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Effect of alley cropping of castor (*Ricinus communis*) and integrated nutrient management practices on productivity status of soil under SAT regions

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ABSTRACT

A study was conducted during 1996 and 1997 to find out the changes in productivity status of soil due to alley cropping of castor (*Ricinus communis* L.) and integrated nutrient management practices at Hyderabad. Physical properties of soil like field capacity (18.1 and 19.9%) and infiltration rate (7 and 7.2 cm/hr) improved, while the bulk density (1.49 and 1.29 mg/m^3) decreased due to alley cropping in both the years over sole cropping of castor. Application of green leaf manures of trees also increased the field capacity and infiltration rate and reduced the soil compaction when compared with no green leaf manuring. *Leucaena* green leaf manuring produced pronounced effect of increasing field capacity (18.9 and 21.2%) and infiltration rate of the soil (7.5 and 8.6 cm/hr) but reduced the bulk density (1.48 and 1.24 mg/m^3) specially under alley cropping with *Dalbergia*. Field analysis of soil samples seasonally for chemical properties indicated that available N, organic carbon, total nitrogen and C : N ratio were found optimum under alley cropping with green leaf manuring 90 days after sowing (DAS) with gradual increase from 30 DAS. Incubation studies at different periods also showed that the soil fertility started building up from initial stages of incubation both under alley cropping and green leaf manuring. However, the soil productivity in terms of available nitrogen, organic carbon, total nitrogen and C : N ratio was found better at 75 days after incubation (DAI) in alley cropping and green leaf manuring as well.

Key words : Alley cropping, Green leaf manures, *Dalbergia, Leucaena, Albizia*

After the Green Revolution, intensification of agriculture gained momentum for more production of foods crops. Since then, less importance was given for soil health and soils were over-exploited with more and more use of chemical inputs to feed the growing population. Subsequently most of the productive soils became unproductive/degraded particularly more in SAT regions. Most of the farmers in drylands are not having easy access for inputs specially for nitrogenous fertilizers as they are resource poor and resorting to poor management practices resulting in low efficiency of applied fertilizers. The soils also poor in organic matter content which decreases microbial activity and inhibiting the release of native nutrients, ultimately affecting the crop productivity. One of the means of accomplishing the goal to improve the productivity of crops with sustained soil health is to adopt healthy crop management practices like agroforestry and application of green leaf manuring. Alley cropping a version of agroforestry has the immense potential to maintain the soil health as the trees are pruned during cropping and lopped material can be used as green leaf manure (Kang *et al.*, 1985). The use of tree leaves as green leaf manures from the trees nearby fields even also helps to improve both the soil physical and chemical properties and helps to maintain organic matter and promotes microbial activity (Hussain *et al.*, 1994). Hence field experiment was carried out at Hyderabad to find out the effect of alley cropping of castor and green leaf manures application on soil health.

MATERIALS AND METHODS

The experiment was conducted during the rainy season 1996 and 1997. The site of the experiment was low in organic carbon, available nitrogen, medium in available P and potash. The treatments included 2 cropping systems of alley cropping of castor with *Dalbergia* (AC) and sole cropping (SC) as main plots, 4 types of green leaf manures, viz. no green leaf manure (GLM_0), *Leucaena* green leaf manure (GLM_1), *Albizia* green leaf manure (GLM_2) and *Dalbergia* green leaf manure (GLM_3), as subplots; and 3 levels of nitrogen, viz. 0 kg N/ha (N_0), 40 kg N/ha

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(N_{40}) and 80 kg N/ha (N_{80}) as sub subplots. All the treatments were replicated thrice in double split-plot design. Green leaf manure was incorporated @ 5 tonnes/ha, 15 days before sowing both in alley cropping and sole cropping areas by opening furrows along with recommended dose of P for better decomposition of green leaf material applied. *Leucaena* and *Albizia* green leaves were obtained from nearby stands, while *Dalbergia* green leaves by pollarding the standing trees *in situ.* Nitrogen was applied as per treatments in 2 split doses, i.e. 15 an 60 days after sowing. Soil samples were collected at 30 cm depth from all the plots before and after cropping analysed for physico-chemical properties. Soil samples were also collected seasonally, i.e. at 30, 60, 90 and 120 days after sowing (DAS), from experimental site and analysed for organic carbon, available nitrogen, total nitrogen and C : N ratio using standard procedures. Soil physical properties like field capacity by satura ion method, bulk density by core sample method and infiltration rate by using infiltration rings were estimated before and after cropping. Incubation studies were carried out in the laboratory. Soil samples from respective treatments were collected at 30 cm depth, dried and sieved through 2 mm sieve. Fully matured fresh leaves from respective sites were collected from 3 leguminous nitrogen-fixing trees (NFTs), viz. *Leucaena, Albizia* and *Dalbergia*. After grinding the leaves paste was made and added to the soil @ 220 mg/100 g soil. This rate is equal to 5 tonnes/ha of green manure applied to the field. The leaves and soil were thoroughly mixed and placed in polythene bags. Distilled water was added to the soil to achieve moisture content of 50% of field capacity. In the control treatment, leaf manure was not added. Nitrogen as urea was applied as per treatment at 100 g to incubated soil at the proportional rate to the rates applied to the field (N_1=43 kg/ha, i.e. 0.3 g) and (N_2 = 80 kg N/ha, i.e. 0.6 g). The incubation bags were sealed and maintained at room temperature throughout the experimental period. Soil moisture content was maintained at 50% of field capacity through periodic additions of de-ionized water. The study was carried out for 120 days in 24 treatments of the experiment through fortnightly sampling for determination of mineralizable N and organic carbon. The crop was sown on 17 July 1996, 14 July 1997 and harvested on 15 October 1996 and 30 October 1997.

RESULTS AND DISCUSSION

Soil physical properties

Field capacity: Field capacity of the site was increased due to alley cropping with *Dalbergia* during both the years, with values of 18.1% (1996) and 19.9% (1997) at 15–30 cm depth when compared with sole cropping (16.6 and 17.2%). This can be explained by the fact that the presence of 8 years old trees of *Dalbergia* might have added litter to the sites besides the root system loosening the soil which might have increased the porosity of the soil. Arnold Budelman (1987) and Hegde (1998) reported similar results of increased moisture retention under agroforestry.

Application of green leaf manures (GLM) of NFTs had profound effect on field capacity compared to no green leaf manuring. *Leucaena* GLM in particular increased the field capacity to a greater extent of 18.9% (1996) and 21.2% (1997) under alley cropping. Other green leaf manures of *Albizia* and *Dalbergia* also had similar effect. Increased organic matter could have improved the soil structure leading to increased water-holding capacity with green leaf manuring. Pathak and Gupta (1987) also reported that addition of *Leucaena* loppings resulted in increased tilth and water retainability.

Bulk density: Both alley cropping and green leaf manuring had greater influence on bulk density in both the years (Table 1). Alley cropping reduced the bulk density of the site during both the years (1.47 Mg/m^3) in 1996 and (1.34 Mg/m^3) in 1997 compared with sole cropping (1.67 and 1.50 Mg/m^3) at15 cm depth. The reason being increased porosity due to loosening of soil mass by tree roots under alley cropping as reported by Pathak and Gupta (1987).

Bulk density was decreased due to application of green leaf manures and the effect was more pronouced under alley cropping. The effect was similar in *Leucaena* GLM (1.48 and 1.24 Mg/m^3), *Albizia* GLM (1.47 and 1.37 Mg/m^3) and *Dalbergia* GLM (1.39 and 1.32 Mg/m^3) compared to GLM_0 (1.52 and 1.46 Mg/m^3) after cropping at 15 cm depth. Before cropping and before application of GLMs the bulk density was found more during 1996 (1.60 Mg/m^3) and 1997 (1.49 Mg/m^3). Reduced soil compaction might be due to improved tilth, increased porosity with addition of organic matter by the application of green leaf manures. Our findings confirm the results of Hegde (1998).

Infiltration rate: Alley cropping of castor with *Dalbergia* increased the infiltration rate of the soil by 1.2 cm/hr (1996) and 1.4 cm/hr (1997) over sole cropping (5.4 and 6.3 cm/hr) after cropping (Table 2). The infiltration rate of the soil was found less before cropping both in sole cropping with 4.8 cm/hr (1996) and 6.0 cm/hr (1997) and in alley cropping with 6.1 cm/hr (1996) and 6.0 cm/hr (1997). The increase in infiltration rate in alley cropping could be explained by the fact that the presence of trees reduced soil compaction and increased the porosity, as reported by Pathak and Gupta (1987). Green leaf manuring of tree leaves had profound effect in increasing

Table 1. Soil physical properties of experimental site before and after cropping as influenced by cropping systems and green leaf manures

Treatment	1996				1997			
	Before cropping		After cropping		Before cropping		After cropping	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
				Field capacity (%)				
Sole cropping (Sc)								
GLM_0	13.2	16.6	13.9	16.9	14.9	16.5	14.9	17.2
GLM_1	14.0	17.5	14.9	18.2	14.5	17.5	15.1	18.4
GLM_2	14.6	16.8	14.9	16.2	15.2	17.2	15.9	17.9
GLM_3	12.0	14.1	12.8	14.9	12.7	14.9	12.9	15.2
Mean	13.5	16.3	14.1	16.6	14.3	16.5	14.7	17.2
Alley cropping(AC)								
GLM_0	15.0	17.2	15.5	17.9	16.6	18.9	16.9	19.2
GLM_1	16.0	18.3	16.7	18.9	17.2	19.7	18.1	21.1
GLM_2	14.8	17.5	15.2	17.8	15.4	19.2	15.9	19.8
GLM_3	16.7	17.3	16.8	17.6	17.6	18.6	18.2	19.2
Mean	15.6	17.6	16.1	18.1	16.7	19.1	17.3	19.9
				Bulk density (Mg/m^3)				
Sole cropping (SC)								
GLM_0	1.75	1.78	1.65	1.69	1.61	1.67	1.59	1.64
GLM_1	1.64	1.72	1.61	1.68	1.60	1.69	1.55	1.59
GLM_2	1.65	1.78	1.57	1.69	1.59	1.61	1.54	1.57
GLM_3	1.66	1.74	1.58	1.69	1.61	1.67	1.56	1.62
Mean	1.67	1.75	1.60	1.68	1.60	1.66	1.56	1.61
Alley cropping (AC)								
GLM_0	1.60	1.65	1.52	1.54	1.49	1.42	1.46	1.32
GLM_1	1.54	1.48	1.61	1.49	1.30	1.52	1.24	1.39
GLM_2	1.57	1.63	1.47	1.53	1.45	1.50	1.37	1.49
GLM_3	1.41	1.58	1.39	1.54	1.37	1.40	1.32	1.32
Mean	1.53	1.62	1.47	1.53	1.40	1.46	1.34	1.36

Table 2. Infiltration rate (cm/hr) of experimental site before and after cropping as affected by cropping system and green leaf manures

	1996		1997	
	Before cropping	After cropping	Before cropping	After cropping
Sole cropping				
GLM_0	4.4	4.6	5.0	5.5
GLM_1	4.6	5.9	6.1	6.5
GLM_2	4.8	5.6	5.7	6.6
GLM_3	5.5	5.5	6.5	6.6
Mean	4.8	5.4	5.8	6.3
Alley cropping				
GLM_0	5.5	5.4	5.4	7.8
GLM_1	6.5	7.5	6.5	8.6
GLM_2	6.6	7.2	6.6	7.0
GLM_3	5.6	7.0	5.6	7.2
Mean	6.1	6.8	6.0	7.7

infiltration rate of the soil over no green leaf manuring and the effect was much more under alley cropping. Application of *Leucaena* GLM increased the infiltration rate a great extent with the value of 7.5 cm/hr (1996) and 8.6 cm/hr (1997) after cropping and even with *Albizia* GLM and *Dalbergia* GLM the increase was similar. Increased organic matter coupled with improved tilth with green leaf manuring might have led to increased infiltration rate of the soil.

Chemical properties

Seasonal study: The values of all chemical properties of soil like available nitrogen, organic carbon, total nitrogen and C:N ratio increased from initial stages and reached peak at 90 DAS (Table 3). However, alley cropping had more available N (297.1 and 467.8 kg/ha), organic carbon (0.73 and 0.73%), total nitrogen (0.063 and 0.061) and C : N ratio (11.63 and 11.63) during 1996 and 1997, respectively, over sole cropping. Improved tilth and porosity under alley cropping are reasons ascribed for improved

Table 3. Chemical properties of the soil under field conditions as influenced by cropping systems, green leaf manures and nitrogen levels

Treatment	Field condition at 90 days after sowing							
	Avaialble nitrogen (kg/ha)		Organic carbon (%)		Total nitrogen (%)		C: N ratio	
	1996	1997	196	1997	1996	1997	1996	1997
Cropping system								
Sole cropping	284.7	452.4	0.63	0.59	0.055	0.051	11.58	11.62
Alley cropping	297.1	469.8	0.73	0.73	0.063	0.061	11.63	11.63
CD (P=0.05)	NS	NS	0.09	0.43	0.08	0.07	0.04	NS
Green leaf manure								
GLM_0	290.3	441.2	0.66	0.62	0.057	0.054	11.6	11.61
GLM_1	295.7	480.5	0.78	0.75	0.067	0.064	11.58	11.60
GLM_2	288.8	467.7	0.66	0.66	0.056	0.052	11.56	11.68
GLM_3	288.9	455.0	0.64	0.61	0.05	0.053	11.62	11.62
CD (P=0.05)	11.78	14.01	0.06	0.37	0.005	0.007	0.12	0.08
Nitrogen level								
N_0	280.8	393.0	0.62	0.59	0.053	0.047	11.64	11.65
N_{40}	291.5	469.2	0.69	0.68	0.060	0.058	11.62	11.61
N_{80}	300.9	521.1	0.73	0.72	0.063	0.062	11.56	11.61
CD (P=0.05)	6.30	10.29	0.03	0.02	0.003	0.009	0.12	0.06

fertility status.

Green leaf manure application significantly affected all the chemical properties. *Leucaena* GLM resulted in higher fertility status in terms of available N (295.7 and 480.5 kg/ha), organic carbon (0.78 and 0.74%), total nitrogen (0.067 and 0.064) and C:N ratio (11.58 and 11.60) over no green leaf manuring. Similar effect was noticed with *Albizia* and *Dalbergia* GLM. Presumably increased microbial activity because of high organic matter with green leaf manuring might have led to mineralization and increased the nutrient status. Release of soil N in available form and addition of N through decomposition was also observed by Jayaraman (1998) through green manuring of *Leucaena,* as it is leguminous, decomposes quickly and releases organic acids.

Analysis of the soil samples collected from the field under different nitrogen levels indicated that with both 40 and 80 kg N/ha, the nutrient status was found improved due to increased availability of nutrients.

Interaction effects did not increase the availability of nutrients significantly. Nevertheless, under alley cropping with green leaf manuring at 40 kg N/ha, the fertility status was found high.

Incubation study : Laboratory analysis of soil samples after incubation (DAI) (Table 4) showed that the release of nutrients was steady from 15 DAI and availability reached peak at 75 DAI and decreased thereafter in all cropping systems, green leaf manures and nitrogen levels.

Cropping systems significantly influenced all the chemical properties of soil at 75 DAI. However, alley cropping of castor with *Dalbergia* resulted in more available N (280.8 kg/ha), organic carbon (0.79%), total nitrogen (0.069) and C : N ratio (11.69) over sole cropping. Reduced soil compaction and improved tilth with increased water retention under alley cropping could have increased the availability of nutrients. Similar results were also reported by Yadav *et al.* (1998) from agroforestry experiments.

The nutrient status of the experimental site was also affected significantly by the application of green leaf manuring. *Leucaena* GLM had more available N (280.8 kg/ha), organic carbon (0.81%), total nitrogen (0.072) and

Table 4. Chemical properties of the soil under incubation as influenced by cropping systems, green leaf manures and nitrogen levels, 75 days after incubation

Treatment	Available nitrogen (kg/ha)	Organic carbon (%)	Total nitrogen	C : N ratio
Sole cropping	270.6	0.74	0.064	11.65
Alley cropping	280.8	0.79	0.069	11.69
CD (P=0.05)	9.29	0.26	0.04	0.04
GLM_0	270.8	0.66	0.056	11.69
GLM_1	280.8	0.81	0.072	11.66
GLM_2	278.3	0.82	0.070	11.67
GLM_3	273.0	0.79	0.068	11.65
CD (P=0.05)	9.43	0.03	0.006	0.08
N_0	261.2	0.71	0.062	11.66
N_1	275.6	0.77	0.067	11.67
N_2	290.2	0.82	0.071	11.67
CD (P=0.05)	3.62	0.02	0.001	0.06

C:N ratio (11.71). Nevertheless, *Albizia* and *Dalbergia* GLMs also produced equal effect on nutrient status over no green leaf manuring. This can be explained by the fact that high concentration of N, low concentrations of lignin and polyphenols in all these leaf manures, might have increased the N mineralization and improved the nutrient status, as reported by Mafangoya *et al.* (1998).

Application of nitrogen too significantly changed the nutrient status. However, both 40 and 80 kg N/ha have produced equal effects in improving fertility status of the soil.

Though interaction effects of the treatments did not differ but alley cropping with green leaf manuring at 40 kg N/ha had remarkable effect in increasing the available nutrients.

The results indicated that the physical properties of soil like water-holding capacity, infiltration rate were improved remarkably, while the bulk density was reduced with alley cropping of *Dalbergia* and green leaf manuring of NFTs. Similarly, the nutrient status of the soil in terms of nitrogen availability, organic carbon and C:N ratio was also increased with alley cropping and green leaf manuring. However, alley cropping with green leaf manuring and nitrogen application had much pronounced effect in improving the soil physico-chemical properties. Therefore, practices of such biological methods will help in improving the productivity of crop simultaneously sustaining the soil health in SAT regions.

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