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 N₂-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 N₂-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

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 permits unrestricted use, distribution, and build upon your work non-commercially. 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. 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°50’ north latitude and 93°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°C to 31.24°C and minimum temperature varies from 14.67°C to 19.38°C. The relative humidity was highest as 90% in the month of August. 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. Crotalaria 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; dug and seeds of rice and maize were sown. 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. 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 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., in sugarcane. Organic carbon plays an important role in maintaining soil health. Highest increase 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., 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 aculeata significantly increased available soil nitrogen due to mineralization of organic nitrogen content. Sharma et al., Constantines & Fownes 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 (9.21% and 28.55%). In subsequent year the value was recorded more (Table 1B). Similar finding was given by Zen et al., that increment of potassium under long term application of organic manure and fertilizer. Duhan et al., 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., 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. Sharma & Mitra 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. Kwasiga et al., 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. |
| T1         | 5.87   | 8.50   | 7.56   | 5.66   | 0.526  | 0.495  | 0.416  | 0.402  | 1.377  | 1.326  | 1.306  | 1.306  |
| T2         | 5.71   | 5.65   | 5.69   | 5.61   | 0.498  | 0.484  | 0.372  | 0.36   | 1.306  | 1.298  | 1.201  | 1.201  |
| T3         | 5.7    | 5.64   | 5.68   | 5.6    | 0.468  | 0.45   | 0.36   | 0.348  | 1.282  | 1.2    | 1.191  | 1.18    |
| T4         | 5.67   | 5.66   | 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 (%)     | 0.13   | 0.02   | 0.12   | 0.15   | 0.02   | NS    | 0.04   | NS    | 0.08   | 0.09   | 0.02   | 0.04   |

Citation: Bora IP, Barua KN. Nutrient management and sustain productivity in degraded jhum agro-ecosystem through organic amendment. Adv Plants Agric Res. 2018;8(6):406–409. DOI: 10.15406/apar.2018.08.00359
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.          |
| T_1        | 462.2         | 450              | 373.92          | 361.3            | 36.96         | 33.64            |
| T_2        | 454.72        | 441.4            | 329.28          | 318.6            | 34.93         | 32.62            |
| T_3        | 403.2         | 392.75           | 345.84          | 334.76           | 32.37         | 29.73            |
| T_4        | 362.88        | 358.72           | 279.2           | 265.1            | 27.51         | 26.42            |
| SE (±)     | 1.99          | 1.65             | 1.99            | 1.68             | 0.07          | 0.4              |
| CD (%)     | 4.49          | 3.72             | 4.49            | 3.81             | 0.15          | 0.92             |

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

| Treatments | Productivity of rice | Productivity of maize |
|------------|----------------------|-----------------------|
|            | Weight 1000 grains (gm) | Grain(Kg/ha) | Straw(Kg/ha) | Weight 100 grains (gm) | Grain(Kg/ha) | Stover(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.          |
| T_1        | 20.67                 | 19.85                | 2210          | 2140                 | 3650          | 3320            |
| T_2        | 19.67                 | 18.72                | 1850          | 1795                 | 3350          | 3030            |
| T_3        | 19.28                 | 18.23                | 1600          | 1490                 | 3140          | 2830            |
| T_4        | 17.33                 | 17.14                | 1410          | 1380                 | 2460          | 2240            |
| SE (±)     | 0.37                  | 0.42                 | 3.72          | 2.98                 | 2.1           | 2.4             |
| CD (%)     | 0.85                  | 0.96                 | 8.4           | 6.73                 | 4.72          | 5.42            |

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      |
| 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_4       | 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., 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.

Acknowledgments

None.

Conflicts of interest

Author declares that there is no conflicts of interest.

References

1. Fujisaka S. A diagnostic survey of Shifting Cultivation in northern Laos: targeting research to improve sustainability and productivity. Agro forestry System. 1991;13:95–109.
2. Garrity D. Sustainable land use systems for sloping uplands in Southeast Asia. In: Technologies for sustainable Agriculture in the tropics. Madison: Special publication. 1993;16:41–46.
3. Raintree JB, Warner K. Agro forestry pathways for the intensification of D. Shifting Cultivation. Agro forestry System. 1986;4:39–54.
4. Shaktawat RPS, Shaktawat PS. Soil fertility status as affected with or without farmyard manure in Kharif crops and fertilizer levels in Berley (Hordeum vulgare). Indian Journal of Agricultural Sciences. 2010;80(9):791–794.
5. Oglesby KA, Fownes JH. Effects of chemical composition on nitrogen mineralization from seven green manures of tropical leguminous trees. Plant and Soil. 1992;143:127–132.
6. Cosico WC. Studies on green manuring in the Philippines. Bulletin 314, Food and Fertilizer Technology Centre, Taipei, Taiwan; 1990;314:16.

7. Ong CK, Daniel JN. Traditional crop sparks new interest as a multi-purpose tree. Agroforestry Today. 1990;2:4–7.

8. Sarma NN, Paul SR, Sarma D. Rainfall pattern and rainfall based cropping system for the hill zone of Assam. Annals of Agricultural Research. 1996;3:223–229.

9. Jackson ML. Soil Chemical Analysis. New Delhi: Prentice Hall of India Pvt. Ltd; 1973. p. 498.

10. Raju RA, Reddy MN. Integrated management of green leaf, compost, crop residues and inorganic fertilizers in rice (Oryza sativa L.) –rice system. Indian Journal of Agronomy. 2000;45(4):629–635.

11. Dahiya R, Malik RS, Jhorar BS. Effect of sugarcane trash and enrich sugarcane trash mulches on rattan cane yield and soil properties. Journal of Indian Society of Soil Science. 2003;51(4):504–508.

12. Sah RR, Rai RK, Mukharjee PK. Effect of green manure dhaincha (Sesbania acuelata) and phosphorus on growth, yield and phosphorus uptake by wheat (Triticum aestivum). Indian Journal of Agronomy. 2000;45(4):707–710.

13. Sharma S, Deb SP, Rameshwar R. Effect of green maturing of sun hemp (Crotolaria juncea L.) on rice yield, nitrogen turnover and soil properties. Crop Research. 2000;19(3):418–423.

14. Constantinides M, Fownes JH. Nitrogen mineralization patterns of leaf-twing mixture from tropical leguminous trees. Agroforestry System. 1993;24:223–231.

15. Zen M, Zin WX, Yao YX, et al. Advantages of application of manure with chemical fertilizers in long term in situ experiments. Soil and Fertilizer. 1992;1:1–6.

16. Duhan BS, Kumar V, Singh N, et al. Effect of green maturing on the yield and uptake of potassium rice. Crop Research. 2001;22(3):330–334.

17. Halepyati AS, Sheelanventar MM. Sesbania rostrata - a new green manure for rice. Indian Journal of Agriculture. 1990;35(3):279–282.

18. Datt N, Bhardwaj KKR. Nitrogen contribution and soil improvement in legume green maturing on the yield and uptake of potassium in rice. Crop Research. 1995;22(3):330–334.

19. Sharma AR, Mitra BN. Effect of combination of organic materials and nitrogen on growth, yield and nitrogen uptake of rice. Journal of Agricultural Science. 1988;111(3):495–501.

20. Goss MJ, Tubeileh A, Goorahoo D. A review of the use of organic amendments and the risk to human health. Adv Agron. 2013;120:275–379.