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Tuber Crop Based Farming System: An Approach to Boost up Livelihood of Marginal Farmers

B.K. Saud[2], S. Alam[2], James George[1], G.N. Hazarika[2], Madhumita Choudhury Talukdar[2], U. Kotoky[2] and B. Gogoi[2]

[1]ICAR- Central Tuber Cops Research Institute, Sreekariyam, Thiruvananthapuram 695 011, Kerala, India

[2]Assam Agricultural University, Jorhat, Assam 785 013, India

Corresponding author: B.K. Saud; e-mail: bijit1969@rediff.com

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Abstract

A research programme was conducted in the farmers' field at Dhenususa, a village in Jorhat district of Assam during 2013-14 to 2015-16. Initial data on land profile, production pattern and livelihood data of the village were taken. The field used by the farmer for rice mono-cropping (0.26 ha) was transformed to tuber crop based farming system model. Different components like tuber crops, floriculture, fruits, vegetables, fish, duck and dairy components were integrated for more income, employment and sustainability. A significant change occurred in rice equivalent yield, farm income and employment after intervention. The tuber crops contributed a major share in the farm income. Among the tuber crops the rice equivalent yield per unit area was maximum in the case of elephant foot yam (4.80 kg m^{-2}) due to higher productivity and better price followed by sweet potato (4.27 kg m^{-2}), greater yam (3.84 kg m^{-2}) and taro (2.77 kg m^{-2}). Among the kharif field crops sugarcane (chewing type) had higher productivity (3.55 kg m^{-2}) in terms of rice equivalent yield. In other horticultural crops banana produced maximum rice equivalent yield (8.50 kg m^{-2}) in the IFS system followed by flower (5.59 kg m^{-2}), ginger (5.50 k gm^{-2}), winter vegetables (4.66 kg m^{-2}) and lemon(4.25 kg m^{-2}). The rice equivalent yield could be increased up to 28.42 t ha^{-1} in a typical rice land from just 3.33 t ha^{-1} by converting the land into farming system model. This was about 8.5 times more than that of previous rice mono-cropping (861%) system. The tuber crop based farming system could generate additional employment up to 615 days from previous employment status of 212 man days per hectare in a year. Hence, this model could change rice mono-cropping in marginal land holdings to a sustainable farming module to attract and retain farmers in farming in agriculturally backward states like Assam.

Key words: Rice, diversification, income, employment

Introduction

Indian economy is very much linked to the advancement of agriculture and that of resource poor marginal and small farmers who constitute 80% of more than 115 million farm families. Sustaining house-hold food security has been an issue of prime importance to majority of the farmers due to soil degradation, groundwater contamination and climate change in present days. To tackle such problems, farming system approach has been widely recognized and advocated as one of the strategies for sustainable production system. Farming system is a resource management strategy to achieve economic and sustained production to meet diverse requirements of farm households while preserving resource base and maintaining a high level environmental quality (Lal and Miller, 1990). The Integrated Farming Systems (IFS) has enabled us to develop an alternate development model to improve the profitability of small sized farming operations in relation to larger ones. The IFS explains a more integrated approach to farming as compared to monoculture approaches. It refers to agricultural systems that integrate livestock and crop production or integrate fish and livestock and may sometimes be known as Integrated Biosystems. The IFS system not only eliminates wastes but also ensure overall increase in productivity for the whole agricultural systems (Toor et al. 2009).

Tuber crops like cassava, sweet potato, aroids and yams have created a niche in the food security of millions especially among the poor farmers nationally and world-wide. The tuber crops are very good source of carbohydrate, protein, minerals and fibre (Odebunmi, 2007). They are the third most important food crops, after cereals and grain legumes. Tuber crops were the saviours and rescuers of millions during period of famine and food scarcity as historical reports reveal. This group of crops can supplement the cereals owing to their high biological efficiency in productivity and nutritional status (Naskar and Ravi, 2011).

Tuber crops are an integral part of existing farming system throughout the North Eastern Part of India. A lot of variability in types, growth habit and edibileness of tuber crops is observed in this part. Tuber crops especially taro and yams are widely consumed by different communities in the region in different forms that contribute meaningfully to the daily diet. Due to heavy rainfall during certain periods few crops can be grown in rainy season and out of that tuber crops (taro, tannia, yams, tapioca) are the most favourable.

The present study was undertaken to improve the economic status as well as to increase the food and nutritional security of the marginal farmers of Assam in NE regions of India.

Materials and Methods

The on-farm trial was conducted during 2013-16 under the All India Coordinated Research Project (AICRP) on Tuber Crops at Dhenususa village of Jorhat district of Assam located in latitude 26° 48° N, longitude 95° 50° E and altitude 90.5 amsl. The aim was to provide financial, food and nutritional security to the people through tuber crop based farming system approach under the rainfed situations of Assam.

Being situated in sub-tropics, the climate of the study site is characterized by hot and wet summer and dry and cool winter with four distinct seasons such as pre-monsoon season (March - May), monsoon season (June - September), post-monsoon season (October - November) and winter season (December - February). The average annual rainfall in the area was recorded as 1900 mm of which the major (70%) rainfall is received during rainy season and 18-27% in the summer season. Mean maximum and minimum annual temperatures recorded were 27.5°C and 17.2°C,respectively with minimum temperature in the month of January and maximum in June. In a year, average relative humidity prevails maximum during summer (80%) and minimum during the winter (60%). The average sun shine hours received during the summer and winter are 6 and 4 hours per day respectively.

Initially, a benchmark survey was conducted and the information was generated on socio-economic and cultural behaviour of the people. The farmers of the villages were mostly marginal having land holdings 55 – 78 cents. A rainfed rice as mono-cropping using traditional variety with poor management practices was the predominant cropping sequence of the locality. The villagers have been rearing livestock also such as cattle, goat and poultry besides culturing fishes in their ponds. However, production and profit from these components were very poor due to use of local breeds, imbalanced feeding and nutritional problem, shortage of fodder, unhygienic rearing, disease problems, unscientific management practices etc. Consequently, the economic status of the villagers was very poor.

Thereafter, module-wise interventions were identified under AICRP on tuber crops of AAU Jorhat Centre supplying the inputs and technical support to improve the socio-economic status ensuring financial and nutritional security of the farmers through tuber crops based integrated farming system approach.The land previously used for mono-cropping was transformed making raised and sunken beds, channels and bunds, water harvesting structure cum fish pond for production of horticultural crops, culturing fish, ducks etc. The raised beds were utilised for tuber crops followed by winter vegetable/flower production. The sunken beds were utilised for winter rice production followed by vegetable production. Infrastructure facilities such as barbed wire fencing (for stray cattle problem), lift irrigation by using power pumps, cattle cum duck house, plastic house, vermicompost units were created for sustainability. The planting materials of different crops (*viz*. tuber crops such as taro var. Jorhat Ahina, greater yams var. Kunwari Aloo, Sweet potato var. Dergaon local, elephant foot yam Var. Gajendra, cassava var. Balijan local; fruit crops such as banana var. Dwarf Cavendish, pineapple var. Kew, lemon var. Assam lemon, tuberose var. Prajwal; summer vegetables(bitter gourd, ridge gourd, okra) and winter vegetables (cabbage, cauliflower, knolkhol, broccoli, tomato, spinach, beet, carrot, coriander leaf, potato, spices(ginger var Nadia) and field crops such as rice (var. Ranjit), sugarcane (chewing type) and fodder crops (*Setaria* grass) were supplied to farmers. Improved varieties of milch cow (local cross breed), ducklings (*Khaki Campbell* breed), fish fingerlings (Rohu, Bahu and Mirika) and earthworms (species: *Eisenia foetida*) were introduced in the farming system along with feed. The rain water harvested was utilized for irrigation purpose.

The tuber crops such taro, yams were planted during February to March each year. Sweet potato was planted in the month of October. The winter rice crop (cv. Ranjit) was transplanted in 20 cm × 20 cm spacing on first week of July each year. The fruit crops were planted in the month of April. The seasonal crops such as summer vegetables were planted during February to March and winter season vegetables were planted during October – November. The crops and animals were produced as per standard package of practice for the state of Assam. Only nutritional and plant protection aspects were different avoiding any chemical application.

Training imparted to build capacity

The farmers of Dhenususa village, Jorhat district of Assam were not aware of improved varieties and improved cultivation technologies of different crops. They did not know about the scientific management Integrated Farming System. Therefore, to build the capacity of the farmers of the village, trainings were imparted to the households on the following:

i. Socio-economic and sustainable development through Integrated Farming System (IFS), crop intensification and crop diversification.
ii. Field oriented programmes on IFS, crop intensification and crop diversification.
iii. Scientific way of cultivation and management of tuber crops.
iv. Benefits of *rabi* and summer crops and their management practices.
v. Horticultural crops such as vegetables, spices, flowers and fruit crops as a component of IFS and their management.
vi. Importance of fodder crops and their management in IFS.
vii. Fish production technology and scientific management of fishery.
viii. Production and management of different live-stock suitable under Assam situations.
ix. Production technology of vermicompost and principle and practices of Integrated Nutrient management.
x. Utilization of by-product as feed for cattle and fishes.
xi. Utilization of bio-wastes for vermi composting and composting process.
xii. Rain water harvesting and its utilization to irrigate the *rabi* crops.

The yield of the crops were converted to rice equivalent yield by using the formula given below:

$$\text{Rice equivalent yield} = \frac{\text{Yield of the crop in kg x Sale price per kg}}{\text{Sale price of rice/kg(Rs 9/kg)}}$$

Results and Discussion

Yield of different crops in tuber crops based integrated farming system under rainfed situation of Assam are presented in Table 1.

In the present study, the tuber crops yield per unit area (rice equivalent yield) was significantly higher than that of rice (Table 1). Among tuber crops the rice equivalent yield per unit area is maximum in the case of Elephant foot yam (4.80kgm^{-2}) due higher productivity and better price followed by sweet potato(4.27 kgm^{-2}), greater yam(3.84kgm^{-2}) and taro(2.77kgm^{-2}). However, consumer preference and marketability was more in the case of Taro. The tuber crops have higher efficiency in conversion of solar energy to food matter even in adverse situation such as drought and flood (Naskar, 2011). Among the kharif field crops sugarcane (chewing type) had also higher productivity(3.55 kgm^{-2}) in terms of rice equivalent yield. Therefore, these crops fit well in crop diversification programme and could be introduced as cash crop. Ali et al. (2012) also recommended crop diversification for this region. Among the other horticultural crops banana produced maximum rice

Table 1. Yield of crops in tuber crop based IFS under rainfed situation of Assam (Data given are mean-value of 3 years from 2013 to 2016).

Crop/Animal	Area(m^2)	Yield/plot(kg)	Yield ha^{-1}	Rice equivalent yield (t ha^{-1})	Rice equivalent yield (t/plot)	Rice equivalent yield (kgm^{-2})
Tuber crops						
Sweet potato (Dergaon Red)	75	90	12.67 t ha^{-1}	42.23	0.32	4.27
Taro (JorhatAhina)	375	425	11.33 t ha^{-1}	27.69	1.04	2.77
Greater yam (KuwariAloo)	26 nos.	46.8	18.00 t ha^{-1}	40.00	0.10	3.84
Elephant foot yam (Gajendra)	37.5	81.6	21.76 t ha^{-1}	48.35	0.18	4.80
Kharif field crop						
Winter Rice (Ranjit)	600	200	3.33 t ha^{-1}	3.33	0.20	0.33
Sugarcane (chewing type)	90	150 pieces	16000 Pieces ha^{-1}	35.55	0.32	3.55
Other Horti-cultural crops						
Bitter gourd	75	90	12.00 t ha^{-1}	20.00	0.15	2.00
Ridge gourd	75	60	8.00 t ha^{-1}	17.77	0.13	1.73
Torai	225	210	9.33 t ha^{-1}	12.95	0.29	1.29
Okra	75	90	12.10 t ha^{-1}	18.82	0.14	1.87
Other winter vegetables*	500	1050	21.00 tha^{-1}	46.67	2.33	4.66
Flower (Tuberose)	136	1360	100000 Spike m^{-2}	55.55	0.76	5.59
Ginger	20	20	10.00 tha^{-1}	55.54	0.11	5.50
Banana	6 nos (11.76m^2)	6 bunch	3500 bunch ha^{-1}	58.33	0.10	8.50
Lemon(Fruits)	6 plants (54m^2)	2100 no.	479850 fruits ha^{-1}	53.31	0.23	4.25
CD (0.05)	-	-	-	-	-	0.15

NB. Greater yam planted in fencing post at 3m distance

Sale Prices (in ₹): Rice@ 9/kg, Sweet Potato @ 30/kg, Taro @ 22/kg, Greater Yam @ 20/Kg, Elephant Foot Yam @ 20/kg, Torai @ 12.5/kg, Sugarcane @ 20/kg, Bitter Gourd @ 15/kg, Ridge gourd @ 20/kg, Okra @ 4/kg, Winter vegetables average @ 20/kg, Flower @ 5/spike, Ginger @ 50/kg, Banana @ 150/bunch, Lime/Lemon @ 1/fruit

*Cabbage, Cauliflower, Knolkhol, tomato, spinach, beet, carrot, coriander leaf, Assamese potato and broccoli

equivalent yield (8.50 kgm^{-2}) in the IFS system followed by flower (5.59 kgm^{-2}), ginger (5.50 kgm^{-2}), winter vegetable(4.66 kgm^{-2}) and lemon(4.25 kgm^{-2}). The productivity of horticultural crops was higher because of more yield and better sale price of the products.The horticulture crops are the major alternative in the crop diversification for more profit in farm sector. Relevancy of horticultural crops are more in the case of small farm holdings (Phuphak, 2016). The rice equivalent yield could be increased up to 28.42 t ha^{-1} in a typical rice land from just 3.33 t ha^{-1} by converting the land into farming system model (Table 2). This was about 8.5 fold more than that of previous rice mono-cropping. This was possible due to modification of land form and land use planning by integration of more profitable components like horticulture, floriculture, fishery, duckery and dairy. The tuber crop based farming system could generate additional employment upto 615 days from previous level of employment 212 man days only per hectare in a year (Table 2). This was possible due to more numbers of enterprises and year round production programmes including more number of crops and animals. Acharya *et al* (2011)also reported enhanced employment in farming system study.

The study on overall economics of the tuber crop based farming system study revealed that there was significant increase in the farm income in terms of net income and benefit cost ratio (Table 3). The average net income increased many fold from ₹ 471.33 to ₹ 61520.33 due to integration of farming components. Similarly the average benefit cost ratio increased from 1.053 to 3.04. This was merely due to the increase in higher productivity and profitability. Singh *et al.* (2006) also reported good effects of diversification in farming in terms of good economic returns.

Conclusion

A comprehensive analysis of the tuber crop based farming systems has enabled us to develop a framework for an alternative development model to improve the feasibility of small sized farm holding in the state like Assam. The changes in cropping pattern have been taking place as a result of modification of land form and substitution from low productivity crops to high productivity crops and integration of other farm enterprises (Kumar and Surabhi,2016).This model could increase land productivity, income of the farmers, balance nutrition, employment and sustainability of the farmer. This could be a model to attract and retain present generation farmers who are very selective in their choice and techno savy. However, we need to frame policies to help the small farmers to diversify their activities towards both on-farm and off-farm activities for enhanced sustainability and productivity.

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Table 2. Increase in productivity and employment in farm land in terms of rice equivalent yield and mandays in IFS(Data given are mean-value of minimum 3 years from 2013 to 2016).

Sl no	Item	Before intervention		After intervention	
		In IFS Plot(net crop area 0.23ha)	Per ha	In IFS Plot (in ton)	Estimated yield (t ha^{-1})
1	Rice equivalent yield (in ton)	0.74	3.33	6.4	28.42
2	Percent increase in productivity (%)	-	-	-	853.45
3	Employment generation (mandays)	55	212	160	615

Table 3. Economics of tuber crop based farming system

Item	Before intervention				After intervention			
	2013-14	2014-15	2015-16	Avg.	2013-14	2014-15	2015-16	Avg.
Gross Income (Rs)	9234	9270	9360	9288.00	56453	86848	128760	90687.00
Expenditure (Rs)	8750	8800	8900	8816.67	25500	30000	32000	29166.67
Net income (Rs)	484	470	460	471.33	30953	56848	96760	61520.33
B:C ratio	1.06	1.05	1.05	1.053	2.21	2.89	4.02	3.04

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