Review Article

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Nutrient management and sustain productivity in degraded jhum agro-ecosystem through organic amendment

Abstract

An experiment was carried out for two consecutive years in shifting cultivation areas of Karbi Anglong district, Assam to evaluate the potentiality of N_2-fixing plants as organic amendment for increment of crop productivity and fertility status of soil. Three leguminous plants *i.e. Crotalaria pallida*, *Sesbania bispinosa*, *Cajanus cajan* were raised along with cultivation of rice and maize. Organic carbon and nitrogen content were significantly higher in soil because of rapid mineralization and steady supply of nutrient due to decomposition of leafy foliage of N_2-fixing plants applied as organic amendment. Significant increase of available phosphorus and exchangeable potassium content was observed in treated plots but it was found to be decreased considerably after harvesting of agricultural crops. All the treatments shows superior yield over control in both the year of experimentation. *C. pallida* increased 56.74% more rice yield in first year and 55.07% in second year in respect of control. Maximum production of straw was also found high in *C. pallida* followed by *S. bispinosa* and *C. cajan*. Economic analysis on productivity of crops conducted in two subsequent years showed maximum cost-benefit ratio in *C. pallida* applied plots which is found to be more effective contrast to other treatments. Maize exhibits significantly high value in compared to rice.

Keywords: Organic amendment, crop productivity, soil nutrient status, shifting cultivation

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Introduction

North Eastern Hill region of India form a highly complex landscape mosaic, inhibited by different tribal groups with their own linguistic and cultural practices. They are mainly dependent of shifting cultivation (Jhum), a widely practiced food production system which is also closely intermingled with their socio-cultural life. Traditionally it was productive and sustainable but in recent time it is blamed as the causal factor of most serious challenges including deforestation, loss of biodiversity, lowering productivity, depletion of soil fertility, erosion and finally deepening impoverishment of jhum dependent communities. Due to continuous cultivation of the area, soil fertility has declined resulting nutrient imbalance that leads limiting crop yields. Indigenous practices of protecting or planting nitrogen fixing plant as organic amendment for increasing nutrient budget and enhance productivity of soil are neither new nor rare in traditional agricultural system. A number of related literature available that includes documentation of farmer's innovation to integrate various legume plants either sequentially or simultaneously for improvement of jhum fallow.[1–3] However, the effect of legume on succedding crops varies considerably depending upon the nature of crop and soil type.[4] Species to be used for fallow improvement that provide plant cover after crop harvest, produce large quantities of biomass, suppress weeds, mobilize plant nutrition from lower soil layers and decompose rapidly. Leguminous species with high leaf nitrogen concentration and low lingo- phenolic compounds such as *Gliricidia sepium, Leucaena leucacephala* and *Sesbania bispinosa* liberate more than half of their leaf nitrogen within two weeks of pruning.[5] The important leguminous plant used as organic amendment is belongs to the genus of *Sesbania, Tephrosia, Leucaena, Mucana, Centrosema, Pueraria, Crotalaria, Cajanus, Indigofera* and *Mimosa.* Such species can be grown *in situ* and incorporated in the field as organic amendment so that the nutrients may be made available to the target crops under cultivation. *Crotalaria pallida*, *Sesbania bispinosa* and *Cajanas cajan* has a fast decomposition rate and can improve both the quality and quantity of soil organic matter.[6,7] Therefore, an experiment was carried out in degraded land under shifting cultivation at Karbi Anglong district of Assam to improve soil fertility and enhancement of agricultural productivity through organic amendment by introducing potential leguminous species.

Materials and methods

An experiment was conducted at Silonijan, Karbi Anglong district of Assam in $25^0$50' north latitude and $93^0$30' east longitude. The area is situated at the foothills of Mikir Ranges and depended upon monsoon receiving nearly 1200 mm rainfall annually. Due to southwest monsoon circulating over low-lying hills and absence of any streamlined movement of wind, summer temperature remains comparatively high. The average maximum temperature varies from 28.65^{0}C to 31.24^{0}C and minimum temperature varies from 14.67^{0}C to 19.38^{0}C. The relative humidity was highest as 90% in the month of August.[8] The experiment was laid out in Randomize Block Design of 5m x 5m plots with spacing of 2m. Total 32 numbers of plots were prepared for 4 treatments and 4 replications with 2 numbers of agricultural crops (rice and maize). Seeds of three leguminous species viz. *Crotolaria pallida, Sesbania bispinosa* and *Cajanus cajan* were collected and sown in the respective plots of experimental site. After three months of growth, plants were incorporated into the soil by cutting it into small pieces. Then it is left for decomposition and mixed thoroughly into the soil. After decomposition, the plots were hoed; dig and seeds of rice and maize were sowed. Soil samples were collected before sowing of agricultural crops and after harvesting. Samples were analysed for soil pH, conductivity, Organic carbon, Nitrogen, Phosphorus, potassium, calcium and magnesium as described by Jackson.[9] Yield data and economics of crops were recorded after harvesting crops. Statistically significance of the data was calculated by ANOVA (5% significant level).

Results and discussion

The soil was sandy loam in texture having pH 5.49, electric conductivity 0.482m Mho, organic carbon 1.18%, calcium 3.2meq/100gm, magnesium 1.6meq/100gm. and 360.32kg/ha, 26.41kg/ha, 324.04kg/ha of NPK respectively. Fertility status of soil improved substantially by the application of organic amendment compared to initial status. Increase pH level was recorded high in treated plot but no significant differences were noticed among the different treatments. pH was found to decreased gradually after harvesting the agricultural crops and comparatively more decline of was noticed in 2nd year cropping (Table 1). Raju & Reddy[10] also confirmed the gradual decline of soil pH in subsequent cropping due to higher salt content in humus. The value of soil conductivity (Table 1A) was followed similar trend with pH and was supported by the findings of Dahiya et al.,[11] in sugarcane. Organic carbon plays an important role in maintaining soil health. Highest increase of organic carbon was recorded in before sowing stage of second year cropping. This must be repeated application of leafy foliage and delayed decomposition of the green manure in the initial year of experimentation. Significant increment of organic carbon was recorded in *C. pallida* applied plots (Table 1A).

Total nitrogen was found to be increased by the application of leafy foliage of legume because of mineralization along with direct fixation of atmospheric nitrogen. During first and second year an increase of 27.37% and 25.45% of N was recorded respectively in *C. pallida* applied plot followed by *S. bispinosa* (25.31% and 23.05%) and *C. cajan* (11.11% and 9.49%) over control (Table 1B). Addition of organic amendment as green manure is beneficial in mobilizing native phosphorus as well as phosphorus for applied fertilizers to the crops. In *C. pallida* applied plot 34.35% and 27.33% increase of phosphorus were recorded during first year and second year experimentation respectively (Table 1B). Sah et al.,[12] reported that higher available nitrogen and phosphorus might be due to more biomass production as well as higher uptake of nutrients. He also stated that incorporation of *Sesbania acuelata* significantly increased available soil nitrogen due to mineralization of organic nitrogen content. Sharma et al.,[13] Constantinides & Fownes[14] studied nitrogen mineralization patterns of leguminous plants and found significant increase in rice yield, nitrogen turnover and soil properties through introducing sun hemp (*Crotolaria juncea* L.). Application of residues of legume plant as organic amendment improves potassium availability of soil significantly. In the present experiment it was found that *C. pallida* was the most effective among the other species tried. It increases potassium 58.95% and 59.73% over control during first year and second year followed by *S. bispinosa* (53.68% and 51.05%) and *C. cajan* 2(9.21% and 28.55%). In subsequent year the value was recorded more (Table 1B). Similar finding was given by Zen et al.,[15] that increment of potassium under long term application of organic manure and fertilizer. Duhan et al.,[16] reported that *C. pallida* releases more soil available potassium in comparison with *S. bispinosa* .

The productivity of agricultural crops significantly increased in all the treatments (Table 2). On the basis of pooled mean data maximum increase of grain yield was recorded in *C. pallida* (rice- 2210kg/h; maize- 2500kg/h) followed by *C. cajan*. In *C. pallida* incorporated plots 56.74% more rice yield was recorded over control whereas 31.21% and 13.48% were recorded in *S. bispinosa* and *C. cajan* respectively. Higher production of straw was found in application of *C. pallida*. Grain yield of maize increased 51.52% over control. Stover yield was also influenced positively by the application of green manure. Duhan et al.,[16] also stated that *Crotolaria juncea* as green manure produced highest yield. Literature also support of *S. bispinosa* is an excellent organic amendment for sub-tropical agro climatic conditions.[17,18] Sharma & Mitra[19] found enhanced productivity of main and succeeding crops due to application of *Sesbania aculeata* as green manure. The possible reasons for highest yield with *Sesbania* may be due to its easy and rapid decomposition, highest dry matter supplied and early release of nutrients to the crop. Kwesiga et al.,[1] recorded that incorporation of *Sesbania sesban* enhanced productivity of maize grain and Stover followed by *C. cajan*. Higher net return in *C. pallida* treated plots of Rs 9580 and Rs 20220 during second year of cultivation was recorded in respect of rice and maize. Benefit cost ratio was recorded as 1.18 and 2.57 that followed similar trend (Table 3).

Table 1A Effect of green manure on pH and conductivity and organic carbon in soil

Treatments	pH				Conductivity(mMho)				Organic carbon(%)			
	Before sowing		After harvesting		Before sowing		After harvesting		Before sowing		After harvesting	
	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.
T_1	5.87	5.8	5.76	5.66	0.526	0.495	0.416	0.402	1.377	1.326	1.306	1.3
T_2	5.71	5.65	5.69	5.61	0.498	0.484	0.372	0.36	1.306	1.298	1.201	1.2
T_3	5.7	5.64	5.68	5.6	0.468	0.45	0.36	0.348	1.282	1.2	1.191	1.18
T_0	5.67	5.56	5.53	5.48	0.402	0.4	0.31	0.301	1.209	1.195	1.033	1.02
SE (±)	0.06	0.01	0.05	0.07	0.01	NS	0.02	NS	0.03	0.04	0.01	0.02
CD (5%)	0.13	0.02	0.12	0.15	0.02	NS	0.04	NS	0.08	0.09	0.02	0.04

T0- control, T1- *Crotolaria pallida*, T2- *Sesbania bispinosa* , T3- *Cajanus cajan*

Table 1B Effect of green manure on NPK content of soil

Treatments	Nitrogen(Kg/ha)				Phosphorus(Kg/ha)				Potassium(Kg/ha)			
	Before sowing		After harvesting		Before sowing		After harvesting		Before sowing		After harvesting	
	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.
T_1	462.2	450	373.92	361.3	36.96	33.64	14.34	14	507.36	499.62	252.17	248.57
T_2	454.72	441.4	329.28	318.6	34.93	32.62	14.32	13.4	490.56	472.5	236.17	234.2
T_3	403.2	392.75	345.84	334.76	32.37	29.73	14.3	13	412.44	402.1	228.7	212.2
T_0	362.88	358.72	279.2	265.1	27.51	26.42	14.3	12.8	319.2	312.8	177.4	162.8
SE (±)	1.99	1.65	1.99	1.68	0.07	0.4	0.22	0.17	1.88	1.3	1.43	1.29
CD (5%)	4.49	3.72	4.49	3.81	0.15	0.92	0.5	0.39	4.26	3	3.24	2.92

Table 2 Effect of green manure on productivity of rice and maize

Treatments	Productivity of rice						Productivity of maize					
	Weight 1000grains(gm)		Grain(Kg/ha)		Straw(Kg/ha)		Weight 100grains(gm)		Grain(Kg/ha)		Stover(Kg/ha)	
	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.	1st Yr.	2nd Yr.
T_1	20.67	19.85	2210	2140	3650	3320	23	22.7	2500	2270	2800	2520
T_2	19.67	18.72	1850	1795	3350	3030	22.6	22.5	2300	2092	2600	2315
T_3	19.28	18.23	1600	1490	3140	2830	21.5	21.3	2040	1865	2380	2140
T_0	17.33	17.14	1410	1380	2460	2240	20.4	20.2	1650	1510	1930	1740
SE (±)	0.37	0.42	3.72	2.98	2.1	2.4	0.52	0.32	2.49	2.05	0.53	1.42
CD (5%)	0.85	0.96	8.4	6.73	4.72	5.42	1.18	0.72	5.63	4.65	1.19	3.22

Table 3 Effect of green manure on economics of rice and maize

Treatment	Rice				Maize			
	Net return(Rs/ha)		B:C ratio		Net return(Rs/ha)		B:CRatio	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	9020	9580	1.11	1.18	18840	20220	2.24	2.57
T_2	5660	6100	0.65	0.7	16104	18600	1.79	2.07
T_3	3540	3780	0.47	0.5	10320	12000	1.32	1.54
T_0	520	1400	0.05	0.12	10680	12780	0.91	1.09

Conclusion

The use of organic amendments to improve soil fertility as well as productivity dates back to thousands of years ago. Goss et al.,[20] stated that wheat took advantages if grown on fields previously cultivated with leguminous plants. The study also concludes that applications of organic amendments of legume plant as green manure enhance productivity of maize more significantly in comparison to rice. Among the three nitrogen fixing plant added as organic amendment *C. pallida* was recorded more potential species in shifting cultivation soil which build up fertility status of soil and enrich crop productivity.

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None.

Conflicts of interest

Author declares that there is no conflicts of interest.

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