

## Productivity improvement in *jhum* fields through integrated farming system

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### ABSTRACT

An experiment was conducted during 2004-07 to establish integrated farming systems in *jhum* (slash and burn agriculture) field in Peren district of Nagaland to identify suitable combination of crops and livestock for better economic return and employment opportunities. Seven cropping systems were tested and integrated in different farming systems. The rice-vegetable pea-beans cropping system was most suitable under *jhum* land of Nagaland. Integration of fish, pig, dairy cattle, duck, and the crops such as rice, vegetable pea and beans showed maximum system productivity, i.e., 126.5 t/ha (rice-equivalent yield). This was followed by cultivation of rice, vegetable pea and beans along with dairy cattle (free grazing), having system productivity of 105.0 t/ha of rice-equivalent yield. However, least system productivity was recorded with cultivation of rice, vegetable pea, beans, hybrid Napier, winter maize and soybean together with dairy cattle, with rice-equivalent yield of 56.6 t/ha. Except piggery, all livestock components (dairy, poultry, duckery and fishery) recorded better economic viability (B: C ratio > 1). The farming-system approach of land use, therefore, could be adopted for sustainable production of *jhum* fields, and combination of rice, vegetable pea, bean, fish, pig, duck and dairy cattle was found to be most sustainable and profitable.

**Key words:** Farming systems, Shifting cultivation, System productivity, Watershed

In Nagaland shifting cultivation is a predominant farming system, especially in hilly tracts. Due to shortening of *jhum* (slash and burn agriculture) cycle from the earlier 15-20 years to 3-4 years now there has been sharp decline in crop yield. Large-scale deforestation, soil and nutrient loss, breakdown of resilience of the ecosystem and invasion by weeds and other species are the common features in eastern Himalayas (Ramakrishnan, 1992). According to one estimate, the rate of land degradation in Eastern Himalaya is almost 2-fold more than the national average of 20.2% (Anonymous, 2000). For holistic development of hill agriculture, commodity-based efforts may not be appropriate to tackle the complex socio-economic needs of people and also for maintenance of ecological balance of the fragile region (Bujarbaruah and Bhatt, 2006). Hence farming system-research approach could be adopted for sustainable crop production and also to conserve the natural resources (Bhatt and Bujarbaruah, 2005). As shifting cultivation has already caused severe environmental degradation in eastern Himalayas, an attempt was made to develop integrated farming-system models for livelihood security of tribal folk of the region. The present communication deals with productivity and profitability analysis of different cropping and farming system models developed in rainfed agro-ecosystem of Peren district.

### MATERIALS AND METHODS

The study was conducted during 2004-07 in Peren district of Nagaland under Jalukie watershed. The experiment was carried out in non-replicated trial to recognize the most noteworthy combination in terms of efficient resource use and economic return of components under integrated farming-system approach. The various components were taken as per the felt need of the local people, to ensure complementarity of crop-animal-fish for achieving food and nutritional security at household level.

Traditionally rice is being grown as main crop in the district. However, to find out suitable diversification of rice-based cropping systems, legumes, fodder maize and other cash crops were selected for this study. *Jhum* rice-fallow, the indigenous cropping system, was treated as the control (CS<sub>1</sub>). 'Nagaland Special' was grown as *jhum* rice. Other varieties include 'Teke', 'Vijaya', 'VI-44', 'All Rounder', 'Pusa Ageti', 'Jalukie Local', 'Local Cucumber', 'Local Beans', 'JS 335' and 'Hybrid Napier 1' respectively of rice, maize, vegetable pea, cabbage, cauliflower, garlic, cucumber, bean, soybean and napier. Though 'Nagaland Special' was sown broadcast, standard agronomic packages of practices were followed for sowing the rest of the crops. Nutrient supply to various crops was ensured through the application of diammonium phosphate, urea, vermicompost, tank silt and green-leaf

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manure of *Crotalaria*. Organic sources were used to meet 50% of the recommended dose of nitrogen, and the remaining nutrient requirements were met through inorganic sources. The common practice of burning rice straw was followed to supplement the potassium requirement of crops in the control plots, i.e., *jhum* field. The amount of different sources were adjusted as per the recommended doses of NPK for specific crop in the various cropping systems. Nutrient composition of different organic sources including the quantity used is depicted in Table 1.

Total six potential rice-based cropping systems was selected, viz. rice-vegetable pea-beans (CS<sub>2</sub>), Napier-winter maize-soybean (CS<sub>3</sub>), rice-cauliflower-fallow (CS<sub>4</sub>), rice-garlic-maize (CS<sub>5</sub>), maize-field pea-cucumber (CS<sub>6</sub>) and maize + rice-cabbage-fallow (CS<sub>7</sub>). Among these cropping systems, rice-vegetable pea-beans cropping system (CS<sub>2</sub>) was found the most economical which integrated with dairy (FS<sub>1</sub>). Likewise, FS<sub>2</sub> represents CS<sub>2</sub> + CS<sub>3</sub> + dairy; FS<sub>3</sub> – CS<sub>2</sub> + fishery + duckery; FS<sub>4</sub> – CS<sub>2</sub> + CS<sub>3</sub> + fishery + dairy; FS<sub>5</sub> – CS<sub>2</sub> + fishery + piggery; FS<sub>6</sub> – CS<sub>2</sub> + piggery + poultry, and FS<sub>7</sub> – CS<sub>2</sub> + fishery + piggery + dairy + duckery. Diversification was achieved at all the three levels of crop, cropping system and farming system through integration of livestock and fishery. An area of 0.25 ha was allotted to each cropping sequence but the data have been extrapolated on hectare basis.

Dairy activity was taken with four crossbred cattle ('Holstein-Friesian') in a single-row rear system. A covered and open area of 10 m<sup>2</sup> was allotted to each cow. Likewise four piglets ('Large Black X') were reared in 0.012 ha area @ 3 m<sup>2</sup>/fattening pig. The duck-shed was allotted 0.04 ha for rearing 50 'Chara Chambelli' ducks. Fifty broiler chicks were allotted 0.04 ha under poultry-shed. The unit cost of cow, pig, chicken and duck was Rs 20,000, Rs 1000, Rs 50 and Rs 40, respectively. The fingerling cost was Rs 0.4 each. Three fish ponds each of 0.025 ha were created to integrate with dairy cattle, duckery and piggery for efficient utilization of wastes from these units. After making the ponds, spill-way (0.60 × 0.45 m) was prepared in each pond to drain the excess water into a drainage channel. Slaked lime - [Ca(OH)<sub>2</sub>] was added to each pond @ 0.5 t/ha to maintain 7.0 to 7.5 pH. One month-old fingerlings were stocked in each pond at the stocking density of 10,000/ha; and the species composition was *Catla catla* (catla), 20%; *Labeo rohita* (rohu), 10%; *Cirrhinus mrigala* (mrigal), 20%; *Hypophthalmichthys molitrix* (silver carp), 20%; *Ctenopharyngodon idella* (grass carp), 20%; and *Labeo gonius* (gonius), 10%. Water samples of each pond were analysed for water temperature, pH, alkalinity, hardness, dissolved oxygen, free carbon dioxide and chloride, using standard methods. The plankton samples (phytoplankton

and zooplankton) were collected (during day time at 12 noon) by filtering 50 litres water from each pond using standard plankton, i.e., nylobolt net having 173-mesh per linear inch.

The cows were fed on a maize, napier grass and soybean straw, grown on 0.25 ha each in different rotations. As a common practice of free grazing during winter and summer, cows were also fed through free grazing involving only labour charges. Each cow of average body weight 300 kg and 8 liters milking capacity were fed with 10.17 kg dry matter through fodder (3.15 kg roughages and 5.25 kg green fodder) and 1.8 kg dry matter through concentrates. On an average 100 g concentrate feed was provided to each broiler and duckling per day. The fish-were harvested in staggered way at an interval of 15 days. The siltation from fish ponds was used as a nutrient source and the amount supplied was deducted from the total nutrient requirement of the crop. The weight gained by animals or birds at the time of slaughter was used for calculating the annual meat production and the values thus obtained were corrected using a dressing percentage of 75.0, 68.0 and 58.0 for pig, broiler and ducks, respectively.

The comparative efficacy of different integrations was calculated in terms of cost of cultivation, gross return, net return and benefit : cost (B : C) ratio. For better comparison, the output from each system and component was converted into rice-equivalent yield (REY) on the basis of prevailing market price of rice (Bhatt and Bujarbaruah, 2005).

## RESULTS AND DISCUSSION

### Productivity

Six cropping systems were tested over the prevailing *jhum* rice monoculture. All the cropping systems were found superior to *jhum* rice alone in terms of REY. However, maximum cropping-system productivity in terms of REY was recorded in rice-garlic-maize (50.9 t/ha) due to good market price of garlic than of maize. It was followed by maize-field pea-cucumber (24.2 t/ha). The highest REY was obtained from garlic (42.9 t/ha). As an individual crop, *jhum* rice yielded the least (1.5 t/ha) and the crop productivity improved with improved agrotechniques of rice cultivation up to 5.0 t/ha. The cropping systems maize + rice-cabbage-fallow, napier-winter maize-soybean, rice-cauliflower-fallow, maize-field pea-cucumber, rice-vegetable pea-beans and rice-garlic-maize recorded 12.8, 13.0, 13.7, 24.2, 24.6 and 50.9 t/ha REY, respectively. The benefit : cost (B : C) ratio for rice was < 1 in all rice-based cropping systems including *jhum* rice. However, the rice cultivation, supported with improved package of practices under rice-vegetable pea-beans cropping system showed B : C ratio closer to 1 due to better yield (Table 2).

The farming system (FS<sub>7</sub>) with components of CS<sub>2</sub> + fishery + piggery + dairy + duckery showed the maximum system productivity, i.e., 126.5 t/ha of REY. The FS<sub>1</sub> was found to be second most productive farming system model with system productivity of 105.0 t/ha REY. However, the least system productivity was recorded in FS<sub>2</sub> with REY of 56.6 t/ha, because of low return from fodder crops. The diversification of enterprises also reduce the risk of total crop failure. The system as a whole with integration of livestock and crop components improved the total productivity through efficient utilization of farm resources and also reduced the dependence on external resources (Table 3).

The integration exploits the complementarities and synergisms that result from the various combinations of crops

and livestock in spatial and temporal arrangements. Thus the equilibrium between different components of farming system helped in bringing the complementarity, which resulted in high productivity. The integration of various components of farming systems that mimic the nature ensures optimal use of sunlight, soil nutrients and rainfall (Singh *et al.*, 2004).

### Economics

Rice crop was found to be less economical and its B : C ratio was <1, though with improved cultivation practice including, high-yielding varieties, the economics was improved marginally. Despite low economic viability, rice is the main cereal crop in the state because it is the staple food crop. Maximum economic viability was recorded

**Table 1.** Nutrient composition (dry-weight basis) of different organic sources used for various cropping systems at experimental site

Nutrient source	Quantity of nutrient sources (t)	Nutrient composition (%)			Quantity of nutrient added by sources (kg)		
		N	P	K	N	P	K
Vermicompost	1.9	2.5	1.0	1.5	47.0	18.8	28.2
Green-manure	1.0	2.5	0.7	2.1	55.2	8.9	53.4
Rice straw	4.8	0.6	0.2	1.4	25.0	6.5	21.0
Silt	1.8	3.1	0.5	0.3	29.2	9.6	67.0

**Table 2.** Economics of various cropping systems and *jhum* rice (mean data of 2004-05 and 2005-06)

Treatment	Cropping system	Yield (t/ha)	REY* (t/ha)	Cost of cultivation (x 10 <sup>3</sup> Rs/ha)**	Net returns (x 10 <sup>3</sup> Rs/ha)**	B : C ratio
CS <sub>1</sub>	<i>Jhum</i> rice - fallow		15.0			
	<i>Jhum</i> rice	1.5	15.0	4.30	4.10	0.95
CS <sub>2</sub>	Rice-vegetable pea- beans		246.4	36.46	95.89	2.60
	Rice	5.0	50.0	14.05	13.95	0.99
	Vegetable pea	5.0	89.3	9.85	34.50	2.23
	Beans	8.0	107.1	12.56	47.44	3.78
CS <sub>3</sub>	Napier -winter maize- soybean		130.2	31.32	41.58	1.32
	Napier	50.0	44.6	10.50	14.50	1.38
	Winter maize (fodder)	35.8	32.0	8.26	9.64	1.17
	Soybean	2.0	53.6	12.56	17.44	1.39
CS <sub>4</sub>	Rice-cauliflower-fallow		137.3	25.70	51.18	2.10
	Rice	4.8	48.0	14.05	12.83	0.91
	Cauliflower	10.0	89.3	11.65	38.35	3.29
CS <sub>5</sub>	Rice -garlic - maize		508.9	67.41	217.53	2.20
	Rice	1.2	49.0	14.05	13.39	0.95
	Garlic	10.7	428.6	45.45	194.55	4.28
	Maize (fodder)	0.8	31.3	7.91	9.59	1.21
CS <sub>6</sub>	Maize-field pea- cucumber		242.4	37.76	97.42	2.00
	Maize	4.8	19.2	7.91	6.92	0.87
	Field pea	2.0	80.4	9.85	30.50	2.10
	Cucumber	3.6	142.9	20.00	60.00	3.00
CS <sub>7</sub>	Maize + rice -cabbage -fallow		127.7	24.35	48.45	2.02
	Maize + rice	0.9	38.4	12.50	10.30	0.82
	Cabbage	2.3	89.3	11.85	38.15	3.22

\*REY=Rice-equivalent yield

\*\*Values/ha have been extrapolated from unit-area basis

with garlic (4.28), followed by beans (3.78), cauliflower (3.29) and cabbage (3.22). *Jhum* rice, however, recorded the minimum cost of cultivation but net returns were low (Table 2).

Maximum net returns/ha (Rs 2,17,530) was obtained from rice-garlic-maize cropping system, followed by maize-field pea-cucumber (Rs 97,415). Rice-garlic-maize cropping system incurred the maximum cost of cultivation (Rs 67,410/ha) but ensured maximum returns. The maximum cost of cultivation was incurred with garlic (Rs 45,450), followed by cucumber (Rs 20,000) but these crops recorded better economics due to high productivity and better market price. Thus vegetable cultivation led to higher net farm income than the production of cereal crops only. Bhatt and Misra (2003) reported relative profitability of horticultural crops compared with cereals is a determining factor in crop diversification.

The fodder crops of Napier and maize recorded comparatively better economics than rice, but were inferior to vegetables and soybean. Among livestock components, dairy recorded high tonnages (24 t/ha of REY) but fishery showed better economic viability. Except piggery, all livestock components showed better economic viability (B: C ratio >1). In terms of net return/year, dairy component showed the maximum (Rs 78,354), followed by poultry, fishery and duckery (Table 4). The least net returns were

obtained from piggery (Rs 11,840). The overall economics was improved due to exploitation of complementarity of agri-horti crops including fishery and livestock components (Fig. 1).

Earlier research findings of Tanjang *et al.* (2006) also proved higher B : C ratio for agri-horti-silvi-pisciculture (2.8) and agri-pisciculture farming systems (3.4) practised by the indigenous tribes of Arunachal Pradesh. Arunachalam *et al.* (2002) also recorded higher B : C ratio (1.4) in agri-horti-silviculture agroforestry system, practised by Nyishi tribes of Arunachal Pradesh. Agri-horticulture farming system practised in Meghalaya also showed higher B : C ratio (1.57) compared with rice monocropping system (Bhatt and Misra, 2003). Another study of Bhatt and Bujarbaruah (2005) also found higher B : C ratio for rice-fish-cattle (1.69), rice-fish-goat (1.44), rice-fish-poultry (1.41), rice-fish-duck (1.31) and rice-pig-fish (1.31) system, developed in eastern Himalayas. Thomas *et al.* (2002) and Mishra and Mohanty (2004) also reported similar results of improvement of economic viability due to integrated approach of land use.

### Employment generation

The farming system FS<sub>7</sub> generated the maximum number of mandays/ha/year (890), followed by FS<sub>4</sub> (675 mandays/ha/year). The crop components involved 160-

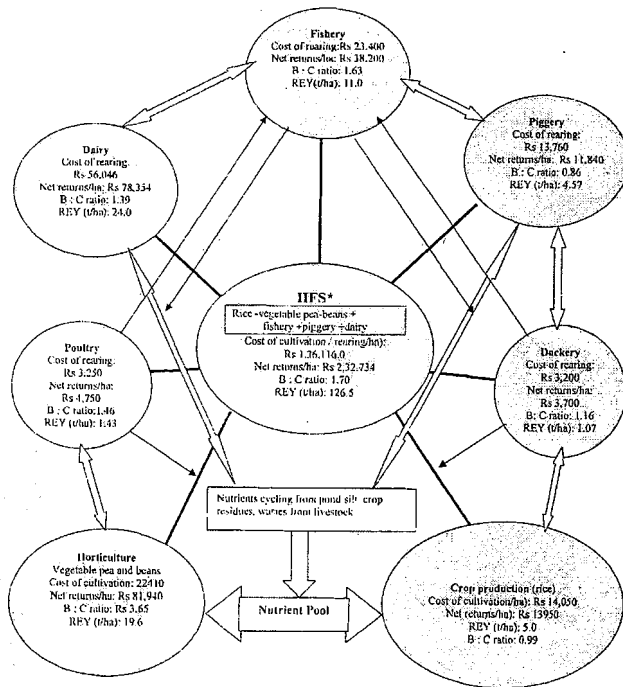
**Table 3.** Area and production under different cropping and integrated farming systems at experimental site

Treatment	Cropping systems			Integrated farming system				
	Cropping system	Net area (ha)	Cropped area (ha)	Cropping intensity (%)	Treatment	Combination of cropping and farming systems	Total area under farming system (ha)	System productivity (t REY/ha/year)*
CS <sub>1</sub>	<i>Jhum</i> rice - fallow	0.25	0.25	100	FS <sub>1</sub>	Rice - vegetable pea - beans + dairy (free grazing)	0.29	105.0
CS <sub>2</sub>	Rice - vegetable pea - beans	0.25	0.75	300	FS <sub>2</sub>	CS <sub>2</sub> (MER**) + CS <sub>3</sub> + dairy	0.59	56.6
CS <sub>3</sub>	Napier - winter maize - soybean	0.25	0.75	300	FS <sub>3</sub>	CS <sub>2</sub> + fishery + duckery	0.32	57.3
CS <sub>4</sub>	Rice - cauliflower - fallow	0.25	0.50	200	FS <sub>4</sub>	CS <sub>2</sub> + CS <sub>3</sub> + fishery + dairy	0.54	61.9
CS <sub>5</sub>	Rice - garlic - maize	0.25	0.75	300	FS <sub>5</sub>	CS <sub>2</sub> + fishery + piggery	0.29	74.9
CS <sub>6</sub>	Maize - field pea - cucumber	0.25	0.75	300	FS <sub>6</sub>	CS <sub>2</sub> + piggery + poultry	0.29	41.9
CS <sub>7</sub>	Maize + rice - cabbage - fallow	0.25	0.50	200	FS <sub>7</sub>	CS <sub>2</sub> + fishery + piggery + dairy + duckery	0.37	126.5

\*System productivity/ha extrapolated from unit-area basis; \*\*Maximum economic returns

**Table 4.** Economics of different components of farming system from one ha of area (mean data of 2004-05 and 2005-06)

Component	Cost of rearing (Rs/unit)	REY (t/unit)	Net returns (Rs/unit)	B : C ratio
Dairy	56 x 10 <sup>3</sup>	240.0	78.35 x 10 <sup>3</sup>	1.39
Poultry	3.25 x 10 <sup>3</sup>	14.3	4.75 x 10 <sup>3</sup>	1.46
Piggery	13.76 x 10 <sup>3</sup>	45.7	11.84 x 10 <sup>3</sup>	0.86
Duckery	3.2 x 10 <sup>3</sup>	10.7	3.7 x 10 <sup>3</sup>	1.16
Fishery	23.4 x 10 <sup>3</sup>	110.0	38.2 x 10 <sup>3</sup>	1.63



**Figure 1.** Integrated intensive farming system model in mid-hills of Nagaland under *jhum* conditions (Estimate of crop is converted on per ha area basis and that of livestock on per actual unit area under study)

180 maydays/ha/year in farming-system approach and livestock generated 675-700 mandays/year. Generation of additional employment opportunities under farming-system approach is due to the diversification and integration of crops, livestock, fishery and horticulture. However, these farming system models are labour intensive, which are essential in eastern Himalayas, where almost for 5 to 6 months the farming families are unemployed. Though the cost of cultivation increased manifolds with inclusion of vegetable cultivation, it increased the total revenue proportionally much higher, indicating favorable economics of diversified agriculture. Bhatt and Bujarbaruah (2005) and Ravisankar *et al.* (2007) also reported increase in employment opportunities in integrated farming system compared with that in commodity-oriented agriculture.

In eastern Himalayas, where shifting cultivation is the main occupation of a majority of population, a shorter *jhum* cycle has put tremendous pressure on resources, affecting the productivity of land caused by land degradation, increased level of soil erosion, hydrological imbalance and forest degradation, leading to low yield and in-

security in food source. Our study reveals that the farming-system approach of land use through integration of agri-horti crops, fishery and livestock has been found most suitable for livelihood security of tribal folk of the region.

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