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Long Term Management of Soil Fertility and Crop Productivity in *Alfisols* of Dryland

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Abstract

A long term field experiment was conducted on cereal-legume cropping sequence leaving summer fallow at Bangalore during 1993 to 2006 in light textured red sandy loam soil to study the effect of long term use of glyricidia, farm yard manure and NPK fertilizers on soil fertility, crop productivity and nutrients losses. Plots of 3,000 m^2 each and having 2.5% slopes were delineated for each treatment. Appropriate instrumentation was done to quantify the nutrients loss. Continuous use of glyricidia to supply recommended N + 50% recommended NPK recorded 16.8 and 142.6% higher yield followed by FYM and NPK in equal proportion (3.22 and 88.6%) in fingermillet and maize respectively as compared to recommended NPK (2,572 kg/ha and 1,150 kg/ha). FYM and 50% NPK recorded 35.8% higher soybean yield followed by FYM with 25.6% as compared to recommended NPK (453 kg/ha). Highest loss of OM, N, P and K were recorded under control and lowest losses were recorded in FYM and NPK in equal proportion, but least P loss (0.39 kg/ha) was recorded with 50% N with through glyricidia + 50% NPK. In soybean, highest loss of OM, N, P and K were recorded in control and least loss of OM, P and K in FYM to supply 50% N + 50% NPK. But least loss of N was in glyricidia to supply 50% + 50% recommended NPK. In maize, highest loss of OM, N, P and K were recorded in control followed by recommended NPK. Irrespective of the crops the mean of seven years indicated that highest loss of OM, N, P and K were under control treatment. Least loss of OM and N occurred under glyricidia to supply 50% + 50% recommended NPK. But least losses P and K were recorded in NPK. Analysis of surface soil samples (0—15 cm) indicated that continuous addition of FYM or glyricidia to supply recommended N alone or along with NPK over a period of 13 years increased OC, biomass carbon and mean weight diameter as compared to NPK alone. Reduction in soil pH in recommended NPK from 5.6 to 4.5 and improvement in organics, increased available N, available K, sulfur, Zn, Cu Mn and Fe in organics alone or along with NPK as compared to recommended NPK.

Key words : Soil fertility, Crop productivity, Management, Dryland, *Alfisols*.

Among production constraints, low soil fertility is the major limitation for increasing and maintaining productivity of dryland crops besides, uncertain rainfall mediated high frequency of run-off and soil loss. Management of soil fertility and crop productivity in long term basis is a pre-requisite for sustainability of dryland agriculture. Crop productivity in drylands depends upon sound nutrients management system. Supply of all essential plant nutrients required for sustainable crop productivity on integrated manner is most important. Improving and maintaining soil fertility for enhancing and sustaining agricultural production under dryland areas is of utmost important for India's food and nutritional security (1).

Methods

A long term field experiment was initiated in 1993 at the site of All India Co-ordinated Research Project for Dryland Agriculture, University of Agricultural Sciences, GKVK, Bangalore. The effects of continuous and long term use of giricidia, farm yard manure and NPK fertilizers were studied on soil fertility, crop productivity and nutrients losses in light textured red sandy loam soil under cereal-legume cropping sequence leaving summer fallow during 1993—2006. The soil of experimental site at the beginning of experiments in 1993 had sandy loam in texture, pH 4.5—5.0, electrical conductivity (<0.2 mmohs/cm), organic carbon (0.3 to 0.4%), available nitrogen (250 kg/ha) available phosphorus (90 kg/ha), available potassium (100 to 120 kg/ha and CEC (7.2 cmol (p^+)/kg). Large sized plots of 3,000 m^2 area with 2.5% slope were delineated with bunds for each treatment. Glyricidia plants were raised on the existing bunds to

Table 1. Grain yield of fingermillet as affected by glyricidia, farm yard manure and NPK fertilizers.

Treatments	5 years mean grain yield (kg/ha)	Increase over NPK (%)	Increase over control (%)	Organic matter	Nutrients loss (mean of 2 years) (kg/ha) N	P	K
T_1 Glyricidia to provide 100% N	2386	–	144.2	31.4	7.55	0.64	4.57
T_2 FYM to provide 100% N	2361	–	141.6	32.95	7.45	0.55	3.63
T_3 50% N glyricidia + 50% NPK	3004	16.8	207.4	26.55	5.85	0.39	3.01
T_4 50% N FYM + 50% NPK	2655	3.2	171.7	26.25	5.15	0.41	2.35
T_5 Recommended NPK	2572	–	163.2	30.72	7.80	0.50	3.55
T_6 Control	977	–	–	36.70	9.86	0.53	4.98

Table 2. Seed yield of maize as affected by glyricidia, farm yard manure and NPK fertilizers.

Treatments	One years seed yield (kg/ha)	Increase over NPK (%)	Increase over control (%)	Organic matter	Nutrients loss (one year) (kg/ha) N	P	K
T_1 Glyricidia to provide 100% N	2050	78.3	469.4	11.7	4.4	1.3	4.1
T_2 FYM to provide 100% N	1620	40.9	350.0	20.9	4.4	1.7	4.9
T_3 50% N glyricidia + 50% NPK	2790	142.6	675.0	19.4	4.2	1.4	6.7
T_4 50% N FYM + 50% NPK	2170	88.7	502.7	39.4	3.3	1.5	6.9
T_5 Recommended NPK	1150	–	219.0	44.7	3.9	1.9	5.3
T_6 Control	360	–	–	54.8	4.5	1.9	7.6

augment green leaf biomass as the source of nutrients and *nase grass* (*Penisetum hohenikere*) as vegetative live barrier. Coshocton wheel and sample collecting tanks were installed to quantify the nutrients loss. The representative sample of run-off water was drawn through this apparatus of 1/200th of total diameter of wheel from each run-off event lead to the sample storage tank through a plastic tube. Run-off sample of 2 liters of each run-off event after thoroughly stirring, the water in the sample storage tank. A few drops of toluene were added to each sample as a preservative. Known volume of run-off water sample was taken and placed on the hot plate for evaporation. After evaporation, the dissolved nutrients in left out residue of run-off water were analyzed using standard procedure. Data on yield were recorded at harvest and soil samples were collected from 0—15 cm depth after the harvest of each crop and were analyzed for different parameters following standard procedure. For soil pH potentiometric

Table 3. Seed yield of soybean as affected by glyricidia, farm yard manure and NPK fertilizers.

Treatments	6 years mean (kg/ha)	Increase over NPK (%)	Increase over control (%)	Organic matter	Nutrients loss (mean of 4 years) (kg/ha) N	P	K
T_1 Glyricidia to provide 100% N	436	–	95.5	38.4	6.18	0.69	3.53
T_2 FYM to provide 100% N	569	25.6	155.1	34.3	6.50	0.65	3.02
T_3 50% N glyricidia + 50% NPK	409	–	83.4	33.9	5.41	0.59	2.93
T_4 50% N FYM + 50% NPK	615	35.8	175.7	30.9	5.77	0.51	2.39
T_5 Recommended NPK	453	–	103.1	43.9	7.95	0.64	2.91
T_6 Control	223	–	–	44.2	9.02	0.97	3.95

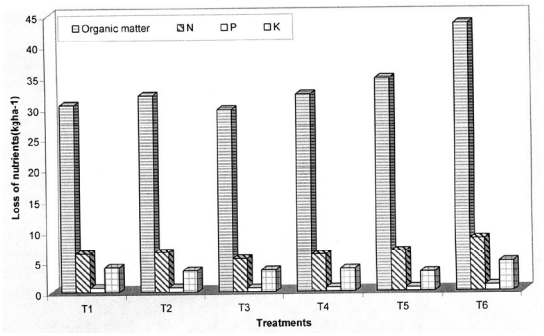

Figure 1. Organic matter and nutrients loss due to different nutrients management practice.

method, electrical conductivity by conductivity method, potassium by neutral normal ammonium acetate extract method, sulfur by turbidometric (ammonium acetate acetic acid extract) method and calcium and magnesium by Versanate titration method (2), organic carbon by wet oxidation (3), available nitrogen by alkaline permanganate method (4), available phosphorous by Bray's method (5) and micronutrients like Zn, Cu, Mn and Fe by DTPA extraction and estimated by atomic absorption spectrophotometry (6). The method outlined by Panse and Sukhatme (7) was followed for the statistical analysis of the data.

Results and Discussion

Continuous use of glyricidia to supply 50% recommended N + 50% NPK (T_3) recorded 3,004 kg/ha with 16.8% and 2,790 kg/ha with 142.6% higher yield followed by farm yard manure to supply 50% N + 50% recommended NPK (T_4) recorded 2,655 kg/ha with 3.2% and 2,160 kg/ha with 88.6% in six years mean grain yield of finger millet (Table 1) and two years mean yield of maize (Table 2) respectively as compared to recommended NPK (2,572 and 1,150 kg/ha). FYM to supply 50% recommended N + 50% NPK (T_4) recorded 615 kg/ha with 35.8% higher soybean yield (Table 3) followed by FYM to supply 100% N (T_2) (569 kg/ha with 25.6%) as compared to recommended NPK (T_5) (453 kg/ha). Combined use of glyricidia and NPK fertilizers recorded higher yield in finger millet and maize. This mainly attributed to continuous incorporation of glyricidia green leaf which facilitated good soil structure, lower run-off rate, lower soil and nutrients loss in addition to supply of nitrogen (3%), potassium (3%) and other micro- and secondary nutrients (8). The percentage increase in yield was more in maize. But soybean recorded higher yield in integrated use of FYM and NPK fertilizers mainly due to high phosphorus and low nitrogen in FYM. Higher nitrogen facilitates more vegetative growth in soybean. Higher response to glyricidia was recorded in fingermillet and maize and soybean responded FYM.

Table 4. Seven years mean of run-off, soil loss and nutrients losses as affected by continuous use of FYM, glyricidia and NPK fertilizers.

Treatments	Organic matter	Nutrients loss (kg/ha) N	P	K
T_1 Glyricidia to provide 100% N	30.5	6.31	0.76	4.02
T_2 FYM to provide 100% N	32.0	6.47	0.77	3.46
T_3 50% N glyricidia + 50% NPK	29.7	5.36	0.65	3.49
T_4 50% N FYM + 50% NPK	32.08	6.00	0.64	3.65
T_5 Recommended NPK	34.65	6.57	0.61	3.09
T_6 Control	43.55	8.61	0.98	4.76

Mean of two years of results on dissolved nutrients loss in run-off in fingermillet crop grown plots (Table 1) indicated that highest loss of organic matter with 36.7 kg/ha, nitrogen (9.86 kg/ha, phosphorus (0.53 kg/ha) and potassium (4.98 kg/ha) under control (T_6). Least loss of organic matter with 26.25 kg/ha, nitrogen with 5.15 kg/ha and potassium with 2.35 kg/ha recorded in FYM to supply 50% recommended N + 50% NPK, but lowest loss of phosphorus with 0.39 kg/ha recorded in glyricidia to supply 50% recommended N + 50% NPK through inorganic fertilizers. Mean of four year study in soybean (Table 3) showed highest loss of organic matter with 44.2 kg/ha, nitrogen with 9.02 kg/ha, phosphorus with 0.97 kg/ha and potassium with 3.95 kg/ha recorded in control and least loss of organic matter in FYM to supply 50% recommended N+ 50% NPK fertilizers with 30.9 kg/ha, phosphorus with 0.51 kg/ha and potassium with

Table 5. Soil fertility status after 5 years, 10 years and 13 years as affected by continuous use of glyricidia, FYM and NPK fertilizers.

Treatments	pH	EC dS/m	OC (%)	Av N	Av P_2O_5 kg/ha	Av K_2O	Zn	Cu	Mn	Fe	Biomass carbon µg/g	Mean weight diameter (MWD) mm
							ppm					
After 5 Years												
T_1	5.0	0.05	0.38	180	120	135	0.67	1.29	24.6	18.6	39.1 (117.2)	1.19 (8.2)
T_2	4.8	0.07	0.41	187	172	164	0.79	1.09	21.0	18.0	70.0 (288.8)	1.37 (24.5)
T_3	4.7	0.06	0.39	182	131	142	0.62	0.98	22.0	20.1	23.0 (27.7)	1.13 (2.7)
T_4	4.7	0.06	0.39	182	161	153	0.66	0.78	21.0	18.6	21.0 (16.6)	1.30 (18.2)
T_5	4.5	0.06	0.36	176	130	122	0.58	0.85	23.0	17.6	18.0	1.10
T_6	4.7	0.05	0.31	142	69	89	0.53	1.10	19.0	16.5	9.3	0.93
After 10 Years												
T_1	5.3	0.07	0.45	196	186	134	0.57	0.82	12.0	17.6	38.7 (86.9)	1.3 (10.2)
T_2	5.4	0.09	0.46	207	206	79	0.84	0.86	31.4	15.2	81.6 (294.2)	1.4 (18.4)
T_3	5.0	0.09	0.40	200	215	113	0.46	0.64	12.0	20.4	36.0 (73.9)	1.23 (4.23)
T_4	5.02	0.09	0.43	216	232	99	0.71	0.84	14.8	19.8	27.6 (33.3)	1.37 (16.1)
T_5	4.63	0.08	0.35	172	185	68	0.53	0.68	12.6	18.8	20.7	1.18
T_6	4.93	0.07	0.32	162	93	53	0.44	0.58	7.1	19.8	10.1	0.85
After 13 Years											Sulfur (ppm)	
T_1	5.6	0.06	0.43	197	159	134	0.97	0.53	20.7	21.2	10.6	–
T_2	5.4	0.07	0.43	228	180	104	1.30	0.87	21.8	24.4	14.3	–
T_3	5.0	0.07	0.45	215	160	127	1.09	0.84	24.8	21.4	12.6	–
T_4	5.2	0.07	0.41	218	183	112	1.40	0.95	19.6	30.0	15.6	–
T_5	4.5	0.06	0.33	184	108	102	0.89	0.50	17.3	20.3	9.5	–
T_6	4.8	0.08	0.30	156	81	59	0.75	0.52	17.2	16.7	6.6	–

2.39 kg/ha. But lower loss of nitrogen was recorded in glyricidia to supply 50% recommended N + 50% NPK fertilizers. In maize grown plots (Table 2) higher loss of organic matter with 54.8 kg/ha per year, nitrogen with 4.5 kg/ha per year, 1.9 kg/ha per year of phosphorus and potassium with 7.6 kg/ha per year recorded in control followed by recommended NPK. Lower loss of organic matter with 11.7 kg/ha per year in glyricidia alone, nitrogen with 3.3 kg/ha per year in FYM to supply 50% recommended + 50% NPK, phosphorus with 0.9 kg/ha per year in recommended NPK and potassium in glyricidia alone and FYM alone. Irrespective of the crops the mean of seven years (Fig. 1 and Table 4) indicated that higher loss of organic matter (43.55 kg/ha), nitrogen (8.61 kg/ha), phosphorus with 0.98 kg/ha and potassium with 4.76 kg/ha under control treatment (T_6). Least loss of organic matter with 29.7 kg/ha, nitrogen with 5.36 kg/ha in glyricidia to supply 50% + 50% recommended NPK. But least loss of phosphorus with 10.61 kg/ha and potassium with 3.09 kg/ha recorded in NPK alone.

Fingermillet and maize grown plots recorded higher nutrient loss than soybean. Higher loss of soil organic matter was followed by nitrogen, potassium and phosphorus. Higher loss of organic matter was mainly due to higher clay loss in soil erosion in addition to lower binding materials and higher nitrogen loss might be attributed to the higher solubility of both ammoniacal and nitrate nitrogen as compared to potassium and phosphorus. Lower amount of potassium was attributed to low quantity of water soluble potassium present in these soils (9). Fixation of phosphorus in acids soils has contributed to lesser dissolved phosphorus in the run-off. Analyzed soil

samples collected from 0—15 cm soil depth after the harvest of the crops indicated that continuous addition of FYM or glyricidia to supply recommended N alone or along with NPK inorganic fertilizers over a period of 13 year (Table 5) recorded increased organic carbon with 24 to 36%, biomass carbon with 17 to 294%, mean weight diameter 2.72 to 24.54% higher as compared to NPK. Reduction of soil pH was observed in recommended NPK alone from 5.6 to 4.5 and improved in organics alone or along with NPK fertilizers. Increased available nitrogen varied from 108 to 183 kg/ha, available potassium 102 to 134 kg/ha, sulfur 9.5 to 15.6 mg/kg, zinc 0.89 to 1.40 mg/kg, Cu from 0.5 to 0.95 mg/kg, Mn from 7.3 to 24.8 mg/kg and Fe 20.3 to 30 mg/kg in organics alone or along with NPK as compared to recommended NPK alone. These findings are attributed to better soil aggregation, less soil and nutrient loss (9, 10).

Conclusion

Soil loss, nutrient loss, sustaining and maintaining soil fertility and crop productivity in rainfed dryland *alfisols* on long term basis can be reduced by combined use of organic sources and NPK fertilizers. Glyricidia can be used as alternate substitute of organic nutrients sources to farm yard manure. Significant response of glyricidia to cereals and pulses to farm yard manure were observed.

References

1. Swarup A. 2002. Lessons from long term fertilizer experiment in improving fertilizer use efficiency and crop yield. Fert. News 47 : 59—66, 71—73.
2. Jackson M. L. 1973. Soil chemical analysis. Prentice Hall, New Delhi, India.
3. Walkley Black L. A. 1934. An experimentation of wet digestion method for determinatining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 34 : 29—38.
4. Subbaiah B. V. and G. L. Asija. 1956. A rapid procedure for the determination of available nitrogen in soils. Curr. Sci. 25 : 259—260.
5. Bray R. H. and L. T. Kurtz. 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Sci. 59 : 39—45.
6. Lindsay W. L. and W. A. Norvell. 1978. Development of DTPA soil test for Zn, Fe, Mn and Cu. Soil Sci. Soc. Am. J. 42 : 421—428.
7. Panse V. G. and P. V. Sukhatme. 1985. Statistically method for agricultural workers. Publ. and Inform. Div., ICAR, New Delhi, India.
8. Anonymous. 2004. Annual progress report of AICRP for dryland agriculture. Univ. Agric. Sci., GKVK, Bangalore, India.
9. Gajanan G. N., B. R. Hegde, Ganapathi, Panduranga and K. Somashekar. 1999. Organic manure for stabilisining productivity : Experience with dryland fingermillet. Tech. Bull., AICRP for Dryl. Agric. Univ. Agric. Sci., GKVK, Bangalore, India.
10. Gajanan G. N., Ganapathi and M. A. Shankar. 2005. Relevance of organic matter for sustainable crop production in dryland—A success story for 25 years. Tech Bull. AICRP for Dryl. Agric., Univ. Agric. Sci., GKVK, Bangalore, India.