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Farming systems approach

for ensuring food and nutrition security

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Location and selection of area

The study area encompassed farming systems of Western Plain zone of Uttar Pradesh in Khatauli block of Muzaffarnagar district comprising Bhangela village, Sonta village and Satheri village through farmer participatory approach.

The Farming System study locations were selected on the basis of agro-climatic and socio-economic status, landholding pattern, farming practices and representing western plain zones of Uttar Pradesh. Major constraints identified in the region were found to be imbalanced crop nutrient application, lack of crop diversification, improper management of insect-pests, scarcity of quality fodder for animals and dearth of improved agricultural practices to name a few.

Number of farm families

Under this programme 1036 households (238 in Bhangela, 400 in Sonta, 398 in Satheri) in a cluster belonging to 3 contiguous villages in Khatauli block of Muzaffarnagar district were chosen. Based on land holding size - landless farmers (36.29%), marginal, small and landless farmers together (87.45%) and medium farmers (2.1%) were present, while large farmers were absent in the adopted villages suggesting defragmentation of landholdings.

OBJECTIVES

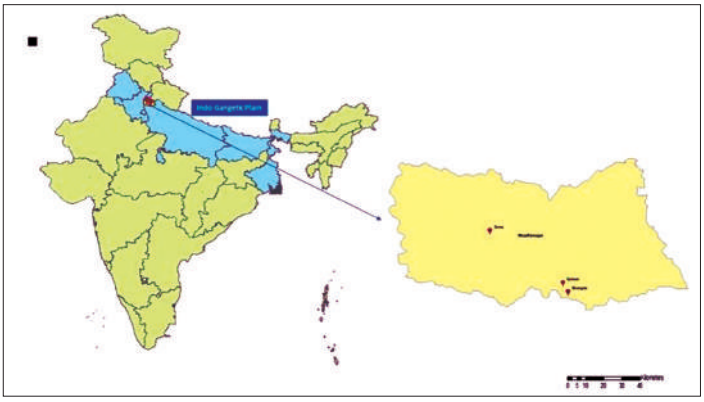
- To understand the constraints and opportunity available in the region along with designing and implementation of holistic farming systems interventions for ensuring food and nutritional security through increasing the farm productivity and profitability with small and marginal farmers in focus.
- To find out new ways of doing and bringing in synergy of the stakeholders.

Crop based module

Cropping module interventions included cropping intensification and diversification; use of improved production technology, HYV, Intercropping, INM, IPM and IWM; emphasis on oilseeds and pulses.

Trench planting of sugarcane in autumn with intercropping of mustard: Sugarcane-ratoon-wheat cropping system is predominant in western Uttar Pradesh which include variety Co 0238 generally planted in the month of May after harvesting of late sown wheat crop, leaving only one month for tillering and canopy formation in first plant of sugarcane resulting in heavy downfall of cane as well as green top yield. Moreover, the is reeling under heavy pressure of pathotypes and biotypes owing to being alone in the vast fray of its cultivation.

Therefore, a strategic intervention by introducing new variety of sugarcane (CoPk 05191) along with sowing of mustard (RH 749) as an intercrop in between 120 cm of interspace as an intercrop in autumn planting with paired row trench method was put in place on the six farmer's fields, two each in Satheri, Bhangella and Sonta. Transplanting of sugarcane (CoPk 05191) through trench paired row method and sowing of mustard as an intercrop in between 120 cm of interspace. Significant increase in cane yield ranging from 34.69 to 52.55% as well as system yield due to intercropping of mustard was observed. Increase in system yield ranged between 58.89% to 86.17% as compared to sole crop of sugarcane with farmer practice in summer crop.



Promotion of improved cultivars of wheat for higher productivity and profitability: Technical interventions in terms of three improved cultivars of wheat (PBW 550, PBW

658 and DBW 90) along with farmers practices (PBW-226) as control were taken for field demonstration and evaluation. Performance evaluation of the various cultivars was done in terms of grain yields and other yield attributing characters like effective tiller number per plant, length of ear, grains per ear and test weight. Besides these parameters, plant height was also considered for study because this is directly related to the stover yields which are the main components of dry fodder for the livestock components of integrated farming systems prevailing in these villages. Management practices like application dose of N, P and K and number of irrigations were applied. Growth, yield attributes and yied significantly improved as compared to farmers practice. Amongst the wheat cultivars PBW-90 secured highest yield of 5326 kg/ha followed by PBW 226 (4573 kg/ha) under late sown condition. The farmers (76.26%) also preferred PBW 90 after harvest of sugarcane crop.

Increase in temperature at grain filling stage reduced wheat yield. The coorelation studies also reflected the same and indicated that high temperature at grain filling stage have significant negative correlation.

Demonstration and evaluation of HYV of mustard: The high yielding variety of mustard (RH-749) along with Varuna variety was sown on 10 farmers' field. The yield of RH-749 under scientific management practice recorded 25.24% higher yield as compared to local variety under farmer practice.

Improved package of practice in wheat: Line sowing of wheat using seed drill and multi crop seed drill was demonstrated at farmers' field. Recommended dose of fertilizer was demonstrated in the package of practice and compared with farmers practice. Weed management in wheat was also included in the improved package through application of weedicide named "Total" (Sulfosulfuron 75% + Metsulfuron methy l 5% WG) @ 16 g in 150 litres water in wheat which was demonstrated at farmers' field. The farmers were convinced to adopt line sowing along with recommended

nutrient management as well as weed control through metsulfuran methyl 15% (WG).

Intercropping of pulses and oilseed in sugarcane: Farmers of this region grow

autumn sugarcane and sole crop where interspace remains unutilized for about 3-4 months. To utilize this space pulses like lentil, chick pea and oilseed mustard was demonstrated which revealed that there is 32.45% to 47% increase in total system productivity.

Balanced fertilizer application and disease/pest management in sugarcane through IPM: Intervention of nutrient and pest management in Sugarcane was executed to address the problem of low production due to imbalance in fertilizer usage and poor plant protection measures. Critical inputs like fertilizers, plant protection chemicals and tricocard, etc. were used in the technological intervention. A total of 659 trials were conducted on management of nutrients (N 175, P 80, K 120, Sulfur 40, Zinc 25 and Boron 5 kg per hectare) and plant protection measures (for controlling shoot borer and milli-bug, Trico card was used 3 times in the rainy season and for the control of pokkahboeng disease Carbendazim @ 0.2% was sprayed on the crop) for improving the yield and quality of sugarcane. It was found that yield of sugarcane was improved to 15.01, 14.66 and 10.22% in Sonta, Sathedi and Bhangela respectively as compared to Farmer's practice.

Horticulture based module

Horticulture modules interventions included, demonstration of improved package of practices in vegetable crop production; exotic vegetable cultivation for higher income; multi-tier cropping of vegetables and promotion of nutritional kitchen garden, and low cost nursery for off season vegetable production/low cost poly house.

Awareness about nutritional kitchen gardening: Farmers were made aware regarding the significance of fruits, vegetables and kitchen gardening. For this, plantation of improved varieties of fruit plants viz. mango, guava and lemon was carried out along with trainings on scientific management of different fruits and vegetables. Promotion of nutritional kitchen gardening on bare land nearby house/water sources, etc. was promoted by providing mini kit of seasonal vegetables to the farmers. Cost of these mini kits were ₹ 35-40/ kit. With such intervention, seasonal vegetable availability for family consumption was ensured which

could easily save ₹ 400 to 700/month which were otherwise spent by farmers towards purchase of vegetables. We observed, estimated average saving of ₹ 500 to 850 during *kharif* (monsoon) and ₹ 1000-1200 during *rabi* (winter) through kitchen gardening. Such interventions were eye opener to many progressive farmers of the study area.

Intercropping for diversification and intensification: Intercropping of pulses (black gram/green gram/ chick pea) in juvenile orchards of guava and litchi for intensification as well as additional income through intercrops and protein source for household nutrition even when the main fruit plants were in growth stage before fruiting started. Intercropping of banana in poplar plantation was demonstrated in sylvi-horti system which not only provided added income from intercrops with diversification and intensification but also provided better micro-climate suited for banana crops as intercrop.

Exotic vegetable cultivation for higher productivity and profitability: Improved package of practice was provided to the farmers for successful cultivation of the exotic vegetables through introduction of exotic vegetables, viz. broccoli, chinese cabbage, kale and lettuce in vegetables module for enhancing profitability along with boundary plantation of papaya to minimize the risk of heavy dependence on single crop besides generating year round income. With adoption of diversified exotic vegetable based cropping system, the net returns from 0.4 ha increased to 119%. The total net returns have increased from ₹ 92,575 to ₹ 2,03,170 with only 9.5% increase in the cost of cultivation. The contribution from animal component to the net income was enhanced by 26% in the improved farming system while there was significant improvement of 219% from the crop module solely due to diversification by exotic vegetables as compared to existing sugarcane based system. The benefit cost ratio was enhanced from 2.11 in the existing farming systems to 3.23 in the improved system. Thus the potential of horticultural crops in enhancing the income of farmers has proved worthy at farmer's field.

Multi-tier cropping for higher productivity and profitability: A multi-tier fruit crop based system comprising of strawberry, sponge gourd and capsicum was field demonstrated in the cluster considering the market accessibility of the NCR region which generated lots of interest from the farmers in the locality. With adoption of multi-tier based system the net return from the system improved to about ₹2.20 lakhs from 0.60 ha land while B:C ratio increased from 2.24 to 3.20. In the multi-tier system strawberry occuped the lowest niche followed by capsicum and then sponge gourd.

Livestock based module

Livestock module interventions included fertility and nutrition management in milch animals, Livestock healthcare/vaccination/ deworming/calcium supplementation, Introduction of improved breeds of poultry, goat and swine, and feed and fodder management through cropping systems diversification.

Livestock improvement

For addressing the problem of infertility, artificial insemination with quality semen was carried out. Supplementation of mineral mixture along with balanced nutrition was carried out for enhancing milk production in mulching animals. Technological intervention, viz. Infertility and nutrition management in milch animals, Mineral mixture, Calcium and vitamin supplements, Promotion and improvement of indigenous breed of cattle, deworming disease management, etc. were carried out under livestock module. Success of the livestock component depended on continuous supply of green fodder and feeds besides mineral mixture.

Technological intervention for improved fodder production: For continuous fodder supply jawar-berseem, Maize-jawar-berseem, Rice-oat+mustard were demonstrated. The improved variety of oat and berseem along with management practices and proper seed rate were also demonstrated which resulted in significant enhancement (27.5% and 29.5% respectively) in green fodder yield (Table 1).

Impact on milk yield due to animal health management and improved fodder supply: Supplementation of mineral mixture along with balanced nutrition was carried out for enhancing milk production in mulching animals along with improved supply of quality green fodder which resulted in improvement in milk yield.

Nutritional and animal management: Nutritional intervention was adopted for improvement in growth and milk production in cattle and buffaloes. Farmers were trained on how to make affordable balance ration using local feed ingredients. Ration of the milking animals was also balanced by supplementing mineral mixture, fortified Calcium

Table 1. Performance evaluation of fodder crops under improved management practices

Crop	Village	No. of demons-trations	Yield (q/ha) improved practice	Yield (q/ha) farmer practice	Increase in yield (q/ha) (%)
Berseem (1 kg seed per 400 m²)	Sounta	35	792.86	613.93	178.93 (29.25%)
	Sathedi		789	613	176 (28.78%)
	Bhayangi-Bhangela		795.9	608.63	187.27 (30.89%)
	Mean		792.6	611.9	180.7 (29.5%)
Oats (Kent)	Sounta	22	474	370	104 (28.17%)
	Sathedi		476.43	367.14	109 (30.21%)
	Bhayangi-Bhangela		466.25	373.75	92.5 (24.97%)
	Mean		472.2	370.3	101.8 (27.5%)

and vitamin mixture (Vimeral). For eradicating calcium deficiency in animals, farm households were provided with fortified Calcium supplement. Besides, vitamin mixtures were also provided to farm households. Medicines were also given for the effective control of endo and ecto-parasites. The details of the feed supplements and medicines, their effects on animals are given in Table 2.

The application of balanced nutrition resulting in overall per day improvement in milk yield in different villages was observed 1.03 ± 0.03 litres/day, which is 12.95% higher as compared to farmer's practice. The per lactation improvement in milk production was 225-250 litres of milk. Not only improvement in milk production but animals showed improvement in reproductive cycles and fertility (by getting timely pregnant).

Animal husbandry: For ensuring the livelihood security of marginal, landless farmer's, animal husbandry based IFS involving piggery, goatary and poultry were carried out and evaluated. Livestock health camps were also organized periodically.

- *Promotion of piggery among landless farmers:* Landless farmers were provided with Large white Yorkshire variety of piglets for enhancing their livelihood through pig rearing. Each farmer was provided with 1 Male and 1 Female piglet. Results indicated 40% increase (Table 3) in their income from pig rearing.
- *Promotion of backyard poultry:* Landless farmers were encouraged to take up backyard poultry for enhancing their livelihood through backyard poultry. Each farmer was provided with 12 birds of CARI Nirbheek. Results indicated 29% increase in their income from poultry rearing (Table 4).
- *Promotion of goatary:* Marginal and landless farmers were provided with Jamanapari goat for enhancing their livelihood through goat rearing. Each farmer was provided with 2 goats. In each village 1 male was maintained, rest being females. Additional income to the tune of 32% was realized from adoption of goatary (Table 5).

NRM based module

NRM based module included

Table 2. Details of feed supplement used for nutritional management of livestock

Name of feed supplement/ medicine	Quantity supplied (nos.)	Dose per adult animal/ day	No. of animals covered	No. of household covered	Effect on animals
Mineral mixture (Agrimin forte)	500 (1 kg pack)	100 g. (milking animals) 50 g. (heifers/dry animals)	500	460	• Improving growth rate, better utilization of absorbed nutrients, increases milk production in animals, improves reproductive efficiency and reduces inter-calving period, improves immunity status.
Calcium	300 (1 litre Pack)	100 ml (milking animals)	300	275	• Sustain milk production, control milk fever and maintain hormonal balance.
Vitamin mix. (Vimeral)	300 (120 ml Pack)	20 ml	300	300	• Removes stress, acts as immune-stimulant, increases milk production, improve growth & egg production.
FENTAS PLUS	500 tab.	1 tab./ 30 kg B.W.	90	90	• Removing Tapeworms, Roundworms, Hookworms and Whipworms
Taktic 5% (Amitraz I.P. (Vet) 50 mg)	200 (6 ml pack)	2 ml/ litre in water	200	200	• Effective control of ticks, mites, lice.
Flupor (Flumethrin-10mg)	200 (30 ml pack)	1 ml/ 10 kg B.W.	200	200	• Effective control of ticks, fleas and lice.

Table 3. Income enhancement through pig rearing

	Village	No. of Households	Increase in Annual income (₹)	Increase in Annual income (%)
Large white Yorkshire (1 M + 1 F to each farmer)	Sounta	15	9400	48.81
	Sathedi		11400	30.48
	Bhayangi-Bhangela		12400	41.96
	Mean		11066	40.42

Table 4. Income enhancement through backyard poultry

	Village	No. of Households	Increase in Annual income (₹)	Increase in Annual income (%)
Nirbheek (12 birds to each farmer)	Sounta	24	13000	31.18
	Sathedi		12500	30.23
	Bhayangi-Bhangela		10800	27.27
	Mean		12100	29.56

composting and vermi-composting; improved small farm tools for reduction in drudgery of farm-women; value addition of farm produce (pickle/jam/jaggery making) and SHG formation for marketing

Composting and vermicomposting for residue recycling and pond management: On site input production and management like vermin-composting, nursery of planting material, seed production, residue management, etc. were done. Vermi-composting at farmer's level was encouraged. Farmers were imparted training for preparation of vermi-compost. The prepared compost was used in vegetable production.

Pond management: In the study cluster, ponds which were otherwise being unutilized and weed infested were used for water chestnut cultivation. The farmers/lease were given technical advise on water chestnut cultivation and fish culture for optimum utilization of water resources through village ponds to generate additional income.

Microclimatic variations in Agri-horti farming system: Four crop environment namely Banana sole crop, Sugarcane sole crop, Poplar + wheat and Poplar + banana were undertaken for quantification of the micro-climate influenced by the different crop combinations. To quantify the variation in micro-climate, *in situ* observations of CO_2 (ppm), RH (%) and temperature (°C) were recorded during clear sky mid-day at two heights i.e. 50 cm and 100 cm above the ground level. The micro-climate condition at 50 cm above the ground in banana sole crop was found to be moderate with 594.2 ppm CO_2, 18.9% RH and 36.9°C temperature in comparison to bare field (592.6 ppm CO_2, 19.3% RH and 35.1°C temperature) and Sugarcane sole crop (594.8 ppm CO_2, 19.2% RH and 37.7°C temperature). In Poplar-banana system significantly higher concentration of CO_2 (596.0 ppm) was recorded however, RH (18.2%) and temperature (35.6°C) were found lower than the banana sole crop. At 100 cm above the ground level, the highest CO_2 concentration (599.9 ppm) was recorded in Poplar+banana farming systems with 18.4% RH and 35.5°C ambient temperature followed by Poplar+wheat with 595.3 ppm CO_2. Better condition of banana crop was recorded under Poplar+banana forestry-horti system than the banana sole crop.

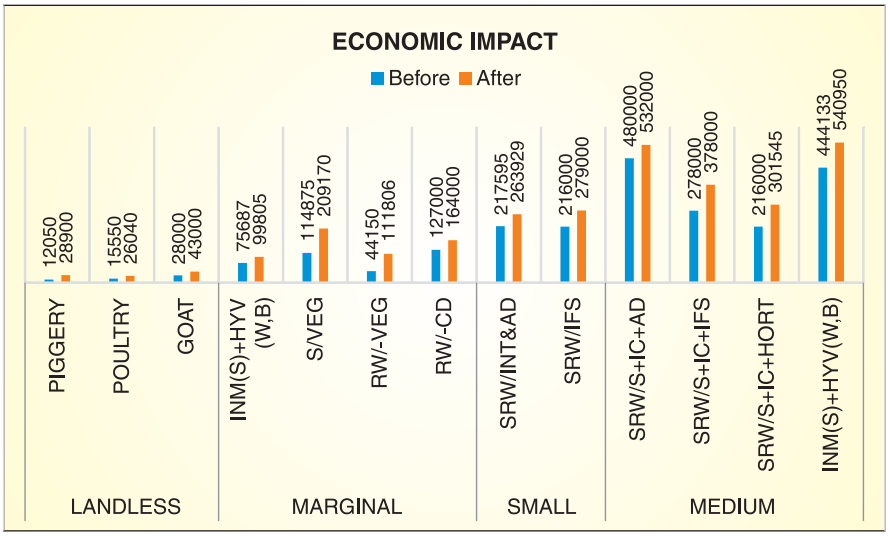
Risk management through SMS based agro-advisory services: Farmers of all the three villages were provided with weekly weather based agro-

advisory for farm management for different modules of farming systems. Besides weekly advisory, need based advisory on crop specific management depending on weather condition requiring immediate attention were also provided. A SMS based agro-advisory service named IIFSRK was started with technical support from C-DAC under which 1036 farmers of all the three villages were registered. Farmers were given information about rainfall predictions as well as improved practices and crop specific disease and pest

In situ observation of the CO_2 (ppm), RH (%) and temperature (°C).

Table 5. Income enhancement through goat rearing

	Village	No of households	Increase in annual income (₹)	Increase in annual income (%)
Jamnapari (2 goats to each farmer) *1 Male and rest female in a village	Sathedi	9	12200	32.79
	Bhayangi-Bhangela		11080	32.5
	Mean		11640	32.65



Economic impact of farming systems approach.

management advisories specific to different season through SMS.

TRAINING

For capacity building the following steps were taken.

- Skill enhancement training (Compost/vermicompost preparation/nursery raising/on-farm processing/mushroom production/ prunning/good agricultural practices, etc training)
- Exposure visits to Agri fair/Krishi unnati mela/ awareness programmes/Kisan gosthi, etc.
- Literature distribution in local languages and agro-advisory services for risk management.
- Demonstration kit on gender friendly improved tools on drudgery reduction were developed. Ergonomically designed improved tools for e.g. improved sickle for harvesting of field crops, fodder crops and improved khurpi were distributed to the women and men farmers for improving the working efficiency and comfort during harvesting and weeding operation respectively.

Further, demonstration of seedling transplanter, direct seed dibbler, improved sickle were conducted through participation of farm women in the study cluster for reduction of drudgery.

- Women Self Help group (Devanjali Mahila Samuh) was formulated in Bhangela village for the skill enhancement in secondary agriculture activities as a diversified income generating avenue. Trainings on value addition and processing of various products were delivered to the women's group. The group has gained expertise in the development of different products, viz. blended squash (guava+orange) and (guava + pineapple + pomegranate) mixed jam (guava +apple + aonla + orange + ramphal) and (guava + pineapple + pomegranate + apple), ginger paste, etc.

Delegates from Argentina.

- Capacity building programmes, public awareness campaigns on improved package of practices of different *rabi* crops was carried out during the reporting period. Farmers were also exposed to new age technologies through exposure visits to Krishi melas, exhibitions. Awareness programme on Swachhata hi Seva, Soil health day, etc which were observed in study clusters for cleanliness drive and soil health management.

Table 6. Farming systems for different category of farmers

Farmers category	IFS module adopted
Land-less	Cow/ Buffalo improved rearing practices of livestock Nutritional kitchen garden Piggery/Goatry/Poultry (Backyard)
Marginal	Sugarcane-ratoon-wheat Rice-berseem Maize-wheat One Cow+ one Buffalo Nutritional Kitchen Garden
Small	Sugarcane + Mustard/lentil/ chickpea Sugarcane ratoon-wheat Rice-berseem /wheat/mustard 1cow/2 buffalo Nutritional kitchen garden
Medium	Sugarcane-ratoon-wheat Sugarcane+wheat/lentil/ chickpea/mustard-ratoon Rice-berseem/ mustard Rice-wheat-moong Rice-wheat-sunhemp Maize/jowar-wheat-cowpea 2 cow/2 buffalo Nutritional kitchen garden

IMPACT

Integrated Farming systems for different category of farmers under IFS module: Based on individual component modules integrated farming systems suitable to different category of farmers were identified and different component technologies were integrated and studied for their impact on economic performance resulting in increased income ranging from 21% to 139% which is presented in Table 6.

CONCLUSION

Farming systems approach proved to be useful tool in enhancing productivity through diversification and intensification as well as profitability for different category of farmers through adoption of improved component technologies along with supplementary and complementary enterprises for optimum use of resources. The holistic approach also aided in meeting household requirement in terms of providing food and nutritional security to the farmers of the locale.

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