Research Paper

ADVANCE RESEARCH JOURNAL OF
CROP
IMPROVEMENT
Volume 3 | Issue 2 | December, 2012 | 88-92

Effect of crop diversification and organic manuring on system productivity and soil health

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ABSTRACT : A field experiment was conducted during 2005-06 and 2006-07 to find out the most remunerative rice based cropping sequence and source of organic nutrition for sustainable production on sandy clay loam soil, low in available N and S and medium in P and K. RGEY was recorded highest with the treatment comprising application of nitrogen through organic manure along with bio-inoculants (*Azotobacter* and PSB) followed by only N through organic manure. RGEY and gross return was recorded significantly higher in rice-potato-onion cropping sequence. Net return was also recorded significantly higher under rice-potato-onion cropping sequence except rice-rajmash-onion. Production efficiency was also recorded significantly higher in rice-potato-onion cropping sequence than rest of the treatments. Nutrient uptake had obtained significantly highest value in rice-maize-cowpea cropping sequence. Nutrient status of the soil and microbial profile got improved significantly under treatment in which 100 per cent RDN was applied through organic manures along with biofertilizers.

Key Words : Crop diversification, Organic manure, Soil healthy

How to cite this paper : Singh, Yogeshwar, Saha, Ruby, Yadav, S.K., Rajput, P.K. and Singh, K. (2012). Effect of crop diversification and organic manuring on system productivity and soil health, *Adv. Res. J. Crop Improv.*, **3** (2) : 88-92.

Paper History : Received : 01.06.2012; **Revised :** 17.08.2012; **Accepted :** 14.10.2012

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Increased consumer awareness of food safety issues and environmental concerns has contributed to the growth in organic farming over the last few years. Organic farming has to be understood as part of a sustainable farming system and a viable alternative to the more traditional approaches to agriculture. During the green revolution, the strategy of intensive external inputs mostly inorganic fertilisers oriented agriculture has depleted soil fertility considerably in all major agricultural production system. This has led to a stagnation of food grain production in recent years inspite of consistent increment in fertiliser use (Abrol *et al.*, 2000). This stagnation in agricultural productivity is often attributed to degradation of soil due to various biotic and abiotic stresses inflicted in soil (Wang *et al.*, 2003). So, application of organic manures is again emerging as an important aspect in giving impetus in sustaining soil health and maintaining there by the productivity levels of soils. There is a gap of approximately 10 mt of NPK between addition and removal of nutrients from the soil. At present, most optimistic estimates show that about 25-30 per cent nutrient needs of Indian agriculture can be met by utilizing various organic sources. Supplementation of entire N through FYM sustains crop productivity at much lower level. Since, the estimates of NPK availability from organic sources are based on total nutrient content, efficiency of these sources to meet the nutrient requirement of crops is not assured as mineral fertilizers. The incorporation of organic manures has favourable effect on soil properties such as pH, organic carbon, water holding capacity and bulk density. It adds plenty of carbon and thus increases heterotrophic bacteria and fungi in the soil, which further increase the activity of soil enzymes responsible for the conversion of unavailable to available forms of nutrients. Besides major nutrients a fair amount of micronutrients *i.e.* Mn, Zn, Cu and Fe are simultaneously added to the soil. Organic farming relies on crop rotations, crop residues, animal manures, legumes, green manures, organic wastes and aspect of biological pest control to maintain soil productivity and tilth to supply plant nutrients and to control insect, weed and other pest. The concept of soil as a living system, that develops the activities of beneficial organisms is the centre to this definition. Keeping these facts in view an attempt has been made to work out the most remunerative high value cropping sequence and suitable source of organic manuring.

RESEARCH PROCEDURE

The field experiment was conducted during the 2005-06 and 2006-07 at Research Farm, Institute of Agricultural Sciences, B.H.U., Varanasi to study the effect of crop diversification and intensification and organic manuring on system productivity and soil health. The soil was sandy clay loam with pH 7.4, organic carbon 0.50 per cent, low in available N (185.50 kg ha^{-1}), S (19.28 kg ha^{-1}) and zinc (0.51 ppm) and medium in P (20.35 kg P ha^{-1}), potassium (210.32 kg K_2O ha^{-1}) and iron (9.85 ppm). The experiment was conducted in split plot design with three replications and seven (7) cropping sequences in main plot namely CS-I rice-potato-onion; CS-II rice-green pea-onion; CS-III rice- potato-cowpea (Green pod); CS-IV rice- green pea -cowpea (Green pod); CS-V rice-rajmash (Green pod)- onion; CS-VI rice-rajmash (Green pod)-cowpea (Green pod) and CS-VII rice-maize(Green cob)-cowpea (Vegetable) and three (3) subplot treatments of nitrogen substitution through organic source namely N_0 (control), N_1 (100% RDN through OM) and N_2 (100% RDN through organic manures + biofertilizer). Organic manures of 100 per cent N was done as 1/3 N through FYM as 1/3 N through poultry manure + 1/3 N through vermicompost. *Azotobacter* and PSB were used as biofertilizers. The FYM, vermicompost and poultry manure contained 0.50, 1.30 and 2.80 per cent N, 0.20, 0.75 and 2.20 per cent, P_2O_5 and 0.50, 1.23 and 1.30 per cent K_2O, respectively. The crop varieties used in experimentation were rice-HUBR 2-1, potato-Kufri Badshah, green pea-early apoorva, rajmash-HUR-137, maize-Pioneer hybrid (X3342), onion-Agrifound light red and Cowpea-Tokito hybrid. The mechanical, chemical and biological properties of soil were analysed initially and at the end of the each cropping sequence annually as per standard procedures as mentioned in Table A. To compare crop sequences, the yield of all the crops were converted into rice grain equivalent yield (RGEY) on price basis (Verma and Mudgal, 1983). Economics of the treatments were computed on the basis of prevailing market rates of the produce and agro-inputs. Production efficiency (kg/ha/day) was calculated by dividing total production (RGEY) in a cropping sequence by 365. As the trend of data was similar in both the years, pooled data are presented.

Table A : Initial parameters of the experimental field

Particulars	Value (0-30 cm soil)	Method employed
Mechanical properties		
Soil separates (%)		
Sand	44.65	
Silt	30.05	Hydrometer method (Bouyoucos, 1962)
Clay	25.08	
Textural class	Sandy clay loam	
Porosity (%)	36.38	
Bulk density (g m^{-3})	1.44	Core Sampler method (Piper, 1966)
Water holding capacity (%)	33.49	Keen box method (Chopra and Kanwar)
Chemical properties		
pH (1: 2.5 soil water ratio)	7.40	Glass Electrode pH Meter (Jackson, 1973)
Electrical conductivity (dS m^{-1} at 25 ^{0}C)	0.35	Electrical Conductivity Meter (Jackson, 1973)
Organic carbon (%)	0.50	Walkley and Black method (Jackson, 1973)
Available nitrogen (kg N ha^{-1})	185.50	Alkaline Permanganate method (Subbaiah and Asija, 1973)
Available phosphorus (kg P ha^{-1})	20.35	0.5 M NaHCO3 Extractable Olsen's Colorimetric method Olsen's (1954)
Available potassium (kg K_2O ha^{-1})	210.32	Flame Photometric method (Ammonium acetate extract) (Jackson, 1973)
Available sulphur (kg S ha^{-1})	19.28	Turbidimetric method (Chesnin and Yien, 1950)
Available iron (ppm)	9.85	Extraction with DTPA solution (Lindsay and Norvell, 1978)
Available zinc (ppm)	0.51	Extraction with DTPA solution (Lindsay and Norvell, 1978)
Available manganese (ppm)	4.25	Extraction with DTPA solution (Lindsay and Norvell, 1978)
Available copper (ppm)	1.81	Extraction with DTPA solution (Lindsay and Norvell, 1978)
Biological properties		
Microbial properties	Population /g oven dry soil	MPN, Cochran's method (1950).
Actinomycetes	24.37×10^4	
Bacteria	46.10×10^5	
Fungi	25.19×10^3	

RESEARCH ANALYSIS AND REASONING

The results obtained from the present investigation have been discussed in the following sub heads:

Effect on yield and production efficiency:

RGEY data related to (Table 1) revealed that RGEY was recorded maximum in CS-I (rice-potato-onion) which was significantly higher than that of other crop sequences. Application of nitrogen through organic manures along with bio-inoculants (N_2) brought about significant increase in yield compared to N_1 and N_0.

Production efficiency was recorded maximum in CS-I (rice-potato-onion) and significantly higher to rest of the treatment. Among various nitrogen substitutions N_2 had recorded significantly higher production efficiency followed by N_1 and lowest in N_0 (control).

Effect on economics:

A perusal of data on economics (Table 1) exhibited that maximum gross return was recorded under CS-I (rice-potato-onion), which was significantly higher than that of other crop sequences. Net return was also recorded maximum under CS-I (rice-potato-onion) which was significantly higher to all the treatments except CS-V (rice-rajmash-onion). Benefit:Cost ratio was recorded maximum CS-VI (rice-rajmash-cowpea) which was significantly higher than all other treatments except CS-VII (rice-maize-cowpea). Among the organic nitrogen substitution, application of N through organic manures along with biofertilizers (N_2) had registered significantly higher gross return, net return as well as B:C ratio and lowest values were observed in N_0 (control).

Soil nutrient and microbial status:

Data on nutrient status and microbial counts (Table 2) exhibited that different cropping sequences did not differ significantly with respect to status of major (N, P, K, S) and minor (Zn, Fe, Cu, Mn) nutrients and microbial status of soil. However, maximum improvement in this respect was observed where vegetable pulse crops were incorporated in the sequences. Application of either organic manure alone (N_1) or with biofertilizer (N_2) significantly improved the soil status with respect to nutrient as well as microbial count under study and the highest value of these were associated with the application of N through organic manures along with biofertilizers. This improvement could be attributed to slower release of plant nutrients from organic manures during the entire crop growing season due to its more humified nature as reported by Chettri *et al.* (2004).

In the light of these results, it can be concluded that the high value crop sequence (rice-potato-onion), which includes vegetables, can be followed to enhance the system productivity and profitability for prosperity of farming community of agro-eco-region identical to eastern Uttar Pradesh. It is also advised to adopt organic manuring with biofertilizers to sustain soil health on long term basis for sustainable crop production.

Table 1 : Effect of different treatments on rice grain equivalent yield, production efficiency and economics of the system (pooled data of two years)

Treatments	System productivity		Economics			
	RGEY (q/ha)	Production efficiency (kg/ha/day)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
Main plot (Crop sequences)						
T_1 [Rice-Potato-Onion]	472.08	129.34	97169	214823	117654	1.21
T_2 [Rice-Green pea-Onion]	331.95	90.94	64484	152271	87787	1.37
T_3 [Rice-Potato-Cowpea (Green Pod)]	424.55	116.32	81349	194118	112770	1.39
T_4 [Rice- Green pea -Cowpea (Green Pod)]	260.40	71.34	48664	120845	72181	1.49
T_5 [Rice-Rajmash (Green Pod)- Onion]	413.58	113.31	70789	188016	117226	1.66
T_6 [Rice-Rajmash(GreenPod)-Cowpea(Green Pod)]	351.63	96.34	54969	160803	105834	1.93
T_7 [Rice-Maize(Green cob)-Cowpea(Vegetable)]	330.75	77.04	55665	156158	100493	1.81
S.E.±	12.90	2.57	-	5841	3496	0.05
C.D. (P=0.05)	38.68	7.71	-	17514	10483	0.16
Sub plot (Organic manures and biofertilizers)						
N_0 [Control]*	184.53	49.02	51491	85629	34138	0.77
N_1 [100% RDN through OM]**	440.72	118.58	75345	202012	126667	1.82
N_2 [100% RDN through OM+ Biofertilizer]***	482.58	130.10	75916	221088	145171	2.06
S.E.±	5.53	1.33	-	2440	1565	0.02
C.D. (P=0.05)	15.90	3.83	-	7028	4506	0.07

Table 2 : Effect of different treatments on fertility status of soil at the end of cycle (pooled data of two years)

Treatments		Organic carbon (%)	Available nutrients (kg/ha)				Available nutrients (ppm)				Microflora profile		
			N	P	K	S	Zn	Fe	Mn	Cu	Bacteria population x 10^5	Actinomycetes population x 10^4	Fungi population x 10^3
Main plot (Crop sequences)													
T_1	Sequence I	0.506	185.79	19.94	205.13	18.86	0.502	10.09	4.32	1.87	59.18	31.48	30.18
T_2	Sequence II	0.523	193.33	21.74	218.43	20.12	0.531	10.18	4.36	1.87	59.76	31.31	28.10
T_3	Sequence III	0.520	190.28	21.14	212.79	20.54	0.521	10.01	4.32	1.86	59.60	31.46	28.33
T_4	Sequence IV	0.525	192.58	21.58	216.62	20.80	0.534	10.14	4.36	1.88	60.16	31.33	29.83
T_5	Sequence V	0.524	191.11	20.98	212.79	20.15	0.535	10.20	4.37	1.86	58.14	31.18	28.07
T_6	Sequence VI	0.526	192.75	22.01	220.48	20.38	0.527	10.05	4.30	1.85	59.98	31.00	27.56
T_7	Sequence VII	0.513	189.14	21.80	210.87	20.29	0.493	9.97	4.27	1.84	59.85	30.78	24.98
S.E. ±		0.015	5.41	0.60	6.06	0.58	0.015	0.29	0.12	0.05	1.72	0.90	0.83
C.D. (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot (Organic manures and biofertilizers)													
N_0	Control	0.481	177.23	19.70	201.35	18.16	0.469	9.45	4.05	1.77	37.56	19.97	18.53
N_1	Organic manure (OM)	0.537	196.98	22.06	219.46	21.07	0.542	10.39	4.45	1.90	63.14	33.76	30.71
N_2	OM + biofertilizer	0.540	197.92	22.17	220.81	21.26	0.549	10.44	4.47	1.91	77.88	40.02	35.13
S.E. ±		0.007	2.48	0.28	2.77	0.26	0.007	0.13	0.06	0.02	0.84	0.44	0.39
C.D. (P=0.05)		0.019	7.13	0.80	7.98	0.76	0.019	0.38	0.16	0.07	2.42	1.25	1.13
Initial		0.50	185.50	20.35	210.32	19.28	0.51	9.85	4.25	1.81	46.10	24.37	25.19

NS=Non-significant

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