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Performance of Integrated Farming System Models for Economic Viability, Water Productivity, Employment Generation, Energy Balance and Soil Health Improvement under Irrigated Conditions

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ABSTRACT: *Three farming system research models were selected with an aim to study the economic viability, water productivity, employment generation, energy balance and soil health improvement of models. A research farm integrated farming system model (Model-I) was carried out in All India Co-ordinated Research Project on Water Management, Mahatma Phule Krishi Vidyapeeth, Rahuri. Model-II as on-farm integrated farming system model was taken in the village Digraj, Tahsil - Rahuri and model-III as research farm sequence cropping model on soybean-wheat was taken at F-Block, Central Campus, Mahatma Phule Krishi Vidyapeeth, Rahuri, District- Ahmednagar. Each farming system model consisted of 2.0 ha area. The research farm IFS model-I under irrigated conditions proved to be more remunerative with highest average net returns of Rs.1,99,848/- indicating better economic viability, higher water productivity (991 Rs./ha.cm), better employment generation capacity (1275 man days/ha/year^{-1}), highest energy balance (4,11,949 MJ) and improvement in soil fertility status as compared to on-farm IFS model-II and research farm sequence cropping model-III. The adoption of research farm IFS model-I on large scale under irrigated conditions of Maharashtra is recommended. On the basis of this, Government of Maharashtra has implemented IFS models in Western Maharashtra, Vidharbha and Marathwada region of Maharashtra on large scale under irrigated conditions on farmer's field.*

Key words: *Integrated farming system, Water productivity, Economics, Energy balance, Employment generation and Soil health.*

INTRODUCTION

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).

The human population of India has increased to 1210.2 million at a growth rate of 1.76 per cent in 2011 over 2001 (1028.7 million) and is estimated to increase further to 1530 million by 2030 (Census of India, 2011). The per capita food grain production is only about 193 kg per year. There are projections that demand for food grains would increase from 234 million tonnes in 2009-10 to 345 million tonnes in 2030 (Government of India, 2009). Hence, in the next two 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 food grains, and is expected to increase by more than 100 per cent from 2000 to 2030.

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 enterprises like dairy, horticultural crops, vegetables, fisheries and poultry. The goal of diversification in agriculture is to stabilize the farm income particularly

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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 field studies on integrated farming system (IFS) were carried out at Mahatma Phule Krishi Vidyapeeth, Rahuri, District- Ahmednagar on 2.0 ha area during 2008-09 and 2009-10. The research experiment was compared with on-farm IFS model-II (Crop, dairy and poultry) at village Digraj, Tahsil-Rahuri, District-Ahmednagar and the sequence cropping (model-III) of soybean-wheat in 2.0 ha land at Rahuri.

The experimental site is located between 19° 47' to 19° 57' N latitude and 74° 84' to 74° 19' E longitudes with altitudinal variation from 495 to 569 metres above mean sea level. The region comes under semiarid 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 to 40.8 and 7.8°C to 23.9°C, respectively. The mean weekly morning relative humidity ranged from 44 to 90 per cent and evening humidity ranged from 13 to 74 per cent. The mean pan evaporation was 4.39 mm with maximum pan evaporation of 12.4 mm in the month of May. Three farming system models on 2.0 ha area each under irrigated conditions were selected to find out the economic viability, water productivity, employment generation, energy balance and soil health improvement of each models.

The on-station integrated farming system model consisted of various components on 2.0 ha area viz., crop (1.50 ha), horticulture (0.40 ha pomegranate

Table 1
Components of integrated farming system models

Model-I : (Research Farm IFS model)

Sr. No.	*Component*	*Area (ha)*	*Area allotted (%)*
1.	Crop production	1.50	75.00
2.	Horticulture (Pomegranate-*Bhagwa*)	0.40	20.00
3.	Dairy (Two P*hule Triveni* cow)	0.05	2.50
4.	Poultry (200 *RIR* birds/batch)		
5.	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)

Sr. No.	*Component*	*Area (ha)*	*Area allotted (%)*
1.	Crop production	1.95	97.50
2.	Dairy (one Jersey cow)	0.05	2.50
3.	Poultry (Local birds)		
	Total	**2.00**	**100.0**

Model-III : (Sequence Cropping model)

Sr. No.	*Component*	*Area (ha)*	*Area allotted (%)*
1.	Soybean-wheat-fallow	2.00	100.0
	Total	**2.00**	**100.0**

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

Sr. No	*2008-09*					
	Summer 2008		*Kharif 2008*		*Rabi 2008*	
	Crop	*Area (ha)*	*Crop*	*Area (ha)*	*Crop*	*Area (ha)*
1.	Lucerne	0.10	Lucerne	0.10	Lucerne	0.10
2.	Hybrid Napier	0.05	Hybrid Napier	0.05	Hybrid Napier	0.05
3.	Sugarcane	0.30	Sugarcane	0.30	Sugarcane	0.30
4.	Banana	0.40	Banana	0.40	Banana	0.40
5.	-	-	Sorghum	0.20	Wheat	0.55
6.	-	-	Pigeon pea	0.35	-	-
7.	-	-	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		*Kharif 2009*		*Rabi 2009*	
	Crop	*Area (ha)*	*Crop*	*Area (ha)*	*Crop*	*Area (ha)*
1.	Lucerne	0.10	Lucerne	0.10	Lucerne	0.10
2.	Hybrid Napier	0.05	Hybrid Napier	0.05	Hybrid Napier	0.05
3.	Sugarcane (R)	0.30	Sugarcane (R)	0.30	Sugarcane (R)	0.30
4.	Banana	0.40	Banana	0.40	Banana	0.40
5.	-	-	Soybean	0.55	Wheat	0.55
6.	-	-	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 IFS model during the year 2008-2009 and 2009-2010

Sr. No	*2008-09*					
	Summer 2008		*Kharif 2008*		*Rabi 2008*	
	Crop	*Area (ha)*	*Crop*	*Area (ha)*	*Crop*	*Area (ha)*
1.	Sugarcane	0.75	Sugarcane	0.75	Sugarcane	0.75
2.	Lucerne	0.20	Lucerne	0.20	Lucerne	0.20
3.	Fallow	1.00	Pigeon pea	0.20	Wheat	0.60
4.			Soybean	0.60	Fallow	0.40
5.			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		*Kharif 2009*		*Rabi 2009*	
	Crop	*Area (ha)*	*Crop*	*Area (ha)*	*Crop*	*Area (ha)*
1.	Sugarcane	0.75	Sugarcane	0.75	Sugarcane	0.75
2.	Lucerne	0.20	Lucerne	0.20	Lucerne	0.20
3.	Fallow	1.00	Soybean	0.80	Wheat	0.20
4.			Fallow	0.20	Chickpea	0.40
5.					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

Sr. No	*2008-09*					
	Summer 2008		*Kharif 2008*		*Rabi 2008*	
	Crop	*Area (ha)*	*Crop*	*Area (ha)*	*Crop*	*Area (ha)*
1.	Fallow	2.00	Soybean	2.0	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		*Kharif 2009*		*Rabi 2009*	
	Crop	*Area (ha)*	*Crop*	*Area (ha)*	*Crop*	*Area (ha)*
1.	Fallow	2.00	Soybean	2.0	Wheat	2.00
Cropped area				2.00		2.00
Fallow area		2.00		-		-
Total area		**2.00**		**2.00**		**2.00**

orchard), dairy (Two *Phule Triveni* milking cow), poultry (200 *Rhode Ireland Rhode* birds /batch), fishery (in 0.05 ha farm pond area *400* fingerlings of integrated culture of *catla, rohu and mrigal*), farm shed, cowshed and poultry house on an area of 0.05 ha. while 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 *kharif* and wheat in *rabi* season and in summer season the whole area was kept as fallow. The entire model was laid on an area of 2.00 ha.

In all the three models, the seeds of cereal, pulses, oilseeds, forage and vegetable crops were obtained from Seed Cell Unit of Mahatma Phule Krishi Vidyapeeth, Rahuri while in on-station IFS model, the seedlings of banana were purchased from Jain Irrigation, Jalgaon. In case of horticultural component, the pomegranate seedlings were obtained from Central Nursery of Mahatma Phule Krishi Vidyapeeth, Rahuri. In dairy component, two *Phule Triveni* cows were purchased from Cattle Unit of this University. In poultry component, the poultry birds were purchased from, Don Bosco Poultry, 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 two 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 and pigeon pea, onion and sweet corn were grown during *kharif* followed by wheat in *rabi* in the year 2008-09. During the year 2009-10, in *kharif* season soybean and okra crops were taken followed by wheat and leafy vegetables fenugreek and spinach in *rabi* season.

The cropping programme followed in on-farm integrated farming system model during the year 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 the year 2008-09, pigeon pea, soybean and groundnut were taken during *kharif* followed by wheat in *rabi* season. During the year 2009-10, in addition to sugarcane, lucerne and 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 model during the year 2008-09 and

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

In on-station integrated farming system model, the recommended packages of practices were 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 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 of 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 farm yard 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 super phosphate 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:K respectively. In on-farm integrated farming system model, the nutrient need of crops was fulfilled through urea, single super phosphate and muriate of potash and other mixed fertilizers. In on-station cropping model, the nutrient need of crops was fulfilled through urea, single super phosphate 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 three days interval. The irrigation water requirement of crops taken under drip and sprinkler were calculated as per following formulae.

1. **Net irrigation requirement (NIR)**

   NIR = CPE × Kp × Kc × Wa × Es × Ls … for drip

   NIR = CPE × Kp × Kc … for sprinkler

2. **Gross irrigation requirement (GIR)**

The total quantity of irrigation water was applied during each irrigation and it was calculated by using following formula:

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

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 *kharif* season, irrigation was done by considering the amount of precipitation received between two 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, lift irrigation, 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.

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

Sr. No.	*Name of crop*	*Season*	*Planting method*	*Seed rate/ha*	*Spacing*	*Fertilizer dose/ha*	*Variety*
A.	**Cash crops**						
1	Sugarcane	*Suru*	Paired planting	20000 two eye budded sets	90-180 x 30cm^2	250:115:115	Co-86032
2	Banana	*Kande Bahar*	Row planting	3265 plants	1.75 x 1.75 m^2	200:40:200/pl.	Grand naine
B.	**Cereal crops**						
1	Wheat	*Rabi*	Drilling	100 kg	22.5cm	120:60:40	HD2189,Trimbak
2	Sorghum	*Kharif, Rabi*	Drilling	40 kg	–	100:50:50	Phule Mauli
3	Sweet corn	*Kharif*	Dibbling	10 kg	60 x 30 cm	100:50:50	Sugar 75
C.	**Pulse crops**						
1	Soybean	*Kharif*	Drilling	75 kg	45 x 10 cm	50:75:00	JS - 335
2	Pigeonpea	*Kharif*	Drilling	15 kg	45 x 10 cm	25:50:00	ICPL-87
D.	Vegetable crops						
1	Onion	*Kharif*	Transplanting	8-10 kg	15 x 10 cm	100:50:50	Phule Samartha
2	Okra	Summer	Dibbling	12-15 kg	30 x 15 cm	100:50:50	Phule Utkarsha
E.	**Forage crops**						
1	Lucerne	Perennial	Drilling	25 kg	30 cm	15:150:40 at the time of sowing	RL-88
2	Maize fodder	*Kharif, Rabi,* Summer	Drilling	75 kg	30 cm	100:50:50	African tall
3	Hybrid Napier	Perennial	Transplanting	40000 setts	90 x 60 cm	50:40:20 at sowing and 25 kg N after every cutting	Phule Jaiwant
F.	**Horticulture crops**						
1	Pomegranate	–	Row planting	750 plants	4.50 x 3.00 m^2	625:250:250/plant	Bhagwa

Table 6
Comparative performance of different farming system models

Treatment	*Cost of cultivation ($x10^{-3}$ Rs./ha)*	*Gross returns ($x10^{-3}$ Rs./ ha)*	*Net returns ($x10^{-3}$ Rs./ha)*	*Annual water availability (ha.cm)*	*Quantity of water utilized (ha.cm)*	*Water productivity (Rs.ha^{-1}cm.)*	*Energy Balance ($x10^{-3}$ MJ/ha)*	*Total employment generation (Man days/ ha/yr)*
Research farm 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
Research farm sequence cropping model-III	53.5	86.1	32.6	87	87	374	153.3	227

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

Sr. No.	*Soil Properties*	*Research farm integrated farming system model (Model-I)*		*On-farm integrated farming system model (Model-II)*		*Research farm cropping sequence model (Model-III)*	
		Initial	*Final*	*Initial*	*Final*	*Initial*	*Final*
A.	Physical properties						
1.	Texture class	Clay loam	-	Sandy clay loam	-	Clay loam	-
2.	Field capacity (%) by weight basis	32.18	34.70	30.10	29.65	34.15	34.90
3.	Permanent wilting point (%) by weight	19.16	18.16	17.19	17.95	20.10	20.30
4.	Available soil moisture (%)	13.02	16.54	12.91	11.70	14.05	14.60
5.	Bulk density (Mg m^{-3})	1.34	1.24	1.40	1.37	1.30	1.25
C.	Chemical properties						
1	Soil pH (1:2.5)	7.97	7.67	8.79	8.90	7.90	7.60
2	EC (dSm^{-1})	0.45	0.37	0.51	0.53	0.40	0.35
3	Organic Carbon (%)	0.60	0.70	0.40	0.41	0.40	0.45
4	Available N ($kgha^{-1}$)	150.52	175.16	130.5	120.0	160.5	178.2
5	Available P ($kgha^{-1}$)	14.11	16.94	16.18	15.90	16.80	15.11
6	Available K ($kgha^{-1}$)	616	672	480.0	455.0	490.0	478.0

The water productivity of each component in different farming system models was worked out by using the following formula

$$\frac{\textit{Water Productivity}}{(Rs./ha.cm.)} = \frac{\textit{Net income of component (Rs.)}}{\textit{Quantity of water utilized for each component (ha.cm.)}}$$

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 one 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 research farm IFS model-I was Rs. 3,61,731/- while in on-farm IFS model-II was Rs. 95,773/- and in research farm sequence cropping model (soybean-wheat) was Rs.53, 550/- .

The average gross income from in research farm IFS model-I was Rs. 5,61,578/- while in on farm IFS model-II was Rs. 1,44,250/- however it was only Rs. 86,163/- in research farm sequence cropping model-III (soybean-wheat).

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

Annual Water Availability

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

Annual Water Utilized

Among the three farming system models the average annual quantity of water utilized was more in research farm IFS model-I was 199 ha cm. Whereas in on-farm IFS model-II was 121 ha.cm and research farm sequence cropping model-III (soybean-wheat) was 87 ha.cm.

Water Productivity

Among the three farming system models, the average water productivity was highest in research farm IFS model-I followed by on-farm IFS model-II and sequence cropping model-III. The average water productivity was highest in research farm IFS model-I (Rs. 991 ha.cm.) followed by on-farm IFS model (Rs.406 ha.cm) and research farm sequence cropping model-III (Rs.374 ha cm.) 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 utilization 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 1275, 657 and 227 man days, respectively in research farm IFS model, on farm IFS model and sequence cropping model (soybean-wheat). This suggested that in research farm integrated farming system model (Model-I) was more efficient for employment generation. 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), Ravisankar *et al.* (2007), Solaiappan *et al.* (2007) and Korikanthimath and Manjunath (2009).

Energy Balance

The average energy balance was more in research farm integrated farming system model (4,11,949 MJ) followed by on farm IFS model (3,25,528 MJ). The lowest energy balance was recorded in research farm sequence cropping (soybean-wheat) model (1,53,379 MJ).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).

Soil Health

The soil pH and electrical conductivity of experimental site was 7.97 and 0.45 dSm^{-1}. It decreased to 7.67 and 0.37 dSm^{-1} at the end of the experiments. The organic carbon content in soil increased over the years in farming system. It was 0.60 per cent at initiation of farming system and raised to 0.70 per cent at the end of farming system experimentation. The soil available nitrogen increased from 150.2 to 175.2 $kgha^{-1}$, phosphorus 14.1 to 16.9 kg ha^{-1} and potassium 616 to 672 kg ha^{-1} 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 dSm^{-1}. It increased to 8.90 and 0.53 dSm^{-1} at the end of the experiments this 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^{-1}, phosphorus 16.18 to 15.90 kg ha^{-1} and potassium 480 to 455 kg ha^{-1} respectively in farming system model on farmer field.

In research farm cropping sequence model, there was 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 microorganisms and their activity, aeration, water holding capacity and soil enzyme activity etc.

Among the three 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.

CONCLUSION

The research farm integrated farming system model-I on 2.0 ha area under irrigated condition was more remunerative in average net returns (Rs.1,99,848/-), water productivity (991.61 Rs/ha-cm), employment generation (1275 man days), energy balance (4,11,949 MJ) and improvement in physical and chemical properties of soil.

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