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RESEARCH ARTICLE

Dynamics of soil fertility in organic farming studies of maize - sunflower – green gram cropping system

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SUMMARY

Field experiments were conducted for two consecutive years (2003-04 and 2004-2005) at S.V. Agricultural College Farm (ANGRAU), Tirupati , Southern plateau and Hills zone of India on red sandy soils consisting Greengram was raised as residual crop during *summer* in a sequence of Maize sown in *Kharif* and Sunflower sown in *Rabi* with the imposition of the treatments to the first two crops of the sequence. There were fourteen treatments comprising of six different sources of nitrogen *viz.*, farm yard manure, vermicompost, neem leaf manure, poultry manure, pig manure and fertilizer to supply recommended dose of nitrogen on equalent nitrogen basis and one absolute control. All the seven treatments were tried with and without the foliar application of *Panchagavya*, thus making the total treatments to fourteen. Regarding the dynamics of various soil fertility parameters *viz*., soil organic carbon, available nitrogen, available phosphorus and available potassium, all of them were found built up to a considerable extent with the use of organic manures to maize and sunflower, while the application of fertilizer to maize and sunflower could just maintain the soil fertility status with neither considerable replenishment nor deterioration.As regards the balance sheet of soil available N, P and K, the highest positive balance of soil available nitrogen was found associated with neem leaf manure, and that of phosphorus was associated with poultry manure while that of potassium was with vermicompost. However, all the organic manures could result in higher balance than with application of fertilizer to maize and sunflower crops. Irrespective of the manurial sources, use of *Panchagavya* did not exert any noticeable effect on fertility enrichment of the soil.

Key Words : Green gram , Organic manures, Growth, Yield, Nutrient uptake, Economics

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With growing concerns about the human health, soil quality and environmental safety need has been felt to rethink over the existing agricultural practices especially the nutrient management. In order to meet the food grain requirement of the country like ours with burgeoning population, sustenance of higher productivity levels is also our bounden duty. Most of the Indian soils contain less than 0.5 per cent organic carbon. Unless it is raised to 0.9 – 1 per cent level, productivity of the soil can not be optimized (Veeresh, 2002). In view of the resurgence of interest in alternative agriculture in recent years, organic farming has been considered to be sound and viable option in most of the countries.In this context, low external input, sustainable agriculture largely focusing on agricultural practices such as green manuring, recycling of crop residues ,animal manure and inclusion of legumes in rotation are important.(Paikaray *et al.*, 2002). Huge quantities of organic materials such as farm yard manure, poultry manure, pig manure, vermicompost, green manures, and crop residues can substitute the inorganic fertilizers to a large extent to maintain productivity and environmental quality (Chaudhary, 2002). In light of the above, investigations were taken up for two consecutive years, with the objective of working soil fertility dynamics of Maize- sunflower-green gram cropping system.

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MATERIALS AND METHODS

Field experiments were conducted for two consecutive years (2003-04 and 2004-2005) at S V Agricultural college farm (ANGRAU), Tirupati , Southern plateau and Hills zone of India on red sandy soils consisting Greengram was raised as residual crop during *summer* in a sequence of Maize sown in *Kharif* and Sunflower sown in *Rabi* with the imposition of the treatments to the first two crops of the sequence. The experiment was laid out in a randomized block design, replicated thrice and the experiment was carried in the same field during both the years of study with undistrubbed lay out . There were fourteen treatments comprising of six different sources of nitrogen *viz.*, farm yard manure, vermicompost, neem leaf manure, poultry manure, pig manure and fertilizer to supply recommended dose of nitrogen on equal nitrogen basis and one treatment of no manuring through any source . All the seven treatments were tried with and without the foliar application of *Panchagavya, thus* making the total treatments to fourteen. The portion of P and K added to the soils was worked out based on the analysis results of the each manure *i.e*. what was the percent of the phosphorus and potassium. The chemical fertilizers was applied as per the zonal recommendations to each the crop of Maize(120 kg ha^{-1} N) and Sunflower(80 kg ha^{-1}). The test cultivars of maize was DHM-103, sunflower was MSFH-17 and Green gram was LGG-460. *Panchagavya* is a mixture of cow dung (1kg), cow urine (750 ml), cow s milk (500 ml), cow s curd (500ml) and cow s ghee (250ml). In addition, sugarcane juice (750ml), tender coconut water (750ml), pure honey (250ml) and ripe bananas (250g) were also added to accelerate the fermentation process Plant samples collected for estimation of dry matter were used to estimate the nutrient uptake at periodical intervals during the crop growth period of all the three crops. The oven dried plant samples used for dry matter estimation were chopped and ground in to fine powder using Willey mill and were analysed for N, P, K by adopting the standard procedures as furnished below. The uptake of N, P, K at harvest of all the three crops was calculated by multiplying the nutrient content with respective dry matter weights and the nutrient uptake was expressed in kg ha^{-1}.

Nutrient	Method	Reference
Organic carbon	Wet digestion method	Walkley and Black (1934)
Nitrogen	Microkjeldhal	Humphries (1956)
Phosphorus	Triple acid digestion (Colorimetry)	Jackson (1973)
Potassium	Triple acid digestion (Flame photometry)	Jackson (1973)

With regarding to soil fertility dynamics, immediately after the harvest of each of the three crops during both the annual cropping cycles, and just before the commencement of each of the two annual cropping cycles soil samples were drawn from individual plots from all the replications and analyzed for organic carbon, available N, P and K by following standard procedures furnished in above table. Nutrient balances were calculated using the formulae given by Singh *et al.* (2005).

Table A: Biochemical properties of *Panchagavya* stock solution

Property	Composition value	Methodology
Total N (mg kg^{-1})	380	Microkjeldhal – Humphries (1956)
Total P (mg kg^{-1})	258	Triple acid digestion (calorimetry) Jackson (1973)
Total K ((mg kg^{-1})	430	Flame Photometry, Jackson (1973)
Total organic carbon (%)	0.85	Wet digestion Walkley & Black (1934)
Total sugar (µg ml^{-1})	215	Nelson Somogyi's hydrolysis – somogyi (1952)
Reducing sugars (µg ml^{-1})	88	
Glucose (mg/dl)	7.5	Malick and Singh (1980)
Sodium (mg kg^{-1})	105	Triple acid digestion (Flame Photometry) Jackson (1973)
Calcium (mg kg^{-1})	28	
Yeast (CFU/ml)	38 X 10^4	Saborauds agar medium
Actinomycetes (CFU/Mml)	4 X 10^2	Ken Knight and Muncie (1939)
Lactic acid bacteria(CFU/ml)	26X10^6	MRS agar
Zn (mg kg^{-1})	0.28	DTPA extractant (AAS) Lindsay and Norvell (1978)
Fe (mg kg^{-1})	0.87	
Mn (mg kg^{-1})	0.20	
Cu (mg kg^{-1})	0.17	

RESULTS AND DISCUSSION

Perusal of the two years data reveals that, fertilizer application could just maintain the status of soil organic carbon in the cropping system, with neither improving nor declining at the end of the annual cropping cycle. While it was found gradually built up compared to the pre-experimental level, after all the three crops raised with the application of organic manures. Among the organic sources tried, neem leaf manure, vermicompost and farmyard manure added more organic carbon to the soil compared to pig manure and poultry manure. Slow decomposition of neem leaf , vermi compost and farmyard manure over other manures may probably the reason for the differences in soil organic carbon .Neverthless, organics did build up the organic content as well as nutrients there by indicating the sustenance of soil productivity. Ramesh and Rao (2009) also reported that soil health could be sustained with organic nutrition due to diversification of soil biota.

Available nitrogen status was higher with neem leaf manure follwed by poultry manure and vermi compost than with pig manure and farmyard manure. Fertilizer application almost maintained the status of available nitrogen , while it was declined with absolute control. The mineralization of organic manures and release pattern of nitrogen into the soil solution differs at large and accordingly and available nitrogen replenished the soil solution. Soil available phosphorus and available potassium status in the cropping system was found built up at the end of annual cropping cycle compared to the pre-experimental level, with the application of organic manures as well as fertilizer. The build up of soil available phosphorus status with varied manurial practices was in the descending order of poultry manure, fertilizer, pig manure, neem leaf manure, vermicompost and farmyard manure, while the build up of soil available potassium status with varied manurial practices was in the descending order of vermicompost, pig manure, neem leaf manure, farmyard manure, poultry manure and fertilizer. The P and K content of different organic sources tried differed to a large extent and the final balances of P and K were in commensurate to their respective contents of P and K in different organic sources. Higher available nutrient status with organic farming practices might be due to slow decomposition of organic components, the losses of N from these fractions may be minimized, in addition to synergistic effect on P and K transformation, the available nutrient status tend to improve slightly compared to the initial nutrient level. All the four soil fertility parameters were found depleted at the end of two year cropping cycles due to non-manuring to any of the crops in the cropping system *i.e.* absolute control during two annual cropping cycles. The results are in line with that of Stockdale *et al.*, 2001), who reported that soil fertility could be sustained with organic nutrition due to tightening the nutrient cycles.

During both the years of study , The highest N,P and K uptake was noticed with application of different organic manures over fertilizer application and sole Panchagavya spraying (Table 2).The highest N uptake was recorded with application of FYM+ Panchagavya followed by application of vermi compost+ Panchagavya. The positive effects of FYM with respect to N uptake was explained by Wade and Ladha (1995) who reported reduced losses of N with FYM due to reduced N loss through leaching. Panchagavya spraying

Table 1 : Effect of various organic farming practices in maize-sunflower-green gram cropping system on Soil organic carbon available nitrogen, phosphorus and potassium

Treatments	Organic carbon (%)		Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
	2004	2005	2004	2005	2004	2005	2004	2005
T_1-No manure	0.21	0.18	117.5	100.6	12.72	8.23	143.2	120.6
T_2- *Panchagavya*	0.21	0.18	117.5	100.2	12.70	8.18	139.8	118.2
T_3-RDF	0.23	0.20	142.2	150.5	25.15	41.40	180.5	205.8
T_4-RDF + *Panchagavya*	0.23	0.20	142.2	149.7	24.52	40.44	178.2	204.2
T_5-Farm Yard Manure	0.42	0.48	163.6	193.1	18.54	22.88	196.8	214.4
T_6-FYM +*Panchagavya*	0.42	0.48	162.8	191.2	18.28	22.43	196.8	212.8
T_7-Vermicompost	0.45	0.50	172.5	210.5	20.60	27.92	208.3	267.3
T_8-T_7 + *Panchagavya*	0.45	0.50	171.2	209.6	20.26	27.64	205.4	264.2
T_9-Neem leaf manure	0.46	0.52	188.2	245.2	22.82	33.63	200.8	218.2
T_{10}-T_9 + *Panchagavya*	0.46	0.52	187.6	244.1	22.45	33.04	198.2	216.8
T_{11}-Poultry manure	0.34	0.40	177.4	224.7	28.26	48.06	194.5	207.2
T_{12}-T_{11} + *Panchagavya*	0.34	0.40	176.5	223.8	27.84	47.04	194.2	206.8
T_{13}-Pig manure	0.34	0.40	169.2	208.1	24.45	39.16	205.3	262.5
T_{14}-T_{13} + *Panchagavya*	0.34	0.40	168.5	205.9	23.88	38.21	204.5	263.8
Initial	0.23	0.32	135.6	145.8	17.63	26.75	176.5	202.5
C.D. (P = 0.05)	0.07	0.06	16.2	19.7	3.5	4.0	18.6	15.8

Table 2 : Effect of various organic farming practices on nitrogen ,phosphorus and potassium uptake in maize-sunflower-greengram cropping system

Treatments	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
	2004	2005	2004	2005	2004	2005
T_1-No manure	76.1	78.4	18.24	20.26	111.6	116.6
T_2- *Panchagavya*	85.5	89.0	18.43	20.74	129.5	119.4
T_3-RDF	210.0	217.8	31.93	34.06	194.8	172.5
T_4-RDF + *Panchagavya*	212.8	221.3	32.20	34.50	208.0	175.4
T_5-Farm Yard Manure	202.8	207.9	33.94	36.36	229.0	234.1
T_6-FYM + *Panchagavya*	221.6	226.2	34.15	36.60	238.2	237.6
T_7-Vermicompost	198.8	204.6	36.66	39.19	260.6	267.4
T_8-T_7 + *Panchagavya*	217.2	221.8	36.85	39.58	252.1	269.9
T_9-Neem leaf manure	189.5	195.8	38.84	41.00	226.7	231.2
T_{10}-T_9 + *Panchagavya*	198.0	204.1	39.04	41.16	225.9	234.7
T_{11}-Poultry manure	190.6	197.2	45.16	48.39	223.6	228.5
T_{12}-T_{11} + *Panchagavya*	199.8	205.0	45.50	48.70	230.7	232.2
T_{13}-Pig manure	200.9	206.5	42.02	44.70	245.4	251.7
T_{14}-T_{13} + *Panchagavya*	219.2	223.4	42.20	45.12	244.5	253.5
C.D. (P = 0.05)	17.3	14.8	2.94	2.67	19.5	18.2

Table 3 : Effect of various organic farming practices in maize-sunflower-greengram cropping system on apparent soil nitrogen balance over two years

Treatments	Initial status (kg/ha)	Added over two years (kg/ha)	Uptake over two years (kg/ha)	Final status (kg/ha)	soil nitrogen balance(kg/ha)
T_1-No manure	135.6	0	154.5	100.6	-189.5
T_2- *Panchagavya*	135.6	0	174.5	100.2	-209.9
T_3-RDF	135.6	400	427.8	150.5	-12.9
T_4-RDF + *Panchagavya*	135.6	400	434.1	149.7	-20
T_5-Farm Yard Manure	135.6	400	410.7	193.1	46.8
T_6-FYM + *Panchagavya*	135.6	400	447.8	191.2	7.8
T_7-Vermicompost	135.6	400	403.4	210.5	71.5
T_8-T_7 + *Panchagavya*	135.6	400	439	209.6	35
T_9-Neem leaf manure	135.6	400	385.3	245.2	124.3
T_{10}-T_9 + *Panchagavya*	135.6	400	402.1	244.1	106.4
T_{11}-Poultry manure	135.6	400	387.8	224.7	101.3
T_{12}-T_{11} + *Panchagavya*	135.6	400	404.8	223.8	83.4
T_{13}-Pig manure	135.6	400	407.4	208.1	65.1
T_{14}-T_{13} + *Panchagavya*	135.6	400	442.6	205.9	27.7

Table 4 : Effect of various organic farming practices in maize-sunflower-greengram cropping system on Apparent Soil phosphorus balance over two years

Treatments	Initial status (kg/ha)	Added over two years (kg/ha)	Uptake over two Years (kg/ha)	Final status (kg/ha)	Phosphorus balance (kg/ha)
T_1.No manure	17.63	0	38.5	8.23	-47.9
T_2. *Panchagavya*	17.63	0	39.17	8.18	-48.62
T_3.RDF	17.63	94.6	65.99	41.4	52.38
T_4.RDF + *Panchagavya*	17.63	94.6	66.7	40.44	50.71
T_5.Farm Yard Manure	17.63	117.62	70.3	22.88	52.57
T_6.FYM + *Panchagavya*	17.63	117.62	70.75	22.43	51.67
T_7.Vermicompost	17.63	166.66	75.85	27.92	101.1
T_8.T_7 + *Panchagavya*	17.63	166.66	76.43	27.64	100.24
T_9.Neem leaf manure	17.63	207.38	79.84	33.63	143.54
T_{10}.T_9 + *Panchagavya*	17.63	207.38	80.2	33.04	142.59
T_{11}.Poultry manure	17.63	314.92	93.55	48.06	251.8
T_{12}.T_{11} + *Panchagavya*	17.63	314.92	94.2	47.04	250.13
T_{13}.Pig manure	17.63	249.96	86.72	39.16	184.77
T_{14}.T_{13} + *Panchagavya*	17.63	249.96	87.32	38.21	183.22

Table 5 : Effect of various organic farming practices in maize-sunflower-greengram cropping system on Apparent Soil potassium balance over two years

Treatments	Initial status (kg/ha)	Added over three years (kg/ha)	Uptake over three years (kg/ha)	Final status (kg/ha)	Soil nutrient Balance (kg/ha)
T_1.No manure	176.5	0	228.2	120.6	-284.1
T_2. *Panchagavya*	176.5	0	248.9	118.2	-307.2
T_3.RDF	176.5	116.2	367.3	205.8	-221.8
T_4.RDF +*Panchagavya*	176.5	116.2	383.4	204.2	-239.5
T_5.Farm Yard Manure	176.5	292.92	463.1	214.4	-132.28
T_6.FYM + *Panchagavya*	176.5	292.92	475.8	212.8	-146.58
T_7.Vermicompost	176.5	499.98	528	267.3	62.78
T_8.T_7 + *Panchagavya*	176.5	499.98	522	264.2	65.68
T_9.Neem leaf manure	176.5	259.22	457.9	218.2	-156.98
T_{10}.T_9 + *Panchagavya*	176.5	259.22	460.6	216.8	-161.08
T_{11}.Poultry manure	176.5	220.42	452.1	207.2	-200.98
T_{12}.T_{11} + *Panchagavya*	176.5	220.42	462.9	206.8	-212.18
T_{13}.Pig manure	176.5	428.56	497.1	262.5	17.46
T_{14}.T_{13} + *Panchagavya*	176.5	428.56	498	263.8	17.86

increased the N uptake of the system irrespective to the source of N. Highest Phosphorus uptake was recorded with application of poultry manure, pig manure, neem leaf manure and vermi compost. Highest Potassium uptake was recorded with vermicompost, followed by pig manure, poultry manure, neem leaf manure. This amply demonstrate that the slowly mineralisable nitrogen from organic sources ensures adequate availability at greater level of absorption and translocation to the plant parts during growing period thereby increased quantities of N in grain. Similarly, the organic sources of N made P and K in available forms for longer period in soil which improved P and K uptake with organic N supply. Organic acids produced during decomposition of organic manures solubilises insoluble P and increases P uptake (Ventural *et al*., 1987). Organic manures on decomposition make K in available forms for longer period in soil (Bouldin, 1987).Higher uptake of N,P and K of the system due to higher N,P,K content in grain and Stover together with higher dry matter production by organic manures application (Das *et al.*, 2003). The lowest N, P and K uptake by the system was recorded with absolute control followed by only Panchagavya spray.

The apparent soil nitrogen balance was positive with application of all the organic manures with and without Panchagavya spraying after two years of experimentation. The highest positive balance of soil nitrogen was associated with application of neem leaf manure followed by neem leaf manure + Panchagavya spraying .Reduced losses of N from neem leaf manuring due to presence of nitrification inhibitors in neem leaf manure.Nitrification inhibiting alkaloids released from neem leaf manuring checks the faster rate of N mineralization (Srinivasulu Reddy, 1988). Sole application of organic manures recorded higher positive balance of soil nitrogen than they coupled with Panchagavya spraying. Differential rates of decomposition consequent variations in losses of nitrogen might be the reason for the deviations in N balance after two years over three crops.

The net phosphorus balance was negative with absolute control and Panchagavya spraying .All the organic manures recorded positive balance of phosphorus and it was higher with poultry manure followed by poultry manure + Panchagavya spraying and pig manure. Superiority of poultry manure over other organic sources due to faster nutrient release on decomposition (Singh *et al.*,1988). Sole application of organic manures recorded higher positive balance of soil phosphorus than they coupled with Panchagavya spraying. Application of organic manures resulted in increased production of organic acids during the decomposition which will reduce the fixation of native and applied phosphorus. The buildup of phosphorus with organic manures in system based nutrient management has been reported by Singh *et al*. (2005). Hundal *et al*.(1992) also elucidated the solubility action of the organic acids to enable higher nutrient uptake.

The positive balance of potassium was noticed with application of vermi compost followed by pig manure and the remaining treatments recorded negative balance of potassium indicated except vermi compost, and pig manure application remaining treatments contributed for potassium uptake rather than potassium build up. This might be due to the fact that increased levels of Potassium can satisfy the sorption sites of clay surfaces and able to improve the exchangeable potassium in soil solution.The findings are in agreement with that of Upendra Rao(2004).The negative potassium balance with sole chemical fertilization was also reported by Yadav *et al* .(1998).

It can be concluded that regarding the dynamics of various soil fertility parameters *viz*., soil organic carbon, available nitrogen, available phosphorus and available potassium, all of them were found built up to a considerable extent with the use of organic manures to maize and sunflower, while the application of fertilizer to maize and sunflower could just maintain the soil fertility status with neither considerable replenishment nor deterioration. Though all the organic manures augmented N,P and K uptake of the system the highest N uptake was recorded with application of FYM+ Panchagavya, Phosphorus uptake was recorded with application of poultry manure, and higher Potassium uptake was recorded with vermicompost. As regards the balance sheet of soil available N, P and K, the highest positive balance of soil available nitrogen was found associated with neem leaf manure, and that of phosphorus was associated with poultry manure while that of potassium was with vermicompost. However, all the organic manures could result in higher balance than with application of fertilizer to maize and sunflower crops. Irrespective of the manurial sources, use of *Panchagavya* did not exert any noticeable effect on fertility enrichment of the soil.

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