health. Generally, it is common thinking that yields of several crops reduce during the initial years under organic farming, but high market value of organically grown produces may be able to compensate the losses in yields Mahapatra *et al.* 2006. On going through the above facts in the mind, a study was conducted to compare the total crop productivity and water productivity of different rice-based cropping systems under organic, inorganic and integrated nutrient management and to find out the impact of various nutrient management and cropping systems on soil properties.

Materials and Methods

The experiment was conducted from *Kharif 2004*-05 to summer 2007-08 at Krishi Nagar Research farm, J. N. Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The soil was sandy clay loam, having pH, 7.4; EC, 0.51 dS/m; OC 0.70% available N, P and K of 264, 12.6 and 282 kg/ ha respectively. The experiment was laid out in strip plot design. The different years was taken as replication for statistical analysis of the data over the different years. The statistical analysis of the data for the year 2007-08 was not possible because of unreplicated treatments, hence, variations were judged on the basis of mean values. In case, data of preceding years became available, the statistical analysis of data was also done. Total 12 treatments consisted with 3 nutrient management practices (100% organics – M_1, 100% inorganics – M_2 and INM as 50% organics + 50% inorganics – M_3) and 4 crop – sequences (Green-manuring by sunnhemp – Rice cv. Pusa Basmati-Wheat cv. HD 4672, -CS_1, Rice cv. Pusa Basmati – Potato cv. K. Sinduri – Okra cv. Parbhani Kranti – CS_2, Rice cv. Pusa Basmati – Berseem cv. JB-1 for fodder and seed – CS_3 and Rice cv. Pusa Basmati-Vegetable pea cv. Arkel-Sorghum for fodder cv. MP Chari-CS_4. Recommended doses of 120:60:40 kg N, P_2O_5 and K_2O/ ha for rice, wheat, Potato and Okra, 20:60:40 kg N, P_2O_5 and K_2O/ ha for Berseem and Vegetable Pea, 100:50:30 kg N, P_2O_5 and K_2O/ ha for Sorghum, respectively.

In case of organic nutrient management,

all manures were applied before final seed bed preparation for sowing of each crop. In case of inorganic nutrient management, full quantity of N, P and K fertilizers were given as basal application in vegetable pea and Berseem. But in wheat, potato, okra and sorghum crops, only 50% of N was given as basal along with full dose of P and K and rest 50% N was top dressed in two equal splits at 20 and 40 DAS. Need based irrigation: intercultural and plant protection (spraying of Neem oil) methods were applied to different treatments.

Results and Discussion

Productivity of entire cropping system

Rice-potato-okra system produced significantly maximum REY_S (187.16 q/ ha) mainly due to inclusion of high value crops like potato and okra during *Rabi* and summer seasons (Table.1).

These results are in close conformity with the findings of several other researchers from different Agro-climatic conditions (Sharma *et al.*, 2004; Pramanik *et al.*, 2007). Rice-Berseem (fodder + seed) system was next to it with REY of 115.49 q/ ha. The high tonnage of green fodder obtained from Berseem during *Rabi* season coupled with very high value seeds by allowing Berseem for seed production resulted into such high REYs, But this system was comparable to rice-vegetable pea-sorghum fodder system producing REYs of 108.94 q/ha. Green-manuring-rice-wheat system produced significantly the lowest REYs (69.08 q/ha) among all the four crop-sequences tested. Among the 3 nutrient management practices, 100% inorganic nutrition produced maximum mean REY (127.44 q/ha) from all crop-sequences, which was almost comparable to those obtained with INM (122.44 q/ ha).

Application of 100% organics under proved significantly the lowest yielder with REYs of 110.62 q/ha among them. It is obvious that the gaps in REY between different nutrient management practices were wider during the early year of experimentation which gradually narrowed down with every advancement in crop-cycles till the present 4th cycle. Thus, it could be believed that organic nutrient management may have an opportunity to equalize the productivity of crops in sustainable manner during 4th coming crop-cycles.

Water productivity

Water is a most important and crucial resource base in agriculture. At present, the universal water crises is being experienced seriously in all sectors of life including agriculture. Therefore, it is imperative to evaluate the water-use efficiency of varying cropping systems tested under different nutrient management practices. Data pertaining to this parameters were not available for the preceding 3 crop-cycles, hence unanalyzed of 2007-08 are interpreted. The water productivity was maximum (86.56 kg/ha/cm) with rice-potato-okra among the 4 crop-sequenced tested. The next best cropping systems were rice-vegetable pea-forage sorghum, rice- berseem and green manuring-rice wheat with water productivity of

Table.1 Mean combined yield in terms of rice equivalent yield of various nutrient management under different cropping system during four consecutive years (2004- 05 to 2007- 08)

Treatment	Rice Equivalent Yield (q/ ha)				
	2004-05	**2005-06**	**2006-07**	**2007-08**	Mean
Nutrient Management					
100% organic	**129.99**	114.81	100.76	96.94	**110.62**
100% inorganic	**157.85**	131.77	112.30	107.86	**127.44**
Integrated (50% each of organic and inorganic)	**149.77**	124.19	108.71	107.11	**122.44**
Cropping System					
Green Manure- Rice-Durum Wheat	**78.93**	78.91	58.32	60.16	**69.08**
Rice-Potato-Okra	**226.69**	178.52	168.35	175.08	**187.16**
Rice-Berseem (fodder and seed)	**149.88**	118.18	104.90	89.01	**115.49**
Rice-Vegetable Pea-Sorghum (fodder)	**127.95**	118.75	97.43	91.62	**108.94**

	Nutrient Management (M)	**Cropping System (CS)**	**M x CS**
SE m±	2.65	3.06	**5.29**
CD at 5%	7.62	8.79	**NS**

NS - Non significant

Table.2 Mean consumptive use of water (cm/ha) under different nutrient management and cropping system during 2007-08

Treatment	**Green Manure-Rice-Durum Wheat**	**Rice-Potato-Okra**	**Rice-Berseem (fodder and seed)**	**Rice-Vegetable Pea-Sorghum (fodder)**	**Mean**
100% organic	181.91	200.87	206..87	176.03	191.42
100% inorganic	184.93	203.66	208.84	179.47	194.22
Integrated (50% each of organic and inorganic)	182.79	201.80	207.17	177.24	192.25
Mean	183.21	202.11	207.62	177.58	192.63

Table.3 Mean water productivity (kg/ha/cm) under different nutrient management and cropping system during 2007-08

Treatment	Green Manure-Rice-Durum Wheat	Rice-Potato-Okra	Rice-Berseem (fodder and seed)	Rice-Vegetable Pea-Sorghum (fodder)	Mean
100% organic	30.85	75.70	42.82	51.69	50.26
100% inorganic	33.47	91.86	43.35	51.90	54.97
Integrated (50% each of organic and inorganic)	34.17	92.20	42.43	51.90	55.17
Mean	32.83	86.58	42.86	51.90	53.46

Table.4 Effect of different nutrient management associated with various cropping systems on changes in physic-chemical properties of soil till the completion of 4th crop –cycle during 2007-08

Treatment	pH	EC (dS/m)	Organic carbon (%)	Bulk density (g/cm^3)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Initial	7.4	0.51	0.70	1.35	264	12.6	282
Nutrient Management							
100% organic	7.2	0.49	0.78	1.36	288	13.0	297
100% inorganic	7.2	0.51	0.71	1.40	271	12.4	271
Integrated (50% each of organic and inorganic)	7.2	0.50	0.74	1.37	278	12.7	291
Cropping System							
Green Manure-Rice-Durum Wheat	7.3	0.50	0.75	1.38	281	12.7	283
Rice-Potato-Okra	7.1	0.49	0.73	1.37	274	12.5	288
Rice-Berseem (fodder and seed)	7.2	0.49	0.74	1.38	279	12.5	287
Rice-Vegetable Pea-Sorghum (fodder)	7.3	0.51	0.75	1.38	283	13.0	287

Table.5. Effect of different nutrient management associated with various cropping systems on changes in biological properties of soil till the completion of 4th crop –cycle during 2007-08

Treatment	Fungi (10^4/g)	Bacteria (10^6/g)	Azotobacter (10^6/g)	PSB (10^6/g)	Actinomycities (10^6/g)
Initial	33.7	35.7	17.5	9.7	5.9
Nutrient Management					
100% organic-M_1	49.3	60.0	31.7	20.5	14.5
100% inorganic—M_2	38.8	36.1	20.7	12.4	7.9
Integrated (50% each of organic and inorganic)-M_3	41.7	44.2	25.4	15.5	11.6
Cropping System					
Green Manure- Rice-Durum Wheat-CS_1	43.6	46.8	27.6	16.3	12.0
Rice-Potato-Okra -CS_2	42.5	46.0	25.6	15.9	10.8
Rice-Berseem (fodder and seed)-CS_3	43.7	47.6	27.8	16.4	11.4
Rice-Vegetable Pea-Sorghum (fodder)-CS_4	43.4	46.7	26.0	16.0	11.1

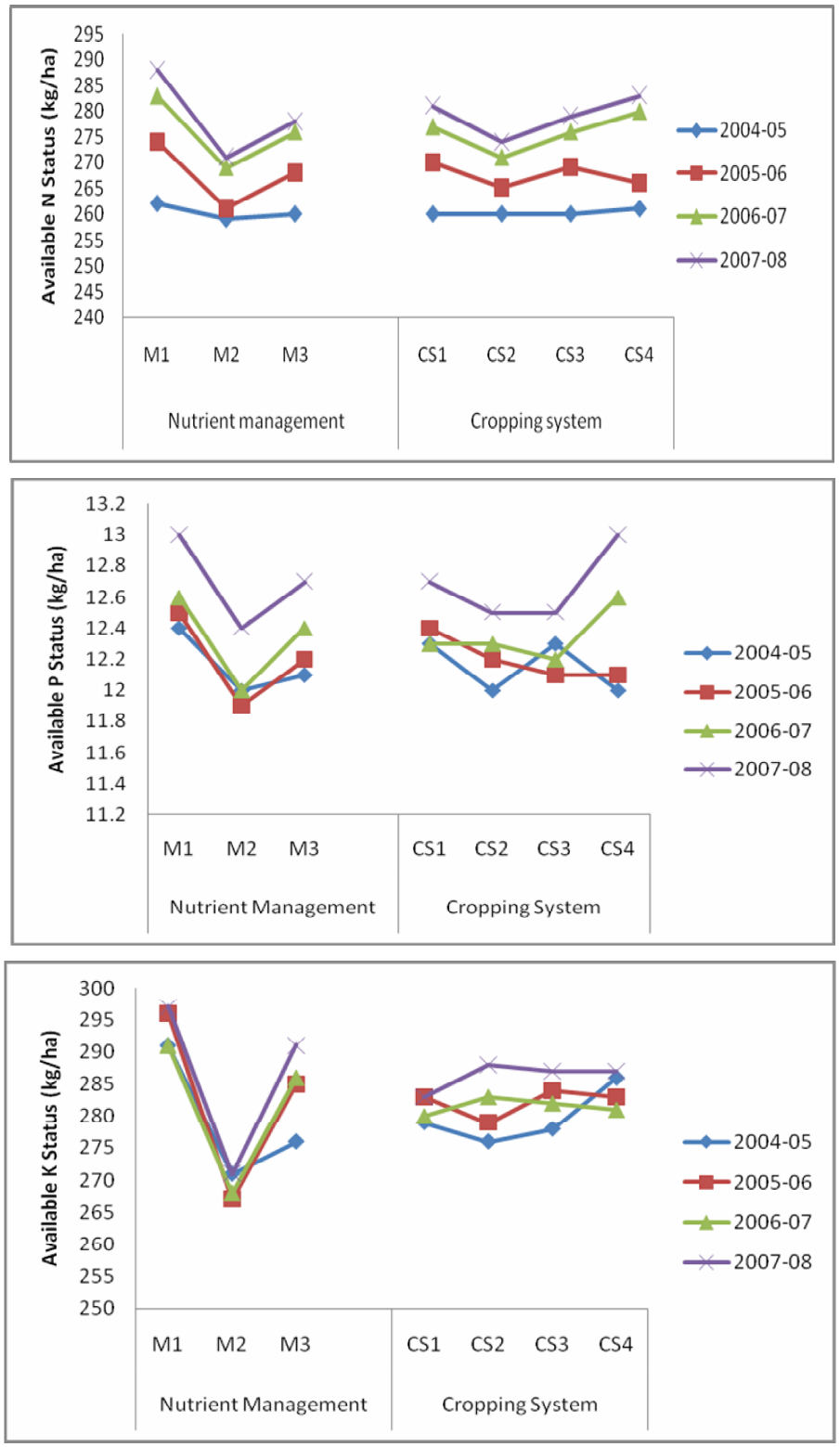
51.90, 42.86 and 32.83 kg/ha/cm, respectively in descending order (Table 3).The productivity of all crop components was maximum with consumptive use of water of 202.11 cm/ha under rice-potato-okra, which attributed to the maximum productivity. Though productivity was comparable with rice-berseem and rice-vegetable pea-sorghum, the lesser consumptive use of water with rice-vegetable pea-sorghum (177.58 cm/ha) resulted into higher water productivity than rice-berseem having consumptive use of water of 207.62 cm/ha. The productivity was minimum under green manuring-rice-wheat having higher consumptive use of water (183.21 cm/ha) than rice-vegetable pea-sorghum attributed to the lowest water productivity. Similar results have been reported by Singh *et al.*, (1997) and Parihar *et al.*, (1999) also from their studies.

The water productivity was comparable between integrated (55.17 kg/ha/cm) and 100% inorganic (54.97 kg/ha/cm) due to almost identical productivity with the same consumptive use of water (Table 3). The 100% organic nutrient management produced minimum water productivity (50.26 kg/ha/cm) because of the lowest system productivity almost with the same consumptive use of water.

Physico-chemical and biological properties of soil

After the completion of fourth crop-cycle under different treatments, it is noted that pH and EC of soil were unchanged over their initial status under all treatments (Table 4). But OC and N contents showed increasing trend with the treatment associated by 100% organics.

Fig.1 Available N, P and K status of soil as affected by different organic, inorganic and integrated nutrient management



These soil parameters were almost maintained in 100% inorganics and integrated nutrient management. (Fig 1). However, integrated nutrient management had superiority over 100% inorganics. The bulk density of soil and available P and K contents almost maintained their parental status after completion of fourth crop-cycle under 100% organics and integrated nutrient management, while 100% inorganics exhibited declining trend in P and K as well as rising trend in bulk density. These results are in close conformity with the findings of Pradhan and Mondal (1997) and Varalakshmi *et al*., (2005).

As regards biological properties of soil, the population of microbes such as fungi, bacteria, azotobacter, PSB and actinomycetes increased remarkably with all cropping systems associated with 100% organic nutrition over their initial status after completion of 4th crop-cycle (Table 5). The values of these microbes declined with integrated nutrient management over 100% organic nutrition, while population of these microbes was minimum under all cropping system with 100% inorganics. Similar improvement in microbial properties of soil with organic nutrition has been reported by Dubey and Agrawal (1999) and Saini *et al.,* (2005) also. Where M_1, M_2 and M_3 are 100% organic, 100% inorganic and Integrated (50% each of organic and inorganic), respectively CS_1, CS_2, CS_3 and CS_4 are Green Manure-Rice-Durum Wheat, Rice-Potato-Okra, Rice-Berseem (fodder and seed) and Rice-Vegetable Pea-Sorghum (fodder), respectively.

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