Research Article

MANAGING SOIL HEALTH OF CROP FIELDS IN NORTH EAST INDIA – SOME POTENTIAL MODULE OF INDIGENOUS RESOURCE CONSERVING TECHNIQUES

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ABSTRACT

Although Resource Conservation Technologies (RCT) has emerged globally as a new paradigm to achieve goals of sustainable production, such unique culture is already in practice in the most remote state of North Eastern Region of India i.e. Arunachal Pradesh, particularly in Lohit and Anjaw districts. The practice of RCT in the form of incorporation of rice (*Oryza sativa*) residue and weed biomass as a source of nutrient is predominant in these districts where no chemical fertilizer and pesticide is applied. In transplanted rice 2/3rd residue is left in the field and recycled for nutrient supply where average rice yield of 2.3-2.7 t/ha is obtained. In this practice, average soil organic carbon level of 1.16% is maintained compared to 0.82% in rice fields without residue management. Such practice has the nutrient potential of 23.5 kg N, 8.6 kg P_20_5 and 48.5 kg K_20/ha, respectively and contributes to yield stabilization. The nutrient recycled through management of weed biomass (5.8 to 7.2 t/ha) is about 91.1 kg N, 15 kg P_20_5 and 87 kg K_20/ha. Farmers also get similar advantage in terms of nutrient enrichment of soil when they keep the field fallow after every 3-4 years of rice cultivation. Incorporation of fresh ricebean (*Vigna umbellata*) biomass (10-12 t/ha) in ginger (*Zingiber officinale*) field is also another traditional in-*situ* soil fertility management practice in Anjaw district of Arunachal Pradesh, where farmers are getting 20-25% higher ginger rhizome yield than without practicing green manuring. Thus, the study concluded that the RCT measures have been adopted by the North eastern farmers since ancient time which needs to blended with the modern farming practices for sustainable agriculture.

INTRODUCTION

The term conservation agriculture (CA) refers to the system of raising crops without tilling the soil while retaining crop residues on the soil surface concurrently conserving the environment. The key elements which characterize CA include: minimum soil disturbance by adopting no-till and minimum traffic for agricultural operations, leave and manage the crop residues on the soil surface, and adopt spatial and temporal crop sequencing/crop rotations to derive maximum benefits from inputs and minimize adverse environmental impacts (Sangar and Abrol, 2005).

Intensive tillage in modern systems leads to gradual decline in soil organic matter content through accelerated oxidation, with a consequent reduction in the capacity of soil to regulate water and nutrient supplies to plants. Burning of crop residues, a common practice in many areas, has been found to cause pollution, greenhouse gas (GHG) emission and loss of valuable plant nutrients. When crop residues are retained on the soil surface in combination with no till, it initiates processes that lead to improved soil quality and overall enhancement of resource-use efficiency (Kayuki and Wortmann, 2001). The benefits of CA are several folds. Direct benefits to farmers include reduced cost of cultivation through savings in labour, time and farm power, and improved input-and-energy use efficiency. More especially, CA practices reduce resource degradation. Gradual decomposition of surface residues improves soil organic matter status, biological activity and diversity and contributes to overall improvement in soil quality (Shaxson *et al*., 2008). CA is a way to reverse the processes of degradation inherent in modern agricultural practices involving intensive cultivation, burning and/or removal of crop residues etc (Abrol and Sangar, 1999).

Most of the practices adopted by the farmers for soil fertility management is on account of the adaptive skills of local people usually derived from the long experience that have often been communicated through the oral traditions and learned through the family members over the generations (Thrupp, 1989). Such types of wisdom are the rich sources of location-specific ecological information and provide the key to understand the people's socio-cultural conditions (Singh *et al*., 2002; Singh, 2003). In the Indian conditions, very little attention has been paid to study and understand the farmers' wisdom and perception about soil fertility management. The indigenous resource conservation techniques followed in various ecosystems and altitudes by the ethnic people are extensively reviewed (Das *et al*., 2012). The objective of this paper is to understand farmers' perception of soil fertility management and interpreting it in the light of modern agriculture.

MATERIALS AND METHODS

The North Eastern Region (NER) of India comprising the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, lies between $22^0$05' and $29^0$30' N latitudes and $87^0$55' and $97^0$24' E longitudes. The region has an area of 26, 2240 Km^2, of which 72.6 per cent is hilly. The region is characterized by diverse agroclimatic and geographical situations. About 63.1 per cent of the total geographical area is under forests, 16.6 per cent under crops and the rest either under non-agricultural uses or uncultivated land. The low area under agricultural crops is due to natural corollary of the physiographic features of the region, as major chunk of the land has more than 15 per cent slope, undulating topography, highly eroded and degraded soils and inaccessible terrain. The region has remained economically backward, though there is an ample potential for development due to abundant natural resources. Soils are mostly loam, acidic in nature and lighter in texture in sloppy lands, while medium texture is observed in valley. The soils belong to order mainly alfisols, entisols, inceptisols and some are mollisols. Organic matter is rich in valley land but mostly unpurified. On steep slope, because of continuous removal of topsoil, organic matter status is poor to medium. In many upland soils, aluminum toxicity is common. The diversity of soil type due to altitude and climatic conditions provide ample scope for raising variety of agricultural crops.

Although CA in India, of late, has emerged as a new paradigm to achieve goals of sustainable agricultural production, such unique culture is already in practice in the most remote state of India i.e. Arunachal Pradesh in general and Lohit and Anjaw districts in particular. It is a major step towards transition to sustainable agriculture. Arunachal Pradesh is the largest state of the region with 83,578 km^2 geographical area, followed closely by Assam (78,440 km^2) while Sikkim is the smallest state having only 7,096 km^2 area. The altitudinal differences coupled with varying physiographical conditions contribute greatly towards climatic variations in the region. The climate of Arunachal Pradesh varies from subtropical to extreme alpine type. The normal average minimum and maximum temperatures vary from 18 to 24.8^{o}C in summer and 9.0 to 17.7^{o}C in winter. Heavy fog is a common feature all over the mountain area of the state for most of the days in the year. The temperature in the now-clad mountain remains - 7^{o}C during winter. The average annual rainfall of Lohit District was about 2250 mm. The average monthly maximum temperature ranged from 17 to 31.5 ^{o}C and monthly minimum temperature ranged from 15 to 25^{o}C.

Table 1. Crop wise area in respect of Lohit District during 2007-08

Sl. No.	Name of crops	Area (ha)
1.	Paddy	10545* (3643 ha)
2.	Maize	8325
3.	Millet	92
4.	Wheat	415
5.	Pulses	1865
6.	Oilseeds	11423
7.	Potato	620
8.	Ginger	890
9.	Turmeric	110
10.	Chillies	125
11.	Sugar cane	20
12.	Vegetables	2300
Total		36730

*Paddy area in Anjaw district

Source: Department of Agriculture, Govt. of Arunachal Pradesh, 2009.

Crop wise area in respect of Lohit District during 2007-08 has been presented in Table 1. The data on grain yield was collected from the farmers' field by crop cutting from 1sqm area. The range of grain yield collected from different sites were recorded and expressed as ton/ha. The straw samples of rice and weed biomass were analyzed (one composite sample from each site) for total N using a micro-Kjeldahl method, while total P and K were determined using sulphuric-nitric-perchloric acid digest (Prasad *et al*., 2006).

Nutrient uptake of straw was estimated by multiplying the N, P and K concentration (%) of straw with their respective yield in kg/ha. The post harvest soil samples were collected (one composite sample from each site) from 0-20 cm horizon for analyzing the organic carbon content (%) available N, P and K status.

RESULTS AND DISCUSSION

Farmers of Lohit and Anjaw districts of Arunachal Pradesh practice various traditional in-*situ* soil fertility management either in rice based or ginger based cropping systems since last 30-40 years. Salient features of some of the conservation practices followed by the farmers in these Districts are discussed below:

Module I

Barring few districts, farmers of Arunachal Pradesh practice monocropping of rice. Since there is a less demand of rice residue for cattle feed (due to plentiful availability of green fodder) in Arunachal Pradesh, farmers leave about 2/3rd residue of rice in the field; only top 1/3rd portion with panicles are cut (Plate 1) at harvest. After harvesting of panicle they are tied together in bundles and kept for a week for drying over the left-over rice residues (Plate 2). The left-over residue remains in the field, and no tillage practice is done before puddling the field in next season (up to May). Residues are incorporated during puddling. Weeds that grow in rice field between harvest of rice and land preparation for succeeding rice are also incorporated along with left-over rice residue. This is a common practice of rice farmers in this belt to ensure long-term soil health of rice field. As a result farmers realize good yield of rice without applying any chemical fertilizer since the beginning of settled rice cultivation (may be 30-40 years) in a particular rice field. This was also evident from higher yield of rice varieties practiced in Lohit district (Table 2) which is much higher than the average rice yield of NE region (1.57 t/ha).

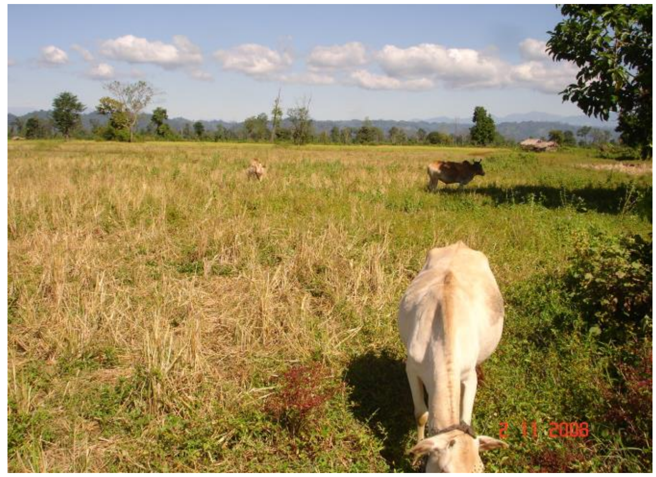

Plate 1: Farmer leave rice residue in field which is also used as grazing field for cattle

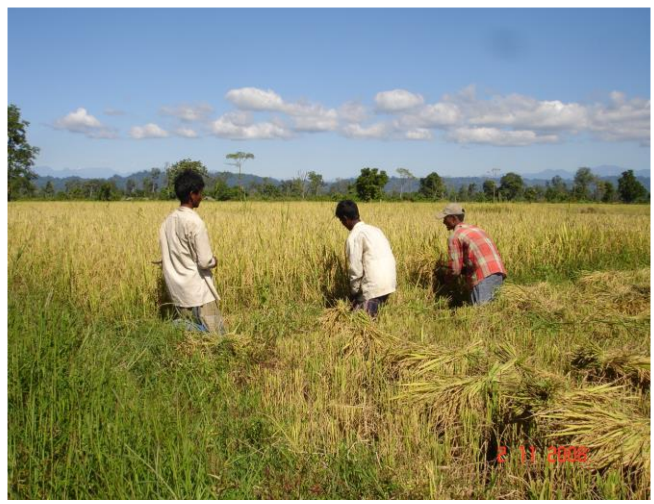

Plate 2: The harvested panicles are dried in the field on top of left over straws to protect damage due to moisture

Table 2. Prevalent rice varieties in Lohit district and their performance

Sl. No.	Variety	Duration (days)	Yield (t/ha)	Av. Straw (t/ha) recycled*
1.	Local Khampti Lahi	110 - 120	2.5 - 3.0	3.75 - 4.50
2.	Ahu Paddy	120 - 125	1.5 - 2.0	2.25 - 3.00
3.	Bahadur	120 - 125	2.6 - 3.0	3.90 - 4.50
4.	Ranjit	110 - 120	2.0 - 2.5	3.00 - 3.75
5.	Basato	115 - 120	3.0 - 3.2	4.50 - 4.80
6.	Bihari Dhan (local)	120 - 125	2.0 - 2.5	3.00 - 3.75
Mean			2.3 - 2.7	3.30 - 3.95

* Straw recycled calculated considering the grain and straw production ratio of 1: 1.5

Source: Direct interview with the farmers

It is learnt from the farmers that since 30-40 years (beginning of rice cultivation) they follow such practice of indigenous in-situ soil fertility management in rice field and till date no fertilizer is being applied. Soil analysis data of such rice field revealed that nutrient particularly N and organic carbon is maintained to support rice growth without applying chemical fertilizer (Table 3). It is found that during the time span of 6 months (Dec – May) the left-over residue is partially decomposed. Since weed grown during these six months is also incorporated in the field along with rice residue, they help in decomposition of rice residue. Because of this, immobilization of N is negligible and farmers never visualized N deficiency even at the early stage of rice growth.

Table 3. Nutrient status of traditional in-*situ* residue management rice fields

Location	Soil organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_20 (kg/ha)
1	1.50	307.3	13.7	175.0
2	1.21	219.5	16.7	160.5
3	1.32	244.3	11.7	153.4
4	0.96	202.0	10.8	162.7
5	0.95	198.3	10.5	163.8
*Sites without residue management	0.82	185.8	8.8	155.7

**Average of five rice fields adjacent to residue managed plots*

Critical analysis revealed that based on 1:1.5 grain to straw ratio and average production of 3.30 -3.95t rice straw/ha, the total residue of 51432 t is incorporated per year from 14188 ha area in two districts, having nutrient potential of 23.5 kg N, 8.6 kg P205 and 48.5 kg K20/ha, respectively. The N, P20 and K20 content in composite weed biomass ranged from 1.35 -1.41, 0.20- 0.24 and 1.31- 1.35%, respectively. The weed biomass production ranged from 5.8 to 7.2 t/ha that has the potential to replenish 80.7 -97.5 kg N, 13.5-15.9 kg P205 and 79- 94.6 kg K20/ha (Table 3). This traditional in-situ soil fertility management not only ensures the food security of the state but also saves considerable amount of N, P, and K and maintain soil health in the long run.

Table 4. Nutrient recycled through crop residue and weed management in various location (farmers field)

Sl. No.	Variety	Nutrient recycled through straw			Nutrient recycled through weed biomass		
		N	P_20_5	K_20	N	P_20_5	K_20
1.	Khampti Lahi (Local)	25.2	9.5	53.7	80.7 (5.85)*	13.5	79.0
2.	Ahu Paddy	16.8	6.05	34.2	88.8 (6.48)	15.0	86.2
3.	Bahadur	26.9	10.1	53.1	97.5 (7.22)	15.9	94.6
4.	Ranjit	21.0	8.1	44.3	87.4 (6.20)	14.9	83.1
5.	Basato (trialed at CKM-WRC)	29.3	10.7	60.0	97.3 (6.95)	16.0	92.4
6.	Bihari Dhan (local)	22.0	7.4	43.1	95.2 (7.00)	14.0	92.4
Mean± SD		23.5±4.5	8.65±1.75	48.1±9.28	91.1±6.68	14.9±1.0	87.1±6.45

*Figure in the parenthesis indicates the respective weed biomass production in tons/ha that is recycled along with rice straw.

Effective management of residues, roots, stubbles and weed biomass can have a beneficial effect on soil fertility through addition of organic matter, plant nutrients and improvement in soil condition (Munda *et al*., 2006; Singh 2003; Sidhu and Beri, 1989; Srivastava *et al*., 1988). Recycling of residues and plant biomass in the soil is the one of the best alternative practices for replenishing the depleted soil fertility, improving the physicochemical properties of the soil and ultimately crop yield (Kayuki and Wortmann, 2001; Kolawole *et al.,* 2004; Das *et al*. 2008).

Module II

Some farmers in Arunachal Pradesh particularly in Lohit and Anjaw districts keep the rice field fallow for 1-2 years after every 3-4 years cropping cycle for regeneration of soil fertility. After harvest of rice, they leave residue/stubbles as such in the field (Plate 3), allow weed to grow and plough the field before growing of next rice crop. In this case also they follow the similar traditional in-*situ* soil fertility management practices as in case of module I. Therefore, the amount of nutrient recycled within the system is similar to module I. Farmer's perception is that, following such practice, there is no dearth of nutrient in rice field and sustainable rice yield could be achieved. This is attributed to minimum disturbance of soil through zero tillage or minimum traffic during fallow period of 1-2 years coupled with residue/biomass management during rice cultivation.

Fallowing as traditional method of restoring soil productivity has been reported (Singh and Singh, 2005) The length of fallow period varied according to the type of soil. The population growth has resulted in family disintegration, land fragmentation, and increase in food requirement and thus declining rate of keeping the land fallow. The farmers of Azamgarh district in eastern Uttar Pradesh, India generally adopt two methods of fallowing. In the first method, land is kept fallow after taking the paddy in the poor soil (*Kiyari*) for over one year and timely plowing is done after every rain. In the second method, the field is fallowed for only one season (4 months) after harvesting *rabi* season crops (Singh and Singh, 2005).

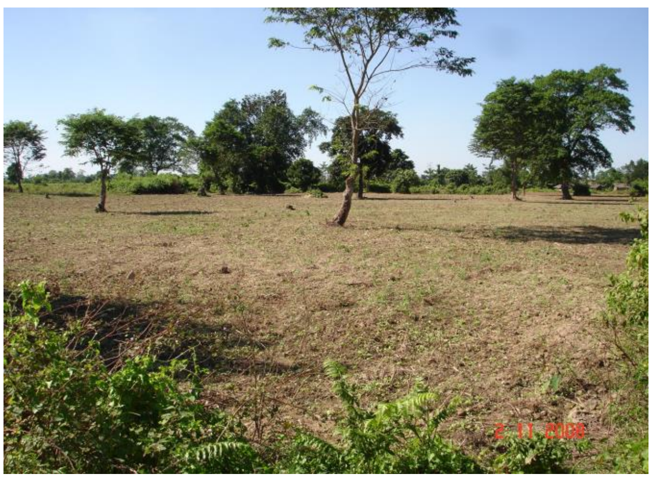

Plate 3: Fallowing for soil fertility enrichment

Module III

Quite a good number of farmers of Anjaw district of Arunachal Pradesh follow a unique traditional in-situ soil fertility management practices for ginger cultivation. Before planting rhizome, they grow ricebean normally used for *dal* (Plate 4). After picking pod, the fresh green biomass of ricebean (10-12 t/ha) is incorporated into the soil before planting ginger rhizome. Between ginger rows they also put dhaincha (*Sesbania aculeata*) seed or perennial pigeon pea (*Cajanus cajan*) (Plate 5) primarily for creating partial shading for ginger and also for supplying nitrogen to rhizome through biological nitrogen fixation. Legumes like ricebean are superior green manure crops as they fix atmospheric nitrogen and add it to the soil nitrogen pool(Carlsson and Huss-Danell, 2003; Mayer *et al*., 2003). Legumes are known to improve soil fertility by adding much needed organic matter (15 t green biomass/ha) in the soils (Sultani *et al.,* 2007). Use of annual forage legumes such as Sesbania, cluster bean (*Cyamopsis tetragonolobus*) and/or ricebean as green manures, can improve soil fertility and can help increase the productivity of the succeeding crop (Carlsson and Huss-Danell, 2003). Green manuring crops, on average reduced soil bulk density (5%), enhanced total porosity (8%), and macropores and large mesopores (28%) (Sultani *et al*., 2007). It is learnt from farmers that this traditional practice of green manuring in ginger cultivation ensures much higher yield (20-25%) and income than ginger yield obtained without green manuring.

Plate 4: Rice bean before planting ginger

Plate 5: Ginger + Dhaincha crops

Growing perennial pigeon pea (as evident from few small farmers filed) may be a better option for tea gardens of NER than the existing practice of plantation in the tea garden because of the fact that pigeon pea plants will serve dual purpose both shedding and nitrogen supply at a much faster (6-8 months) time. Pigeonepa has the potential to supply more than 8 t/ha of pruned biomass which contains about 3.29% N, 0.67 % P and 1.43 % K. Addition of *C. cajan* leaf biomass to soil also improved soil organic carbon content and soil available N, P and K status Tomar *et al*., 2007). Some tea farmers in Tripura grow perennial pigeon pea along the contours during initial year of establishment of tea for shade, soil conservation as well as *dal*. An important potential benefit of intercropping pigeonpea and maize (*Zea mays*) is the improvement of soil nitrogen status resulting from the addition of litter and biological nitrogen fixation (Chirwa, 2003).

CONCLUSION

Peoples of North Eastern Region of India have been following some indigenous resource conserving technologies for soil health management from time immemorial in rice fields, which are eco-friendly, inexpensive and utilizes on-farm and locally available resources. In the global climate change scenario, it is high time to look back to those traditional practices for restoring ecosystem with appropriate refinement and blending of modern technologies for sustainable agriculture.

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