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Yield, Productivity and Economics of Integrated Farming System under Irrigated Conditions of Western Maharashtra

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Authors' contributions

This work was carried out in collaboration among all the authors. Author PPK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author USS guided the research study and also managed the analysis. Author VGP managed the analysis of the study. Authors SCP and SBS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted at All India Co-ordinated Research Project on Integrated Farming System, Mahatma Phule Krishi Vidyapeeth, Rahuri to develop integrated farming system model for irrigated conditions of Western Maharashtra. The model was designed for 1 ha area with crop, horticulture, dairy, goat, poultry and vermicompost unit. The integrated farming system model generated system productivity in sugarcane equivalent yield of 375 t ha^{-1}. The gross monetary returns from combination of crop + horticulture + dairy + goat + poultry + vermicompost unit were 10,55,758 and net monetary returns was 4, 58, 943 with B:C ratio (1.77). Of this total net returns obtained from integrated farming system model, the per cent contribution of different components were crop (25%), horticulture (4%), dairy (24%), goat (18%), poultry (29%) and vermicompost (7%). Employment generation in integrated farming system model was 422 Man days $year^{-1}$.

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1. INTRODUCTION

In the present situation the biggest challenge is to provide food for the ever increasing population which is increasing in a sky-rocketing manner while it's quite impossible to increase the area of production. So, the real challenge is to increase the productivity to feed the fast growing population. Assumption of present Indian population estimation was 1.3 billion by 2020. The demand for food on the basis of present consumption pattern would likely to increase from 300 to 350 mt as against present production (approximately 260 mt) [1]. Conventional agriculture has caused economic problems associated with increased costs of energy-based inputs, lessened farm incomes etc. It has also produced ecological problems such as poor ecological diversity, soil erosion, and soil and water pollution. Integrated Farming System (IFS) is considered as one of the best option towards intensification of small holder farm income to ensure sustainable livelihood. Integration of resources is made through a combination of land, water and animal resources of a farm with careful planning including recycling of bio-resources [2].

The Indian rural economy is mainly dependant on small and marginal farmers which constitute 85 per cent of the total farming community but posses only 44 per cent of total operational land. Due to economic conditions most of the farming operations are labour oriented and requires lot of man-power as well as energy and even after this hard work the farmer is not left with good amount of returns and hence result poor livelihood. The cost of cultivation either exceeds or is less than equal to the returns he receives at the end of farm products sale. Development of an alternative solution is an urgent need to stabilise farmer's income. Integrated Farming System is an interdependent, interrelated often interlocking production systems based on few crops, animals and related subsidiary enterprises in such a way that maximize the utilization of nutrients of each system and in minimize the negative effect of these enterprises on environment. The interrelated, inter-dependent and interlocking nature of IFS involves the utilization of primary and secondary produce of one system, as basic input of the other system, thus making them mutually integrated as one whole unit.

Crop-based agriculture is highly season-specific, with peaks of labour requirement at certain time of year and farmers don't have adequate employment during the rest time of the year. The IFS has ability to generate additional employment and more equitable distribution of employment throughout the year, and thus ensures a steady sink for local labour force. This system is a labour intensive system, which creates on-farm employment and most of the labour required in the production process is contributed by the farmer and his family members [3].

2. MATERIALS AND METHODS

The study was carried out at All India Co-ordinated Research Project on Integrated Farming Systems, Mahatma Phule Krishi Vidyapeeth, Rahuri district Ahmednagar, Maharashtra. Geographically Central Campus of Mahatma Phule Krishi Vidyapeeth, Rahuri is situated between 19° 48' and 19° 57' North latitude and 74° 52' and 74° 19' East longitude, and its mean height above sea level is 395 to 565 meters. This tract is lying on the eastern side of Western Ghats and falls under rain shadow area. It comes under transition belt having semi-arid climate. It receives most of the rainfall from South-West monsoon, commencing from middle of June. The IFS model of 1 ha area comprised of crop, horticulture, dairy, goat, poultry and vermicompost unit.Details of the components are given in Table 1. Layout of Integrated Farming System model is given in Fig. 1.

Okra and cluster bean were cultivated in cropping system-I during summer okra on 0.10 ha and cluster bean on 0.05 ha area. To avoid the shading of horticultural trees over vegetable crops and hurdle in cultivation practices as well as harvesting of drumstick. The vegetable crops were not cultivated under horticultural component. Average yield of both the years (2018-2020) was used for analysis. The integrated farming system was analysed for productivity, profitability and employment generation. The system productivity was worked out by converting the yield of different components in to sugarcane equivalent yield (t ha^{-1}) based on farm gate price of the produce. The formula used for component and system productivity given by De Wit, [4] is given below.

Table 1. Details of the components in IFS Model

Sr. No.	Components			Area (ha)
A	Cropping systems			-
	Kharif	*Rabi*	Summer	-
1	Maize	Chickpea	Summer vegetables(Okra and Cluster bean)	0.15
2	Soybean	Onion	Sweet corn	0.15
3	Cotton	Wheat	-	0.15
4	Sugarcane			0.15
5	Lucerne			0.10
6	Hybrid Napier			0.05
7	Total			**0.75**
B	Horticulture (Mixed planting) 31 plants each 8 m × 8 m distance			**0.20**
8	Guava (Sardar-49)			-
9	Pomegranate (Bhagwa)			-
10	Custard apple (Balanagar)			-
11	Drumstick (Bhagya)			-
12	Intercropping of Marigold (Calcutta marigold yellow and orange)			-
C	Dairy			-
13	Two *Phule Triveni* cows + two calves			**0.01**
D	Goat			**-**
14	*Sangamneri* goats (10 Does + 1 Buck)			**0.01**
E	Poultry (1600 birds year^{-1})			**-**
15	*RIR/ Kaveri* birds 400 Birds batch^{-1} Four batches year^{-1}			**0.01**
16	Vermicompost 4 NADEP beds and 5 Tetra vermibeds			**0.02**
17	Total			**1.00**

$$SEY = \frac{\sum(\text{Production } (t^{-1}) \text{ of } i^{th} \text{ crop/component x price } (t^{-1}) \text{ of that } i^{th} \text{ crop/component})}{\text{Price of Sugarcane } (t^{-1})}$$

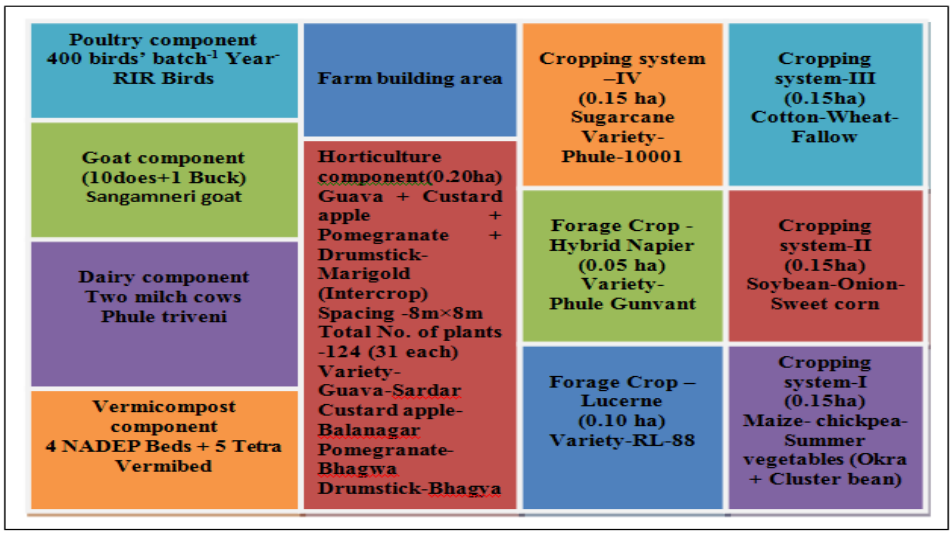

Fig. 1. Layout of IFS model at AICRP on Integrated Farming System, MPKV, Rahuri

3. RESULTS AND DISCUSSION

The details of yield obtained from various components in IFS are given in Table 2 to Table 5.

3.1 Crop Component

Crop yield obtained from various crops during *kharif* season in IFS were maize grain yield 9.37 q, stover yield 14.51 q, soybean grain yield 3.48

q and stover yield 3.90 q from 0.15 ha area. Cotton yield was 4.12 q having stalk yield of 4.85 q. *Rabi* crops consisted of chickpea, onion and wheat. The respective yield of *rabi* crops were chickpea grain 4.65q, onion bulb 35.06q and wheat grain 6.72 q. During summer in cropping system-I two vegetable crops okra and cluster bean were cultivated. Okra yield on 0.10 ha area was 11.93 q and the by-produce yield was 9.12 q. Cluster bean was grown on 0.05 ha area which gave yield of 2.85q and by-produce yield accounted 2.28 q. In cropping system-ii sweet corn yielded 3056 No. of cobs and 15.89 q stover yield during summer. Sugarcane yield was 155 q and the trash yield was 11.45 q. Forage crops lucerne yielded 122.50 q which was cultivated on 0.10 ha area and hybrid napier 74.22q on 0.05 ha area (Table 2).

From 0.75 ha area occupied by crop component the net returns obtained were □1,18,137, the total cost of cultivation was □ 1,45,553. The results regarding economics were similar with Singh et al. [5], Yadav et al. [6], Surve et al. [7], Singh and Burark [8], Sharma et al. [9] and Patel et al. [10].

Table 2 Yield and prices of field crops in crop component

Cropping system	Area (ha)	Yield (q ha^{-1})					
		Kharif		***Rabi***		**Summer**	
		Main produce	**By produce**	**Main produce**	**By produce**	**Main produce**	**By produce**
Maize-Chickpea-Summer vegetables (okra and cluster bean)	0.15	9.37	14.51	4.65	5.75	11.93 2.85	9.12 2.28
Soybean-Onion-Sweet corn	0.15	3.48	3.90	35.06	0.44	3056	15.89
Cotton-Wheat	0.15	4.12	4.85	6.72	6.00	-	-
Perennial crops							
Sugarcane	0.15	155	11.45	-	-	-	-
Lucerne	0.10	122.50	-	-	-	-	-
Hybrid napier	0.05	74.22	-	-	-	-	-

Chart 1. Profitability of different cropping system in crop component

Cropping system	Area (ha)	Yield (q ha^{-1})						Total		
		Kharif		***Rabi***		**Summer**				
		GR	**NR**	**GR**	**NR**	**GR**	**NR**	**GR**	**CoC**	**NR**
			(□)							
Maize-Chickpea-Summer vegetables (okra and cluster bean)	0.15	17333	5854	17190	6031	30625 16308	20196 8472	81455	40905	40550
Soybean-Onion-Sweet corn	0.15	11886	2014	28057	10720	32939	16451	72882	43697	29185
Cotton-Wheat	0.15	23110	8936	15295	4513	-	-	38405	24957	13448
Perennial crops										
Sugarcane	0.15	39404	18480	-	-	-	-	39404	20925	18480
Lucerne	0.10	24185	14197	-	-	-	-	31545	15069	16475
Hybrid napier	0.05	7360	2279	-	-	-	-			
Total	0.75	-	-	-	-	-	-	**263690**	**145553**	**118137**

3.2 Horticulture Component

Yield from fruit crops in initial two years 2018-2019 and 2019-2020 of experiment was not obtained as it takes three years for fruiting and establishment of orchard. Therefore, yield obtained from drumstick and marigold was taken from horticultural component of IFS model (Table 3).

Yield obtained from marigold and drumstick was 7.9 q and 4.96q, respectively. The net returns obtained from horticulture crops were 13363. It was observed that marigold plays an important role as intercrop especially during the Indian festival season of *Dasshera* and *Diwali*. These festivals provide an opportunity for getting high prices for flowers produce. Drumstick has great importance in horticultural component as it starts yielding from the first year of planting. *Bhagya* is dwarf variety, having self pruning property and less prone to disease and pest incidence. Dwarf characteristic of drumstick decreased the time of harvesting. Drumstick is a cherished vegetable during summer. Supply and demand relationship plays an important role during summer. In summer there is less supply of vegetables in markets compared to demand, which increases prices of vegetables. Summer is a peak time of drumstick harvesting. The recent awareness about nutritional value of drumstick has increased its demand in market.

3.3 Livestock Component

From dairy component 4299 litres of milk was obtained during a 12 months period. The manure obtained from dairy was 6069 kg. Two calves were born in a year to both of the cows giving additional profit. The weight of 10 does and a buck was 342 kg. 11 kids were born in first year out of which 7 kids were sold weighing 210 kg. Remaining 4 does were added in the main herd. The average weight of the goats was 584 kg. Milk yield obtained in a year from goat component was 156 litres. Goat manure obtained during a period of 12 months was 3543 kg. Total 1600 birds in four batches of 400 birds were reared in a year. The total live weight of 1600 birds was 3179 kg and poultry manure obtained weighed 1178 kg (Table 4).

The capital investment on goat increases with increase in intensity or number of animals in herd [11]. Goats are high remunerative livestock component giving more than two B:C ratio overtime [12].Compared to conventional farming system the total net returns increased with adoption of various enterprises in integrated farming system [13]. The suitable combination of enterprise in the integrated farming system generates additional income. These results were in agreement with Ponnusamy and Devi [14]. Poultry farms are more viable and economic overtime. These results were in agreement with Pawariya and Jheeba [15].

3.4 Vermicompost Component

The total vermicompost obtained 7385 kg. Vermiwash collected from the compost was 263 litres and the vermiculture sold was 18360 (No.). Vermicompost as a finished product has more demand in organic manure market. Vermicompost is rich in macro as well as micronutrients. The returns obtained from vermicompost were higher than the investment (Table 5).

3.5 Integrated Farming System Model

The integration of different components on 1 ha area resulted into a total system productivity in sugarcane equivalent yield was 375 t ha^{-1}. The net returns obtained from IFS model was 4,58,943. Integration of goat component in the existing model increases the net income. Intensifying poultry batches also increased net returns. Limited employment is generated from crop component alone. Integration of different components generated additional employment. The IFS model generated an employment of 422 man days $year^{-1}$.

Table 3. Yield of horticultural component in IFS model

Horticulture Component	Yield (q)	Gross monetary returns (□)	Cost of cultivation	Net monetary returns	B:C ratio
Drumstick	4.96	38580	25217	13363	1.53
Marigold	7.90				

Drumstick: □ 30 kg^{-1}, Marigold: □ 30 kg^{-1}

Table 4. Yield of livestock components in IFS model

Component	Production	Yield	GR	Cost of production	NR	B:C ratio
			(□)			
Dairy	Milk (lit.)	4299	164252	113378	50875	1.45
	Cow dung (kg)	6069				
	Calf (No.)	2				
Goat	Milk (lit.)	155.5	185848	120710	65138	1.54
	Live weight (kg)	584				
	Manure (kg)	3543				
Poultry	Live weight (kg)	3179	319373	170228	149145	1.88
	Manure (kg)	1178				
Total	-	-	**669473**	**404316**	**265157**	**1.65**

Dairy: milk □ 34 litre^{-1}, cow dung 1.5 kg^{-1} , calf : 9000
Goat: meat □ 300 kg^{-1}, milk □40 litre^{-1}, goat manure □ 1.25 kg^{-1}
Poultry: live weight □ 100 kg^{-1}, □ 1.25 kg^{-1}

Table 5. Yield of Vermicompost component in IFS model

Vermicompost component	Yield	GR	COC	NR	B:C ratio
Vermicompost (kg)	7385	59080	21730	62285	3.87
Vermiwash (lit.)	263	6575			
Vermiculture (No.)	18360	18360			
Total	-	84015	21730	62285	

Vermicompost: □8 kg^{-1}, vermiwash: □ 25 litre^{-1}, Vermiculture: □ 1 worm^{-1}

Table 6. Productivity, Profitability and employment generation of IFS model

Particular	Crop	Horticulture	Dairy	Goat	Poultry	Vermicompost	Total
Productivity (t ha^{-1})	**86**	**15**	**57**	**69**	**125**	**23**	**375**
CoC	145553	25217	113378	120710	170228	21730	596816
GR	263690	38580	164252	185848	319373	84015	1055758
NR	118137	13363	50875	65138	149145	62285	458943
B:C	1.81	1.53	1.45	1.54	1.88	3.87	1.77
Employment generation	107	23	98	137	32	22	422

Crop in combination with livestock and other suitable enterprises not only provided income but round the year employment, employment in lean season where relaxation is observed in traditional agriculture Ravisankar et al*.,* [16].The observed results were in agreement with Surve et al*.* [7], Goverdhan et al. [17], Kumar et al. [18], Babu et al*.* [19], Patel et al*.* [10] and Tejaswara Rao et al*.* [20].

Setboonsarng [21], Sharmin et al*.* [22] and Goswami and Dasgupta [23] discussed about role of woman in IFS, which is beneficial as it provides employment to woman in poultry rearing, cattle rearing and goat rearing. Since resources for livestock are produced on farm (fodder and poultry feed) woman doesn't require traveling longer distances. Farm outputs are sold in local market which gave cash income.

4. CONCLUSION

The IFS provides diversified cropping system within 1 ha area which fulfils the requirement of cereals, pulses, oilseeds, fruits and vegetables of the farm family. The IFS having combination of Crop + Horticulture + Dairy + Goat + Poultry + Vermicompost achieved higher system

productivity of 375 sugarcane equivalent yield (SEY t ha^{-1}). Economically livestock components provided income round the year. Intensified poultry batches were found to be profitable in the studied model. Along with poultry, goat and vermicompost component were also found economical. The mean net returns obtained from Crop + Horticulture + Dairy + Goat + Poultry + Vermicompost 4,58,927, respectively. Addition of components in the IFS helped in employment generation up to 422 man days $year^{-1}$. In order to double farmer's income and generate employment round the year IFS approach is better over specialized farming system.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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