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Nutrient Management Strategies for Enhancing Productivity of Dryland Crops in *Alfisols*

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ABSTRACT: Soils in rainfed areas are poor in nutrients and low in organic matter as a result of continuous application of inorganic fertilizers. In order to sustain crop productivity, important nutrient management strategies have been studied at Dryland Agriculture Project, Gandhi Krishi Vigyan Kendra, Bangalore since 1978. In soil with high phosphorus status, balanced nutrition through application of nitrogen (50 kg/ha), potassium (25 kg/ha), calcium (lime @ 300 kg/ha), magnesium ($MgCO_3$ @ 150 kg/ha) and boron (Borax @ 10 kg/ha) recorded higher finger millet grain yield of 3706 kg/ha. The soil available nitrogen and potassium is low and phosphorus is medium, SSNM for a targeted finger millet yield of 4000 kg/ha with the application of 155:45:203 kg N, P_2O_5, K_2O/ha could achieve the yield of 3971 kg/ha during 2008-09. Application of 150% of recommended potassium (37.5 kg/ha) along with recommended N and P (50 and 40 kg/ha) improved the yield of finger millet on potassium deficient Alfisols. Soil application of $ZnSO_4$ @ 12.5 kg/ha and borax @ 10 kg/ha along with recommended NPK (seed treatment with molybdenum @ 2 g/kg of seed in pulses) increased yield of finger millet and pulses in soils deficit in zinc and boron. Soil application of borax @ 10 kg/ha and $ZnSO_4$ @ 5 kg/ha coupled with foliar spray of $ZnSO_4$ @ 0.5% and boron @ 0.25% at flowering stage improved the yield of groundnut. *In-situ* incorporation of horsegram at 8-10 weeks improved the soil fertility apart from increasing grain yield in the succeeding finger millet crop, with a saving of 50% recommended N. Application of FYM and recommended NPK increased the yield of dryland crops like finger millet and groundnut. Finger millet rotation with groundnut further increased the yield of finger millet by 25%.

Key words: Fingermillet, nutrient management, Alfisols, dryland

Food and nutritional security, sustainability and profitability are the main focus of present and future agricultural development. In order to feed the ever growing population with limited land and water resources, it is essential to boost farm productivity. This has to be achieved using sustainable and improved technologies as there is a limitation in the horizontal expansion of area under plough. Management of nutrients has a crucial role to play in sustainable agriculture. Sustainable food production can be achieved with proper attention in irrigated system, but it is a challenging task in dryland situation due to aberrant weather conditions. Of the 141 M ha of net sown area in the country, 80 m ha is rainfed. Rainfed agriculture contributes 40% of food grain production. Despite considerable progress in irrigation development over the Five Year Plans, 85% of coarse cereals, 83% in pulses, 42% in rice, 70% in oilseeds and 65% in cotton are still cultivated as rainfed (CRIDA, 2011). Nearly 75% of the total cultivated area in Karnataka is under dryland ecosystem which is contributing nearly 55% of total food grain production (Anon., 2011). Due to low availability of FYM, continuous application of only chemical fertilizers coupled with moisture stress has a deleterious effect on soil physico-chemical properties. This has created an imbalance in nutrient requirement for crop growth, build up of certain nutrients especially phosphorus which antagonize the uptake of other nutrients and limited use of potash fertilizers, resulted in decline in crop productivity (Hegde and Dwivedi, 1993).

Sustainability in crop productivity is possible by adoption of the important nutrient management strategies like balanced nutrient management, site specific nutrient management, higher potassium nutrition in K deficient soils, use of green leaf manure, micronutrient management and integrated nutrient management based on soil test results which also maintain soil health. The present paper is an attempt in this direction.

Materials and Methods

Field experiments were conducted during past 34 years at the All India Coordinated Research Project for Dryland Agriculture (AICRPDA), GKVK, Bangalore under rainfed situation on various nutrient management strategies in fingermillet, groundnut and pulses.

The AICRPDA, Bangalore Centre is located at the University of Agricultural Sciences, GKVK Campus, Bangalore-65, 4 km away from the main entrance, at 77^0 39' 22.1" East longitude, 13^0 05'13.0" N latitude and 929 MSL altitude. This centre comes under Bangalore North taluk and Bangalore Urban district. The normal annual rainfall of the zone is 928 mm in 57 rainy days ranging from 528 to 1374 mm with 23% co-efficient of variability. The zone receives rains in two peaks during May (100 mm) and August-September (132-2001 mm). The major share is from South-West monsoon (June-September) with 518 mm accounting to 55.76% followed by North-East monsoon (October-December) with 234 mm accounting to 25-30%.

Balanced nutrient management studies were initiated during *kharif* 2007 to 2011 under rainfed situation in deep, yellowish red, sandy loam soils, where in secondary nutrients like Calcium and Magnesium and micronutrient (Boron) were applied to study their response on grain yield of finger millet.

The initial soil pH was 5.70, EC - 0.08 dS/m, organic carbon - 0.40%, available N - 160 kg/ha, P_2O_5 - 70 kg/ha, K_2O - 110

kg/ha, Ca- 2.2 me 100/g, Mg- 1.2 me 100/g, B- 0.35 ppm. The experiment was laid out in a randomized block design with six treatments (Table 1) with different combination of nutrients and replicated four times.

There is a need to supply the nutrients considering the crop need, soil fertility level and other agro-ecological situation, which is known as site specific nutrient management (SSNM). This approach although is considered as risky option under dryland situation due to uncertainty of rainfall distribution, integrating with suitable soil moisture conservation measures and cropping system yields better returns. Hence, studies were conducted from 2008- 09 to 2011-12 to study the response of finger millet + pigeonpea intercropping system with a row spacing of 30 for fingermillet and 60 cm for pigeonpea in 8:2 row proportion with conservation furrow in-between pigeonpea rows for a targeted yield of 4.0 t/ha under site specific nutrient management on *Alfisol* having pH 5.70, EC 0.07 dS/m and 0.47% organic carbon. The available N, P and K status was 165, 50 and 90 kg/ha, respectively. The exchangeable calcium and magnesium content was 2.0 and 1.2 me/100 g, respectively while, DTPA extractable zinc was 0.83 ppm. The experiment consisted of eight treatments (Table 2) and replicated thrice in randomized block design. For a targetted yield of 4 t/ha, the NPK uptake is 119.2, 45.2 and 156.0 kg/ha, respectively. Since the soils were medium in available phosphorus, the fertilizer was applied in the dose equal to uptake, while available nitrogen and potassium was low and hence the fertilizers were applied 30% more than their uptake. 50% of N and full dose of P_2O_5, K_2O, lime and zinc sulphate were applied as per the treatments at the time of sowing, remaining 50% nitrogen was applied after 30 days of sowing as topdress. The yield of intercrop (pigeonpea) was converted into finger millet grain equivalent yield (FGEY) considering the yield and prevailing price of the produce.

In drylands, most of the farmers do not use potash fertilizer which has resulted in K depletion over the years due to increased area under high yielding varieties and porous soils resulting in leaching. Considering that crops respond well to potassium in K deficient soils, field experiment was conducted during *kharif* 2007 to 2011 to study the response of fingermillet to the application of different grades and time of application of potassium. The initial soil pH was 5.70, EC-0.07 dS/m, organic carbon-0.46%, available nitrogen- 159 kg/ha, available phosphorus-60 kg/ha and available potash-110 kg/ha. The experiment was laid out in a randomized block design with nine treatments (Table 3) and replicated three times with a gross plot size of 6.0 × 5.4 m^2 and net plot size of 5.4 × 4.8 m^2.

Dryland crops especially pulses respond to application of micronutrients (Hegde and Gajanan, 1995) to the tune of 2-3 q/ha. Among the micronutrients in eastern and central dry zones, zinc deficiency of 70-72% and boron deficiency of 25-27% was observed in *Alfisols*, necessitating the need for application of zinc and boron. The studies on micronutrient management on various crops was conducted from 2001-02 to 2007-08. Zinc and boron in various combinations were applied through soil application and foliar spray to various crops.

A field experiment was conducted from 1999 to 2001 to study the effect of different sources of organic matter and their combinations on productivity of finger millet. The initial pH of experimental site was 4.90, EC 0.2 dS/m, organic carbon 0.36%, available N 159 kg/ha, available P_2O_5 87 kg/ha and available K_2O 78 kg/ha. The experiment was laid out in a randomized block design with thirteen treatments (Table 5) and replicated thrice with a gross plot size of 3.0 × 3.0 m^2 and net plot size of 2.4 × 2.0 m^2. Nitrogen was applied as per the treatment while recommended P and K were applied as basal dose.

Table 1 : Grain yield of finger millet as influenced by balanced nutrition management

Treatment	Grain yield (kg/ha)						B-C ratio
	2007	2008	2009	2010	2011	Mean	
T_1-Control (No fertilizers)	1190	1686	2140	1697	2303	1803	2.11
T_2-Rec. N and K (No P)	3291	2292	3169	2541	3363	2931	2.68
T_3-Rec. N and K + lime @ 300 kg/ha + $MgCO_3$ @ 150 kg/ha	3399	2689	3283	3314	3906	3318	2.60
T_4-Rec. N and K (No P) + Borax @10 kg/ha	3446	2589	3327	3043	3691	3219	2.83
T_5-Rec. dose of N and K + lime @ 300 kg/ha + $MgCO_3$ @ 150 kg/ha + Borax @ 10kg/ha	4245	3092	3403	3748	4042	3706	2.69
T_6-Rec. N, P_2O_5 and K_2O	3798	2462	3270	2904	3555	3198	2.65
SEm ±	133	156	246	199	179	-	-
CD (P=0.05)	402	469	732	600	539	-	-

Table 2 : Influence of site specific nutrient management on mean yield of finger millet

Treatment	Grain yield (kg/ha)					B-C ratio
	2008	2009	2010	2011	Mean	
T_1- 100% N, P_2O_5 and K_2O (50:40:25 kg/ha)	2745	2419	2090	2212	2367	2.04
T_2- T_1 + Zn SO_4 @12.5 kg/ha	2869	2882	2424	2413	2647	2.19
T_3- Rec. P_2O_5 + 125% of N,K_2O	3093	2932	2572	2762	2840	2.38
T_4- T_3 + Zn SO_4 @ 12.5 kg/ha + Lime (300 kg/ha)	3024	3214	3138	3280	3164	2.34
T_5- Rec. P_2O_5 + 150% N, K_2O	2918	2990	2867	2969	2936	2.43
T_6- T_5 + $ZnSO_4$ @ 12.5 kg/ha + Lime (300 kg/ha)	3082	3059	3341	3386	3217	2.38
T_7- SSNM for targeted yield of 4.0 t/ha (155 : 45: 203 kg/ha N, P_2O_5 and K_2O)	3971	3530	3852	3823	3794	2.73
T_8- Control (No Fertilizers)	1520	1979	1667	1557	1681	1.73
SEm±	121.0	147.0	275.0	184.4	-	-
CD (P=0.05)	369.0	444.0	835.0	559.7	-	-

Continuous use of only inorganic fertilizers has increased the crop productivity in the initial stages. However, it has declined over the years as a result of deterioration of soil health. There is a good potential to reduce the gap of nutrient exhausted and nutrient added through combined use of organic and inorganic fertilizers. Hence, an experiment was initiated in 1978 to study the long term effect of organics, fertilizers and their integration on soil health and crop productivity with 5 treatments (Table 6) replicated twice. The initial soil pH was 5.00, EC 0.20 dS/m, organic carbon 0.40%, available N 290 kg/ha, available P_2O_5 22.4 kg/ha and available K_2O 191 kg/ha. Sustainability yield index was worked out for mean yield as follows (Sharma *et al*., 2004).

Sustainability yield index (SYI) = (A-SD) /Y_{max}

Where,

A = Average yield over the years for a particular treatment

SD = Standard deviation for the treatment

Y_{max} = Maximum yield obtained in any of the treatment over the years

Results and Discussion

Balanced nutrient management

The pooled data for 5 years (2007-11) showed that, the mean finger millet grain yield was higher in recommended dose of N and K_2O + lime @ 300 kg/ha + $MgCO_3$ @ 150 kg/ha + Borax @ 10 kg/ha (3,706 kg/ha) compared to recommended N, P_2O_5 and K_2O (3,198 kg/ha) with a higher benefit-cost ratio of 2.69 (Table 1). The soil of experimental site was having low calcium, magnesium and boron, hence the response to application of these nutrients was observed in the treatment. The balanced fertilization might have increased root density and proliferation, which aid in extensive exploration and supply of nutrients and water to the growing plants, resulting in increased growth and yield. Application of balanced fertilization recorded higher fingermillet grain yield response (15.88%) when compared to recommended N, P_2O_5 and K_2O which has not received secondary and micronutrients and excess of phosphorus *i.e.*, imbalanced fertilization. This has clearly demonstrated the necessity of balanced nutrition in the days to come similar to the observations of Rego *et al*. (2007).

Site specific nutrient management (SSNM)

The grain yield of finger millet varied significantly among different treatments and over years also (Table 2). Highest yield of 3,971 kg/ha grain which is almost nearing the target of 4 t/ha was achieved during 2008-09 with mean of 3,794 kg/ha in site specific nutrient management approach (155:45:203 kg N, P_2O_5, K_2O/ha) which was arrived at by analyzing the soil samples and based on the crop uptake. Similar results were reported by Anon. (2008) in finger millet where they received yield of 4 t/ha with a target of 4.5 t/ha under site specific nutrient management treatment. Higher yield in site specific nutrient management approach was also attributed to better crop growth as a result of better nutrient supply and effective utilization of conserved rain water in the conservation furrow between two rows of pigeonpea. Similar observations were made by Srinivas *et al*. (2008) in case of *rabi* sorghum. A favorable B-C ratio (2.73) showed economic viability of site specific nutrient management technology for upscaling as against 2.04 in 100% N, P_2O_5 and K_2O (Table 2).

Potassium management for dryland crops

The results of pooled data for 5 years (2007-11) showed that (Table 3) the mean grain yield of finger millet was higher (3626 kg/ha) when potassium was applied at 150**%** of recommended dose (37.5 kg) as basal dose along with recommended N and P when compared to recommended NPK i.e. 50:40:25 kg/ha (3015 kg/ha). Hanway and Johnjon (1985) reported that application of high level of K increased leaf K content and seed yield of

soybean under stress conditions. The economic analysis of K_2O application showed that highest B: C ratio of 3.00 was recorded with recommended N, P_2O_5 and 150 % K_2O compared to lower B: C ratio (2.71) with recommended N, P_2O_5 and 150 % K_2O (Table 3). Similar results of higher yield and economic returns were obtained from farmers' field at Alanatha, Kanakapura Taluk, Ramanagar District in finger millet crop under rainfed situation (Table 4).

Further, higher application of potassium beyond 150% of recommended dose did not have significant effect on increasing the grain yield. Robiul Alam *et al.* (2009) found that the grain yield of wheat progressively increased with the application of K and then decreased. The increase in grain yield was 16.8% over recommended N, P_2O_5 and 100 % K_2O application. Similar response of K on grain yield was also reported by Dwivedi (2001) in wheat.

Micronutrient management

Soil application of $ZnSO_4$ @ 12.5 kg/ha and borax @ 10 kg/ha along with recommended NPK increased yield of finger millet. Whereas, for groundnut soil application of borax @ 10 kg/ha and $ZnSO_4$ @ 5 kg/ha coupled with foliar spray of $ZnSO_4$ @ 0.5% and boron @ 0.25% at flowering stage improved the yield. Similar results were obtained by Narayana *et al.* (2008) and Srinivasarao *et al*. (2008). Similarly, studies on micronutrient management for enhancing productivity of finger millet-pulse-oilseed based production system was conducted from 2004-05 to 2007-08. The results indicated that soil application of $ZnSO_4$ @ 12.5 kg/ha, borax @ 10 kg/ha along with NPK and seed treatment of molybdenum @ 2 g/kg of seeds in horsegram (25:38:25), soybean (25:50:25), cowpea (20:50:25), green gram (12:25:25), pigeonpea (25:50:25), field bean (25:50:25), sunflower (37.5:50.0:37.5) and castor (38:38:25) recorded

Table 3 : Influence of potassium management on mean yield of finger millet

Treatment	Grain yield (kg/ha)						B-C ratio
	2007	2008	2009	2010	2011	Mean	
T_1 - Rec. N (50kg), P_2O_5 (40 kg) + Zero K_2O	1647	1844	3188	2508	2636	2365	2.16
T_2 - Rec. FYM (10 t/ha)	1705	1518	3462	2899	2914	2500	1.89
T_3 - Gliricidia (7t) equal to Rec. FYM (10 t/ha)	2377	1555	3578	2750	2820	2616	2.05
T_4 - Rec. N, P_2O_5 + Rec. K_2O (25kg) basal dose	2887	2047	3891	3084	3166	3015	2.71
T_5 - Rec. N, P_2O_5 + Rec. K_2O in two splits (basal and tillering stages)	2971	1815	3618	3055	2997	2891	2.56
T_6 - Rec. N, P_2O_5 + 150% of Rec. K_2O (basal)	3972	2586	4504	3424	3646	3626	3.00
T_7 - Rec. N, P_2O_5 + 150% of Rec. K_2O in two splits (basal and tillering stages)	2913	1726	4208	3159	3429	3087	2.71
T_8 - Rec . N, P_2O_5 + 200% of Rec. K_2O (basal)	3333	2509	4379	3214	3500	3387	2.90
T_9 - Rec. N, P_2O_5 + 200% of Rec. K_2O in two splits (basal and tillering stages)	2822	2313	4236	3051	3478	3180	2.68
SEm±	259	178	295	313	118	-	-
CD (P=0.05)	776	530	511	938	354	-	-

Table 4 : Influence of potassium management on yield of finger millet at ORP site, Alanatha, Kanakapura, Ramanagara District

Treatment	Grain yield (kg/ha)					B-C ratio
	2008	2009	2010	2011	Mean	
T_1- Farmers' practice (65:48:0 kg N, P_2O_5 and K_2O/ha)	1375	2500	2000	1066	1735	1.80
T_2- Recommended N (50 kg), P_2O_5 (40 kg) and K_2O (25 kg)	2845	4300	2900	1745	2948	2.95
T_3- Recommended N, P_2O_5 and 150% of Recommended K_2O as basal dose	3290	4750	3250	1891	3295	3.25
T_4- Recommended N, P_2O_5 + 150% Recommended K_2O in two splits (basal and tillering)	3125	4550	3050	1840	3141	3.08

higher seed yield by 8-31% in pluses (800 kg/ha of green gram, 150 kg/ha of 1500 kg/ha of pigeonpea, 1200 kg/ha of cowpea, 800 kg/ha of field bean, 1100 kg/ha of horse gram) and 15-37% in oil seeds (1100 kg/ha of groundnut, 1700 kg/ha of sunflower, 1300 kg/ha of soybean, 1200 kg/ha of castor and 1000 kg/ha of sesame) over farmers' practice. This translated to a B:C ratio of 2.45 in finger millet, 2.14 in green gram, 2.12 in pigeonpea, 2.01 in cowpea, 2.37 in field bean, 1.39 in horse gram, 2.11 in groundnut, 1.50 in sunflower, 2.79 in soybean, 1.29 in castor and 2.21 in sesame.

Green manuring in drylands

The results on application of green manure indicated that, the mean grain yield of finger millet was higher (3307 kg/ha) with application of 50% of N through (GLM + FYM) and 50% through chemical fertilizers (Table 5). In another study conducted on incorporation of horsegram through *in-situ* green manuring at pre-flowering stage (60 to 65 days after sowing) coupled with establishment of vegetative barrier of *Pennisetum hohenekere*, the results showed that live barrier of *Pennisetum hohenekere* with *in-situ* incorporation of horse gram biomass (18 to 20 t/ha on fresh weight basis) gave a finger millet grain yield of 3307 kg/ha compared to recommended NPK (2460 kg/ha). It was possible to save 50% recommended dose of N to finger millet crop apart from maintaining soil health through *in-situ* incorporation of horse gram.

Integrated nutrient management

The results of the long term study across 34 years (Table 6) indicated that, under finger millet mono cropping, integrated nutrient management (FYM @ 10 t/ha and NPK @ 50:50:25 kg/ha) continued to show higher mean grain yield (3225 kg/ha) when compared to application of only NPK (2078 kg/ha). Addition of FYM, buffers the fluctuation in yield leading to sustainable productivity as reported by Ghosh (1987) and Hegde and Gajanan (1995). The mean grain yield of finger millet over a period of 19 years was increased by 20.43% (3884 kg/ha) under crop rotation with groundnut as compared to monocropping which was mainly due to increased rate of mineralization of organic matter as a result of crop rotation improving the biological activity of soil (Gajanan *et al*., 2005). This clearly indicates that by adopting crop rotation along with INM, yield stability is possible in finger millet under dryland situation. INM recorded higher sustainability yield index of 0.70 in monocropping and 0.68 in rotation when compared to only NPK where sustainability yield index was 0.34 in monocropping and 0.33 in rotation.

The mean pod yield of groundnut was highest with application of FYM @ 10 t/ha (1230 kg/ha) which provided balanced nutrients. The pod yield of groundnut was reduced with addition of fertilizers, which might be due to over-consumption of nutrients which increased plant height and gynophores did not penetrate into soil properly leading to increased unfilled seeds.

Table 5 : Grain yield of finger millet as influenced by application of green leaf manure (1999-2001)

Treatment	Grain yield (kg/ha)			
	1999	2000	2001	Mean
T_1: Control	2646	1201	682	1510
T_2: 100% NPK	2733	2951	1815	2500
T_3: Recommended N through GLM + FYM + CR	3246	1663	593	1834
T_4: 50% Recommended N through GLM + FYM + CR and 50% NPK	4236	2734	1975	2982
T_5: 50% Recommended N-GLM + 50% N-FYM	3896	2227	1041	2388
T_6: 50% Recommended N-GLM + 50% N-CR	3160	1620	914	1898
T_7: 50% Recommended N-FYM + 50% N-CR	2256	1245	914	1472
T_8: 50% Recommended N-(GLM + FYM) + 50% NPK	4583	3602	1736	3307
T_9: 50% Recommended N-(GLM + CR) + 50% NPK	3818	1809	1875	2501
T_{10}: 50% Recommended N-(FYM + CR) + 50% NPK	4062	2899	2377	3113
T_{11}: Recommended N-FYM	3385	1571	721	1892
T_{12}: Recommended N-GLM	3506	2314	561	2127
T_{13}: Recommended N-CR	2881	1185	1202	1756
SEm±	397	333	240	-
CD (P=0.05)	1117	955	705	-

FYM: Farm yard manure; GLM: Green leaf manure (Glyricidia); CR: Crop residue (Maize)

Table 6 : Influence of long term nutrient management practices on mean yield of finger millet under rotation and mono-cropping (pooled data of 34 years)

Treatment	Finger millet mono-cropping (1978-2011)	SYI	Groundnut yield in rotation (1992-2010)	Finger millet yield in rotation (1993-2011)	SYI	% increase in yield due to rotation
T_1 - Control	719	-0.08	420	756	-0.13	5.2
T_2 - FYM @ 10 t/ha	2426	0.45	1230	3068	0.47	26.4
T_3 - FYM @ 10 t/ha + 50% N, P_2O_5 and K_2O	2875	0.59	1102	3633	0.61	26.4
T_4 - FYM @ 10 t/ha + 100% N, P_2O_5 and K_2O	3225	0.70	1019	3884	0.68	20.4
T_5 - 100% N, P_2O_5 and K_2O (50:50:25 for finger millet)	2078	0.34	690	2517	0.33	21.1

SYI: Sustainability yield index

Table 7 : Chemical properties of soil as influenced by continuous application of FYM, NPK fertilizers and their integration under fingermillet monocropping and fingermillet-groundnut rotation (2010-11)

Treatment	pH	EC	OC	Av. N	Av. P_2O_5	Av. K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu
	(1:2.5)	(dS/m)	(%)	(kg/ha)			meq/100g				(ppm)		
Fingermillet-monocropping													
Initial (1978)	5.00	0.20	0.40	170.00	09.00	160.00	-	-	-	-	-	-	-
T_1	5.00	0.09	0.26	94.34	18.25	113.21	1.39	0.52	5.21	6.12	2.54	0.45	0.40
T_2	5.41	0.13	0.41	148.78	20.03	136.41	4.02	2.91	16.12	14.54	10.54	1.60	1.00
T_3	5.38	0.14	0.43	156.03	100.21	210.50	4.00	2.50	16.35	15.04	16.50	1.98	1.21
T_4	5.73	0.15	0.60	217.72	112.00	159.21	4.80	2.70	17.12	17.24	15.21	1.65	1.20
T_5	5.12	0.09	0.34	123.37	42.12	142.23	2.64	1.29	9.00	10.48	9.45	1.41	1.01
SEm±	0.14	0.005	0.012	13.43	5.07	10.25	0.53	0.02	0.69	0.37	0.20	0.03	0.01
CD (P=0.05)	0.55	0.021	0.04	52.80	20.00	40.30	0.20	0.07	2.73	1.45	0.79	0.15	0.04
Fingermillet-groundnut rotation													
T_1	5.30	0.07	0.30	109.50	39.62	47.25	1.25	0.75	4.52	8.450	6.65	0.53	0.98
T_2	5.61	0.13	0.51	186.30	65.32	119.80	3.80	3.10	9.58	17.12	8.84	1.45	1.56
T_3	5.50	0.11	0.49	178.30	100.24	139.80	4.41	2.40	12.54	19.85	18.45	1.62	1.62
T_4	5.82	0.06	0.53	214.50	150.32	204.50	4.35	2.00	17.45	23.15	22.87	1.68	1.70
T_5	5.12	0.15	0.33	120.40	85.63	159.60	2.56	1.85	8.00	14.25	10.87	1.25	1.42
SEm±	0.22	0.02	0.17	6.70	2.05	6.39	0.24	0.14	0.48	0.39	0.36	0.05	0.08
CD (P=0.05)	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89

T_1- Control; T_2- FYM @ 10 t/ha; T_3- FYM @ 10 t/ha + 50% Rec. N, P_2O_5 and K_2O (25:25:12.5 kg NPK/ha); T_4 - FYM@ 10 t/ha + Recommended N, P_2O_5 and K_2O (50:50:25 kg NPK/ha); T_5- Recommended N, P_2O_5 and K_2O (50:50:25 kg NPK/ha)

Similar observations were made by Prabhugowda Patil (2001). The influence of long term nutrient management practices on soil fertility status after 33 years demonstrated that, INM helped in increasing soil available major and micronutrients (Table 7) by reducing fixation of phosphorus, chelation of acid forming cations, better micronutrient availability to crops, promotion of aggregation, increased soil microbial biomass and organic matter.

Conclusions

All the important nutrient management strategies studied in this paper such as, balanced nutrient management, site specific nutrient management, higher potassium nutrition in K deficient soils, use of green leaf manure, micronutrient management and integrated nutrient management based on soil test results have been proved to be beneficial in improving the crop yields besides maintaining soil health.

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