Indian Journal of Agronomy **59** (4): 518–526 (December 2014)

Research Paper

Evaluation of different integrated farming systems under irrigated situations of Maharashtra

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Received : July 2013; Revised accepted : August 2014

ABSTRACT

Three farming system models were evaluated during 2008–09 and 2009–10 at Rahuri, Maharashtra, to study their effect on the economic returns, water productivity, employment generation, energy balance and soil health improvement. On-station integrated farming system (IFS), model-I, involving field crops, horticulture, dairy, poultry and fishery was developed at the research farm. Similarly, an on-farm IFS model involving crop, dairy, poultry was developed in Digraj village of Ahmednagar district (model-II). An on-station cropping sequence model involving soybean [*Glycine max* (L.) Merr.]–wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] was taken for comparison (model-III). These models were developed in 2.0 ha area under irrigated condition. On-station and on-farm IFS models were found more remunerative than the on-station cropping sequence model, showing maximum net returns of ₹1,99,848, water productivity (₹991/ha-cm), employment generation (1,275 mandays/ha/year) and energy balance (4,11,949 MJ/ha), while the on-farm IFS model resulted ₹48,477, ₹406/ha-cm, 657 man-days/year and 3,25,528 MJ/ha values of these parameters respectively. These values for the Model-III were the minimum with ₹32,613, ₹375/ha-cm, 227 man-days and 1,53,379 MJ respectively. Thus, integrated farming system (IFS) proved promising and remunerative to soybean–wheat cropping system with higher net returns, water productivity, employment generation and energy output.

Key words : Integrated farming system, Economics, Energy, Water productivity, Employment generation

Farming system is a complex inter-related matrix of soil, plants, animals, implements, power, labour, capital and other inputs controlled by farming families and influenced to varying degrees by political, economical, institutional and social forces that operate at many levels (Mahapatra,1992). Farming systems research is considered a powerful tool for natural and human resource management in developing countries like India. This is a multidisciplinary whole-farm approach and effective in solving the constraints of small and marginal farmers. The approach aims at increasing income and employment from smallholdings by integrating various farm enterprizes and recycling of crop residues and by-products within the farm itself (Behera and Mahapatra, 1999; Singh *et al.*, 2006).

The human population of India has increased to 1,210.2 million at a growth rate of 1.76% in 2011 over 2001 (1,028.7 million) and is estimated to increase further to 1530 million by 2030 (Census of India, 2011). The national foodgrain production for last 3–4 years was hovering around 234 million tonnes. The per capita foodgrain production is only about 193 kg/year. There are projections that demand for foodgrains would increase from 234 million tonnes in 2009–10 to 345 million tonnes in 2030 (Government of India, 2009). Hence, in the next 2 decades the production of food grains needs to be increased @ of 5.5 million tonnes annually. Simultaneously, the demand for high-value commodities, viz. fruits, vegetables, livestock products, fish, poultry etc., is increasing faster than foodgrains, and is expected to increase by more than 100% from 2000 to 2030. The farming system has huge potential for diversification in India and its importance increasingly recognized and focused for utilization of available potential. Changing consumption and demand patterns and new trade opportunities have provided impetus to greater diversification of farming systems through emphasis on horticulture, animal husbandry, milk, poultry, fish and other animal products, non-food crops such as fibre, mushroom, spices and condiments, medicinal and

Based on a part of Ph.D. Thesis of the first author submitted to Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra 2010 (unpublished)

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aromatic plants and agro-forestry. These enterprizes need to be emphasized through scientific land use planning and resource optimization.

Crop diversification is governed mostly by price fluctuation in the market and inclusion of new crops in production system, with a view to utilize unexplored and little explored resources to raise the income. Diversification should not be restricted to crop and cropping system only but also to farm enterprizes like dairy, horticultural crops, vegetables, fisheries and poultry. The goal of diversification in agriculture is to stabilize the farm income particularly on small farms and to withstand the challenges of trade liberation. Therefore, crop diversification from less-remunerative to more-remunerative crops, need-based, demand driven, location specific and national goal seeking is a continuous and dynamic concept, which involves spatial, temporal, value-addition and resource-complementary approaches. This diversified food basket will provide food security and improve the quality of life by adding to nutritional status of people.

Integrated farming system approach is not only a reliable way of obtaining fairly high productivity with considerable scope for resource recycling, but also a concept of ecological soundness leading to sustainable agriculture. Farming system represents an appropriate combination of farm enterprises, viz. cropping systems, horticulture, livestock, fishery, forestry, poultry and the means available to the farmers to raise them for profitability. The goals of sustainable integrated farming systems are soil and water conservation, soil-productivity restoration, improvement in air and water quality, reduction in the use of external inputs, overall increase in farm productivity and income.

MATERIALS AND METHODS

The present investigation was conducted during 2008–09 and 2009–10. The experiment was conducted at 3 locations, out of which the on-farm IFS model-I (crop, horticulture, dairy, poultry and fishery) was taken up at All India Co-ordinated Research Project on Water Management (AICRPWM), Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, on 2.0 ha area, while the on-farm IFS model-II (Crop, dairy and poultry) was taken on 2.0 ha area in the village Digraj, Rahuri, Ahmednagar and the on-station sequence cropping model-III (soybean-wheat) was under-taken at F-Block, Central Campus, Mahatma Phule Krishi Vidyapeeth, Rahuri, on 2.0 ha area.

The physical and chemical properties of soil in 3 farming system models were determined by adopting standard methods. Geographically, the Central Campus of the MPKV, Rahuri (19° 47' – 19° 57' N, 74° 84' – 74° 19' E and 495–569 m above mean sea level). The region comes under semi-arid tropical zone with an average rainfall of 520 mm. The rainfall is erratic and unevenly distributed in 15 to 45 rainy days. Agro-climatically, the area comes under the drought-prone area of Maharashtra. The maximum and minimum weekly temperature during the study period ranged from 26.1–40.8 and 7.8°C–23.9°C respectively. The mean weekly morning relative humidity was 44–90% and evening humidity ranged from 13–74%. The mean pan evaporation was 4.39 mm with maximum pan evaporation of 12.4 mm in May.

The on-station integrated farming system model consisted of various components (Table 1) on 2.0 ha area, viz. crop (1.50 ha), horticulture (0.40 ha pomegranate orchard), dairy (2 Phule Triveni milking cow), poultry (200 Rhode Ireland Rhode birds/batch), fishery (in 0.05 ha farm pond area 400 fingerlings of composite culture of catla, rohu and mrigal), farm shed, cowshed and poultry house on an area of 0.05 ha. The on-farm integrated farming system model consisted of various components, viz. crop (1.95 ha), dairy (1 Jersey cow), poultry (10 birds), cow and poultry shed on an area of 0.05 ha. The entire model was laid on an area of 2.00 ha and on-station cropping sequence model consisted of only crop component, i.e soybean in the rainy season (*kharif*) and wheat in winter (*rabi*) season, and in the summer season the whole area was kept as fallow. The entire model was laid on an area of 2.00 ha.

In all the 3 models, the seeds of cereal, pulses, oilseeds, forage and vegetable crops were obtained from Seed Cell Unit of the Mahatma Phule Krishi Vidyapeeth, Rahuri, while in on-station IFS model, the seedlings of banana were purchased from a firm of Jalgaon. In case of horticultural component, the pomegranate seedlings were obtained from the Central Nursery of the MPKV, Rahuri. In dairy

Table 1. Components of integrated farming system models

Component	Area (ha)	Area allotted (%)
Model-I : (On-station IFS model)		
Crop production	1.50	75.00
Horticulture (Pomegranate–Bhagwa)	0.40	20.00
Dairy (Two Phule Triveni cow)	0.05	2.50
Poultry (200 RIR birds/batch)		
Fishery (400 fingerlings of integrated culture of catla, rohu and mrigal fish)	0.05	2.50
Total	2.00	100.00
Model-II : (On-farm IFS model)		
Crop production	1.95	97.50
Dairy (one Jersey cow)	0.05	2.50
Poultry (10 Local birds)		
Total	2.00	100.0
Model-III : (On-station cropping model)		
Soybean-wheat-fallow	2.00	100.0
Total	2.00	100.0

component, 2 Phule Triveni cows were purchased from Cattle Unit of this University. In poultry component, the poultry birds were purchased from a Poultry firm, Ahmednagar. In fishery component, the fish fingerlings of *catla, Rohu and Mrigal* were purchased from the office of fishery, Mula dam, Rahuri. For plant protection measures the insecticides and fungicides were purchased from private agri-clinic centres, while the medicines required for dairy and poultry component were purchased from medical stores.

The source of irrigation water in on-station integrated farming system model was from 2 tube-wells with a 7 HP and 3 HP submersible pumps and also Mula canal water while in on-farm integrated farming system model was only one well with a 5 HP electric pump and in on-station cropping sequence model, canal water was the source of irrigation.

The cropping programme followed in on-station integrated farming system model during the year 2008–09 and 2009–10 is given in Table 2.

Sugarcane, banana, lucerne and hybrid napier are perennial crops. Hence these crops were grown during 2008–09 and 2009–10. The additional crops like sorghum, pigeonpea and onion were grown during the *kharif* followed by wheat and sweet corn in the *rabi* during 2008–09. During 2009–10, in the *kharif* season soybean and okra crops were taken followed by wheat and leafy vegetables fenugreek and spinach in the *rabi* season.

The cropping programme followed in on-farm integrated farming system model during the 2008–09 and 2009–10 are given in Table 3. The farmer had grown sugarcane as a perennial crop during both the years as a fresh crop as well as a ratoon crop, while lucerne was grown as a perennial crop during both the years as a forage crop for animal component. The lucerne crop was grown on 0.20 ha area but the animal component was only one jersey cow hence surplus lucerne green fodder was sold in the market. During 2008–09, pigeonpea soybean and groundnut were taken during the *kharif* followed by wheat in *rabi* season. During 2009–10, soybean were grown in *kharif* on 0.80 ha area followed by wheat on 0.20 ha and chickpea on 0.40 ha area in *rabi* season.

The cropping programme followed in on-station cropping model during 2008–09 and 2009–10 is given in Table 4. During 2008–09 and 2009–10 in soybean–wheat sequence cropping model, the soybean was grown on 2.0 ha area in the *kharif* season followed by wheat in the *rabi* season. During summer season whole area was kept as a

Table 2. Cropping programme followed in on-station IFS model during the year 2008-09 and 2009-10

2008–09					
Summer 2008		Rainy season 2008		Winter 2008–09	
Crop	Area (ha)	Crop	Area (ha)	Crop	Area (ha)
Lucerne	0.10	Lucerne	0.10	Lucerne	0.10
Hybrid napier	0.05	Hybrid Napier	0.05	Hybrid Napier	0.05
Sugarcane	0.30	Sugarcane	0.30	Sugarcane	0.30
Banana	0.40	Banana	0.40	Banana	0.40
-	-	Sorghum	0.20	Wheat	0.55
-	-	Pigeon pea	0.35	–	–
-	-	Onion	0.10	Sweet corn	0.10
Cropped area	0.85		1.50		1.50
Fallow area	0.65		–		–
Total area	1.50		1.50		1.50
2009–10					
Summer 2009		Rainy season 2009		Winter 2009–10	
Crop	Area (ha)	Crop	Area (ha)	Crop	Area (ha)
Lucerne	0.10	Lucerne	0.10	Lucerne	0.10
Hybrid napier	0.05	Hybrid Napier	0.05	Hybrid Napier	0.05
Sugarcane (R)	0.30	Sugarcane (R)	0.30	Sugarcane (R)	0.30
Banana	0.40	Banana	0.40	Banana	0.40
-	-	Soybean	0.55	Wheat	0.55
-	-	Okra	0.10	Leafy vegetables	0.10
Cropped area	0.85		1.50		1.50
Fallow area	0.65		–		–
Total area	1.50		1.50		1.50

Table 3. Cropping programme followed in on-farm integrated farming system model during the year 2008–09 and 2009–10

2008–09					
Summer 2008		Rainy season 2008		Winter 2008–09	
Crop	Area (ha)	Crop	Area (ha)	Crop	Area (ha)
Sugarcane	0.75	Sugarcane	0.75	Sugarcane	0.75
Lucerne	0.20	Lucerne	0.20	Lucerne	0.20
Fallow	1.00	Pigeonpea	0.20	Wheat	0.60
		Soybean	0.60	Fallow	0.40
		Groundnut	0.20		
Cropped area	0.95		1.95		1.55
Fallow area	1.00		—		0.40
Total area	1.95		1.95		1.95
2009–10					
Summer 2009		Rainy season 2009		Winter 2009–10	
Crop	Area (ha)	Crop	Area (ha)	Crop	Area (ha)
Sugarcane	0.75	Sugarcane	0.75	Sugarcane	0.75
Lucerne	0.20	Lucerne	0.20	Lucerne	0.20
Fallow	1.00	Soybean	0.80	Wheat	0.20
		Fallow	0.20	Chickpea	0.40
				Fallow	0.40
Cropped area	0.95		1.75		1.55
Fallow area	1.00		0.20		0.40
Total area	1.95		1.95		1.95

Table 4. Cropping programme followed in on-station sequence cropping model during year 2008–09 and 2009–10

2008–09					
Summer 2008		Rainy season 2008		Winter 2008-09	
Crop	Area (ha)	Crop	Area (ha)	Crop	Area (ha)
Fallow	2.00	Soybean	2.00	Wheat	2.00
Cropped area			2.00		2.00
Fallow area	2.00		-		-
Total area	2.00		2.00		2.00
2009–10					
Summer 2009		Rainy season 2009		Winter 2009-10	
Crop	Area (ha)	Crop	Area (ha)	Crop	Area (ha)
Fallow	2.00	Soybean	2.00	Wheat	2.00
Cropped area			2.00		2.00
Fallow area	2.00		-		-
Total area	2.00		2.00		2.00

fallow.

In on-station integrated farming system model, the recommended packages of practices adopted for getting higher yield from all the crops grown under crop and horticulture component are given in Table 5. Land preparation was carried out with the help of tractor–drawn implements. Most of the intercultural operations in case of sugarcane, banana and pomegranate were carried manually as well as by using power tiller. All plant–protection measures whenever necessary were carried out as per recommended schedule. Sowing of agronomical crops was done with the help of tractor drawn ferti-seed drill. Transplanting was done in vegetable crops, i.e. chilli and brinjal, and dibbling was done in okra and sweet corn. Planting operation was carried out for sugarcane, banana and pomegranate. All the crops were sown as per the recommended plant spacing. In on-farm integrated farming system model, the land preparation as well as sowing of different crops was done by hiring the bullocks. In research farm cropping sequence model, the land preparation, sowing of soybean

Table 5. Agronomic practices followed in on-station integrated farming system model (model-I)

Name of crop	Season	Planting method	Seed rate/ha	Spacing	Fertilizer dose (NPK kg/ha)	Variety
Cash crops						
Sugarcane	*Suru*	Paired planting	20,000 two-eye budded sets	90-180 × 30 cm^2	250:115:115	'Co 86032'
Banana	*Kande bahar*	Row planting	3,265 plants	1.75 × 1.75 m^2	200:40:200 g/plant	'Grand Naine'
			Cereal crops			
Wheat	Winter	Drilling	100 kg	22.5cm	120:60:40	'HD2189', Trimbak
Sorghum	Rainy season, *rabi*	Drilling	40 kg	–	100:50:50	'Phule Mauli'
Sweet corn	Rainy season	Dibbling	10 kg	60 × 30 cm	100:50:50	Sugar 75
			Pulse crops			
Soybean	Rainy season	Drilling	75 kg	45 × 10 cm	50:75:00	'JS 335'
Pigeonpea	Rainy season	Drilling	15 kg	45 × 10 cm	25:50:00	'ICPL 87'
			Vegetable crops			
Onion	Rainy season	Transplanting	8–10 kg	15 × 10 cm	100:50:50	'Phule Samartha'
Okra	Summer	Dibbling	12–15 kg	30 × 15 cm	100:50:50	'Phule Utkarsha'
			Forage crops			
Lucerne	Perennial	Drilling	25 kg	30 cm	15:150:40 at the time of sowing	'RL 88'
Maize fodder	Rainy season, *rabi,* summer	Drilling	75 kg	30 cm	100:50:50	'African tall'
Hybrid Napier	Perennial	Transplanting	40,000 setts	90 × 60 cm	50:40:20 at sowing and 25 kg N after every cutting	'Phule Jaiwant'
Horticulture crops						
Pomegranate	Perennial	Row planting	750 plants	4.50 × 3.00 m^2	625:250:250 g/plant	'Bhagwa'

in *kharif* and wheat in *rabi* season was done with the help of tractor-drawn implements.

The crops grown in on-station integrated farming system model were manured with farm yard manure received from dairy component. For crops like sugarcane, banana and pomegranate, the green manuring with sunhemp was done before planting of these crops to enrich the soil with organic matter. In addition, droppings received from poultry unit were also applied to high remunerative vegetable crops. In on-farm integrated farming system model, the farmyard manure obtained from one jersey cow was used for crop component while in research farm cropping sequence model, the general recommended dose of fertilizer was applied.

The fertilizer management in on-station integrated farming system model of crop component was fulfilled through urea, single superphosphate and muriate of potash and other mixed fertilizers. Whenever necessary, micronutrient application was carried out as per the recommended schedule. Most of the crops were grown under pressurized irrigation systems. The fertigation was done with the help of water soluble fertilizers, viz. 19:19:19, 0:52:34, 13:0:45, 12:61:0, 13:40:13, 17:44:0 and 0:0:50 of N: P_2O_5 K_2O respectively. In on-farm integrated farming system model, the nutrient need of crops was fulfilled through urea, single superphosphate and muriate of potash and other mixed fertilizers. In on-station cropping model, the nutrient need of crops was fulfilled through urea, single superphosphate and muriate of potash and other mixed fertilizers. Whenever necessary, micronutrient application was carried out as per the recommended schedule.

The water requirement of all the components in different farming system models were worked out. In on-station integrated farming system model, irrigation was scheduled at alternate day for the crops irrigated by drip irrigation and in micro-sprinkler irrigations was scheduled at every 3 days interval. The irrigation water requirement of crops taken under drip and sprinkler were calculated as per following formulae.

Net irrigation requirement (NIR)

$$NIR = CPE \times Kp \times Kc \times Wa \times Es \times Ls \quad \dots \text{ for drip}$$

$$NIR = CPE \times Kp \times Kc \quad \dots \text{ for sprinkler}$$

Gross irrigation requirement (GIR)

The total quantity of irrigation water was applied during each irrigation and it was calculated as :

$$GIR = \frac{NIR}{UC}$$

Irrigation was done on the basis of cumulative pan evaporation. The quantity of water applied per plot per irrigation was calculated and measured in the field with the help of replogal flume. During the *kharif* season, irrigation was done by considering the amount of precipitation received between 2 irrigations. In on-farm integrated farming system model and sequence cropping model the irrigation was applied to crops as per the critical growth stages of the crop.

The daily water requirement for dairy and poultry were measured considering the water requirement for drinking, washing, cleaning and other domestic use. The water requirement of fishery unit was calculated by considering the daily pan evaporation and quantity of water added to maintain maximum depth of water for fish development.

Water budgeting was calculated in the way of how much water was available from the different water sources, viz. canal, well, tube-well and precipitation. Water budgeting is very important while deciding the cropping pattern as well as selection of different components in farming system.

The water productivity of each component in different farming system models was worked out as:

$$\text{Water productivity (₹/ha-cm)} = \frac{\text{Net income of component (₹)}}{\text{Quantity of water utilized for each component (ha-cm)}}$$

The component-wise as well as model-wise energy balance was worked out by subtracting the energy input from energy output. The energy balance (input and output) of different components was worked out by the procedure given by Verma *et al.* (1994).

The labour required for various activities in crop production given as man-days/ha/year. A man working for 8 hours in a day is considered as 1 man-day. A woman working for the same period is treated as 2/3 man-days and computed to man-days.

Three farming system models under irrigated conditions were evaluated to find out the economic viability, water productivity, employment generation, energy balance and soil health improvement of each model.

RESULTS AND DISCUSSION

Economics

The average cost of cultivation in on-station IFS model-I was ₹ 3,61,731, while it was ₹95,773 in on-farm IFS model-II and ₹53,550 in sequence cropping model (soybean–wheat) (Fig. 1). The average gross income from in on-station IFS model-I was ₹5,61,578, while in on farm IFS model-II it was ₹1,44,250. The minimum average gross income was ₹86,163 in on-station sequence cropping model (soybean–wheat).

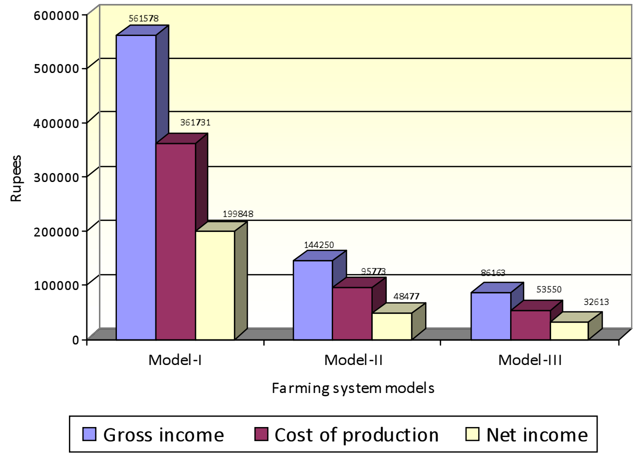

Fig. 1. Average economics of different farming system models, Model-I: On-station IFS model; Model-II: On-farm IFS model; Model-III: On-station cropping model

The average net income realized in on-station IFS model-I was maximum (₹1,99,848) as compared to on-farm IFS model-II (₹48,477) and in on-station sequence cropping model (₹32,613). The economics indicated the research farm integrated farming system model is economically viable.

Annual water availability

Among the 3 farming system models, the average annual water availability was higher in on-station IFS model-I (203 ha-cm), followed by on-farm IFS model-II (122 ha-cm) and on-station sequence cropping (soybean–wheat) model-III (87 ha-cm) (Table 6).

Annual water utilized

Among the 3 farming system models, the average annual quantity of water utilized was more in on-station IFS model-I (199 ha-cm), whereas in on-farm IFS model-II it was 121 ha-cm and in on-station sequence cropping model was 87 ha-cm (Table 6).

Water productivity

Among the 3 farming system models, the average water productivity was the highest in on-station IFS model-I, followed by on-farm IFS model-II and on-station sequence cropping model. The average water productivity was the highest in research farm IFS model-I (₹991 ha-cm), followed by on-farm IFS model (₹406 ha-cm) and research farm sequence cropping model-III (₹374 ha-cm.) (Fig. 2). The higher water productivity under in research farm integrated farming system model-I was mainly attributed to higher biological productivity of field crops and horticultural components and adoption of micro-irrigation system (drip and micro-sprinkler) for efficient water utili-

Table 6. Comparative performance of different farming system models

Treatment	Cost of cultivation (×10^3 ₹/ha)	Gross returns (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Annual water availability (ha-cm)	Quantity of water utilized (ha-cm)	Water productivity (₹/ha-cm)	Energy Balance (×10^3 MJ/ha)	Total employment generation (man-days/ ha/year
On-station IFS model-I	361.7	561.5	199.8	203	199	991	411.9	1275
On-farm IFS model-II	95.7	144.2	48.4	122	121	406	325.5	657
On-station cropping model-III	53.5	86.1	32.6	87	87	374	153.3	227

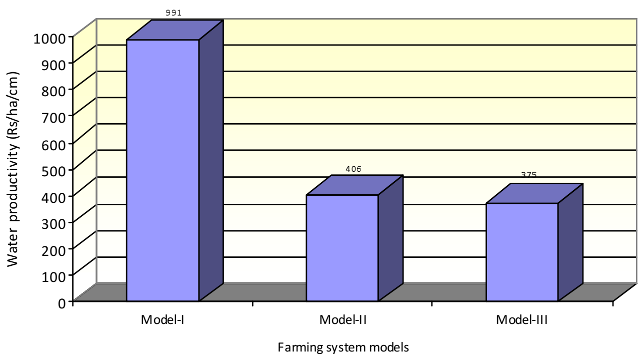

Fig. 2. Average water productivity of different farming system models, Model-I: On-station IFS model; Model-II: On-farm IFS model; Model-III: On-station cropping model

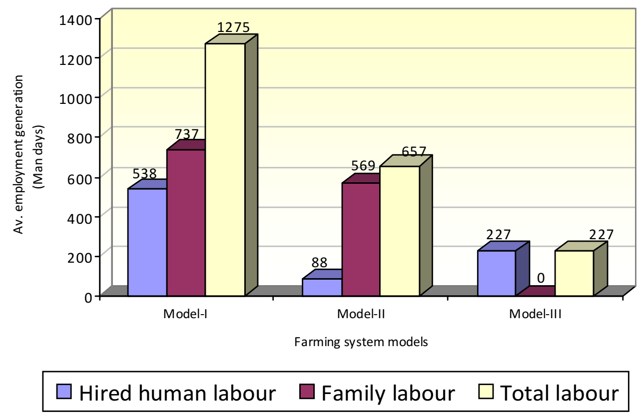

Fig. 3. Average employment generated through different farming system models, Model-I: On-station IFS model; Model-II: On-farm IFS model; Model-III: On-station cropping model

zation and inclusion of different components, viz. dairy, poultry and fishery, for diversified use of water. Thus, IFS model was more suitable for efficient water use for augmenting the water use productivity.

Employment generation

The average employment generated in farming system models were 1,275, 657 and 227 man-days respectively, in on-station IFS model, on-farm IFS model and sequence cropping model. This indicated that in research farm integrated farming system model (Model-I) was more efficient for employment generation (Fig. 3). This might be because of its diversified nature, viz. inclusion of field crop, horticultural crops, dairy, poultry and fishery components as which are competent enough for generating employment throughout the year. These results are inconformity with the findings of Ramrao *et al.* (2005), Esther Sheikinah and Sankaran N. (2007), Solaiappan *et al.* (2007) and Korikanthimath and Manjunath (2009).

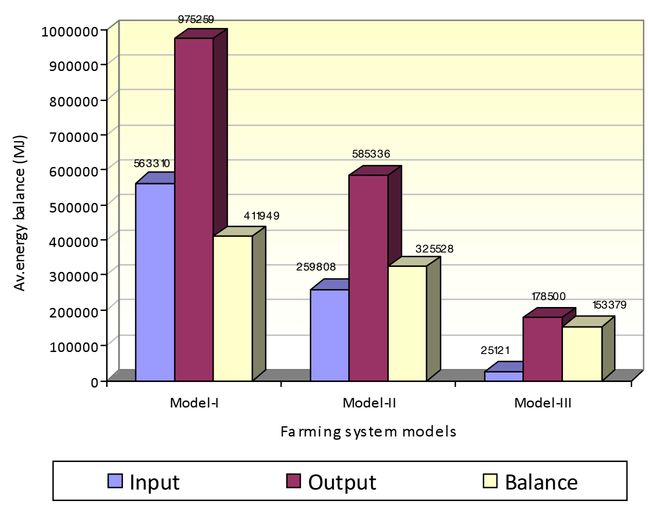

Fig. 4. Average energy balance in different farming system models, Model-I: On-station IFS model; Model-II: On-farm IFS model; Model-III: On-station cropping model

Energy balance

The average energy balance was more in on-station integrated farming system model (411,949 MJ/ha), followed by on-farm IFS model (325,528 MJ/ha) (Fig. 4). The lowest energy balance was recorded in research farm sequence cropping model (Table 6). The highest energy balance under IFS was mainly attributed to higher productivity of crop and dairy. Similar results were reported by Rangaswamy *et al.* (1996), Ramrao *et al.* (2005) and Esther Shekinah and Sankaran (2007).

Table 7. Physio-chemical properties of soil of different farming system models at initiation and after completion of research work

Soil Properties	On-station IFS model-I		On-farm IFS model-II		On-station cropping model-III	
	Initial	Final	Initial	Final	Initial	Final
Physical properties						
Texture class	Clay loam	-	Sandy clay loam	-	Clay loam	-
Field capacity (%) by weight basis	32.18	34.70	30.10	29.65	34.15	34.90
Permanent wilting point (%) by weight	19.16	18.16	17.19	17.95	20.10	20.30
Available soil moisture (%)	13.02	16.54	12.91	11.70	14.05	14.60
Bulk density (Mg/m^3)	1.34	1.24	1.40	1.37	1.30	1.25
Chemical properties						
Soil pH (1:2.5)	7.97	7.67	8.79	8.90	7.90	7.60
EC (dS/m)	0.45	0.37	0.51	0.53	0.40	0.35
Organic Carbon (%)	0.60	0.70	0.40	0.41	0.40	0.45
Available N (kg/ha)	150.52	175.16	130.5	120.0	160.5	178.2
Available P (kg/ha)	14.11	16.94	16.18	15.90	16.80	15.11
Available K (kg/ha)	616	672	480.0	455.0	490.0	478.0

Soil health

The soil pH and electrical conductivity of experimental site was 7.97 and 0.45 dS/m (Table 7). It decreased to 7.67 and 0.37 dS/m at the end of the experiment. The organic carbon content in soil increased over the years in farming system. It was 0.60% at initiation of farming system and raised to 0.70% at the end of farming system experimentation. The soil available nitrogen increased from 150.2 to 175.2 kg/ha, phosphorus 14.1 to 16.9 kg/ha and potassium 616 to 672 kg/ha respectively in research farm integrated farming system model.

In on-farm IFS model the soil pH and electrical conductivity of experimental site was 8.79 and 0.51 dS/m. It increased to 8.90 and 0.53 dS/m at the end of the experiment, might be due to less quantity of water availability in summer season, accumulation of salts and less quantity of organic matter from dairy and poultry unit. The soil available nitrogen decreased from 130.50 to 120 kg/ha, phosphorus 16.18 to 15.90 kg/ha and potassium 480 to 455 kg/ha respectively, in farming system model on farmer field.

In research farm cropping sequence model, there was an improvement in the physical as well as the chemical properties of soil. This might be due to shedding of soybean leaves at the time of physiological maturity of plant which raised the organic carbon, population of soil micro-organisms and their activity, aeration, water-holding capacity and soil-enzyme activity etc. Among the 3 farming system models, there was better improvement in fertility status of soil in research farm integrated farming system model as compared with on-farm integrated farming system model and research farm sequence cropping model.

The results revealed that the integrated farming system (2.0 ha) with enterprize combination of cropping (1.5 ha), horticulture (0.4 ha), cows (2 milking cows) and poultry (200 birds/batch) in 0.05 ha area and fishery in farm pond (0.05 ha) as per the land *ration* apportioned above is the best for the irrigated situations of Western Maharashtra. This system resulted in increased water productivity, employment generation for the family labour round the year and energy balance and better economic gains. It also provided the best avenue for recycling of resources and residue generated in the system, with resultant nutrition addition as witnessed from increased returns from the crop supplied with composted cow manure.

Thus, it can be concluded that IFS with cropping, horticulture, dairy, poultry, fishery was highly productive, profitable and efficient alternative system for conventional soybean–wheat cropping system.

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