Title

Effect of continuous cropping on changes in crop productivity nutrient budgets and soil properties with and without FYM under pearl millet - mustard – cowpea cropping sequence

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Introduction

The decline in soil fertility due to deficiency of nutrients other than the applied in the form of chemical fertilizers and the decline in organic carbon are the matter of nutrient imbalance which has been recognized as one of the most important factors that limit crop yield. Addition of organic manures along with chemical fertilizers is known to stimulate organic matter turnover which affect the inter conversion of different fractions of the nutrients and modify their availability in the soil (Stevenson, 1986). The long-term application of chemical fertilizers alone under intensive cropping may deplete the reserve pool of non-applied nutrients and carbon, which, if not properly managed, leads to deterioration of soil productivity. The present investigation was undertaken to study the long term effect of FYM and fertilizer (NP) application on crop yields, nutrient uptake and changes in different soil fractions of NPK under a pearl millet-mustard-cowpea (F) cropping sequence.

Material and Methods

A long-term field experiment was started by the Micronutrient Project (ICAR), at Anand campus Anand in 1980 to study the effect of continuous cropping on depletion pattern of nutrients especially of micronutrients on a light textured soil with medium fertility (*Typic Ustochrept*). The experiment was modified in 1994 and continued until 2006-07 to study the role of cattle farm yard manure (FYM) in maintenance of soil fertility and productivity at different fertility levels (0, 50, 100 and 150 % recommended dose of NPK ha^{-1}) under pearl millet (*kharif*, var.GHB-558) - mustard (*rabi,* var.GM-2) - summer cowpea (var.EC4216) cropping sequence in a randomized block design (two factors i.e. FYM (F) and Fertility Levels with the eight treatments combinations: F_0FL_0, F_0FL_1, , F_0FL_2, , F_0FL_3, F_1FL_0, F_1FL_1, , F_1FL_2, , F_1FL_3) with three replications. The recommended fertilizers doses of NPK applied to pearl millet, mustard and cowpea (Fodder) were 80-40-0, 50-50-0 and 25-50-0, respectively. The well decomposed FYM at 10 t ha^{-1} was applied to every pearl millet crop as per treatment before sowing since modification of the experiment in 1994. At harvest, yield data of crops were recorded; and soil and plant samples were collected. The soil samples were analyzed for pH, EC, OC, available N, P, K, S and DTPA-micronutrients as per the standard methods (Page *et al*., 1982). The di-acid (HNO_3:$HClO_4$ - 4:1) extract of plant samples was used for analysis of total P, K, S and micronutrients using standard analytical methods.

Results and Discussion

Effect of FYM and fertility levels on crops yield

The FYM and fertilizer (NP) application irrespective of FL and F levels increased yields of the crops over corresponding control treatments in all individual years (Tab..1). However, there was a reduction in overall productivity of the pearl millet grain and mustard seed under both FYM and fertility (FL) treatments over the years except in 2005-06 which was mainly due to exceptionally favorable rainfall conditions. The productivity of pearl millet grain and mustard seed declined by about 64 and 41 per cent after five years over corresponding yield of 3450 and 1660 kg ha^{-1} in 2002-03. Similar reductions were also noticed under F as well as FL treatments.

In general, the decline in productivity of the crops could be mainly ascribed to long-term effect of intensive cropping on the same site which gradually disturbed the balanced nutrition of the crops due to higher removal of major and micronutrients without their supplementation in appropriate quantity. In case of cowpea; there was an overall increase in the fodder yield which caused an improvement by 7 and 10 per cent under F_0 and F_1 irrespective of fertility levels in 2007 over the corresponding yield in 2003, respectively. It was also observed that the growth of

crops was poor when the crops did not receive any fertilizer or FYM application (i.e. in $F_0N_0P_0$, Tab. 1a). The FYM application alone could improve the crops yields over the years; and the effect was more pronounced in case of pearl millet followed by mustard; while the legume cowpea did not show remarkable differences among the treatments.

The interaction effect of F x FL in 2003, 2004 and 2006 was found significant which indicated that the maximum pearl millet grain yield could be recorded under F_1FL_3 treatment which was at par with F_1FL_2 (Table 1b). It indicated that the fertilizer application along with FYM application at 10 t ha^{-1} was necessary for higher grain yield of pearl millet. The interaction effect of F x FL was found non-significant in mustard and cowpea in all the years.

The enhancement in productivity of the crops due to FYM application could be due to its beneficial role in improving soil physical, chemical and biological properties (Maji and Mandal, 2004). The FYM application supplemented all essential nutrients in appreciable quantities besides organic matter in the soil. Similarly, the application of NP fertilizers alone also ensured the adequate nutrition of the crops for N and P which also may have caused a priming effect leading to better utilization of native secondary and micronutrients resulting in improved crop growth and, thereby, higher dry matter production.

Effect of FYM and fertility levels on nutrient removal

In general, the FYM and fertilizer application improved nutrient uptake by pearl millet and mustard over F_0 and FL_0 treatments (Table 2). The increase in microbial counts and thereby enhanced bio-chemical reactions due to organic matter addition at 10 t ha^{-1} yr^{-1} during 2002 – 06 (5 years) in $F_1N_0P_0$ treatment resulted in total addition of about 249, 183, 215, 104, 12, 3 and 1 kg of N, P, K, Fe, Mn, Zn and Cu, respectively, enhanced nutrient availability and ,thereby, uptake. In case of fertility treatments, the depletion of the nutrients was more pronounced at higher fertility causing a mismatch in nutrients supply vs demand. It was clearly noticed that there was a remarkable depletion of N and K under all the treatments; while except in control (F0N0P0), there was a buildup in P balance. The effect of K mining due to increased N levels was also noticed. The growing of crops three times in a year for about three decades exploited the native nutrients reserve of the soil to a greater extent disturbing the equilibrium among different fractions of the nutrients. The only NP fertilization caused mining effect on reserve of nutrients viz., K, S and micronutrients; and reduced their availability which adversely affected the growth and productivity of the crops.

Table 1a: Effect of FYM and fertility levels (FL) on crop yields (kg ha^{-1}) in a long-term field experiment

Treatments	Pearl millet grain yield (kg ha^{-1})					Mustard seed yield (kg ha^{-1})					Fodder yield (kg ha^{-1})				
	2002	**2003**	**2004**	**2005**	**2006**	**2003**	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**
FYM levels															
F_0	2602	1415	1060	1895	887	1375	1263	1095	1858	852	2916	3378	3162	3252	3117
F_1	3451	2355	1712	2498	1245	1663	1485	1294	1892	983	3130	3338	3645	3684	3445
S. Em. ±	47	58	42	63	67	27	36	47	17	20	45	60	55	65	66
CD (P=0.05)	143	175	128	190	203	83	109	141	NS	61	136	NS	166	197	201
Fertility levels															
FL_0	2406	1036	925	1606	601	927	831	669	1283	353	2714	3165	2790	2605	2904
FL_1	2809	1963	1310	2212	926	1433	1245	1091	1598	834	3056	3264	3333	2764	3099
FL_2	3279	2145	1535	2477	1239	1751	1593	1552	2165	1184	3159	3482	3497	3966	3334
FL_3	3611	2396	1773	2491	1498	1965	1827	1467	2454	1298	3163	3522	3995	4536	3786
S. Em. ±	66	81	60	89	94	39	51	66	24	29	64	84	77	92	94
CD (P=0.05)	202	247	181	269	287	117	154	200	72	86	193	256	234	279	284
F x FL	NS	Sig.	Sig.	NS	Sig.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 1b: Interaction effect of FYM and fertility levels on crop yields in a long term field experiment

FYM levels	FL_0	FL_1	FL_2	FL_3	S. Em. ±	CD (P= 0.05)
	Pearl millet grain yield					
	Year 2003					
F_0	755	1279	1620	2007	115	349
F_1	1318	2648	2670	2785		
	Year 2004					
F_0	817	956	1040	1427	84	256
F_1	1034	1664	2030	2118		
	Year 2006					
F_0	512	833	1161	1042	134	405
F_1	690	1019	1317	1954		

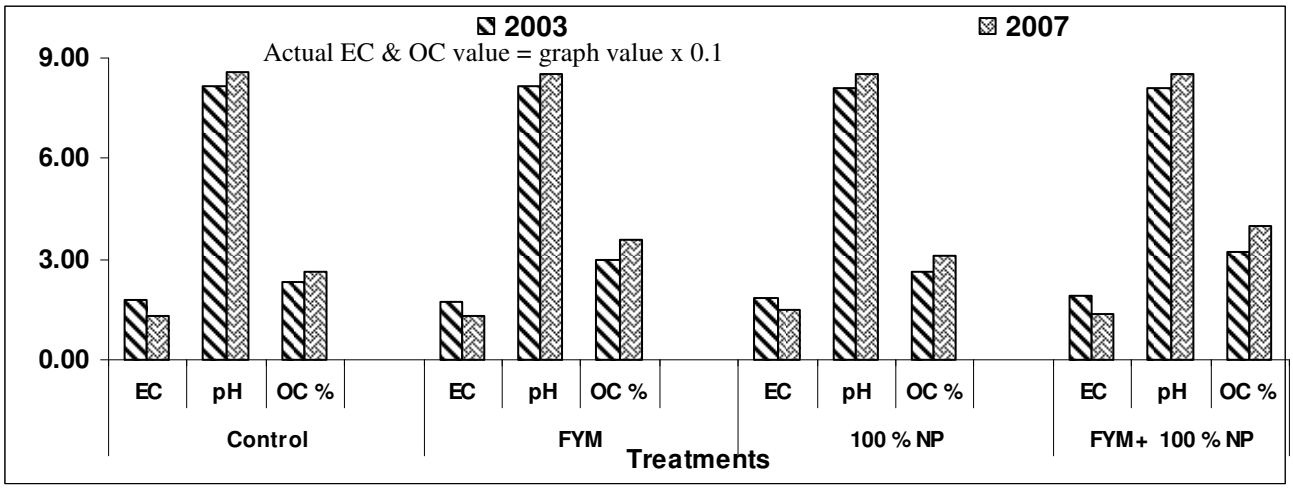
Table 2: Nutrient budget (kg ha^{-1}) under pearl millet – mustard – cowpea cropping sequence (2002 – 07)

Treatments	Total nutrient addition (kg ha^{-1})			Total nutrients removed by the sequence (kg ha ^{1})			Balance of nutrients (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
$F_0N_0P_0$	0	0	0	560	55	311	(-) 560	(-) 55	(-) 311
$F_0N_1P_1$	388	154	0	868	87	480	(-) 481	67	(-) 480
$F_0N_2P_2$	775	308	0	1140	114	624	(-) 365	194	(-) 624
$F_0N_3P_3$	1163	462	0	1202	136	660	(-) 39	326	(-) 660
$F_1N_0P_0$	249	183	215	789	90	485	(-) 540	93	(-) 270
$F_1N_1P_1$	637	337	215	1081	133	690	(-) 445	204	(-) 475
$F_1N_2P_2$	1024	491	215	1359	165	822	(-) 335	326	(-) 607
$F_1N_3P_3$	1412	645	215	1501	196	839	(-) 89	449	(-) 624

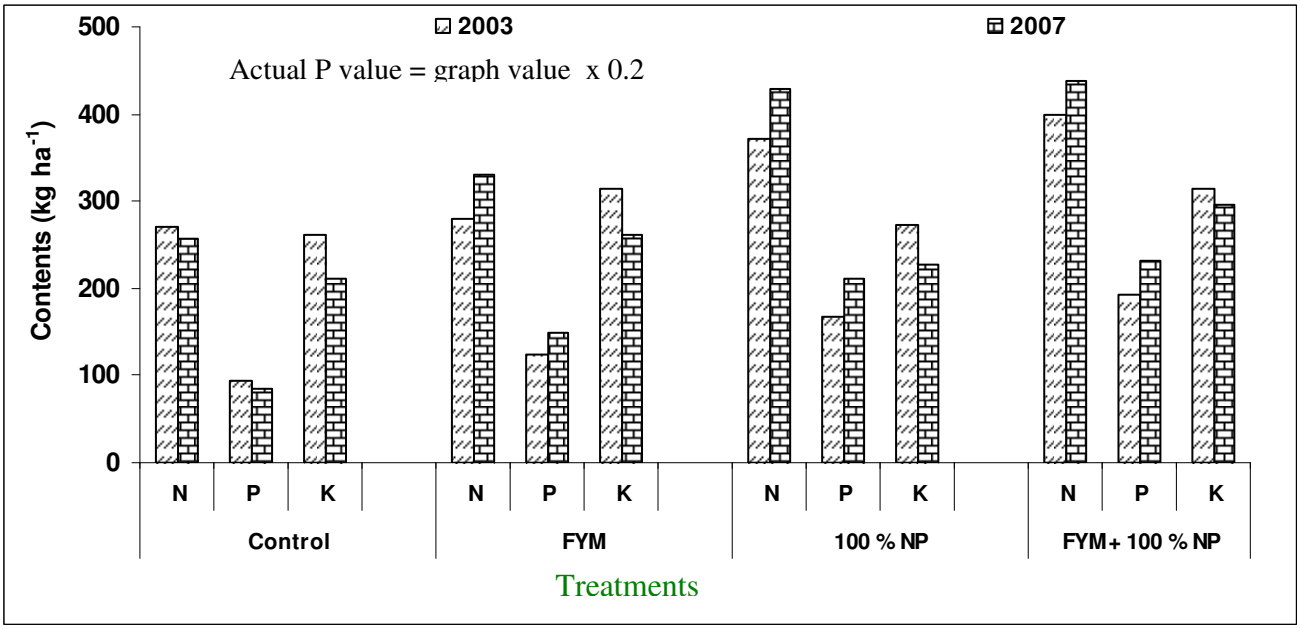
Effect of FYM and Fertility levels on soil properties

In general, the soil pH increased over the years, while EC significantly decreased in 0-15 cm depth (Fig. 1). The soluble salts content under FYM and FL treatments (irrespective of NP and FYM levels) were higher than F_0 and FL_0 treatments. The soil OC increased by 19 per cent in five years over its initial value in 2003 (0.31 %) due to FYM (F_1) application; while it declined in the control reducing the availability of nutrients causing poor crop growth (Tolanur and Badanur, 2003).

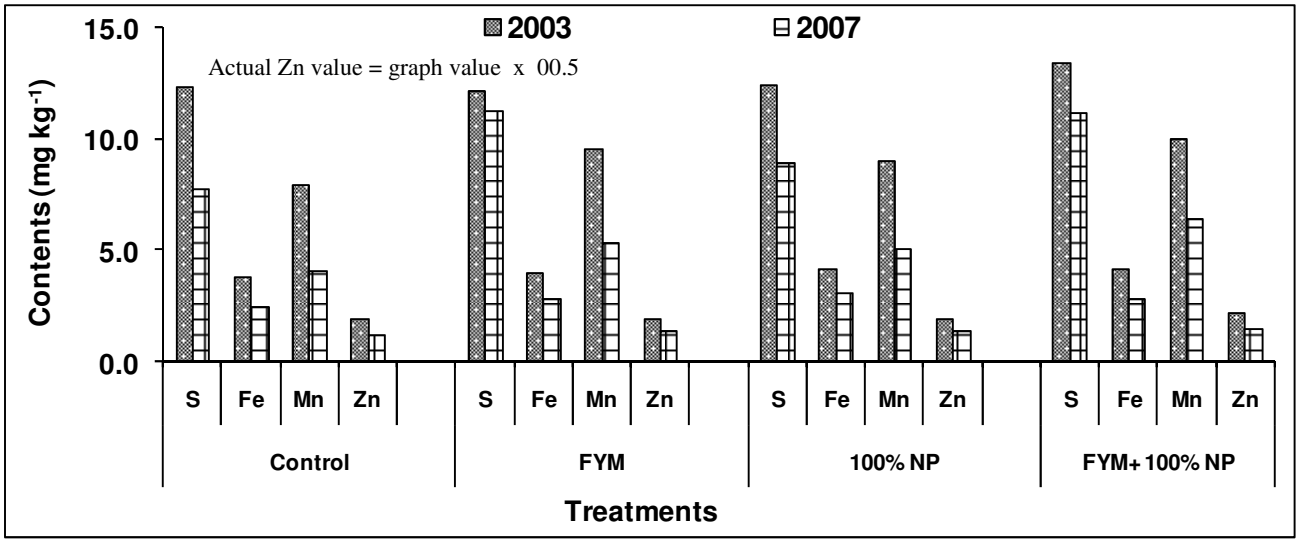
The treatments of FYM and fertility (irrespective of NP and FYM levels, respectively) enhanced soil available N and P in 2007 by 13 and 25 per cent each over F_0 and FL_0 treatments, respectively in 2003. Contrary to N and P availability, that of K and S were found decreased by about 16 and 18 per cent due to FYM and by 15 and 28 per cent due to fertility (100 % NP) treatments in 2007 over corresponding availability values in 2003 (Fig. 1). The FYM application significantly increased DTPA-Fe, Mn, Zn and Cu over control (F_0FL_0) in surface soil while contents of available N, P, K, S, Fe, Mn and Zn decreased in control by 5, 10, 20, 37, 35, 49 and 35 per cent, respectively after five years of cropping (Fig. 1). The increase or maintenance of available nutrients due to FYM addition is in accordance with its beneficial role in improving important properties of the soil (Nambiar, 1994).



A: Soil pH, EC and organic carbon



B: Available N, P and K



C: Available S and DTPA – Fe, Mn & Zn

Fig. 1: Effect of different treatments on changes in important soil properties

Conclusions

The overall results of the study indicated the importance of FYM application to provide balanced nutrition to the crops grown under intensive cultivation. Further, the inclusion of leguminous crops like cowpea (fodder) was found advantageous. Besides, the study underlined the need for supplementation of limiting nutrients like K, S and deficient micronutrients to provide balanced nutrition to the crops for sustainable higher productivity under intensive cropping.

References

Blake L, Johnston AE, Poulton, PR, Goulding, KWT. Changes in soil phosphorus fractions following positive and negative phosphorus balances for long periods. Plant and soil, 2003; 254 (2): 245-261.

Maji NC, Mandal SR. Effect of long-term application of fertilizers and manure on chemical and physical properties of soil. Environment and Ecology, 2004; 22(3): 430-434.

Nambiar KKM. In: Soil fertility and crop production under long-term fertilizer use in India. ICAR, New Delhi, 1994: 144.

Page AL, Miller RH, Keeney DR. In: Methods of Soil Analysis (Part 2), Published by 677 South Segoe Road, Madison, Wisconsin, USA; 1982: 225 – 246, 403 – 430 & 643 – 698.

Santhy P, Muthuvel P, Selvi D. Nitrogen fractions status and impact on yield, uptake and available nitrogen in long term fertilizers experiment. Madras Agricultural Journal, 2001; 88 (1-3), 26-31.

Singh B, Singh Y. Potassium imbalance and sustainability of the Rice- Wheat cropping system in South Asia, In: Proc. International symposium on balanced fertilization for sustaining crop productivity at Punjab Agricultural University, Ludhiana, India, 2006:157-178.

Stevenson FW. In: Cycles of soil C, N, P, S and micronutrients. Jhon Wiley, NY, 1986: 380.

Tolanur SI, Badanur VP. Changes in organic carbon, available N, P and K under integrated use of organic manure, green manure and fertilizer on sustaining productivity of pearl millet-pigeonpea system and fertility of an *Inceptisol*. Journal of the Indian Society of Soil Science, 2003; 51(1): 37-41.