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Development of Organic Nutrient Management Package in Maize-Groundnut System in Alfisols of Karnataka

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Abstract: *Organic farming has gained momentum to improve the soil productivity and sustainable yield in various crops. The information on organic farming was limited in cropping system and the study was conducted on organic farming in cropping system at Agricultural and Horticultural Research Station, Kathalagere, Karnataka state from 2003-04 to 2013-14 to develop the organic farming packages for system based high value crops. The experiment comprise of eight treatments. Among all the treatments, the T_1- 50% recommended NPK + 50% N as FYM + inorganic sources of micro-nutrients as per soil test(10 kg $ZnSO_4$/ha) has given maximum system equivalent yield (SEY) of 5.22-10.57t/ha/yr after third year of conversion period followed by T_6-T_2 + bio fertilizer containing N and P carriers and 4 year conversion period followed similar trend. After 10^{th} year conversion period T_7 recorded maximum system equivalent yield of 5.22 to 10.04 t/ha/yr followed by T_1 (50% recommended NPK + 50% N as FYM + inorganic sources of micro-nutrients as per soil test(10 kg $ZnSO_4$/ha). The Maize-Groundnut cropping system along with organic source of nutrient has achieved the sustainability.*

I. Introduction

Maize (*Zea mays* L.) is called "King of Cereals". It is one of the important cereal crop next only to wheat and rice in the world. It is nutrientexhaustive and production potential crop, its productivity closely depends on nutrient management system, maize being C_3 plant, byvirtue of easy management andwider adaptabilityhas led to the stabilizationin an area and production in India. However, the average productivity of Maize is very low (2482 kg/ha) from an area of 11.95 million ha (Anon.2010).

Groundnut is the major crop under oilseeds accounting for 6.3 % of the total cropped area in Karnataka. The cultivated groundnut (*Arachishypogaea* L.) belongs to family Fabaceae. In Karnataka, it is cultivated in 8.12lakhha with a production of 4.6 lakh tons (Anon. 2010). The groundnut has higher oil content (46-52%) and protein (25-36%) content depending upon on the variety. The productivity of maize and groundnut is low due to poor nutritional management and lack of scientificbased crop rotation which has lead to depletion of soil carbonintensive and continuous cropping practices on Alfisols have resulted in rapid decline of nutrients in soil organic matter (Henao and Baan ante, 2006).Alfisols are known to have undergone moderate leaching, susceptible to surface compaction, erosion and acidify rapidly under continuous cultivation. Thesoil has low water retention capacity and is deficient in Nitrogen, Phosphorous and have multiple nutrient deficiencies of K, Ca and Zn fixation tendencies lead to susceptible to soil erosion and compaction.Moreover, continuous use of mineral fertilizer can have detrimental effects on soil properties. On strongly weathered, poorly buffered soils of the semi-arid tropic soils like Alfisols, using inorganic fertilizer as the main source of nutrients can lead to rapid decline in crop yields because of acidification and soil compaction. At this juncture, a keen awareness has sprung on the adoption of organic farming as a remedy to cure the ills of modern chemical agriculture. Organic agriculture is a unique production management system which promotes and enhances health of agro-ecosystem, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm input.

To overcome this, the alternative cropping system is cereal-legume rotations has long been recognized in Karnataka for restoring soil fertility and increasing crop productivity (Livleen Shukla,2013). Rotations shift the biological balance in the soil, reducing build-up ofpests and diseases and sustain productivity of the cropping system (Kumawat et al., 2009). Keeping in view, the Maize- Groundnut cropping systemwith organic source of nutrients is potential productive systemfor sustainable productionis aappropriate researchable issue.

II. Methodology

Experimentsite

A long term field experiment was conducted from 2003-04 to 2013-14 at Agricultural and Horticultural Research Station, Kathalagere whichcomes under the Southern Transitional Zone (zone-7) covering Shimoga, Davanagere, part of Hassan and Mysore districts of Karnataka. Agricultural & Horticultural Research Station,

Kathalagere is located in the heart of the Bhadra Command area between 13^02^1 latitude and 76^015^1 E longitude at an elevation of 561.6 m above the MSL.The climate is semi-arid with an average annual rainfall of 655 mm distributed between May and October. Mean maximum and minimum temperatures are 34^0C and 19^0C during the months of March to January respectively taken as reference. The soils are classified under Alfisols (Sandy clay loam in texture). Alfisols are known to have undergone moderate leaching, are susceptible to surface compaction, erosion and acidify rapidly under continuous cultivation. The soil is having low water retention capacity and multiple nutrient deficiencies of N, P, K, Ca and Zn and P fixation. The initial soil fertility levels were (pH - 5.30, EC - 0.14 dSm^{-1}, organic carbon - 0.52 %, available phosphorus - 12.0 kg/ha, available potash - 273.6 kg/ha).

Chemicals and Reagents

All chemicals and regents were procured from Merck ^{R} India Ltd. Double distillation water was used throughout the analysis.

Experimental- set up and crop management

The experiment was laid out with eight treatments with different organic sources of nutrients (Treatment details are given in Table 1). Land was prepared by using mouldbold plough followed by passing cultivator and leveler to bring the soil to a fine tilth. Maize seeds were sown in rows of 60 cm apart with 30cm spacing between plants. For the summer crop groundnut, seeding was done in rows of 30 cm apart with 10 cm spacing between seeds. Intercultural operations were done at 30 & 45 DAS. Plant protection measures were organicallyfollowed(Neem oil spray) for both the crops as and when pest and diseases were noticed. Yield data on Maize crop during Kharif followed by Groundnut crop during summer were collectedin net plot area and average was made. Similarly, soil samples were collected after the harvest of summer groundnut crop and analyzed for different parameters like pH, electrical conductivity, organic carbon, available phosphorus and available potash content by following the standard methods to study the changes in the soil fertility levels. The plant samples (grain and straw separately) of both the seasons were collected after the harvest of crop and analyzed for uptake of nitrogen, phosphorus and potassium content by following standard methods and was calibrated using grain and straw yields data. All the results were averaged for each treatment and drawn conclusion.

Instruments

Organic carbon (Walkley and Black method, 1934) and nitrogen content of soil were estimated by using (Olsen et al., 1954), Phosphorous contents were estimated calorimetrically using spectrophotometer (Analytic Jena A G. Germany). For the estimation of potassium, Flame photometer (Systronics 128, India) was used and for other minerals, Atomic Absorption Spectrometer (Analytic Jena AG, Germany) was used.

Table 1: Treatment details

Treatments	Kharif (Maize) - Summer (Groundnut)
T_1	50% recommended NPK + 50% N as FYM + inorganic sources of micro-nutrients as per soil test(10 kg $ZnSO_4$/ha)
T_2	Different organic sources each equivalent to 1/3 of recommended N (FYM + vermicompost + non-edible oil cake).
T_3	T_2 + intercropping or trap crop (location specific in each season).
T_4	T_2 + agronomic practices for weed and pest control (No chemical. pesticides and herbicides).
T_5	50% N as FYM+ rock phosphate to substitute the P requirement of crops + phosphate solubilizing Bacterial culture (PSB).
T_6	T_2 + bio fertilizer containing N and P carriers.
T_7	100% NPK + secondary and micro-nutrients based on soil test (10 kg $ZnSO_4$/ha).
T_8	Dummy plot.

III. Results

Yield of Maize-Groundnutsequentialcropping system

Among all the treatments, the T_1- 50% recommended NPK + 50% N as FYM + inorganic sources of micro-nutrients as per soil test(10 kg $ZnSO_4$/ha) has given maximum system equivalent yield (SEY) of 5.22 to 10.57t/ha/yrafter third year of conversion period followed by T6-T_2 + bio fertilizer containing N and P carriers and 4^{th}year conversion period followed similar trend. After 10^{th} year conversion period T_7has recorded maximum system equivalent yield from 5.22 to 10.04 t/ha/yr followed by T_1(50% recommended NPK + 50% N as FYM + inorganic sources of micro-nutrients as per soil test(10 kg $ZnSO_4$/ha). Overall fourth year conversion period has shown better results in all the treatments when compared to 10^{th} year conversion period which could be due to gradual decomposition of organic manures and its slow availability to crop throughout the growing period (Gunriet al., 2004 and Rajkhowa and Baroova, 1994). The similarity in yields among different organic

sources indicates better utilization of nutrients from all the sources (Ahmed et al., 2006). Naturally available N derived from mineralized soil N and biological nitrogen fixation by free living and plant associated diazotrophs present in soils. Similar results were obtained by Yaduvanshi (2003).

Nutrient studies

Organic Carbon

The results at harvest of 10th cropyeardid not show any variation among the treatments. There was an improvement in organic carbon content which ranged from 5.20 to 6.70 g kg^{1}in (T_6-T_2 + bio fertilizer containing N and P carriers) with 30 per cent increase in organic carbon content and similar trend was observed in organic source appliedtreatmentswhich may be attributed to higher contribution of organic source of nutrient to the soil in the form of crop residues, which upon decomposition might have resulted in enhanced organic carbon content of the soil (Udayasoorian, et al., 1988 and KamleshKukrejaet al., 1991).

Available phosphorus

The results furnished in table 3 showed that the available P status has increased in many treatments at harvest compared from initial status to 10th year crop cycle. However, during 10th year crop cycle there was improvement in available P status T5 (1.38%)and T6 (4.24%) and negative trend was observed in other treatments. The increase was prominent in treatment which received organic source of nutrient which could be attributed to the influence of organic manure which enhanced the labile P in the soil by complexing Ca, Mg and Al (Subramanian and Kumaraswamy, 1989).

Available Potassium

The available K status has increased over the years (Table 3), it was more prominent in treatment receiving only organic source of nutrient during both the seasons. In particularly, T_1(21.94%)and T_7 (17.12%) increased during 10th year conversion period. This could be due to continuous cropping of groundnut followed by maize as added residual nitrogen in all the treatments as observed by Laxminarayana (2006). The long term studies have clearly proved the importance of organic manuring in improving the physical and chemical conditions of soil under maize- groundnut cropping sequence (Achieng et al, 2010).

Uptake of nutrients

The data on NPK uptake by maize-groundnut cropping system (Initial year2003-04 to 2013-14) are presented in Table 4. The results showed increased nutrient uptake pattern corresponding to the yield throughout the experimental period. N uptake was increased from 16.2 per cent to 56.96 per cent. Similarly, P uptake was increased from 15.74 per cent to 21.79 per cent however negative trend was observed in T_1 and T_7 treatments, this could be due the application of inorganic source of nutrients. K uptake was also increased from 13.57 per cent to 81.89 per centfrom initial to 10th years conversion period, this may be attributed to favorable effect of organic manure addition, higher biomass and yieldof groundnut and maize (Achieng et al, 2010).

IV. Conclusion

Maize-Maize is the predominant cropping sequence in Karnataka state with mono-cropping over the years and excessive dependence on chemical fertilizers that has lead to decrease in soil N and Alfisols are known to have undergone moderate leaching, are susceptible to surface compaction, erosion and acidify rapidly under continuous cultivation. They also have low water retention capacity and multiple nutrient deficiencies of N, P, K, Ca and Zn and P fixation. In view of this, growing of maize- groundnut cropping system with organic source of nutrient has improved the soil structure, biological activities, cat ion exchange and water holding capacity inthe system has resulted in fixing free-living and plant associated rhizobium, which internhas contributed for buildup of soil N and other nutrients. Ithas proved the sustainable productive system.

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Table 2. Effect of organic source of nutrients on crop yield (t ha^{-1}) in Maize-Groundnut in different phases of crop cycles

Treat.	Initial yield level				Mean yield upto conversion period (1st -3 rd crop cycles)				Mean Yield after conversion period (4th-10th crop cycles)				Overall Mean Yield (10th crop cycles)			
	Kharif	Rabi	Summer	SEY*	Kharif	Rabi	Summer	SEY*	Kharif	Rabi	Summer	SEY*	Kharif	Rabi	Summer	SEY*
T1	5.52	-	-	5.52	5.27	-	1.75	10.57	5.82	-	1.66	11.15	5.14	-	1.53	9.98
T2	4.94	-	-	4.94	4.44	-	1.48	8.84	4.95	-	1.59	10.08	4.35	-	1.41	8.82
T3	5.12	-	-	5.12	4.73	-	1.60	9.70	5.22	-	1.45	10.83	4.61	-	1.35	9.53
	-	-	-		0.11	-	0.13		0.24	-	0.22		0.19	-	0.16	
T4	4.97	-	-	4.97	4.64	-	1.48	9.03	4.83	-	1.51	9.69	4.34	-	1.37	8.63
T5	4.32	-	-	4.32	4.03	-	1.60	8.75	4.63	-	1.54	9.62	4.05	-	1.42	8.51
T6	5.34	-	-	5.34	5.00	-	1.68	9.93	5.16	-	1.60	10.40	4.65	-	1.48	9.32
T7	5.22	-	-	5.22	4.75	-	2.15	9.03	5.67	-	1.68	11.05	4.90	-	1.65	10.04

*** SEY**: System equivalent yield

Table 3. Changes in soil fertility under organic nutrient management in Maize-Groundnut system

	Initial soil fertility				Average soil fertility after 10th crop cycles				% I/D* over initial				Average increase over T7 in 10 yrs			
Treatments	O.C	Av.N	Av.P	Av.K	O.C	Av.N	Av.P	Av.K	O.C	Av.N	Av.P	Av.K	O.C	Av.N	Av.P	Av.K
	g kg^{-1}	Kg ha^{-1}			gkg^{-1}	Kg $^{-1}$ ha			-	-	-	-	-	-	-	-
T_1	5.2	325	16.40	191.30	6.42	-	15.44	233.28	23.46	-	-5.85	21.94	1.25	-	5.27	-3.96
T_2	5.2	325	16.40	191.30	6.56	-	15.91	219.72	26.15	-	-2.99	14.85	-0.91	-	2.16	1.97
T_3	5.2	325	16.40	191.30	6.57	-	16.18	218.45	26.35	-	-1.33	14.19	-1.07	-	0.44	2.56
T_4	5.2	325	16.40	191.30	6.37	-	14.94	220.22	22.50	-	-8.88	15.12	2.04	-	8.77	1.74
T_5	5.2	325	16.40	191.30	6.68	-	16.63	220.56	28.46	-	1.38	15.29	-2.69	-	-2.24	1.58
T_6	5.2	325	16.40	191.30	6.76	-	17.10	221.09	30.00	-	4.24	15.57	-3.85	-	-4.92	1.34
T_7	5.2	325	16.40	191.30	6.50	-	16.25	224.04	25.00	-	-0.89	17.12	-	-	-	-
Min	-	-	-	-	6.19	-	14.63	214.61	-	-	-	-	-	-	-	-
Max	0.52	325	16.40	191.30	6.82	-	17.58	239.89	-	-	-	-	-	-	-	-

* I/D-Increase or decrease

Table 4: Changes in total nutrient uptake (kgha^{-1}) under organic nutrient management in Maize-Groundnut system

Treatments	Initial nutrient uptake (kgha^{-1}) i.e at end of 1st crop cycle				Average (kg^{-1}) i.e from first crop cycle to last crop cycle				% Changes over initial (last year vs. First year)				Changes over T7 average			
	N	p	K	Total	N	p	K	Total	N	p	K	Total	N	p	K	Total
T_1	130.34	24.43	71.68	226.45	152.00	22.39	81.41	255.80	16.62	-8.34	13.57	21.85	16.31	-13.79	14.47	5.66
T_2	103.10	19.47	53.89	176.46	124.18	20.46	69.97	214.60	20.44	5.06	29.83	55.34	47.04	8.17	52.25	35.82
T_3	106.83	18.66	59.64	185.13	135.96	21.60	75.42	232.98	27.26	15.74	26.47	69.47	41.91	12.86	37.58	30.78
T_4	100.76	18.79	55.34	174.89	136.56	20.55	74.31	231.42	35.53	9.36	34.28	79.17	50.46	12.08	48.27	36.93
T_5	82.50	16.62	45.28	144.40	129.49	20.24	82.36	232.09	56.96	21.79	81.89	160.64	83.76	26.71	81.21	63.89
T_6	108.26	21.39	65.20	194.85	160.46	22.32	84.50	267.27	48.21	4.34	29.60	82.15	40.03	-1.54	25.84	21.44
T_7	103.65	22.95	60.52	187.12	151.60	21.06	82.05	254.71	46.26	-8.23	35.58	73.61	46.26	-8.24	35.58	24.53