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CONTENTS

Management of crop with livestock and allied enterprises for sustainable livelihood of small farmers in north Indian plains

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ABSTRACT: This paper presents insights into integrated farming systems (IFS) of crops with livestock and allied enterprises, implemented in on-station situation. Research studies have demonstrated the technical feasibility and economic viability of integrated farming systems. Compared with traditional cropping system (rice-wheat), the proposed 1.0 ha IFS model (crops+dairy+horticulture/agroforestry+fisheries+ vermin-compost/biogas+ kitchengarden) brought increased productivity, revenue and better resource recycling. The productivity in rice equivalent grain yield (REGY as t /ha/yr) and net returns from inclusion of allied enterprises in IFS were about 31.34t REGY/ha/yr and Rs 234730, respectively as compared to 9.5 t REGY/ha/yr and Rs94,800 respectively in case of rice-wheat cropping system. Besides facilitating cash income, integrated farming system generates additional employment of 250 workdays for family labour. It also sustains soil productivity through the recycling of organic nutrient sources (50.8%) from the enterprises involved.

Key words: Crop, livestock, livelihood, small farmers, sustainable

The 21st century agriculture in India is facing the challenge to achieve sustainable food security with shrinking land resources to meet the requirement of the prognosticated population of more than 1.50 billion in the country. Because of the declining per capita availability of land in India,there is hardly any scope for horizontal expansion of land for food production (Chaturvedi *et al.,*2012). Only vertical expansion is possible by integrating appropriate farming components that require lesser space and time to ensure regular income to the farmer (Singh *et al*., 2018). Further, modest increments in land productivity are no longer sufficient for the resource-poor farmers.

Intelligent management of available resources, including optimum allocation of resources, is important to alleviate the risks related to land sustainability (Ates *et al*., 2018). Moreover, a proper understanding of interactions and linkages between the components would improve food security, employment generation as well as nutritional security. Mixed crop-livestock systems can improve nutrient cycling while reducing chemical inputs and generate economies of scope at the farm level (Ryschawy *et al*., 2012). This approach can be transformed into a farming system that integrates crops with enterprises such as – agroforestry; horticulture; cow, sheep and goat rearing; fishery; poultry and duck rearing; mushroom production; sericulture; biogas and vermicompost production– to increase the income and improve the standard of living of small and marginal farmers The challenge of such an integrated farming system (IFS) is to upgrade technological and social disciplines on a continuous basis and integrate these disciplines to suit the region and the farm families in a manner that will ensure increased production with stability, ecological sustainability, and equitability.

The farming system approach makes the system so holistic that recycling of farm wastes, crop residues and remains of different farm enterprises; fulfil about 90 % of the nutritional requirement of the system itself. IFS also advocates self-sufficiency in nutrient budgeting therefore, on one hand, reduces the dependency on external inputs and on the other provides balanced and rich nutrition to the system. Interestingly, the system will produce food, feed, fodder, milk, fuel, etc. and other nutrition requirements of the family (Mekuria and Mekonnen, 2018). However, it is not possible to suggest a single/ common model of farming system for each and every farm situation as it will differ in size and preposition of the enterprises to be integrated with the existing farming system and according to farmer's resources and his family requirements. Based on characterization survey and experience gained in the field of specialization, a livestock+fisheries+ vermicompost/biogas+kitchengarden based farming system module consisting of crops + livestock +horticulture/agroforestry was standardized for small and marginal farmers with assured irrigation. Research studies were carried out in irrigated *Tarai* region at the Govind Ballabh Pant University of Agriculture and Technology (GBPUAT), Pantnagar since 2011 and have demonstrated the technical feasibility and economic viability of the IFS. Besides facilitating cash income, this farming system model generated additional employment for family labour and minimized the risk associated with conventional cropping system. Possibilities of linkages among different components of farming system was also explored at the field level to evaluate the efficiency of integrated component technologies in terms of productivity, income increase and employment generation, and to quantify the nutrient flow efficiency of linked components to soil. This paper presents some insights of IFS of livestock with crops and allied enterprises, implemented in research farm situation.

MATERIALS AND METHODS

The field experiment was conducted at GBPUAT, Pantnagar which falls in North Western Himalayan Region and is located in '*tarai*' region about 30 km southward of foothills of 'Shivalik' range of the Himalayas. Geographically, this centre is situated at 29°N latitude, 79°30" E longitude and at an altitude of 243.8 meter above mean sea level. The IFS model was developed involving cropping, and enterprises like rearing of milch cow, horticulture/ agroforestry, fisheries, and vermicomposting/biogas unit, in different combinations in which the residue and by-products of one component would be recycled by another. The data presented in this research paper are forthe year 2017-18. The recycling process would reduce the cost of production per unit of grain, milk, fruits, compost, etc., and thereby widen the gap between the production cost and net return. Out of 1.0 ha farm, 0.47 ha was used for cropping different crops so as to meet out the requirement for cereals, oilseeds, pulses of 5 members farming family and round the year requirement of green and dry fodder for milch animals. The 0.19 ha area was assigned to a horticulture unit, comprising of guava trees planted in paired rows. Karonda was planted on the boundary of horticulture unit for dual purpose of hedge and fruits. Another 0.18 ha area was allotted to poplar-based agroforestry unit planted with different under storey crops. Hybrid Eucalyptus was also planted on 0.05 ha area having fodder and pulses as intercrops. Bunds of all fields were utilized for fodder production by planting Napier grass. Area of 0.06 ha of farmland was utilized for fisheries component and remaining 0.05 ha under the dairy unit (cattle shed for 3milching cows including store) and vermicompost unit for recycling.

Components in Farming System

Crops (0.47 ha)

The crop activity in IFS consists of field crop (67 %), vegetable crop (6%) and fodder crops (27%) that are suitable for irrigated conditions. The cropping systems in field crops were as follows:

A. Rice (Direct Seeded Rice)– vegetable pea/ potato-maize/Okra
B. Rice (DSR)-wheat (Zero Till)-moong
C. Sorghum Multicut (Fodder)-yellow sarson-urd
D. Rice (Transplanted Puddled Rice)-berseem+ oat+mustard (Fodder)-maize+cowpea (Fodder)

Dairy (0.06 ha)

Livestock components and vermicomposting were taken in 0.06 ha.

Milch cows (0.03 ha)

Three cross bred milch cows (Holstein-Friesian) were taken for the study. The cows were maintained in such a way that milk production continued throughout the year. The TSS of milk was assessed regularly for quality control.

Vermicompost/biogas(0.02 ha)

Compost pits were made for composting crop residues and farm wastes. The cow dung obtained from milch cows, field and fodder crop residues were used for making vermicompost. The quantity of available manure was calculated on the basis of dry weight. The total quantity of solid waste on wet and dry weight basis and their nutrient potential before and after composting were recorded. Biogas unit with capacity of $2m^3$ was established for effective recycling of cow dung and production of slurry which was further recycled for compost production.

Horticulture/Agroforestry unit (0.42 ha)

Horticulture unit was planted in 0.19 ha with guava (80) var. Pant Prabhat (8m x 4m) and lemon var. Pant lemon 5 (80) (8m x 4m) with karonda (100) at boundary at the spacing of 1metre. In agroforestry unit poplar (90) was planted at 5mx 4m spacing (0.18 ha) with turmeric as under storey crop and hybrid clonal Eucalyptus (80) at the spacing of 3m x 2m (0.05 ha) with turmeric as intercrops. In the rows of trees, Napier grass was planted to get round the year green fodder for animals. Farming system treatments were compared by quantifying physical indicators of sustainability based on system productivity, profitability and employment generation. The productivity of the components integrated in each system was finally converted as rice grain equivalent on the basis of prevailing unit price of the produce in each component. The productivity of cross-bred milch cows was assessed using the milk yield and from the sale of vermicompost obtained from them. Labour requirement for various activities were recorded and given as man-days per year. A man or woman working for 8 hours a day was considered as one man day. The labour utilized in the different enterprises in a system were added to get man-days per ha per year. The economics of each enterprise was calculated based on the economic produce of that enterprise.

Fisheries unit (0.06 ha)

Pond of 600 m^2 area having six varieties of fishes namely katla, rohu, nain, silver carp, grass carp and common carp. Cattle shed washing is fed into the pond after every fifteen days. Mustard oil cake, rice bran are given as feed along with berseem and Azolla as per season. Pond water is utilized for irrigating vegetables grown on its dykes. Silt of pond rich in nutrients is added to horticulture every alternate year.

RESULTS AND DISCUSSION

Productivity

Integration of cropping with components like milch cows and vermicompost resulted in higher productivity. The mean rice equivalent yield (REY) was about 9,580 kg/ha/year under traditional cropping system whereas under IFS, the rice equivalent yield was 31341 kg/ha/year (Table 1&2) about three times higher than traditional rice-wheat system. Dairy component along with vermicomposting contributed maximum (17784.5 kg/ha/yr) followed by crops (9250.3 kg/ha/yr). Horticulture/Agroforestry component contributed 3144.9 kg/ha/yr REY (Table 1).Inclusion of high-yielding varieties and allied components would have helped in increasing the productivity and as a result the rice equivalent yield increased. This corroborates the findings of (Rangasamy*et. al.*, 1995 and Chaturvedi *et al.*, 2008).

Profitability

Relative efficacy of different farm enterprises in IFS model is summarized in Table 2. Dairy component contributed maximum (52.6%) to total gross returns (Rs277535) followed by crops (29.1%) and horticulture/agroforestry unit (9.79%). The dairy unit consists of 3 milch animals. They were maintained in such a way that at least one cow was in milk throughout the year. By keeping 3 animals, a net income of Rs114113.5/year could be achieved. Net returns were also highest for dairy unit, contributing 48.6% of total net returns of IFS model. However, B:C ratio was highest for kitchen garden unit (3.0) and lowest for horticulture/agroforestry component (0.63) due to higher cost of production. Total B:C ratio of IFS model was 0.8. Dairy unit came out to be most efficient enterprise in terms of returns as monetary efficiency of IFS system was 644Rs/ha/day contributed maximum by dairy unit (313Rs/ha/day) followed by crop unit (206Rs/ha/day).

Compared with traditional cropping system, mixed crop and livestock farming system brought increased revenue, which might be due to resource recycling (Ryschawy *et al.*, 2012). Resource recycling by way of the utilization of green and dry fodder cultivated in the field which accounts for a major part of the cost of maintenance of cows would have reduced the cost of production. The purchase of fertilizers for the crops is also reduced by way of recycling the manures from animal components, vermicompost as organic fertilizers accounts for 23.1 % saving in input cost and by engagement of family labour there was about 38.4% savings in input cost (Table 3). The resource and residue recycling had reduced the cost of production of a unit of economic produce *viz.*, milk from milch cows than when produced with total dependence on external inputs. This agrees with the findings of Jayanthi (2007) and Radhamani (2001).

Employment

IFS treatments generated more workdays of employment (man-days) compared with the traditional system involving cropping (Table 2). Cropping in traditional system (rice-wheat) generates 150 workdays per ha per year, while the various cropping systems under IFS generated 160 workdays of employment. Apart from crops, maximum of 210 workdays per ha per year were generated from animal components in IFS followed by 59 workdays by horticulture / agroforestry unit. A total of 450 workdays was generated in IFS system recording additional benefit of 300 workdays.
Additionally, 20 workdays per ha per year was generated from the fisheries component. Employment generation in cropping is limited to the key operations of sowing, intercultural operations

Table1: Production of different enterprises in Rice equivalent (kg) in Integrated Farming System model

Enterprises	Production in Rice Equivalent (kg)			
Cropping Systems	*Kharif*	*Rabi*	Summer	Total
Rice-Vegetable pea-Maize	785	1306.5	321.8	2413.3
Rice-Potato-Okra	790	611.6	587.8	1989.4
Rice-Wheat-Moong	635	643.6	287.7	1566.3
Sorghum Multicut (Fodder)-yellow sarson-urd	577.4	521.3	459.8	1558.5
Rice- Berseem(F)+Oat(F)+Mustard-Maize(F)+ Cowpea(F)	575	829.8	318.0	1722.8
Horticulture /Agroforestry				
Poplar+ Eucalyptu+Turmeric		725.5		
Guava + Karonda		2419.4		
Dairy Unit				
(Milk production) (3 cows)		16687.7		
Vermicompost		1096.8		
Fisheries		1161.3		

Table 2: Relative efficacy of different farm enterprises in the integrated farming system model

IFS component	Gross returns (Rs/year)	Cost of Production (Rs/year)	Net returns (Rs/year)	B:C Ratio	Monetary efficiency (Rs/ha/day)	Employment (Mandays)
A. Field Crops	153295	78157.5	75137.5	0.96	206	160
B. Horticulture/Agroforestry	51650	31600	20050	0.63	55	59
C. Dairy (Milk production)	277535	163421	114113	0.7	313	210
D. Fisheries+Duckery	20185	10125	10060	0.99	28	21
E. Vermicompost+Compost+Biogas	22744	8875	13869	1.56	38	-
F. Kitchen garden	2000.0	500	1500.0	3.0	4	-
Total	527409	292679	234730	0.8	644	450

and harvest, and labour is not required during the rest of the year. Contrary to this, employment generation in a multi-enterprise farming system is spread uniformly throughout the year.

Resource recycling

The required resources feed for animals; substrate for compost production; and organic manure for field crops can be secured at minimal cost through proper integration in the farming system (Figure 1). The reduction in production cost through recycling, which is up to 61.4 per cent over a commercial dairy farm, would help improve the net profit of the dairy unit. Vermicomposting is an effective process of using earthworms to recycle farm residues such as wheat and rice straw, sugarcane straw, maize stalks, turmeric leaves, vegetable wastes, tree litter, and problematic weeds like parthenium– into rich manure that increases humus content of the soil. It is a boon for sustainable agriculture. Earthworms are able to convert 1,000 tonnes of moist organic waste into 300 tonnes of rich dry vermicompost. It can consume almost all kinds of organic matter, equivalent to its body weight every day. In 45-60 days, 1 kg of earthworm (approximately 1,000-1,250 worms) would produce roughly 10 kg of vermicast, the nutrient-rich excreta of the worm. Matured vermicompost is applied at the rate of 5 t/ha. The dung collected from 3 cows was sufficient to generate 2.0 tonnes of vermicompost and 7.0 tonnes of compost. The economic produce and their by-products of crop activity (maize grain, sorghum grain, cake obtained after extraction of oil from mustard seed and soybean) will be utilized for the preparation of concentrate for dairy animals. Thus, the cost of production could be reduced as compared to the commercial dairy units.

The total quantity of vermicompost obtained from IFS was approximately 2.0 tonnes which was applied to Horticulture units raised in 0.19 ha of land area, respectively. In the traditional cropping system, the residue generated is less as compared with IFS. The nutrient contents in vermicompost were, respectively: nitrogen –1.5 per cent; phosphorus (P_2O_5) –075 per cent; and potassium (K_2O) 0.8 per cent. The manures obtained were both recycled as nutrient input to the crops after composting. The system of crop +milch cows + vermicompost+horticulture/agroforestry could provide better bio-resource utilization and recycling. Synergistic interaction of the farming system in terms of labour, resources and residue recycled. The decrease in dependence on external inputs for all the systems, second year onwards indicates that over long periods of time, IFS will become more self-sufficient and thus sustainable. This is in line with

Table 3: Total Inputs' cost and per cent share of the inputs purchased/generated and recycled within the system:

Components of IFS Model	Value of inputs purchased frommarket and % share(Rs)	Value of Inputs generated and recycled within farm and % share(Rs)	Value of farm labour engaged and % share(Rs)	Total Input Cost(Rs)
Crops+Dairy+Hort./AF+Fisheries	112850 (38.6%)	67329 (23.0%)	112500 (38.4%)	292679

Table 4: Nutrient saving through recycling of on- farm by products, wastes and residues in IFS Model

Source of nutrients and nutrient content (%) (N: P: K) On dry wt. basis	Available Quantity At farm (kg)	Released amount (Approx.) of nutrients (kg)			Total (Approx.) released amount of nutrient NPK (kg)
		N	P_2O_5	K_2O	
Crop residues (dry wt.) i) Mung/Urd/Veg Pea/Okra (1.29:0.36:1.64)	2665	34.4	9.6	43.7	87.7
ii) Poplar leaves (2.00:0.15:0.90)	550	11.00	0.83	4.95	16.8
iii) Eucalyptus leaves (1.02:0.21:1.06)	350	3.57	0.73	3.71	8.0
vi) Cowdung (dry wt.) as vermicompost (1.5:0.75:0.8) & compost (0.5:0.25:0.5)	2000+7000	65.0 30+35	32.5 15+17.5	51.0 16+35	148.5
Total	-	114	43.7	103.3	261

the findings of Jayanthi *et al*. (1997).

The crop residues of legumes litter of poplar and eucalyptus, sugarcane leaves and verimcompost were recycled into the system to meet out the nutritional requirement of crops, horticultural and agroforestry trees. Total nutrient saving through recycling of on- farm by products, wastes and residues in IFS Model was to the tune of 261 kg NPK (49%) as against the requirement of 531 kg/ha (Table 3). Maximum NPK recycling was for nitrogen (43.67%) followed by potassium (39.4%) and phosphorus (16.7%). Vermicompost prepared from cow dung contributed maximum in recycling of nutrients into the system. Nutrients recycled through fermented cow urine mixed with neem and eucalyptus leaves were used as pesticides also contributed to nutrient recycling.

Based on the research, it was concluded that IFS approach is better than traditional system in its contribution to productivity, profitability, economics and employment generation for small and marginal farmers of North Indian Plains. It is clear from the above results that IFS enhances productivity, profitability and insures nutrition security of the farmer and sustains soil productivity through recycling of organic source of nutrients from the enterprises involved.

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