Oryza Vol. 51 No.1, 2014 (55-60)

Effect of Integrated nutrient management on rice under mountainous foothill of Manipur

J Lhungdim[1*], SK Chongtham[2], LN Singh[1], MK Singh[3] and RN Meena[3]

[1]Central Agricultural University, Imphal, Manipur - 795 004
[2]Punjab Agricultural University, Ludhiana, Punjab-141027, India
[3]Banaras Hindu University, Varanasi, Uttar Pradesh - 221005
**Email : ginlhungdim@rediffmail.com*

ABSTRACT

Two field experiments were conducted during wet season 2008 and 2009 to evaluate the best integrated nutrient management system for rice in the mountainous foothill conditions of Manipur. The field experiments were conducted comprising of 15 treatments with integrated approach of nutrient management involving fertilizer, compost and rice husk ash (RHA) at various levels. On the basis of mean of two years, the treatment 100% RDF + RHA @ 5t ha^{-1}, receiving 100% recommended dose of fertilizer (RDF) (N-P-K: 100- 80-50 kg ha^{-1}) with 5t ha^{-1} RHA showed maximum yield (1.76 t ha^{-1}) which was at par with 100%+FYM @ 5t ha^{-1} giving 1.74 t ha^{-1}. The performance of 100% RDF + compost @ 5t ha^{-1} however, was significantly lower than RHA and FYM at the same level of each input but showed better performance than all other treatments except all organic sources @ 5t ha^{-1}. Control with no input showed lowest yield in both the years. Plant biometric characters showed a mixed response of performances. Yield components like, panicle length, tiller numbers, grain numbers, test weight etc. were better with the treatment, 100% RDF + RHA @ 5t ha^{-1}. Nutrient uptake was significant between the best treatment 100% RDF + RHA @ 5t ha^{-1} and the rest including control, except 100% RDF + FYM @ 5t ha^{-1}. The highest cost : benefit ratio was however, recorded with Compost @ 5t + FYM 5t + RHA 5t ha^{-1}. Hence, the use of pure organics (FYM+Compost+RHA) would be a profitable proposition which is not only economical, but also eco-friendly in widening the traditional jhum cycle.

Key words: *compost, economics, fertilizer, FYM, Jhum rice, RHA, yield*

The resource poor tribal farmers are generally deprived of the modern technologies of cultivation including inputs to augment their low rice production in the North east India, more particularly in Manipur. The low or no profit associated *Bush-fallow* agriculture also called *Jhum* cultivating or Shifting cultivating, an age old traditional cultivation system still in practice in the region, is the only option owing to their socio-economic condition and geo-physiographic location.

Upland *jhum* cultivation involves slashing of forest-usually with the help of fire-followed by phases of cultivation and fallow periods. Nonetheless, due to increasing requirement for cultivation of land, cycle of cultivation followed by leaving land fallow reduced from 15-20 years to 8-10 years opening up challenges for managing the forest and environment"(Tanjang 2009). In NER, over a 100 tribal ethnic minorities are practising shifting cultivation on 3869 km^2 of which, Manipur alone has 900 km^2 as per Govt. of India report (Anonymous, 2002). Cropping on *jhum* fallows in North-eastern India is predominantly done for one year in a *jhum* cycle. If second year cropping is done, expanse of the forest land required for slashing and burning could be reduced significantly. Inorganic and organic manuring in isolation and in combination responded differently. The soil fertility decreases rapidly in the second year and is very poor in the third year. The cultivation during the third year and beyond is usually uneconomical (Tawnenga *et al*, 1996). Field elevation ranges gentle to steep slopes. Roder (2001) reported possibilities of upland agriculture, even on slopes of 60%. Due to economic constraints, farmers stay away from modern technologies including nutrient management. This aggravated the economic instability of the *Jhum* farmers, placing a big challenge of technological intervention.

Disorders in crop growth, development and yield are commonly observed in upland *jhum* agriculture, more after one year of cultivation. Phosphate and nitrogen deficiencies are the most important nutrient disorders in upland conditions. Potassium is however, supplemented with the resultant ash from burning as the nutrient source (Roder, 2001). As a result, the amount of these elements may be insufficient for better plant growth. Ash is another low cost input in agriculture. Priyadharshini and Seran (2009) also reported that Paddy husk ash contains 1.31% K_2O and 0.66% P_2O_5 and its application @ of 4.5 t/ha is suitable for obtaining high yield of crops. Therefore, application of chemical fertilizers can be a good practice to fulfill the upland rice nutrient requirements. In view of this exigency of ameliorating the 'nutrient hunger' encountered by the upland rice with very low productivity per unit area, the present study has been aimed and conducted to help the ill fated poor hill farmers in their compelling pursuit for livelihood, economic sustenance and better standard of living.

MATERIALS AND METHODS

The average temperature during the two experiments was 28 and 32^oC with an annual rainfall of 1150 and 1240 mm, respectively. The first experiment was conducted in the second year after utilization of the initial soil fertility during the first *jhum* cultivation (without external nutrient input). The recommended dose of fertilizer (RDF) was 100-80-50 kg N-P-K ha^{-1} with Urea, SSP and MOP as the sources of nutrients respectively. The treatment combinations were, Control, 25%RDF+compost@15t ha^{-1}, 25%RDF + FYM @ 15t ha^{-1}, 100% RDF, 25%RDF+RHA @ 15t ha^{-1}, 50% RDF + compost @ 10t ha^{-1}, 50% RDF+ FYM @ 10t ha^{-1}, 50% RDF + RHA @ 10t ha^{-1}, 75% RDF + compost @ 7.5t ha^{-1}, 75% RDF + FYM @ 7.5t ha^{-1}, 75% RDF + RHA @ 7.5t ha^{-1}, 100% RDF + compost @ 5t ha^{-1}, 100% RDF + FYM @ 5t ha^{-1}, 100% RDF + RHA @ 5t ha^{-1}, Compost @ 5t + FYM 5t + RHA 5t ha^{-1}.

Seeds were sown for the first and second trial on 15 April 2008 and 16 April 2009, respectively. A spacing of 30x15 cm was maintained. Data for all the biometric parameters were recorded at harvest by random selection of five plants from each plot (size, 5x3 m^2). Harvest was done in the first week of November on 80% maturity in both the years. Compost was made by pit composting of crop residues, vegetable wastes and different weeds (water hyacinth dominated). The treatments were laid in completely randomized block design (CRBD) with three replications in log contour plot fashion (to reduce soil erosion) on the 15% slope of the field site. The soil of the experimental site was silty clay with a mean 5.5 pH, 1.0% Organic Carbon, 255-24-60 kg N-P-K ha^{-1}. Nitrogen was applied in three splits, one-fourth at sowing, remaining half at tillering and the rest at booting stage. Full quantities of compost, RHA, P and K were applied during land preparation, a week before sowing. Sowing was done with 2-3 seeds hill^{-1}. All the laboratory and statistical analyses were done as per standard procedures.

RESULTS AND DISCUSSION

Chemical fertilizer is usually not required in upland rice and a long fallow period of at least eight years under secondary forest is required to generate soil fertility. However, Mustapha, (2004) suggested that upland rice often needs a higher level of fertilization than does lowland rice per unit of production. There was yield increase in *jhum* rice particularly when the *jhum* field was cultivated for the second and third time, continuously with externally managed plant nutrients. Yield of upland rice increased significantly when N is applied with phosphorus as also reported by Dunsmore (1970). Evident from the grain yield data of our two years experiment, it is observed that the local genotype receiving N-P-K@ 100-80-50 kg ha^{-1}) with 5t ha^{-1} RHA outperformed the rest with the highest yield 1.76 t ha^{-1}. They are non-significant showing a close yield level. Fertilizer applied at 100% recommended dose with organic sources outperformed all levels including control. As far as the yield attributes are concerned, there is no remarkable difference within the same levels of input. However, between the different levels, biometric characters like plant height, tillers, panicle length flag leaf characters, filled grains differed significantly.

Compost increases the yield of upland/*jhum* rice significantly in acidic and phosphorus deficient soils. In the present study, application of compost is effective due to the acidic nature of the soil (pH 5.5). The yield performances of compost applied plots are significantly better than those with control as also observed by Gupta (1986) on good performance of compost in upland rice. The better performance of water hyacinth (*Eichhornia crassipes* Mart) dominated compost over control on the upland *jhum* rice could be due to the soil physical structural improvement and its nutrient content. Bates *et al*. (1976) reported that, compost made from water hyacinth contains 2.02% N, 1.10% Phosphoric acid (P_2O_5), 2.5% K_2O and 3.9% lime (CaO) with a C/N ratio of 13. Due to this fair content of the water hyacinth compost, water infiltration capacity and aeration is created. All the levels of Compost showed better yield than control. However, lower level of compost in conjunction with 100% RDF + compost @ 5t ha^{-1} exhibited better yield than higher compost level with 25%RDF+compost@15t ha^{-1}, 50% RDF + compost @ 10t ha^{-1} and 75% RDF + compost @ 7.5t ha^{-1}. Similar positive effect of *Eichhornia crassipes* compost was reported by Rajkhowa *et al.,* (2002) in their study on water hyacinth incorporation into the rice field for decomposition.

Proper utilization of Rice husk ash (RHA), wasted mostly during rice dehusking and milling has not been done in agriculture despite its fair content of potash and other micro elements. Hartinee *et al*., (2010) observed that, nitrogen from ash in shifting cultivation may fulfill only a fraction of the requirements as it is mostly lost in burning. As a result, the amount of these elements may be insufficient for better plant growth. In the present study, maximum yield of *jhum* rice (1.76 t ha^{-1}) has been observed with the application of 5t ha^{-1} of RHA along with 100% RDF. RHA also showed better performance over compost or FYM at the same level of 10t ha^{-1} with 75% RDF. It is also observed that, lower level of RHA in conjunction with 100% RDF + RHA @ 5t ha^{-1} exhibited better yield than higher compost level with 25%RDF + RHA @ 15t ha^{-1}, 50% RDF + RHA @ 10t ha^{-1} and 75% RDF + RHA @ 7.5t ha^{-1}. Nottidge *et al*. (2009) supported the finding that, RHA application could increase the pH value of the soil from the initial value of 5.16 to 6.20.This factor might have attributed to the better yield of hill rice, as hill soils are mostly acidic in nature. Hashim *et al*.,(1996) also reported that RHA contains 80.26% silica, 0.38% phosphorus, 1.28% potassium, 0.21%

Table 1. Effect of INM on the biometric characters, yield attributes and yield of Jhum rice

Treatments	Effective tillers plant^{-1}		Filled grains panicle^{-1}		Panicle length (cm)		Test weight (g)		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Control	6.90	6.87	71.11	74.50	14.83	15.60	24.37	24.33	0.93	0.87	1.69	1.67
25% RDF + Comp.15 t ha^{-1}	7.67	9.23	94.34	87.27	17.27	17.93	27.00	26.90	1.34	1.28	2.52	2.18
25 % RDF+ FYM 15 t ha^{-1}	10.03	9.47	92.00	93.33	17.27	17.33	27.73	26.97	1.47	1.43	2.54	2.67
25% RDF+ RHA 15 t ha^{-1}	7.30	8.73	78.66	88.47	17.33	16.33	27.80	27.20	1.48	1.42	2.66	2.76
100%RDF alone	7.60	8.87	99.87	103.20	18.00	18.33	29.17	28.45	1.56	1.49	2.63	2.72
50 % RDF + 10 t Compost	7.40	8.37	89.57	86.93	15.67	17.00	28.23	27.73	1.24	1.28	1.86	2.54
50 % RDF + 10 t FYM	9.73	8.40	99.83	102.83	16.00	16.67	27.20	26.80	1.33	1.39	2.02	2.47
50% RDF+ 10 t RHA	9.23	9.60	90.64	98.17	17.27	18.00	28.73	28.67	1.42	1.43	2.54	2.52
75% RDF + 7.5 Compost	7.40	7.70	93.55	98.67	17.00	16.00	28.33	27.87	1.50	1.49	2.26	2.66
75 % RDF +7. 5 t FYM	9.27	9.37	75.00	104.67	17.60	17.00	28.23	28.63	1.58	1.48	2.42	2.55
75 % RDF + 7.5 t RHA	9.23	10.53	89.65	99.53	18.33	17.67	28.80	28.67	1.47	1.52	2.34	2.84
100% RDF + 5 t Compost	9.67	9.30	77.67	105.67	16.00	17.33	28.27	28.07	1.74	1.64	2.76	2.80
100% RDF + 5 t FYM	10.40	9.17	68.07	109.33	18.53	18.33	26.53	27.33	1.78	1.71	2.90	2.93
100% RDF + 5t RHA	11.17	10.63	118.79	112.87	19.67	19.00	29.23	29.87	1.78	1.73	2.63	2.85
5 t Comp.+5t FYM+5t RHA ha^{-1}	9.80	9.90	93.63	109.00	16.00	16.33	27.10	27.38	1.64	1.66	2.78	2.67
LSD (P<0.05)	1.532	1.605	16.279	10.222	2.234	NS	1.429	1.177	0.08	0.08	0.30	0.28

magnesium and 0.56% Ca. The multi nutrient content of RHA and its contribution towards organic matter addition might have resulted in the best yield performance, but only when integrated with fertilizer. The finding is in line with Priyadharshini and Seran (2009).

Utilization of fym in upland rice resulted in higher grain yield compared to control and all the treatments under test. There is high non-significance between 100% RDF + FYM @ 5t ha^{-1} and the best performing treatment 100% RDF + RHA @ 5t ha^{-1} in respect of yield showing a close yield level, 1.76 t ha^{-1} and 1.74 t ha^{-1}, respectively, indicating that, FYM is not inferior to RHA. Such close trends are observed in other yield contributing characters too. It is also observed that, lower level of FYM in conjunction with 100% RDF + FYM @ 5t ha^{-1} exhibited better yield than higher compost level with 25%RDF + FYM @ 15t ha^{-1}, 50% RDF+ FYM @ 10t ha^{-1} and 75% RDF + FYM @ 7.5t ha^{-1}. This indicated that, integrated nutrient application with nutrient rich inputs (fertilizer) on the higher side of the dose always give better yield. Naing Oo, (2010) also reported that combining FYM and inorganic fertilizers increased shoot dry matter, tiller and panicle number $hill^{-1}$, grain number $panicle^{-1}$ and grain yield and increased soil organic matter, CEC, N, P and K..

Yield of upland rice was found to be increased remarkably with pure organic sources of plant nutrients Compost @ 5t + FYM 5t + RHA 5t ha^{-1} receiving FYM+RHA+compost @ 5t ha^{-1} each. The pure organic sources performed better than all the treatments except 100% RDF + RHA @ 5t ha^{-1} (integrated) in respect of grain yield. The result is corroborated by Yankaraddi *et al* (2009) who reported that, pure organic sources (Coffee pulp compost @ 5t ha^{-1}+RHA @ 2t ha^{-1}) perform better than control but not as good as the integrated treatment with fertilizer. The comparatively less nutrient content in the organic sources, but a good soil structure building ability, reducing bulk density, increasing organic matter and water holding capacity in the soil might have attributed to good yield performance over control.

Rice yield achieved from integrated application of nutrients have been observed with better performance over sole applications or pure organics.

Table 2. Effect of INM on NPK uptake (Grain) and economics (₹) of *Jhum* rice cultivation

Treatments	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})		Cost of cultivation(x10^3)		Net return (x10^3)		Benefit-cost ratio	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Control	4.00	4.10	4.37	3.60	23.67	23.00	7.72	7.87	8.19	11.30	1.06	1.44
25% RDF + compost 15 t ha^{-1}	7.00	6.93	6.77	6.20	35.27	36.00	13.22	13.46	13.38	14.75	1.01	1.09
25 % RDF+ FYM 15 t ha^{-1}	8.50	8.77	7.50	6.67	38.10	39.17	16.97	17.21	12.04	14.00	0.71	0.81
25% RDF+ RHA 15 t ha^{-1}	7.83	7.97	7.27	6.47	38.33	38.47	11.72	11.96	17.61	19.08	1.50	1.59
100% RDF alone	9.17	9.23	8.23	6.67	41.37	41.37	14.71	15.22	16.05	17.18	1.09	1.12
50 % RDF + 10 t ha^{-1} Compost	9.93	9.90	7.83	7.53	36.60	36.60	13.72	14.05	10.48	13.44	0.76	0.95
50 % RDF + 10 t ha^{-1} FYM	10.90	10.97	8.43	8.03	36.73	36.73	16.22	16.55	9.69	13.23	0.60	0.80
50% RDF+ 10 t RHA	10.43	10.27	8.47	8.30	36.27	38.20	12.72	13.05	15.39	18.06	1.21	1.38
75% RDF + 7.5 ha^{-1} Compost	11.87	11.87	8.27	8.20	38.33	39.37	14.84	15.26	14.37	16.69	0.97	1.09
75 % RDF +7. 5 t ha^{-1} FYM	13.00	13.20	8.73	8.80	42.07	42.07	16.72	17.14	14.20	14.92	0.85	0.87
75 % RDF + 7.5 t ha^{-1} RHA	11.23	11.70	8.47	8.40	44.03	44.03	14.09	14.51	14.77	18.13	1.05	1.25
100% RDF + 5 t ha^{-1} Compost	13.03	12.90	9.30	8.77	52.17	52.17	15.96	16.47	18.03	19.05	1.13	1.15
100% RDF + 5 t ha^{-1} FYM	14.33	14.13	9.77	9.90	60.03	60.03	17.21	17.72	17.70	19.42	1.03	1.09
100% RDF + 5t ha^{-1} RHA	16.27	16.67	10.27	9.90	66.53	66.53	15.46	15.97	20.50	23.13	1.33	1.44
5 t Comp.+5 t FYM+5 t ha^{-1} RHA	14.33	14.20	8.83	8.70	48.57	48.57	12.22	12.37	20.08	23.49	1.64	1.90
LSD ($P<0.05$)	1.23	1.23	0.50	0.63	2.636	2.193	-	-	-	-	-	-

Note: Cost of Urea, SSP and MOP - ₹ 8, 9 and 9 kg^{-1} (2008); ₹ 8.50, 9.50 and 9.50 kg^{-1} (2009); Cost of FYM, Compost and RHA- ₹ 50, 25 and 15 q^{-1} (2008 and 2009); Sale rate of paddy = ₹ 1800 and 2000 q^{-1} (2008 and 2009); Sale rate of Straw ₹ 100 q^{-1}. Labour -₹ 86 $manday^{-1}$ (2008 and 2009).

Treatments with higher level of Fertilizer (100% RDF) in the integrated application outperformed the other lower levels in all the plant characters and yield. However, the level differences in case of organic sources do not exhibit the yield differences, as long as fertilizer is on the higher side in the combination. Such integrated effect with FYM @ 10t ha^{-1} +RHA@ 2t ha^{-1} + 100% RDF giving maximum rice yield has been reported by Yankaraddi *et al.* (2009). Integrating nutrient rich fertilizer with good soil structure building organic sources like FYM, Compost, or RHA, each possessing their own beneficial purposes, outperformed the rest in both the years. In our experiment, 100% RDF + compost @ 5t ha^{-1}, 100% RDF + FYM @ 5t ha^{-1}, 100% RDF + RHA @ 5t ha^{-1} recorded comparatively higher yield than 100% RDF at the same dose. Both the treatments showed significantly higher yield over control in both the years.

There are many factors that govern nutrient uptake of the crop. Singh and Modgal (1978) observed that the total dry matter yield and the uptake of P and K by the crop at harvest increased due to nitrogen application; among split application treatments, nitrogen applied through soil alone seemed to be more favourable to P and K uptake than splits involving nitrogen application in the similar fractions through soil+foliage, respectively. In the present investigation, the better NPK uptake is observed with the treatment 100% RDF + RHA @ 5t ha^{-1} receiving 5t ha^{-1} of RHA+ fertilizer (100% RDF). Maximum NPK uptake of 16.7, 10.08 and 66.53 kg ha^{-1}, respectively were exhibited by this treatment combination. Control plots showed least nutrient uptake.

Cultivation of upland or *Jhum* rice is one of the most uneconomical practice particularly in the North-Eastern region of India. Rice being the staple food of the region finds a central place to sustain their livelihood even when it is uneconomical. The present study revealed that, the net profit/return ranges from ₹ 8190/- (Control) to 20,500/- (100% RDF + RHA @ 5t ha^{-1}) in 2008 and ₹11,130/- (Control) to ₹ 23,49 (100% RDF + FYM @ 5t ha^{-1}) in 2009 respectively. The Cost: benefit ratio was highest in Compost @ 5t + FYM 5t + RHA 5t ha^{-1} during both the years (1:1.64 and 1:1.90, respectively) while, control showed higher CBR in both the years (1:1.06 and 1:1.44, respectively) than some treatments like, 25%RDF+compost@15t ha^{-1}, 25% RDF + FYM @ 15t ha^{-1}, 50% RDF + compost @ 10t ha^{-1}, 50% RDF+ FYM @ 10t ha^{-1}, 75% RDF + compost @ 7.5t ha^{-1} and 75% RDF + FYM @ 7.5t ha^{-1}, but was at par with 100% RDF and 100% RDF + compost @ 5t ha^{-1}. In the second year, control was at par with 50% RDF + RHA @ 10t ha^{-1} and 100% RDF + RHA @ 5t ha^{-1} but showed better CBR than all the treatments except 25%RDF + RHA @ 15t ha^{-1} and Compost @ 5t + FYM 5t + RHA 5t ha^{-1}.

Evaluation and assessment of all the nutrient sources under trial, it was concluded that, for *jhum* agriculture in sloppy fields of the NE states, application of externally managed plant nutrients could augment the crop productivity if land is used more than once at the same site. Rice husk ash, a good source of nutrients dumped as waste, also sometimes, a nuisance to the milling industries could be integrated with inorganic fertilizers as it recorded maximum rice yield. However, owing to higher monetary benefit, pure organic source combination, FYM+Compost+RHA @ 5t ha^{-1} each was found to be most viable, economical and sustainable proposition of commercial rice production under *jhum* agriculture.

REFERENCES

Anonymous 2002. Basic Statistics of NER, Govt. of India, North Eastern Secretariat, Shillong, p.p. 42.

Bates RP and Hentges JF 1976. Aquatic weeds-eradicate or cultivate? Econ. Botany, 30(1):39-50.

Dunsmore JR 1970. Experiment on the fertility of dry rice in Sarawak, Malaysia. Exptl. Agric. 6:239-244.

Gupta P and O'Toole JS 1986. Upland rice: a global perspective, IRRI, p.p. 220.

Hartinee A, Hanafi MM, Shukor J and Mahmud TMM 2010. Model comparisons for assessment of NPK requirement of Upland rice for maximum yield. Malaysian J. of Soil Sc.14: 15-25.

Hashim AB, Hussin A and Siva KB 1996. Nutrient content in Rice Husk Ash of some Malaysian Rice varieties. Pertanika Journal of Tropical Agricultural Science 19 (1) : 77-80.

Mustapha MC 2004. Management of rice production systems to increase productivity in the Gambia, West Africa. Ph.D Thesis, submitted to Faculty of the Graduate School of Cornell University, 30 p.

Naing Oo A, Banterng P, Polthanee A and Trelo-Ges V 2010. The effect of different fertilizers management strategies on growth and yield of upland black glutinous rice and soil property. Asian J. of Plant Sc. 9:414-422.

Nottidge DO, Balogun RB and Nioku NR 2009. Effect of rice-husk ash on exchange acidity, growth and yield of groundnut (*Arachis hypogaea* L.) in an acidic ultisol. Global J.of Agril. Sciences 8(1):122-124

Priyadharshini J and Seran TH 2009. Paddy husk ash as a source of Potassium for growth and yield of Cowpea (*Vigna unguiculata* L.) The Journal of Agricultural Sciences 4 (2):68

Rajkhowa DJ, Kalita R, Das J and Kandali R 2002. Allelopathic effect of Eichhornia crassipes and Ipomea canea on rice. Indian Journal of Weed Science 34 (3&4): 278-279.

Roder W 2001. Slash-and-burn rice Systems in the hills of northern Laos PDR: Description, challenges and opportunities. International Rice Research Institute, Los Banos, Philippines, p.p. 201.

Singh BK and Modgal SC 1978. Dry matter production, phosphorus and potassium uptake as influenced by levels and method of nitrogen application in upland rice. Plant and Soil 50:691-701

Tanjang S 2009. Traditional slash and burn Agriculture as a historic land use practice: a case study from the Ethnic Noctes in Arunachal Pradesh, India. World Journal of Agricultural Sciences 5 (1): 70-73.

Tawnewnga Shankar Uma and Tripathi RS 1996. Evaluating second year cropping on jhum fallows in Mizoram, north-eastern India. Phytomass dynamics and primary productivity. Journal of Bio Science, 21 (4): 563-575

Yankaraddi H, Dineshkumar M and Madaiah D 2009. Effect of coffee pulp compost and rice hull ash on growth, yield and nutrient uptake in rice. Karnataka J. Agric. Sci., 22 (4):751-754