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Performance Evaluation of Organic and Inorganic Fertilizers for Sustainable Productivity of Rice in Shifting Cultivation of Karbi Anglong District, Assam

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Abstract An experiment was conducted in shifting cultivation areas of Karbi Anglong district, Assam for two successive years to make a comparative study on crop yield and fertility status in soil by solo and combined application of green manure and inorganic fertilizer. Legume (*Albizzia procera +Dalbergia sisso*), non-legume (*Gmelina arborea + Trewa nudiflora*) and weed species (*Chromolaena Odorata +Lantana camara*) were aprlied as green manure with or without incorporation of inorganic fertilizer. The experiment was laid down in split plot design. During second year, repetitive treatment was carried out in half of the plots and no additional treatment was done in another half to see the yield differences. Upland variety of rice was broadcasted in equal amount in each plot during the rainy season. Combined application of green manure along with inorganic fertilizer showed significant increase of grain and straw yield of rice as well as fertility status in soil. Maximum yield was recorded in legume green manure applied plot with recommended dose of NPK (6.94 q ha^{-1}). Significant increase of productivity (7.58 q ha^{-1}) and nutrient status was recorded during the successive year that received repetitive treatment. Observation concluded that combination of *A.procera* and *D. sisso* as green manure was more potential which can significantly increase fertility status of soil and enrich crop productivity particularly when amended with inorganic fertilizer.

Keywords Shifting cultivation, Productivity, Nutrient status, Fertilizer, Evaluation.

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Introduction

Shifting cultivation is a traditional system of subsistence food production among the tribal communities in hilly terrain of North Eastern region of India. It is a cyclic agricultural system involving slashing and burning of land, followed by phases of cultivation by mixed cropping and abandoned as fallow after cultivation is over after certain period of time. Recently due to widening gap in demand and supply following steep rise in hill population and its associated pressure on agricultural land *jhum* cycle has reduced to as low as three years (Bruun et al. 2006, Rathore et al. 2010). Soil fertility is unable to recover in such a short period and *jhum* farmers could not have any other alternative to cope up with this problem. Declining fertility has resulted reduce crop yield, severe weed infestation, increase run -off and also shortage other forest products. There is a need to manage this present system so that this will be economically sound to ensure increased and sustainable levels of production of crop as well as increase the nutrient status of soil. Generally *jhum* fields of NE India are dominated by weedy shrubs as well as variety of legume and non-legume plants. *Jhum* cultivators usually cut the tree to fulfill their demand of fuel wood and remaining part was left for fodder. The leaves of these plants are rich with nutrients and may be use as green manure in nutrient deficient soil for sustainable productivity. Leguminous green manure plants through the legume effect improve nutrient status as well as biological properties in soil (Baddeley et al. 2017). *Albizzia procera* and *Dalbergia sissoo* are nitrogen fixing, semi deciduous tree species, which are available in shifting cultivation area. The leaves of these plants are palatable contained more protein, easily decomposable and rich source of nitrogen when used as a green manure. Besides leguminous plant some non-legume and weedy shrubs also have properties to use as green manure in nutrientdeficient soil. Jama et al. (2000), Singh et al. (2004) have evaluated the potential contribution to soil fertility of species like *Alchornea cordifolia, C.odorata, Calliandra calathyrsus, L.camara* and *Pennisetum purpurum, Tithonia diversifolia* as green manure. *L.camara* is one of the most widely prevalent shrubs in shifting cultivation area, which is spreading at an alarming rate in fallow areas. Its periodic cutting for manuring purpose would reduce its excessive growth and enhance the productivity of crop. Ghadge and Jadhav (2013), Choudhary and Acharya (1993) reported that *L. camara* mulch in silty clay loam Alfisol retained 32% of moisture compared to 9% under no mulch treatment during 50 days of study. According to them thorny much of *L.camara* not only conserved soil moisture, but it kept off insects pests, and prevented the crops from damages by hares and wild rats. Rameshwar and Argaw (2016) stated that proper utilization of *L.camara* biomass through appropriate technologies may help in supplementing chemical fertilizer besides adding organic matter to the soil.*C.odorata* is another dominant noxious weed in *jhum* fallows which could be used to improve the buildup of nutrient status specifically high amount of potassium content released in soil (Kanmegne et al.1999). *C.odorata* as raw material have potentiality to be used as compost and its application achieving optimal fertility for rice crop (Jamilah and Juniarti 2017). In succulent biomass of **C.odorata** contains high N and P content and could be used to help substantially in N and P economy of crops if incorporated in the soil (Krishna Murthy et al. 2011). *G. arborea* and *T. nudiflora* are also other non-leguminous semi-deciduous plants, which are available in study areas and released nutrient to the soil through litter decomposition. Selvi and Kalpana (2008) also describe the scope and strategies of intercropping green manure with rice. This paper highlighted the contribution of solo application of green manure and combination with inorganic fertilizer towards the enhancement of crop productivity as well as to improve fertility status in soil in shifting cultivation areas of NE India.

Materials and Methods

The study was conducted in the shifting cultivation area belonging to the villages MenTeron, under Bokajan Block of, Karbi Anglong district (25°50´ North latitude and 93°30´ East longitude) of Assam. The climate of the area can be distinguished as humid sub tropical type. The area is situated at the foothills of Mikir Ranges and depended upon monsoon receiving nearly 1200 mm rainfall annually. Rainfall is high during month of July to September and low during November to March. Due to southwest monsoon circulating over low-lying hills and absence of any streamlined movement of wind, summer temperature remains comparatively high. Relative humidity was highest in the month of August. The soil is red sandy loam and of laterite origin i.e. Oxisol.

Site preparation

After extensive survey sites were selected and depending on willingness farmers were identified Slashing and burning operation was carried out in the selected sites and plots measuring 5 m ×5 m were prepared with 2 m spacing between the replication.

The experiment was laid down in split plot design with eight treatments and control plots replicated three times. Total 51 Nos of plot were prepared for both initial and repetitive treatment along with control. Green leaves of legume (*A. procera*+*D. sisso*), non-legume (*G. arborea* + *T. nudiflora*) and weedy shrubs (*C. odorata* +*L. camara*) were collected and chopped into small pieces, spread uniformly into the soil surface @ 10 ton ha^{-1}. Then it was left for decomposition for 27 days. In combined treatment of green manure and inorganic fertilizer standard dosage of fertilizer were mixed with green manure. Solo application of NPK was also done. After decomposition of green manures plots were hoed, dig and local upland varieties of rice (70 g) were broadcasted in each plot during the month of May.

Treatment combinations

C_0-Control (No incorporation), T_1 - Legume green manure applied plot (*A. procera*+*D. sisso*),T_2-Non-legume green manure applied plot (*G.arborea*+*T.nudiflora*),T_3–Weed green manure applied plot (*C.odorata*+*L.camara*), T_4-NPK applied plot (Urea-50kg, DAP-50 kg, MOP-25kg), T_1F–Legume green manure + NPK (Urea-50kg, DAP-50,MOP-25 kg) applied plot, T_2F–Non-legume green manure +NPK (Urea-50kg, DAP -50, MOP-25kg) applied plot,T_3F–Weed green manure+ NPK (Urea-50kg, DAP-50, MOP-25 kg) applied plot.

After harvesting of first year three replication of each treatment were again treated with green manure and fertilizer like initial year (repetitive treatment) and three replication were left as such without any incorporation (for residual effect). Control plots were remain same as previous year. Productivity of upland rice in plot incorporated with green manure along with inorganic fertilizer, solo application of green manure and solo application of inorganic fertilizer was documented.

Soil sample collection

Composite soil samples were collected from surface layer (0–15 cm) of each treatment before sowing of rice seeds and after harvesting of crops. After air-drying, the soil samples were passed through a 60 mesh sieve and stored in airtight bottles as described by Pandeya et al.(1968) . pH of the soil was determined with the help of pH meter (Jackson 1973). Organic carbon was estimated by Walkley and Black's method (1934). Total nitrogen was analyses by Kjeldhal's method as described by Jackson (1973). Available phosphorus was estimated by Spectro photometrically and potassium was estimated by Flame emission method (Jackson 1973).

Productivity analysis

Rice was harvested in the month of August-September. Grain and straw yield of rice for each treatment was recorded in both the year and analyzed statistically.

Results and Discussion

The initial soil nutrient status of experimental plot was recorded as follows : Sandy loam having 75.4% sand,14.9% silt and clay 9.7%, pH 5.44, conductivity 0.62 $mMhocm^{-1}$, bulk density 1.07 g/cm^3,moisture content 15.44%, organic carbon 2.27%, total nitrogen 0.185%, available phosphorus 0.0416 ppm and exchangeable potassium 0.802 meq/100g.

Effect of green manure on grain yield
and yield attributes of rice

Grain and straw yield of rice significantly increased under all the treatments over control (Table 1). Legume green manure enhanced productivity of rice grain and straw than non-legume green manure application. In the initial year, legume green manure incorporated plots recorded highest yield of rice (6.87q ha^{-1}) and straw (11.84 q ha^{-1}) followed by weedy green manure (6.14 q ha^{-1}) and non-legume green manure (5.35 q ha^{-1}) respectively. Highest yield was found with optimal dose of inorganic fertilizer associated with legume green manure (6.94 q ha^{-1}) and least in non-leguminous green manure (5.57 q ha^{-1}) applied soil. Legume green manure (6.87 q ha^{-1}) applied plot recorded more yield over inorganic fertilizer applied plot (6.60 q ha^{-1}) alone. Meena et al. (2016) also recorded the highest yield of rice with *Dhaincha* grown at the ratio of 2 : 1 Kumar et al. (2010), Dhakal et al. (2016) stated that legume green manure also prevent

Table 1. Productivity of rice (q/ha). C_0 =Control, T_1=Legume GM, T_2 = Non-legume GM, T_3 = weed GM, T_4= Inorganic fertilizer, T_1F =Legume GM + NPK, T_2F = Non-legume +NPK, T_3F = weed GM +NPK, T_4=Inorganic fertilizer (standard dose of NPK).

	Grain yield q/ha				Straw yield q/ha			
Treatments	1st year	Residual treatment	2nd year	Repetitive treatment	1st year	Residual treatment	2nd year	Repetitive treatment
C_0	4.67		4.43		8.38		8.08	
T_1	6.87	7.14		6.75	11.84	12.54		11.92
T_1F	6.94	7.58		7.08	12.46	12.96		12.75
T_2	5.35	5.67		5.29	9.20	10.68		9.86
T_2F	5.57	5.89		5.18	9.79	11.88		10.72
T_3	6.14	6.84		6.48	11.27	11.84		10.69
T_3F	6.58	6.92		6.17	11.55	11.94		10.94
T_4	6.60	6.98		6.44	9.71	11.55		10.68
SE ±	0.81	0.78		0.71	1.44	1.15		1.09
CD (5%)	0.88	0.84		0.76	1.02	1.21		0.85

nutrient leaching, decrease weed growth, and reduce the harmful effect of agrochemicals and soil-borne phytopathogens.

In the successive year of cultivation plots received repetitive treatment showed maximum quantity of crop yield in legume green manure along with inorganic fertilizer (7.58 q/h) applied plot. More or less same trend of productivity as in initial year was observed in other green manure application. Least amount of crop yield in 2nd year cultivation was noticed in plots where no fertilizer and green manure application was done (6.75 q/ha^{-1}). Kayeke et al. (2007), Tolanur and Badanur (2003) have reported that the efficiency of yied increase when inorganic fertilizer applied along with green manure. Among these treatments, green manure along with inorganic fertilizer treatment proved superior in respect of grain and straw yield of rice. The superiority is attributed to its fast decomposition, which probably led to release of nutrient (Islam et al. 2016).

Nakhone and Tabatabai (2008) studied nitrogen mineralization in five legume residues and five different soils. Sharma and Verma (2000) demonstrate the addition of *L.camara* biomass on different soil nitrogen fraction in rice-wheat cropping system which builds up the level of N fraction in soil and enhance crop productivity. Sharma et al. (1995) also found the enhancement of productivity grain yield of rice by 0.3 tha^{-1} and of spring wheat by 0.7 tha^{-1}, due to application of *Sesbania* as green manure.

Nutrient status of soil

Nutrient status of soil was significantly influenced due to addition of green manure and fertilizer. No remarkable variation was noticed at the initial stage of experiment. Acidity of the soil was observed to decline slightly due to application of green manure while less value of pH was recorded in solo application of inorganic fertilizer (Table 2a). Legume green manure incorporated with inorganic fertilizer plot shows significantly high value of pH (T_1F-6.38) than non-legume green manure treated plot (T_2F-6.06). After harvesting of crop the pH value declined due to heavy absorption of nutrients by the crop.

Significant decline in pH value was noticed during second year with or without application of green manure and fertilizer (Table 2a). Raju and Red-

Table 2a. pH value of soil under different green manure and inorganic fertilizer treatments.I-Before cropping, H-After harvest.

Treat ments	1st year		Repetitive treatment	2nd year	Residual treatment	
	I	H	I	H	I	H
C_0	5.27	5.08	5.14	5.02	5.14	5.02
T_1	6.33	5.95	6.12	5.88	5.78	5.52
T_1F	6.38	6.24	5.43	5.16	5.36	5.08
T_2	5.28	5.04	5.40	5.37	5.24	5.18
T_2F	6.06	5.65	5.26	5.18	5.16	5.07
T_3	5.59	5.44	5.66	5.26	5.47	5.18
T_3F	5.48	5.36	6.38	6.05	5.38	5.24
T_4	4.63	4.57	5.32	5.22	5.66	5.27
SE ±	0.59	0.53	0.44	0.97	0.22	0.16
CD (5%)	0.64	0.58	0.64	1.02	0.26	0.38

Table 2b. Percentage of organic carbon in soil under different green manure and inorganic fertilizer treatments.

Treat-ments	1st year		Repetitive treatment		2nd year	Residual treatment
	I	H	I	H	I	H
C_0	1.68	1.24	2.12	1.46	2.12	1.46
T_1	2.24	1.78	2.42	1.84	2.29	1.63
T_1F	2.46	1.84	2.59	1.98	2.37	1.73
T_2	2.08	1.55	2.23	1.65	2.03	1.48
T_2F	2.15	1.64	2.48	1.72	2.16	1.56
T_3	2.14	1.37	2.26	1.35	2.16	1.27
T_3F	2.25	1.48	2.48	1.59	2.27	1.38
T_4	2.28	1.62	2.34	1.58	2.18	1.49
SE ±	0.12	0.15	0.021	0.067	0.11	0.05
CD (5%)	0.36	0.46	0.026	0.18	0.18	0.12

Table 2c. Available nitrogen content (kg/ha) in soil under different green manure and inorganic fertilizer treatments.

Treat-ments	1st year	Repetitive treatment		2nd year	Residual treatment	
	I	H	I	H	I	H
C_0	1578	1451	1614.8	1526.8	1614.8	1526.8
T_1	1669.5	1516	1769.5	1688.5	1656.2	1548.4
T_1F	1778.4	1542.6	1882.4	1769.5	1761.0	1634.4
T_2	1523.5	1508.4	1626.8	1554.0	1604.8	1527.1
T_2F	1564.2	1429.8	1657.2	1575.3	1634.2	1544.5
T_3	1560.5	1448.3	1628.0	1584.4	1564.0	1434.8
T_3F	1581.8	1414.0	1677.5	1557.2	1578.5	1468.2
T_4	1611	1568.2	1746.3	1548.7	1645.3	1514.2
SE ±	22.56	56.58	44.89	66.45	62.22	59.13
CD (5%)	28.68	62.76	58.62	78.85	68.55	64.84

dy (2000), Adesoji et al. (2014) also confirmed that pH value declined in subsequent cropping without application of organic manure.

Incorporation of green manure improved the organic carbon content in soil (Table 2b). Highest value was recorded in recommended dose of inorganic fertilizer with legume green manure (2.46%) incorporated plot and lowest in non-legume green manure applied (2.15%) plot . Inorganic fertilizer applied along with weed species as green manure (2.25%) has shown more organic carbon than non-legume species (2.15%). Increment of organic carbon content due to use of fertilizer could be attributed to high contribution of biomass to the soil in the form of crop stubbles and residues. Organic carbon remarkably increased in consecutive year of cultivation in repetitive treatment. This finding is the agreement with the result of Bellakki and Badnur (1997). *A. procera* and *D. sissoo* as green manure crops were almost at par with respect of organic carbon in soil.

Table 2c represents the effect of green manure and inorganic fertilizer on nitrogen content in soil. Incorporation of green manure with inorganic fertilizer remarkably increased nitrogen content over solo green manure incorporation (1669.5 kg ha^{-1}). Among the treatments, leguminous green manure was found to contribute more nitrogen in soil compared to non-leguminous and weed species. Maximum amount of nitrogen content was recorded in plots where legume green manure was applied along with inorganic fertilizer (1778kg ha^{-1}) followed by non-legume and weed respectively. Significant increase of available soil nitrogen could be due to mineralization of organic nitrogen . Incorporation of fertilizer associated with green manure further accelerated N mineralization in soil. Nitrogen content was slightly increased in residual treatment due to decomposition of straw and stubbles. Islam et al. (2015), Bharadwaj and Omanwar (1994) observed that recommended dose of fertilizer and green manure contributed significantly towards the increase of nitrogen content in soil. Nitrogen content declined significantly from 10.4 to 22.6% after harvesting of crop. This may be due to absorption of nitrogen content by the rice crop. Maximum amount of nitrogen content in soil was recorded with the combination of crop residues and inorganic fertilizer. It was significantly higher over crop residues alone being at par with inorganic fertilizer.

Table 2d showed that green manure incorporated with inorganic fertilizer released a considerable amount of available phosphorus in soil (26.56 kg ha^{-1}). Highest amount of phosphorus content was found in legume green manure (24.36 kg ha^{-1}) and least in non-legume (19.14 kg ha^{-1}) treatment. Inclusion of green manure is beneficial in mobilizing native phosphorus. The higher available nitrogen and phosphorus by green manuring might be due to higher biomass producation as well as higher uptake of nutrients (Sah et al. 2000). Favorable effect of green manure and inorganic fertilizer upon the supply of phosphorus in soil was also studied by Singh (1994). Repetitive incorporation of green manure either alone or combined with inorganic fertilizer

Table 2d. Available phosphorus content (kg/ha) in soil under different green manure and inorganic fertilizer treatments.

Treat-ments	1st year I	H	Repetitive treatment I	2nd year H	Residual treatment I	H
C_0	11.6	9.78	12.9	11.8	12.9	11.8
T_1	24.36	20.45	32.54	26.62	28.55	22.44
T_1F	26.56	20.14	29.47	23.26	27.73	21.68
T_2	19.14	11.14	27.38	21.51	25.85	20.15
T_2F	21.67	16.44	21.52	18.36	21.37	19.54
T_3	20.4	18.59	26.72	20.59	23.64	19.36
T_3F	23.34	18.26	23.84	18.26	21.52	17.48
T_4	24.12	18.41	29.12	20.57	22.38	19.62
SE ±	2.65	2.98	5.87	4.44	1.44	1.90
CD (5%)	3.68	5.46	8.46	6.75	2.86	3.82

increased available phosphorus in soil.These results indicate that integrating the use of fertilizer with green manure enhance the available P content of soil, as built up of available P matches to that attained by application of standard dose of inorganic fertilizer. However, after harvesting of crop, phosphorus was gradually declined in all treatments in both the years due to absorption by the crops.

Exchangeable potassium content also showed same trend as noticed in available phosphorus. Highest amount of potassium content was found in combine incorporation of green manure (678.5 kg/ha^{-1}) as compared to green manure (636.8 kg/ha^{-1}) alone. Experiment revealed that incorporation of legume green manure released more potassium in soil than weed and non-legume green manure. This might be due to the addition of potassium by the green manure (Daliparthy et al.1992). However in the 2nd year treatment a large amount of straw was incorporated along with green manure and inorganic fertilizer which enhance potassium content in soil. Among these treatments weed green manure with inorganic fertilizer (718.8 kg ha^{-1}) have showed maximum amount of potassium content than other treatments. Potassium content was significantly high in all repetitive treatment. Similar finding was given by Zen et al. (1992) that increment of potassium under long term application of organic manure and fertilizer. Sharma et al. (2000), Duhan et al.(2001) also supported that green manuring of sun hemp had a significant effect on organic carbon, total and available nitrogen, available phosphorus contents of the soil. After harvesting of crop , potassium content was gradually declined due to heavy absorption by the crops. However, it becomes replenished in successive year through the decomposition of straw.

From the result it can be concluded that application of legume and selected species of weed as green manure sustainably increase the productity in *jhum* soil. Soil nutrient status was also significantly influenced due to addition of green manure along with inorganic fertilizer which was found remarkably high in repetitive treatments. Hence , for improvement of fertility status in soil under shifting cultivation and sustainability in crop production an integrated management approach that combines the use of fertilizers and green manures may play a crucial role.

References

Adesoji AG, Abubakar IU, Labe DA (2014) Soil chemical properties as affected by incorporated legumes and nitrogen in soil with maize (*Zea mays* L.) in a semi-arid environment. Int J Agric Innovations and Res 3 (3) : 2319–2473.

Baddeley JA, Pappa VA, Pristeri A, Bergkvist G, Monti M, Reckling M, Schläfke N, Watson CA (2017) Legume-based green manure crops. In : Bokern D, Stoddard FL, Watson CA (eds). Legumes in cropping systems Murphy. CAB Int, pp 125—138.

Bellakki MA, Badnur VP (1997) Long term effect of integrated nutrients management on properties of vertisol under dry land agriculture. J Ind Soc Soil Sci 45 (3) : 438—442.

Bharadwaj VB, Omanwar PK (1994) Long term effect of continuous rotational cropping and fertilizer on fertilization on yields and soil properties—II. Effect on EC, pH, organic matter and available nutrients of soil. J Ind Soc Soil Sci 42 (3) : 387—392.

Bruun TB, Mertz O, Elberling B (2006) Linking yields of upland rice in shifting cultivation to fallow length and soil properties. Agric, Ecosyst and Environ 113 : 139–149.

Choudhary RS, Acharya CL (1993) A comparison of evaporation losses from soil different tilths and under mulch after harvest of rice. Soil and Tillage Res 28 : 191—199.

Daliparthy J, Chatterjee BN, and Mandal SS (1992) Changes in soil nitrogen, phosphorus and potassium under intensive cropping sub-humid tropics of India. Soil Science and Plant Anal 23 : 1811—1814 .

Dhakal Y, Meena RS, Kumar S (2016) Effect of INM on nodulation, yield, quality and available nutrient status in soil after harvest of green gram. Leg Res 39 (4) : 590—594.

Duhan BS, Kumar V, Singh N, Kher AP (2001) Effect of green manuring on the yield and uptake of potassium rice. Crop Res 22 (3) : 330—334.

Ghadge S, Jadhav B (2013) Effect of *Lantana* manures on nutrient content of fenugreek (*Trigonella foenum graecum* L.). Biosci Discovery 4 : 189—193.

Islam MR, Ryhana Z, Hoque MA, Huda A, Begum MLN (2016) Residual effect of green manure on the growth and yield of BRRI dhan 28. J Environ Sci & Natural Resour 9 (1) : 35—40.

Islam S, Paul NK, Alam R,Uddin, Sarkar U, islam A, Park S (2015) Responses of rice to green manure and nitrogen fertilizer application. Online J Biol Sci 15 (4) : 207—216.

Jackson ML (1973) Soil Chemical Analysis, Prentice Hall of India Pvt Ltd New Delhi , pp 498.

Jama B, Palm CA, Buresh RJ, Niang A, Gachengo C, Nziguheba G, Amadalo B (2000) *Tithonia diversifolia* as a green manure for soil fertility improvement in western Kenya : A Rev Agrofor Syst 49 : 201—222.

Jamilah M, Juniarti Y (2017) *Chromolaena odorata* compost affected soil chemical and rice crop (*Oryza sativa* L.). Agrotechnol 6 (1) : 155—160.

Kanmegne J, Duguma B, Henrot J, Isirimah NO (1999) Soil fertility enhancement by planted tree-fallow species in the humid lowlands. Cameroon Agrofor Syst 46 : 239—249.

Kayeke J, Sibuga PK, Msaky JJ, Mbwaga A (2007) Green manure and inorganic fertilizer as management strategies for witchweed and upland rice. Afr Crop Sci J 15 (4) : 161—171.

Krishna Murthy R, Basavaraj B, Raveendra HR, Srinivasa N, Prakash SS, Jagadeesh BR (2011) Influence of weeds as organic materials on nutrient availability, content and uptake of secondary nutrients by rice . Int J Sci and Nature 2 (3) : 597—601

Kumar R, Srivastava S, Srivastava M, Sinha A (2010) Effects of organic amendments on soil mycoflora. Asian J Pl Path 4 (2) : 73—81.

Meena BL, Rattan RK, Datta SP, Meena MC (2016) Effect of iron application on iron nutrition of aerobic rice grown in different soils. J Environ Biol 37 : 1377—1383.

Nakhone L, Tabatabai MA (2008) Nitrogen mineralization of leguminous crops in soils. J Pl Nutr and Soil Sci 171 (2) : 231—241.

Pandeya SC, Puri GS, Singh JS (1968) Research Methods in Plant Ecology. Asia Publishing House, Bombay.

Raju RA, Reddy MN (2000) Integrated nutrient management of green leaf, compost, crop redidues and inorganic fertilizers in rice (*Oryza sativa* L.) rice system. Ind J Agron 45 (4) : 629—635.

Rameshwar HY, Argaw A (2016) Biodegradation of *Lantana camara* using different animal manures and assessing its manorial value for organic farming, South Indian. J Biol Sci 2016 2 (1) : 52—56.

Rathore S, Karunakaran K, Prakash B (2010) Alder based farming system a traditional farming practices in 381 Nagaland for amelioration of *jhum* land. Ind J Traditl Know 9 : 677—680.

Sah RR, Rai RK, Mukherjee PK (2000) Effect of green manure Dhaincha (*Sesbania aculeata*) and phosphorus on growth, yield and phosphorus uptake by wheat (*Triticum aestivum*). Ind J Agron 45 (4) : 707—710.

Selvi RV, Kalpana R (2008) Scope and strategies of intercropping green manure crops in rice –A review Agric Rev 29 : 145—150

Sharma RP, Verma TS (2000) Effect of long-term *Lantana* addition on soil phosphorus fractions crop yields and phosphorus uptake in rice—wheat cropping in North-West Himalaya acid alfisols. J Ind Soc Soil Sci 48 (1) : 107—112.

Sharma S, Dev SP, Rameshwar (2000) Effect of green manuring of sun hemp (*Crotolaria juncea* L.) on rice yields, nitrogen turnover and soil properties. Crop Res 19 (3) : 418—423.

Sharma SN, Prasad R, Singh S (1995) The role of mungbean residues and *Sesbania aculeata* green manure in the nitrogen economy of rice-wheat cropping system. Pl and Soil 172 (1) : 123—129.

Singh Y (1994) Integrated nutrient management in rice—wheat cropping system. In : Proc of Nat Symp on integrated input management for efficient crop production, held during 22-25th Feb. 1994 at Tamil Nadu Agricultural University. Coimbatore.

Singh J, Bora IP, Baruah A (2004) Nutrients status and yield performance of Rice (*Oryza sativa* L.) as affected by green manuring and inorganic fertilizer in degradd shifting cultivation soils. J Trop For 20 (1& 2) : 11–16.

Tolanur SI, Badanur VP (2003) Effect of integrated use of organic manure and fertilizer N_2 on sustaining productivity *rabi* Sorghum—Chick pea system and fertility of a Vertisol. J Ind Soc Soil Sci 51 (1) : 42—44.

Walkley K, Black CA (1934) An examination of Degtiareff methods for determining soil organic matter and a proposed modification of the chromic acid titration methods. Soil Sci 37 : 29—38.

Zen M, Zin WX, Yao YX, Yang YF (1992) Advantages of application of manure with chemical fertilizers in a long term *in situ* experiments. Soil and Fertil 1 : 1—6.