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RESEARCH ARTICLE

Farmers' Participatory Coconut based Integrated Farming Systems for Sustainable Farm Productivity in High Rainfall Zone of Tamil Nadu

Thavaprakaash. N*[1] and Premavathi. R[2]

*Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore – 641 003.

[2]ICAR-Krishi Vigyan Kendra, Tamil Nadu Agricultural University, Thirupathisaram – 629 901.

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ABSTRACT

Coconut is the most important crop and the livelihood of Kanyakumari farmers. The cultivation of coconut alone yielded poor farm income. The Krishi Vigyan Kendra intervened for a sustainable income of farmers through integrated farming system (IFS) approach. Four coconut-based IFS models, *viz.,* 1. Coconut + Cow + Biogas + Vermicompost, 2. Coconut + Cow + *Desi*-chicken + *Azolla* + Vermicompost, 3. Coconut + Goat + *Azolla* + Vermicompost and 4. Coconut + Goat + Cow + Turkey + *Azolla* + Vermi-compost were demonstrated at farmers' field. Results revealed that generally, all IFS models were better than the farmers' practice in terms of coconut equivalent yield (CEY) and economic parameters. Among IFS models, model 2 had produced the highest CEY of 46184 kg/ha, gross return (Rs. 1016048/ha), net return (Rs. 742048/ha) and also B:C ratio (3.71) besides adding more nutrients to the soil. Hence, it is concluded that Coconut based IFS is more economical and sustainable in general and Coconut + Cow + *Desi*-chicken + *Azolla* + Vermi-compost model in particular in high rainfall zone of Tamil Nadu.

Keywords: *Integrated farming system, Coconut, Farmer's participatory mode, System productivity, Economic return, farm sustainability*

INTRODUCTION

India is an agrarian country, the Indian economy is predominantly rural, and agricultural-based one. Size of landholding is shrinking over the period, possesses a severe challenge to the sustainability and profitability of farming (Murugan, 2015). Given the decline in per capita availability of land, it is imperative to develop strategies and agricultural technologies that enable adequate employment and income generation, especially for small and marginal farmers who constitute more than 80 per cent of the farming community. Under the situation of the gradual shrinking of landholding, it is necessary to integrate land-based enterprises like fishery, poultry, livestock, fodder crops, field and horticultural crops, etc. within the biophysical and socio-economic environment of the farmers to make farming more profitable and dependable (Behera *et al*., 2004). No single farm enterprise is likely to sustain the small and marginal farmers without resorting to integrated farming systems (IFS) for the generation of adequate income and gainful employment year-round (Mahapatra, 1994). The farming systems approach is, therefore a valuable approach to address the problems of sustainable economic growth for farming communities in India. Hence, there is an imperative need for the development of location-specific integrated farming systems to enhance farm productivity, soil fertility, income from a unit area of land and sustainability.

Integrated farming systems focus on the integration of crops and livestock into production systems that involve best management practices, maintaining a high level of soil fertility and productivity and seek to replace external inputs of energy, agrochemicals and labor with available on-farm resources and natural biological cycles and processes. In the Kanyakumari district, most of the areas, the farm and home are away and not together and hence, there is less practice of mixed farming. Due to this, the farmers are rearing their animals in their backyards of the house and bringing the fodder from their fields to feed them. This process increased the input cost and became less economical. Cropping alone is also not remunerative due to the high labor cost and adaption of poor package of practices. Hence, the farmers are facing a lot of problems.

Coconut, rubber, rice, banana, mango, tapioca, vegetables, spices, and condiments are the predominant crops in Kanyakumari district. About

*Corresponding author's e-mail: thavaprakaash.n@tnau.ac.in

25000 ha of the land area is covered with coconut crop. Due to the geographical location, coconut is grown naturally without much care, still yields higher and bigger size of nuts.

However, past one or two decades, adoption of poor management practices such as closer spacing, using local seedlings for planting, non-adoption of proper manures and fertilizers, poor pest and disease management, etc. led poor yield and income to the farmers. There are farms where the farm and home are together, where there is a lot of scope for integrating the cropping with animal components. Those farms identified and IFS models demonstrated to enhance the productivity, profitability and sustainability of farmers.

MATERIAL AND METHODS

Location and demonstration

Farmers' participatory integrated farming system (IFS) was demonstrated in the farmers' field of Kanyakumari district, Tamil Nadu, during 2016-2017. The district is located in the southern part of Tamil Nadu, classified as high rainfall zone that receives 1369 mm per annum. Rainfall is received both southwest and northeast monsoon seasons besides summer and winter showers.

Detailed field survey of coconut farmers was conducted in all nine blocks of the district, and secondary data was obtained from the line department officials about the farmers' dwelling. Based on the survey report, the farms were visited personally and the farmers were interacted to know their interest in promoting IFS in their farm as a demonstration unit and finally, the farmers were selected. Based on the current scenario like the land area under cultivation, coconut cropped area in their field, animals reared, shelters for animals, feed for the animals, crop wastes (straw or stalk) management, etc. the components of IFS were chosen.

Four different coconut-based IFS models were demonstrated at the farmers' field during 2016-17. Details of IFS components are given in Table 1.

Model 1: Coconut + Cow + Biogas + Vermi-compost

Model 2: Coconut + Cow + *Desi*-chicken + *Azolla* + Vermi-compost

Model 3: Coconut + Goat + *Azolla* + Vermi-compost

Model 4: Coconut + Goat + Cow + Turkey + *Azolla* + Vermi-compost.

The fodder requirement of the animal component is met through fodder crops such as Bajra napier grass [*Pennisetum glacum* x *P. purpureum* - CO (BN) 5], guinea grass [*Panicum maximum* - Co (GG) 3], *Desmanthus virgatus* and border crops such as Agathi (*Sesbania grantiflora*), Subabul (*Leuciana leucacephala*), etc.

Recycling process

In dairy-based IFS, fodder was raised under coconut trees and fed to the cows as green fodder. Cow-dung was utilized for the production of biogas, the gas was utilized for home consumption, and slurry let out from the biogas units was dried properly before feeding the vermi-worms for the production of the vermicompost. The cow-dung also directly fed to the vermicompost after proper partial decomposition and drying. The compost, in turn, made available to the crops (both coconut and fodder).

In goat/*Desi*-chicken based IFS, the waste let out by the goat or *Desi*-chicken birds or turkey birds are fed to the vermi-worms as feed material after partial decomposition. *Azolla* was utilized as feed for the poultry birds, which contains more protein. The vermicompost was in-turn, fed to coconut and fodder crops. Fodder was utilized for goat in addition to birds.

Evaluation of IFS

Productivity in terms of coconut yield and component yield (dairy, turkey, goat, and *Desi*-chicken birds) were recorded and expressed as Coconut equivalent yield (CEC) as follows.

$$\text{Coconut equivalent yield (kg/ha)} = \frac{\text{Productivity of component (kg/ha)} \times \text{Cost of component (Rs./unit)}}{\text{Cost of coconut (Rs./kg)}}$$

Economic parameters like cost of cultivation, gross return, the net return, benefit-cost ratio and per day return were worked out and expressed as Rs./ha. Gross return was calculated based on the productivity of cropping (Coconut), dairy, vermicompost, turkey, goat and *Desi*-chicken birds. Net return was calculated by deducting the cost of cultivation from gross return. Benefit-cost ratio was worked out for each treatment by dividing the gross return by the cost of cultivation.

Nutrient addition in terms of quantity of ultimately produced vermicompost by each unit was assessed and expressed in kg. In conventional farmers' practice, the manure obtained was taken into consideration. Based on nutrient content (N, P, and K) in the manures, the nutrients gain was worked out by multiplying the quantity of manures with the nutrient content.

RESULTS AND DISCUSSION

System productivity

The productivity of the respective components integrated into each system was finally converted to coconut equivalent yield (CEY) based on the

Table 1. Components of IFS

IFS Model	Area of coconut (ha)	Cow (No.)	Goat (No.)	Desi-chicken birds (No.)	Turkey (No.)	Bio-gas (m3)	Azolla	Vermicompost
1	0.4	2	-	-	-	1.0	-	+
2	1.0	20	-	50	-	-	+	+
3	0.3	-	5	-	-	-	+	+
4	1.0	2	35	-	20	-	+	+

Note: (-) Component is absent in the IFS (+) Component is included in the IFS

prevailing unit cost of crop produces and allied components. System productivity was worked out from various components combined in the different IFS units is presented in Table 2.

Table 2. System Productivity (Coconut equivalent yield) of coconut-based integrated farming system units

Farming system	Component productivity (kg ha^{-1})					
	Cropping (Coconut)	Cow	Turkey	Goat	Desi-chicken	System productivity
Coconut + Cow + Biogas + Vermi-compost	8092	13623	0	0	0	21715
	(37.3%)	(62.7%)				(100.0%)
Coconut + Cow + Desi-chicken + Azolla + Vermi-compost	3002	40909	0	0	2273	46184
	(6.5%)	(88.6%)			(4.9%)	(100.0%)
Coconut + Goat + Azolla + Vermi-compost	9990	0	0	7568	0	17558
	(56.9%)			(43.1%)		(100.0%)
Coconut + Goat + Cow + Turkey + Azolla + Vermi-compost	8568	4091	3409	7955	0	24023
	(35.7%)	(17.0%)	(14.2%)	(33.1%)		(100.0%)

Data not statistically analysed.

Values in parenthesis indicates the percentage contribution of individual component to the total

The system productivity in terms of CEY was varied among the IFS units due to the components combined. Maximum system productivity (46184 kg/ha) was obtained in IFS model 2 comprising of Coconut + Cow + *Desi*-chicken + *Azolla* + Vermicompost. In this system, cow component had contributed 88.6 per cent (40909 kg/ha) to the total productivity compared to the base component coconut with the production of 3002 kg/ha. All other IFS models had produced almost half of the system productivity (17558 to 24023 kg/ha) to model 2. The next best IFS model based on the system productivity was model 4 (Coconut + Goat + Cow + Turkey + *Azolla* + Vermicompost) with CEY of 24023 kg/ha. On the contrary to model 2, in model 4, the contribution of cow was much lesser (17.0%) to the total productivity, but, the contribution made through cropping (coconut) and the goat was 35.7 per cent (8568 kg/ha) and 33.1 per cent (7955 kg/ha), respectively.

Table 3. System Productivity (Coconut equivalent yield) of farmers' farming practice

Farming system	Component productivity (kg ha^{-1})			
	Cropping (Coconut)	Cow	Turkey	System productivity
Coconut	7568	0	0	7568
	(100.0%)			(100.0%)
Coconut + Cow	6255	25491	0	31745
	(19.7%)	(80.3%)		(100.0%)
Coconut	6660	0	0	6660
	(100.0%)			(100.0%)
Coconut + Cow + Turkey	5682	4091	2727	12500
	(45.5%)	(32.7%)	(21.8%)	(100.0%)

Data not statistically analyzed.

Values in parenthesis indicate the percentage contribution of the individual component to the total

The least productivity (17558 kg/ha) was recorded with model 3 (Coconut + Goat + *Azolla* + Vermicompost). The variation among IFS models was mainly due to the choice and size of components integrated in the IFS. In model 4, higher system productivity was recorded due to the cow component, which had shared about 88.0 per cent. Milch animals guaranteed better income due to the lucrative price of milk besides ensuring the availability of year-round manure to the base crop (Coconut). Singh *et al.* (2013) and; Desai (2015) also obtained higher income in IFS due to the inclusion of milch cows in their system.

Table 4. Comparing system productivity (CEY) of IFS with farmers' practice

IFS Model	IFS components	Farmers practice	Coconut equivalent yield (kg/ha)		Yield increase (kg/ha)	Percentage increase
			IFS	Farmers practice		
1	Coconut + Cow + Biogas + Vermi-compost	Coconut	21715	7568	14147	187
2	Coconut + Cow + *Desi*-chicken + *Azolla* + Vermi-compost	Coconut + Cow	46184	31745	14439	45
3	Coconut + Goat + *Azolla* + Vermi-compost	Coconut	17558	6660	10898	164
4	Coconut + Goat + Cow + Turkey + *Azolla* + Vermi-compost	Coconut + Cow + Turkey	24023	12500	11523	92

Data not statistically analyzed.

Yield increase (kg/ha) of IFS over farmers' practice

Percentage increase by IFS over farmers' practice

All the IFS models had produced higher system productivity compared to the respective conventional farming units (Table 3). Wherever the cow/goat component was included, its contribution was much higher than the cropping component. In general, the inclusion of cow components in IFS increases the scope of production of more manure (cow dung), which was either be used for the production of biogas and further, was fed to vermi-worms as a feed or directly for the production of vermicomposting. Bird component was combined with *Azolla*, which provided additional assurance of feed to the animals in general and birds, in particular. This has reduced the input cost, which in turn increased the system productivity. Economic advantages of the dairy component in irrigated areas, as reported earlier by Sivamurugan (2001) and Jayanthi *et al*. (2009) are concomitant to the present finding.

Table 5. Comparative economic analysis of IFS with farmers' practice

IFS model	Gross return (Rs./ha)		Total cost of cultivation (Rs./ha)		Net return (Rs./ha)		B:C ratio		Per day return (Rs.)	
	IFS	FP	IFS	FP	IFS	FP	IFS	FP	IFS	FP
1	477722	166500	149850	133200	327872	33300	3.19	1.25	898	91
2	1016048	698400	274000	544000	742048	154400	3.71	1.28	2033	423
3	386280	146520	163170	99900	223110	46620	2.37	1.47	611	128
4	528496	275000	165000	185000	363496	90000	3.20	1.49	996	247

Data not statistically analyzed.

IFS – Integrated farming system FP – Farmers' practice

Model 1: IFS: Coconut + Cow + Biogas + Vermi-compost; FP: Coconut

Model 2: Coconut + Cow + *Desi*-chicken + *Azolla* + Vermi-compost; FP: Coconut + Cow

Model 3: Coconut + Goat + *Azolla* + Vermi-compost; FP: Coconut

Model 4: Coconut + Goat + Cow + Turkey + *Azolla* + Vermi-compost; FP: Coconut + Cow + Turkey

The increase of CEY due to the implementation of IFS over the farmers' existing practice was ranged between 6660 and 31745 kg/ha (Table 3 and 4). Though the increase of CEY was higher in model 2 (Coconut + Cow + *Desi*-chicken + *Azolla* + Vermicompost), the percentage of increase of CEY over the farmers' practice was more (187% and 164%) in model 1 (Coconut + Cow + Biogas + Vermicompost) and model 3 (Coconut + Goat + *Azolla* + Vermicompost), respectively. This was due to the reason that milch cows were the component in the farmers' practice itself in model 2 and hence, there was no much change in the CEY. However, in the model 1 and model 4, in the farmers' practice, there was no animal components (milch cow) and the when milch cows and goats were included in IFS model 1 and 3, respectively, the CEY had increased. It indicates the dominance of animal components (milch cows or goats) in the IFS models. Singh *et al.* (1993) and Murugan (2015) already reported that the addition of milch cow sustained the IFS farm holdings. Similarly, Esther Shekinah (2005) and Ramasamy *et al*. (2015) also enlightened the impact of the inclusion of goats in IFS.

Economics

The economics of the integrated farming system and also, the conventional farming was analyzed in terms of gross return, the net return, benefit-cost ratio, and per day return for the component combinations (Table 5).

Among the different integrated farming systems, the highest gross return (Rs. 1016048/ha) and net return (Rs. 742048/ha) were obtained due to the integration of Cow + *Desi*-chicken + *Azolla* + Vermicompost with Coconut (Model 2). This system also resulted in a higher per day return of Rs. 2033 with a benefit-cost ratio of 3.71. It was followed by the combination of Cow + Goat + Turkey + *Azolla* + Vermicompost with Coconut (Model 4), which recorded higher net return (Rs. 363496/ha) and per day return of Rs. 996. All other integrated farming system units had produced lower per day

return than these two systems. Invariably, all the farmers practices did record lower gross return (Rs. 146520 to 698400/ha), net return (Rs. 33300 to 154400/ha), B:C ratio (1.25 to 1.49) and per day return (Rs. 91 to 423) compared to all the IFS models and also to the respective IFS models under demonstration. Higher productivity from milk yield from a cow at higher market price (Rs. 40/litre) as door delivery mechanism besides more market demand for *Desi*-chicken birds which fetched higher price had increased the gross and net returns with Cow + Goat + Turkey + *Azolla* + Vermi-compost integrated farming system. Higher benefit-cost ratio (3.97) was recorded under the above-said farming system was mainly due to increased income and reduced cost of expenditure. Expenditure was reduced in the farming system was mainly due to the reduction of fodder cost, which was grown in the farm itself, and *Azolla* was produced on the farm which was fed to the animals and birds. Besides, the Vermicompost produced through the wastes was well utilized for the production of fodder and also to Coconut. Rangasamy *et al.* (1990); and Kandasamy (1998) also reported higher income in dairy and poultry-based farming system than cropping alone. Integration of improved cropping system with dairy and allied enterprises increased the per day return compared to cropping alone as reported by Sivamuruagn (2001) and Thirukumaran (2002) is concomitant to the present finding.

Manure production and nutrient addition

Manures emanated from animal components, and thereby the production of vermicompost and their nutrient addition in terms of nitrogen, phosphorus and potassium are given in Table 6.

Table 6. Manure production and nutrient accumulation in IFS and farmers' practice

IFS Model	Manure obtained (kg/ha)		Vermi-compost produced (kg/ha)		Nutrients added (kg/ha)					
					Nitrogen		Phosphorus		Potassium	
	IFS	FP	IFS	FP	IFS	FP	IFS	FP	IFS	FP
1	12155	0	7902	0	165.9	0	64.0	0	95.6	0
2	31675	26200	19026	0	386.2	131.0	159.8	52.4	247.3	103.8
3	5461	0	3280	0	94.8	0	39.4	0	61.0	0
4	4223	2982	3012	0	69.9	14.9	23.8	6.0	43.1	11.8

Data not statistically analysed.

IFS – Integrated farming system FP – Farmers' practice

Model 1: IFS: Coconut + Cow + Biogas + Vermi-compost; FP: Coconut

Model 2: Coconut + Cow + *Desi*-chicken + *Azolla* + Vermi-compost; FP: Coconut + Cow

Model 3: Coconut + Goat + *Azolla* + Vermi-compost; FP: Coconut

Model 4: Coconut + Goat + Cow + Turkey + *Azolla* + Vermi-compost; FP: Coconut + Cow + Turkey

Irrespective models, manures obtained from IFS models were much higher (4223 to 31675 kg/ha) than the manure from farmers' practice (0 to 26200 kg/ha). Higher quantum of manures generated in the IFS models was mainly due to an increased number of animal components, which yielded more manures. Equally, the nutrients added were also higher in IFS models compared to farmers conventional practice. A higher quantity of manures from the IFS models, in turn, increased the quantity of nutrients. Besides, in all IFS models, the manures were converted into vermicompost which naturally have more nitrogen (2.03 to 2.80%), phosphorus (0.79 to 1.21%) and potassium (1.21 to 1.86%) content compared to manures (FYM) which contained 0.48 to 0.52 per cent nitrogen, 0.19 to 0.22 per cent phosphorus and 0.38 to 0.44 per cent potassium content. Among IFS models, model 2 produced an increased quantity of manure, vermicompost (31675 kg/ha), and nutrient addition (386.2 kg nitrogen, 159.8 kg phosphorus and 247.3 kg potassium) compared to all other models. The attributed reason was that the model is dominated by milch cows, which would produce more manures compared to the other ruminant (goat) and *Desi*-chicken and turkey. Thirukumaran (2002), Esther Shekeinah (2005); and Murugan (2015) also had a similar opinion that compared to conventional practices, IFS would produce more manures and in turn, nutrient addition.

CONCLUSION

The demonstration results revealed that the model 2 had produced the highest system productivity (46184 kg/ha), gross return (Rs. 1016048/ha) and net return (Rs. 742048/ha) and also B:C ratio (3.71). Besides, the model also generated more manures and added more nutrients compared to others. The income of conventional farming systems in their respective all units' was lower than the IFS. Hence, it is concluded that the IFS approach not only enhancing the system productivity but also the economics returns. Among different units, Coconut + Cow + *Desi*-chicken + *Azolla* + Vermicompost was more economical and would sustain the production and profit of coconut farmers compared to all other integrated farming systems and conventional farmers' practices in high rainfall zone of Tamil Nadu.

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