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Sugarcane Based Integrated Farming System in Sub-Tropical India: A Tool for Increasing System Productivity and Farmer's Profitability

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Introduction

Integrated farming system is one of the important principles for achieving the goal of higher yields of different component crops and enterprises, livelihood security, soil health management, nutritional security, by-product recycling, eco-friendly farming/agri-system, employment generation through various component/enterprises throughout the year by adapting principles of the sustainable agriculture.

Advantages of Integrated Farming System

1. Increasing Productivity 2. Profitability
3. Better recycling of products/wastes 4. Adopting new technology
5. Increase in Input Efficiency 6. Employment Generation
7. Good Soil Health8. Pollution free environment
9. Solution to Energy Crisis 10. Solution to Fodder Crisis
11. Solving the fuel and wood crisis12. Protection from deforestation
13. Income throughout the year14. Providing a balanced diet
15. To improve the standard of living of the farmers.

Components of Integrated Farming System

Crop production and animal husbandry have been practiced in India for centuries, which is a major component of the integrated farming system. It has been meeting the needs of the growing population for food, fodder and firewood. In this system, animals are reared on crop by-products/agricultural wastes and animal power is used for farm operations and animal waste (dung

and urine) is used as manure and fuel and it can also be used in fish farming, duck farming etc. Similarly, in an integrated farming system, the primary and secondary products for one system are interconnected, interdependent and interconnected and are used as basic productive materials for the other system, thus making all systems a whole. Integrated as a unit. This helps in reducing the reliance on procuring inputs from the open market, called cash inputs, whereby the integrated farming system is a self-contained subsidiary unit and a permanent system, running concurrently. The inclusion of more than one component provides additional employment and income to the farming families. The following are the components of an integrated farming system:

Agriculture

Depending on the existing natural resources and available irrigation facilities, suitable cereal crops, oilseed crops, pulses, commercial crops and horticultural crops can be grown. Crop residues, grains (shrunken, broken etc.), spoiled fruits and vegetables can be used to feed buffalo, bull, chicken, pig, rabbit, sheep, goat etc. It helps in the recycling of agricultural waste and reduces dependence. External inputs procured on the basis of cost are also reduced, later on the power of bullocks can be used as manure for agricultural works and cattle dung. Similarly, poultry, sheep, goats, ducks, rabbits could also be sold to get additional income. Integrated farming system; Environmental risk forms the basis for mitigating price volatility and risk, and gives farmers the opportunity to have multiple options, including alternative and similar ventures. The farmer knows that it is the genotype, animal activities and livestock; Increases the number of integrated enterprises. The implication is that agricultural systems approach at both the core and micro level as well as further research and appropriate extension strategies are required to promote sustainable production systems. It helps in judicious combination of different enterprises, which not only helps in using the available resources more effectively and efficiently, but the product of one enterprise can act as productive material for another.

Horticulture

Horticultural crops such as fruits, vegetables, flowers, spices, medicinal and aromatic crops can be included in the integrated farming system. Fruit crops like mango, ber, guava etc. are less intensive, require less water and give assured income to the farming family for a long time. The space between

rows of crops can be used for growing food, fodder and vegetable crops. Cultivation of fruits, vegetables, flowers etc. at weekly, fortnightly, monthly, bi-monthly, quarterly, half yearly intervals help in earning income throughout the year from these various components. The availability of cash provides a kind of incentive to the small and marginal farmers throughout the year, so that they can adopt the techniques of improved varieties, fertilizers, pesticides etc., which is not possible under traditional farming due to paucity of funds.

Forestry

Forest-trees are an indispensable component in the agricultural system. Food, Fiber (7 Fs in real terms – Food, Fiber, Fuel, Fodder, Fruit, Fertilizer and Cereal); It plays a vital role in serving mankind by providing shelter, tree component under farming system helps in effective utilization of above and below soil surface. It helps agriculture to get income and income from the farm for the whole year in view of innumerable benefits to mankind. To meet our growing demand for fuel and industrial timber, it is appropriate to integrate agro-forestry with integrated farming. The production level of fuel and industrial wood can be increased without harmful effect on other activity.

Dairy

The integration of crops and forestry as well as enterprise like dairy has become more relevant under the current ecology and socio-economic conditions, dairy farming helps in providing better nutrition, quality organic manure, additional income and employment to the family. The integration of fish and duck farming, along with farming, dairy enterprise helps in getting maximum profit and proper utilization of animal waste.

Poultry farming

Integrated farming system involving poultry birds helps in effective utilization of agricultural waste, grain, vegetables and fruit residues to provide additional income to the farming households. Additionally, poultry manure produced in large quantities can either be used for harvest or used as inputs for fish and duck farming or, if sold in large quantities, to obtain additional income. Apart from the additional income, additional employment is also generated throughout the year for the farming family.

Fish farming

Farming of fish along with dairy, poultry, pig farming etc. helps in effective utilization of manure and large amount of nutrients present in the manure are available to the fish. Ponds and paddy fields could have been used for this purpose. This different model of rice-fish-poultry system, proposed to study the above details, is given below.

1. Traditional-Paddy-Paddy System.

2. Paddy-fish-poultry system.

(a) Fish pit is dug in the corners of the paddy field.

(b) Fish pits are dug in the centre of the paddy field.

(c) Fish pits are dug on one side of the paddy field.

(d) Fish pits are dug on one side of the paddy field, which are connected by trenches.

Duck rearing

Duck rearing along with fish helps in achieving high productivity in fish. Agricultural waste like broken grains, paddy husks, poor quality grains etc. can be fed to the ducklings. Ducks act as excellent fertilizer for the pond and release nutrients into the soil at the bottom of the pond in search of food, which increases the productivity of the ponds, resulting in increased fish production. In return, the ducks get a clean and healthy environment to live in. The sale of eggs gives additional profit. Duck + Fish system suits very well with polyculture of fish, as Duck + Fish has good compatibility. Ducks feed on such organisms from ponds which are aquatic insects, tadpoles and larvae of aquatic weeds etc.

Mushroom Cultivation

The integration of crop and mushroom cultivation is a better combination in an integrated farming system. Farmers can cultivate mushroom in their homes and fields as an ingredient in farming to get nutritious food and extra income. Straw of paddy, wheat and small millet can be used for mushroom cultivation. Mushroom provides an additional income and employment to the farming family. There is no time to rest in agriculture in the present day's competition. Among the various occupations, mushroom cultivation fits best into any integrated farming system, it is organic recycling of crop residues as well as a suitable source of income, especially among women unemployed with low land and laborers. To get employment, from mushrooms.'

Apiculture

Linking apiculture with agriculture helps in increasing the yield level of crops by cross-pollination and also produces honey providing additional income to the farmers. Sunflower crop and other cross-pollinated crops have seen up to 20 percent increase with 3 to 4 beehives distributed over an area of one hectare. 100 boxes can be kept in one hectare. It needs to be noted that there should be mustard or flowering crops at an aerial distance of 3 km from the box. 40-45 kg of honey can be obtained from one box. That is, 4000-4500 kg of honey can be obtained from one hectare, provided there should be availability of flowers in good quantity.

Kitchen Gardening

This component of kitchen gardening helps the farming family to provide fresh vegetables and fruits daily. It improves the nutrition of the family with limited resources. A part of the farm can be reserved for kitchen gardening. Family members including children can spend their free time in maintaining the kitchen garden. Especially old people can spend their time in kitchen gardening. Surplus produce from the kitchen garden can be sold to earn additional income.

Vermiculture

Integrated Farming System Vermi-compost can be made in Integrated Farming System by using various agricultural wastes like crop residue and animal waste. This out-of-cash product helps in getting rich organic manure by reducing the cost of material. Excess vermi-compost can be sold to get additional income.

There are so many crops/enterprises may be incorporated to strengthen the system to make more profitable, productive and sustainable. These are Goat rearing, Sheep rearing, Pig rearing, Rabbit rearing, Azolla cultivation, Sericulture (silk rearing), Fodder Production, Nursery, Seed Production etc.

Model of Sugarcane Based Integrated Farming System

Sugarcane cultivation in India dates back to pre-Vedic period and presently the country stands second largest producer of sugarcane (355.0 mt) and sugar (more than 32.0 mt) in the world after Brazil. In India Evolution of 'Co' canes and scientific interventions in terms of its production and protection technologies as well as farm mechanization and use of new farm implements, tools have

revolutionized the sugarcane cultivation with the result than present productivity level ranges from 78 t/ha in subtropics to 85 t/ha in tropics on total acreage of over 4.77 m ha with productivity of 74.4 t/ha realized at the national level. Cost of inputs in this long duration crop is very high. The profitability of sugarcane farmer's and its productivity may be increased by crop diversification, inter cropping, additional more local feasible need-based enterprises and crops resulting livelihood security, soil health improvement, nutritional security, by-product recycling, eco-friendly farming/sugarcane based agri-system. This system will help employment generation through various components/enterprises throughout the year.

Keeping above points, ICAR-IISR, Lucknow has planned and execute the sugarcane based integrated farming system since last two years. The highlights of recommendations up to this stage are presented below:

Autumn planted sugarcane-based IFS: (2019-20)

- Sugarcane alone-Rs, 267500/ha.
- Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) fetched net income of Rs.303140 / ha.
- Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) + Horticultural Crop (Banana) +Backyard Poultry (Breed-Asheel, Nirbheek, Kadaknath) fetched net income of Rs.315370 / ha.
- Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) + Horticultural Crop (Karonda boundary plantation) + Backyard Poultry (Breed, Asheel, Nirbheek, Kadaknath) + Fisheries (Rohu, Catla) + Vermicompost (*Eisenia fetida*) fetched net income of Rs.373980 / ha.

Spring planted Sugarcane based IFS:(2019-20)

- Sugarcane alone-Rs, 256000/ha.
- Sugarcane + Vegetables (Bottle gourd, Sponge gourd Tomato, Brinjal Pumpkin, Onion) fetched net income of Rs.287940/ha.

- Sugarcane + Vegetables (Bottle gourd, Sponge gourd Tomato, Brinjal Pumpkin, Onion) + Horticultural Crop (Banana) + Backyard Poultry (Breed- Asheel, Nirbheek, Kadaknath) fetched net income of Rs.299970 / ha.
- Sugarcane + Vegetables (Bottle gourd, Sponge gourd Tomato, Brinjal, Pumpkin, Onion,) + Horticultural Crop (Banana) + Backyard Poultry (Breed- Asheel, Nirbheek, Kadaknath) + Fisheries (Rohu, Catla) + Vermicompost (*Eisenia fetida*) fetched net income of Rs.355830/ha.

Autumn planted Sugarcane based IFS: (2020-21)

- Sugarcane alone (Var. CoPk 05191)- gave Rs, 259200/ha. net income
- Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) fetched net income of Rs.324102 / ha.
- Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) + Horticultural Crop (Banana) +Backyard Poultry (Breed-Asheel, Nirbheek, Kadaknath) fetched net income of Rs.356862 / ha.
- Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) + Horticultural Crop (Karonda boundary plantation) +Backyard Poultry (Breed, Asheel, Nirbheek, Kadaknath) + Fisheries (Rohu, Catla, Nain) + Vermicompost (*Eisenia fetida*) + Apiculture + Mushroom. fetched net income of Rs.462412 / ha.

Spring planted Sugarcane based IFS:(2020-21)

- Sugarcane alone (Var. CoPk 05191)-Rs. 255800/ha.
- Sugarcane + Vegetables (Bottle gourd, Sponge gourd, Tomato, Brinjal, Pumpkin, Onion,) fetched net income of Rs.325040 / ha.
- Sugarcane + Vegetables (Bottle gourd, Sponge gourd Tomato, Brinjal, Pumpkin, Onion) + Horticultural Crop (Banana) + Backyard Poultry (Breed- Asheel, Nirbheek, Kadaknath, Quail) fetched net income of Rs.357800 / ha.
- Sugarcane + Vegetables (Bottle gourd, Sponge gourd, Tomato, Brinjal, Pumpkin, Onion) + Horticultural Crop (Banana) + Backyard Poultry (Breed- Asheel, Nirbheek, Kadaknath, Quail) + Fisheries (Rohu, Catla, Nain) + Vermicompost (*Eisenia fetida*) + Apiculture + Mushroom fetched net income of Rs.453350 / ha.

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Table 1: Productivity and profitability of different components of the cropping/farming system integrated with sugarcane (Autumn planted Sugarcane)-2019-20

SN	Cropping/Farming systems	Cost of Production (Rs/ha.)	Gross Income (Rs/ha.)	Net Income (Rs/ha.)	Income from component crop/ enterprise (Rs/ha.) or enterprises /unit
1.	Sugarcane (Sole) var. CoLk 09204	165000	432500	267500	-
2.	Sugarcane + Vegetables (including horti. crops) Throughout year	173400	476540	303140	35640
3.	Sugarcane + Vegetables (including horti. crops) Throughout year + Backyard poultry	182500	497870	315370	12230
4.	Sugarcane + Vegetables Throughout year (including horti. crops) + Backyard poultry + Fisheries + Vermicompost	198900	572880	373980	58910
Total additional income					**106780**

Table 2: Productivity and profitability of different components of the cropping/farming system integrated with sugarcane (Spring planted Sugarcane)-2019-20

SN	Cropping/Farming systems	Area (ha.)	Cost of Production (Rs/ha.)	Gross Income (Rs/ha.)	Net Income (Rs/ha.)	Income from component crop/ enterprise (Rs/ha.) or enterprises /unit
1.	Sugarcane (Sole) var. CoLk 09204	1.60	160000	416000	256000	-

2	Sugarcane + Vegetables (including horti. crops) Throughout year	1.79	171000	458990	287940	31940
3	Sugarcane + Vegetables (including horti. crops) Throughout year + Backyard poultry	1.89	178500	478470	299970	12030
4	Sugarcane + Vegetables Throughout year (including horti. crops) + Backyard poultry + Fisheries + Vermicompost	2.0	185930	569920	355830	55860
Total additional income						**99830**

Table 3: Fruits Crops and other enterprises throughout year (2019-20)

SN	Fruits/ enterprises	Area (ha.)	Production (kg/q/t/ha.)	Cost of production (Rs.)	Gross Income (Rs.)	Net Income (Rs/ha.)
1.	Karonda planted on Boundary wall	100 Running meter	300 kg.	1800	25000	23200
	Papaya	0.05 ha.	400 kg.			
	Banana (Vegetable Purpose)		50 kg.			
Total				**1800**	**25000**	**23200**
2.	**Enterprises: Backyard Poultry**					
	Hen undressed		56 kg.			
	Hen eggs		690 pcs			

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	Fisheries	0.05ha.	200 kg.	13450	61980	48530
	Vermicompost		500 kg.			
Total				**13450**	**61980**	**48520**

Table 4: Productivity and Economic feasibility of different components of the cropping/farming system integrated with sugarcane (Autumn planted Sugarcane)-2020-21.

SN	Crop/enterprises	Area (ha.)	Production (kg/q/t/ha.)	Cost of production (Rs.)	Gross Income (Rs.)	Net Income (Rs/ha.)
1.	Sugarcane (Sole) CoPk 05191	0.8 ha	101 tonnes	165000	424200	259200
2.	Vegetables Crops					
	Garlic, Fenugreek, Coriander, Brinjal, Green Chili, Cabbage, Pea, Soya, Sauf, Bottle guard, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion, Okra, Cowpea, Banana (Vegetable purpose), Papaya, Cucurbit	0.2 ha	1891.5 kg	18650	63412	44762
	Maize		864 pcs			
Total			**1891.5 kg 864 pcs**	**18650**	**63412**	**44762**
Grand total all crops and enterprises				**183650**	**487612**	**303962**

Table 5: Profitability of different components of the cropping/farming system integrated with sugarcane (Autumn planted Sugarcane)-2020-21.

SN	Cropping/Farming systems	Cost of Production (Rs/ha.)	Gross Income (Rs/ha.)	Net Income (Rs/ha.)	Income from component crop/

					enterprise (Rs/ha.) or enterprises/unit
1.	Sugarcane (Sole) var. CoPk 05191	165000	424200	259200	-
2.	Sugarcane + Vegetables (including horti. crops) Throughout year	185450	509552	324102	64902
3.	Sugarcane + Vegetables (including horti. crops) Throughout year + Backyard poultry	195450	552312	356862	32760
4.	Sugarcane + Vegetables Throughout year (including horti. crops) + Backyard poultry + Fisheries + Vermicompost + Apiculture + Mushroom	203900	666312	462412	105550
Additional income from no.4 S-IFS modal Rs. =203212/ha.					

Table 6: Productivity and Economic feasibility of different components of the cropping/farming system integrated with sugarcane (Spring planted Sugarcane)-2020-21.

SN	Crop/ enterprises	Area (ha.)	Production (kg/q/t)	Cost of production (Rs.)	Gross Income (Rs.)	Net Income (Rs/ha.)
1.	Sugarcane (Sole) CoPk 05191	0.8 ha.	99 tonnes	160000	415800	255800
2.	Vegetables Crops					
	Bottle gourd, Sponge gourd, Tomato,	0.2 ha	1540 kg	10680	54530	49100

	Cowpea, Brinjal, Cucurbit, Okra					
	Maize		960 pcs		3450	
	Pachoi		60 pcs		600	
	Chinese Gobhi		120 pcs		1200	
Total		**1.0 ha.**		**10680**	**59780**	**49100**
Grand Total all crops and enterprises				**170680**	**475580**	**304900**

Table 7: Profitability of different components of the cropping/farming system integrated with sugarcane (Spring planted Sugarcane)-2020-21.

SN	Cropping/Farming System	Cost of Production (Rs/ha)	Gross Income (Rs/ha)	Net Income (Rs/ha)	Income from component crops/enterprises (Rs/ha) or enterprises/unit
1.	Sugarcane (sole) var. CoPk 05191	160000	415800	255800	-
2.	Sugarcane + Vegetables (Including hort. Crops) throughout year	172480	497520	325040	69240
3.	Sugarcane + Vegetables (Including hort. Crops) throughout backyard poultry	182480	540280	357800	32760
4.	Sugarcane + Vegetables (Including hort. Crops) + Backyard poultry + Fisheries + Vermicompost + Apiculture + Mushroom	190930	654280	453350	95550

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Additional income from no.4 S-IFS modal-= Rs. 197550 /ha.

Table 8: Fruits Crops and other enterprises throughout year (2020-21)

SN	Fruits/Enterprises	Area (ha)	Production (kg/q/t/ha)	Cost of production (Rs/ha or Rs/enterprises)	Gross Income (Rs/ha)	Net Income (Rs/ha)
1.	Karonda planted on boundary wall side	100 running meters	250 kg	1800	10000	20140
	Papaya (var. Pusa nanha)	0.05 ha	358 kg		10740	
	Banana (var. G-9)		60 kg		1200	
Total				**1800**	**21940**	**20140**
2.	Enterprises (Backyard poultry)					
	Hen undressed	0.05 ha	70 kg	10000	14000	32760
	Hen eggs		1050 pcs		12600	
	Quail		180 pcs		10800	
	Quail eggs		180 pcs		360	
	Mushroom		50 kg		5000	
Total				**10000**	**42760**	**32760**
	Fisheries	0.01 ha	500 kg	8450	100000	95550
	Vermicompost		800 kg		4000	
	Apiculture		50 kg		10000	
Total				**8450**	**114000**	**95550**

Rate of different commodities and produce as per prevailing market rates/mandi rates.

Conclusion

- Autumn planted Sugarcane based IFS: (2019-20) -The results clearly indicate that autumn sugarcane based integrated farming system as Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato,

Cauliflower, Spinach, Carrot, Fababean, Onion) + Horticultural Crop (Karonda boundary plantation) + Backyard Poultry (Breed, Asheel, Nirbheek, Kadaknath) + Fisheries (Rohu, Catla) + Vermicompost (*Eisenia fetida*) fetched additional income of Rs.106780/ha.

- Spring planted Sugarcane based IFS:(2019-20)-The results clearly indicate that spring sugarcane based integrated farming system as Sugarcane + Vegetables (Bottle gourd, Sponge gourd Tomato, Brinjal, Pumpkin, Onion,) + Horticultural Crop (Banana) + Backyard Poultry (Breed- Asheel, Nirbheek, Kadaknath) + Fisheries (Rohu, Catla) + Vermicompost (*Eisenia fetida*) fetched net income of Rs.355830 / ha. fetched additional income of Rs.99830/ha.
- Autumn planted Sugarcane based IFS:(2020-21)- The results clearly indicated that autumn sugarcane based integrated farming system as Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion, Brinjal, Green chilli, Cabbage, Pea, Soya, Sauf, Bottle guard, Okra, Cowpea, Cucurbit, Maize) + Horticultural Crop (Karonda boundary plantation + Papaya + Banana) + Backyard Poultry (Breed, Asheel, Nirbheek, Kadaknath, Quail) + Fisheries (Rohu, Catla, Nain) + Vermicompost (*Eisenia fetida*) + Apiculture + Mushroom fetched net income Rs.462412/ha. and fetched additional income of Rs.203212/ha.
- Spring planted Sugarcane based IFS:(2020-21)-The results clearly indicate that spring sugarcane based integrated farming system as Sugarcane + Vegetables (Bottle gourd, Sponge gourd, Tomato, Brinjal, Pumpkin, Onion, Maize Fenugreek, Pachoi, Chinese gobhi) + Horticultural Crop (Banana, Karonda, Papaya) + Backyard Poultry (Breed- Asheel, Nirbheek, Kadaknath, Quail) + Fisheries (Rohu, Catla, Nain) + Vermicompost (*Eisenia fetida*) + Apiculture + Mushroom fetched net income of Rs.453350/ ha. fetched additional income of Rs. 197550/ha.

Varieties /breeds of crops and enterprises taken in the systems

Sugarcane- CoPk 05191, CoLk 09204; Vegetables- Bottle gourd (Kashi ganga), Spong gourd (Kashi khushi), Tomato (Kashi ayan), Brinjal (Kashi uttam), Pumpkin (Kashi harit), Green chili (Kashi anmol), Coriander (kashmini), Fababean (Cherry), Okra (Kashi kranti); Fruits- Banana (G-9), Papaya (Pusa Dwarf); Poultry Breed- Ashil, Kadaknath, Nirbhik; Fish Breed-Rohu, Catla, Nain; Vermicompost (*Eisenia fetida*), Apiculture (*Apis mangifera*).

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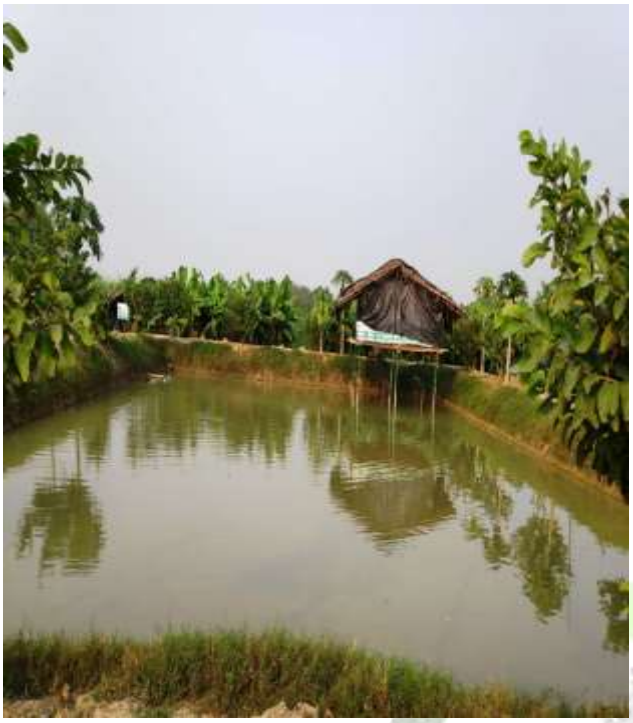
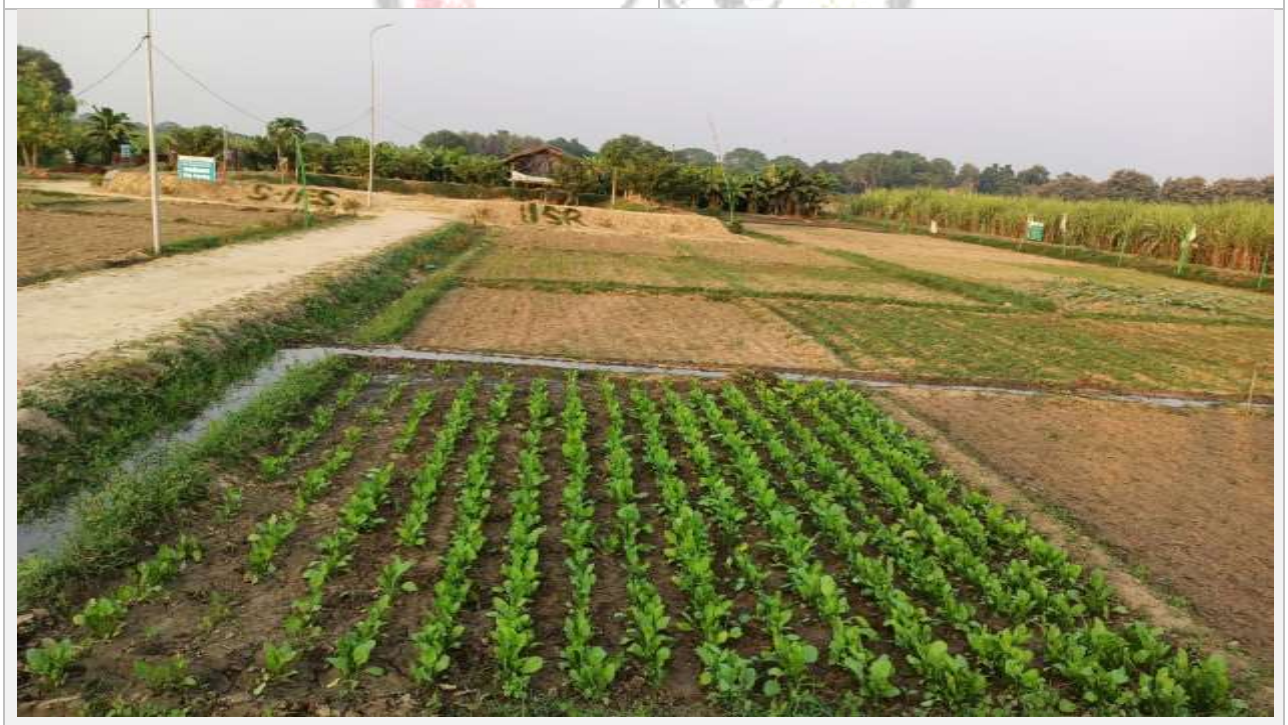


A view of Sugarcane based IFS model at IISR, Lucknow, Uttar Pradesh

A view of Fish production



A view of Sugarcane based IFS model at IISR, Lucknow, Uttar Pradesh

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Fish culture in small pond

Intercropping of coriander var. Kashmiri with banana var. G-9

Backyard poultry breeds (Neerbheek & Asheel) above under sugarcane-based IFS

Fish production (Rohu, Catla and Nain)

Crop diversification of Banana (var. G-9) and Maize (var. RMH 4212)

Bumper fruiting of boundary plantation of Karonda (var. Christs thorn) under sugarcane-based IFS

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Autumn planted sugarcane var. CoLK 9204 (sole crop)

Intercropping of maize (var. RMH 4212) + Cowpea (var. Kashi Nidhi)

Carrot var. Doctor

Brinjal var. Kashi Sandesh

Broccoli var. Green giant

Tomato var. Kashi Anupam + Coriander var. Kashmiri

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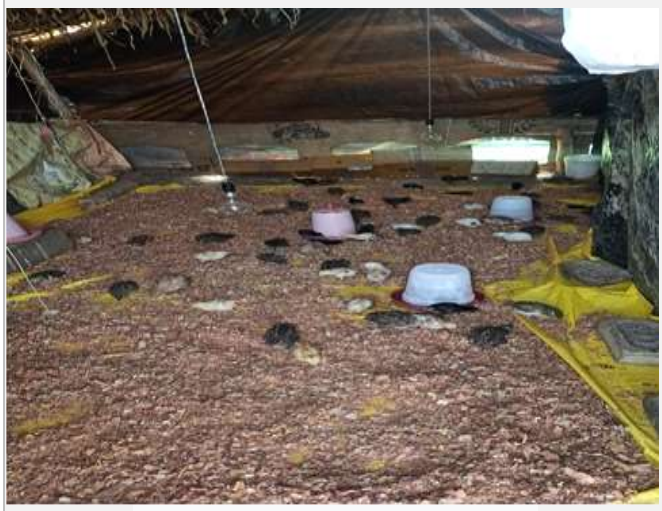
Garlic var. G 323

Mustard var. T-9 + Vegetable pea var. Suruchi



Quail chicks from CARI, Bareilly

Apiculture at fisheries pond along with Guava var. L-49

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Scientists and Officials Visited Sugarcane IFS Model