



Integrated Farming Cafeteria: A General Framework for Promoting Integrated Farming at Landscape Level

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Abstract: Integrated farming, encompassing precisely a synergistic combination of crops, agroforestry and livestock, is needed to attain sustainability and economic viability of farms and address challenges of climate change. The approach offers a holistic solution to the challenges of monoculture systems dependent upon a few selected crops. Integrated farming must be flexible enough to accommodate new innovations in crops, cultivars or other changes to optimize resource use and to meet demands. This essentially requires exposure of farming community to combinations of innovations and alternative options. To fulfil this objective, we describe here the concept of Integrated Farming Cafeteria (IFC), its uniqueness and relevance to promote integrated farming at landscape level. IFC established at the ICAR-Central Arid Zone Research Institute, Jodhpur on 2.1 ha in 2022, accommodated 130 varieties of 16 field crops, 9 of five horticultural crops and 10 of eight fodder crops, grown with recommended practices, in addition to several soil and water conservation technologies (residue recycling, water harvesting, micro-irrigation) and other interventions (solar pump, precision farming, boundary plantation) that reduce cost of production and enhance income from farming. More than 5800 farmers visited IFC, from 2022 to 2025 with a well-defined purpose to personally witness and compare the advantages of water and soil management practices, new crops and improved crop varieties over their traditional methods. Visits were planned to coincide with crop stages from flowering to maturity. IFC was instrumental in enabling farmers to observe, test, and record the performance of modern, sustainable agricultural practices firsthand. IFC, as an innovation, would go a long way to enhance farmers understanding of modern agricultural interventions and foster adoption of integrated farming.

Key words: Farming cafeteria, improved varieties, production technologies, adoption, resilience, sustainability, integrated farming.

Integrated farming is the need of the hour due to its potential to address multiple contemporary challenges including food

security, climate change, sustainability and the economic viability of small-scale farms. It is precisely a synergistic combination of crops, agroforestry and livestock, designed to create a self-sustaining farm to maximize resource use efficiency, reduce cost of production, diversify income and boost overall productivity, resilience and sustainability. This approach offers a holistic solution to the limitations of conventional monoculture systems dependent upon a few selected crops.

Agro-climatic conditions comprising of amount and distribution of rainfall, soil type, temperature, humidity, solar radiation and water availability; and socio-economic conditions of farmers govern the choice of crops in farming pattern of any region. Collectively, these factors determine whether the farming system is environmentally sustainable and economically viable for that specific region. Accordingly, different farming systems have been developed and deployed adapting combinations of components (such as specific crops, livestock, water and soil management etc.) to suit local environments, economic needs, and sustainability goals.

Integrated farming, by nature, has to be dynamic to accommodate new innovations in terms of novel crops, cultivars or other changes to optimize resource use and meet changing demands. This essentially requires exposure of farming community to combinations of new innovations and alternative options. We describe here the concept of Integrated Farming Cafeteria (IFC), its uniqueness and relevance to promote integrated farming at land-scape level especially in arid agri-ecosystem.

The Concept

Farming systems are indeed highly varied, and it is practically impossible to showcase every farming model at one place. Moreover, there is no universal farming system that can cater to needs of diverse farming community because of the diversity of environmental conditions, economic constraints, and cultural preferences. The ideal farming approach is highly context-dependent and must be tailored to the specific local factors. Therefore, there can be two alternatives: either existing farming can be optimized by adding a new complementary component or existing system can be tweaked to enhance efficiency and synergy through

advanced management tools and practices. Adding components generally increases diversification, while the tweaking focuses on optimizing existing synergies.

Many possible alternatives should be demonstrated at a common place so that farmers can observe and assess various tested and validated technologies in a real-time situation through a combination of physical demonstrations and interactions - not only with experts but also among peers. The IFC consisting of combinations of various annual and perennial crops, and interventions in soil and water conservation, low-cost protected cultivation, pest management, solar energy and boundary plantation for productive and protective purposes can serve this objective. With this purpose the IFC is established at the ICAR-Central Arid Zone Research Institute (ICAR-CAZRI), Jodhpur in a compact block to allow farmers to visually inspect and select specific components or entire systems that can be integrated into their existing farming situations to enhance productivity and to build climate resilience depending upon the available resources with farmers. IFC essentially demonstrates a range of choices of selecting crops and their cultivars to fulfil food, fruits and fodder requirements. At the same time, technologies for soil, water, weed, pest and nutrients management; use of solar energy in farming; cultivating high-value crops in protected cultivation; and growing fruit trees on boundary are also amalgamated to reduce the cost of cultivation and to enhance farm income. Concept of IFC is a next-stage evolution of Crop Cafeteria started in the ICAR-CAZRI in 2016 (Mahla *et al.*, 2020) amalgamating feedback of farmers and stakeholders to make it more inclusive and broader particular for small and marginal farmers. The IFC can serve as a practical, "seeing is believing" mechanism for display and dissemination of technologies related to management of new crops, agroforestry, water resources and soil health.

At this time, it must be fully recognized that IFC is not a demonstration of any single specific integrated farming system (IFS) model. As the name indicates, IFC is a cafeteria that showcases the wide choices for farmers with respect to new crops, cultivars, and other soil and water management interventions that might motivate them to adopt on their existing

farm. On the other hand, IFS is a designed farm unit where outputs from one enterprise (e.g., crop residue) become inputs for another (e.g., animal feed, compost), creating a circular flow. Unlike, any individual IFS which combines a given set of individual components, IFC serves as a, “scientific, knowledge-based, and farmer-participatory” hub that showcases a wide variety of agricultural and allied components. Rather than being as a rigid, singular model, IFC follows a “cafeteria” approach, encouraging farmers to observe, understand, choose, adopt, and integrate various components tailored to

their specific agro-climatic conditions and resource availability. Thus, IFC is a specific and innovative educational model demonstrating various farming practices at one location for farmers to learn and choose from, rather than being a single farm system itself.

Layout and Management

IFC was established in 2022 on a 2.1 ha area, equal to average land holdings in arid Rajasthan, conveniently located on main road of the institute with easy access to all stakeholders. The soil is sandy loam which is

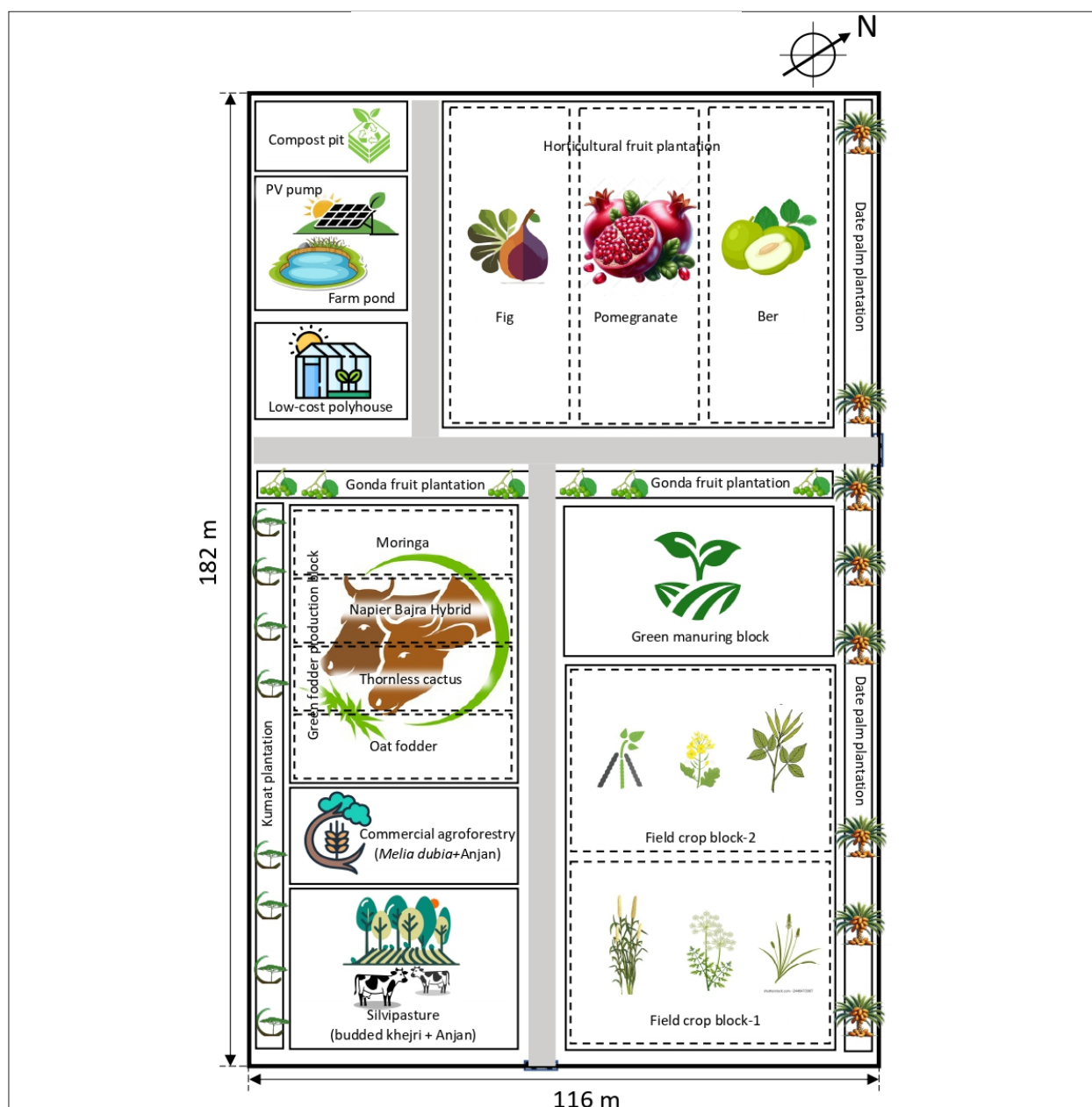


Fig. 1. Schematic layout of the Integrated Farming Cafeteria on 2.1 ha at the ICAR-CAZRI, Jodhpur.

Table 1. Recommended package of practices followed with respect to crop geometry and nutrient management in field and fodder crops grown as rainfed or irrigated in the Integrated Farming Cafeteria

Crops	Spacing (cm)		Seed (kg ha ⁻¹) or Seedling (no.) rate	N:P:K dose (kg ha ⁻¹)	Rainfed/ irrigated
	R × R	P × P			
Field crops					
Pearl millet	45	10	4.0	60:40:0	Rainfed
Clusterbean	45	10	12.0	20:40:0	Rainfed
Mung bean	45	10	15.0	20:40:0	Rainfed
Moth bean	45	10	10.0	20:40:0	Rainfed
Proso millet	30	10	10.0	20:20:0	Rainfed
Barnyard millet	30	10	8.0	20:20:0	Rainfed
Foxtail millet	30	10	8.0	20:20:0	Rainfed
Cumin	30	5	10.0	30:20:0	Irrigated
Isabgol	30	5	4.0	30:20:0	Irrigated
Mustard	45	10	4.0	60:40:0	Irrigated
Quinoa	45	15	2.5	20:40:0	Irrigated
Amaranthus	45	15	2.0	60:40:0	Irrigated
Fenugreek	30	10	20.0	20:40:0	Irrigated
Fodder crops					
Bajra napier hybrid	1 m	1 m	10000 plants ha ⁻¹	100:70:25	Irrigated
Cactus thornless	1 m	1 m	10000 plants ha ⁻¹	40:30:0	Partially irrigated
Moringa	1 m	1 m	10000 plants ha ⁻¹	40:30:0	Irrigated
Fodder sorghum	30 cm	10 cm	45 kg ha ⁻¹	80:50:40	Rainfed
Fodder pearl millet	30 cm	10 cm	12 kg ha ⁻¹	80:50:40	Rainfed
Oats	30 cm	10 cm	110 kg ha ⁻¹	10:50:40	Irrigated
Lucerne	30 cm	5 cm	20 kg ha ⁻¹	10:50:40	Irrigated
Guinea grass	50 cm	50 cm	40000 plants ha ⁻¹	80:35:30	Irrigated

R×R row to row distance; P×P plant to plant distance.

true representative soil type of arid regions. The area is divided in 6 blocks accommodating field crops, horticultural crops, fodder crops, agro-forestry, polyhouse and solar panels (Fig. 1). Soil and water conservation technologies like rainwater harvesting, drip irrigation, residue recycling and green manuring having been provisioned in different blocks to deal with specific local needs and promote sustainable resource management.

All constituent field, horticultural and fodder crops were maintained as per the recommended package of practices with respect to crop geometry, nutrient, and weed, pest and disease management (Table 1). Only recommended cultivars of field and horticultural crops of the region were accommodated in the cafeteria. The crops were maintained either as rainfed (in kharif) or irrigated (in rabi) as per the standard recommendations. The improved production technologies such as land levelling,

right time of sowing, appropriate seed rate, seed treatment, line sowing, spacing, nutrient and pest management were followed. Weeds were controlled either with tractor-drawn weeder or manually.

A rainwater harvesting pond of 5 lakh litres capacity (20 m length × 12 m width at the top; 16 m length × 8 m width at bottom; 3 m depth) was established in the IFC (Fig. 2). To utilize harvested rainwater for irrigation purpose, a submersible pump of 5 HP was used. Fifteen solar panels, each of 330 W capacity were installed to generate solar energy which was converted into electricity to operate the pump for providing drip-based irrigation to vegetables and horticultural crops. Seepage losses of stored water from a pond were checked by lining it with an HDPE sheet (300-500μ) while evaporative losses were reduced by spreading thermocol balls (combination of two sizes: 4



Fig. 2. A view of rainwater-harvesting pond (5 lakh litre capacity) and solar panels (5 kW capacity) in the Integrated Farming Cafeteria. Horticultural crops and composting unit can be seen in the background.

and 8 mm diameter in 1:3 ratio) over the water surface of the farm pond.

Five horticultural crops are grown in IFC, viz., pomegranate (*Punica granatum*), ber (*Ziziphus mauritiana*), fig (*Ficus carica*), date palm (*Phoenix dactylifera*) and gonda (*Cordia dichotoma*). The last two are raised as boundary plantation. Recommended crop geometry specific to each crop accommodated 715, 277 and 950 plants ha^{-1} in pomegranate (3.5 m x 4.0 m), ber (6.0 m x 6.0 m) and fig (3.0 x 3.5 m) ensuring optimum plant population, effective light interception, and better aeration, which collectively enhance growth, yield, and fruit quality. Precise fertigation delivery was assured by using 16 mm drip laterals with an emitter capacity of 8 Lhr^{-1} and four emitters per plant, applied at 2-day intervals in the morning hours in pomegranate and fig especially during fruiting season. Crop-specific nutrient management involving organic manures and water-soluble fertilizers are adopted to improve soil health, nutrient availability, and long-term sustainability. Nutrients were applied both as basal application and fertigation through water soluble fertilizer grades. Well-decomposed farm yard manure along with humic acid and bioformulation (*Trichoderma viride* and *Arbuscular mycorrhiza* fungi) was applied immediately after annual pruning in pomegranate and fig.

A naturally-ventilated polyhouse (NVP) of size of 384 m^2 (24 m x 16 m), double

span with central height of 6.5 m and gutter height of 4 m was erected in the IFC (Fig. 3). This can accommodate several high-value crops like seedless cucumber, cherry tomato, tomato, seedless brinjal and coloured capsicum for maximizing the resource-use efficiency and profits. Among these, cucumber is predominantly grown in both polyhouse and net-house structures, particularly in arid and semi-arid regions. Two crops of cucumber were taken by planting in mid-April and mid-September. Cucumber was grown using raised beds (9" high) with 80 cm top width and 60 cm space between 2 beds. Direct seeding was done in summer crop while 15-days old seedlings were transplanted in autumn-winter crop. Planting was done at 50 cm intervals in a zig-zag fashion in paired rows spaced about 40 cm apart on beds. All prescribed cultivation practices were followed to raise good crop. For irrigation, drip lines (laterals) with pressure compensating non-drain inline emitters with discharge rate of 2 Lhr^{-1} were laid for each row. Irrigation was provided every morning between 9 to 10 am to maintain optimum soil moisture in the top 15-20 cm soil layer. Along with irrigation water, soluble fertilizers were applied as per schedule through manual injector (venturi). Weeds were removed manually as and when appeared, though there is less infestation of weeds under polyhouse. Flowers emerging at lower nodes, up to 25-30 cm of plant height, were removed to promote



Fig. 3. Naturally-ventilated polyhouse (NVP) erected in the Integrated Farming Cafeteria.

a balance between early vegetative growth and fruiting through optimized assimilate partitioning. The deformed or crooked fruits, if any, were discarded as they appeared. Older, matured leaves at the lower canopy were also removed to maintain ground-level ventilation. The internal microclimate of polyhouse was regulated through intermittent operation of foggers (5-6 seconds 'on' followed by 45-50 seconds 'off' managed by cyclic times) during mid-day (11 am to 3 pm) in peak summer. Care was taken to prevent leaf wetting to minimize the risk of foliar diseases. Cucumber fruits reached harvest maturity 35-40 days after planting in the summer crop and 40 to 45 days after planting in the autumn-winter crop. Cucumber fruits were harvested regularly on alternate days on attaining the optimum size (130-150 g weight).

Performance of Components

Field crops

Good management resulted in excellent growth and development of crops in cafeteria. Wide differences were observed between the mean yields of rabi and kharif crops, with the former providing 46% higher grain yield than the later. This is expected as the crops in kharif season were raised as rainfed and moisture stress is a major constraint in kharif season, while rabi crops were cultivated with irrigation at critical growth stages as per their requirement. Among kharif crops, pearl millet proved to be the highest yielder (2982 kg ha⁻¹) followed by clusterbean and mung bean. In the rabi season, quinoa provided the highest yield (3078 kg ha⁻¹) closely followed by mustard (3057 kg ha⁻¹) (Fig. 4).

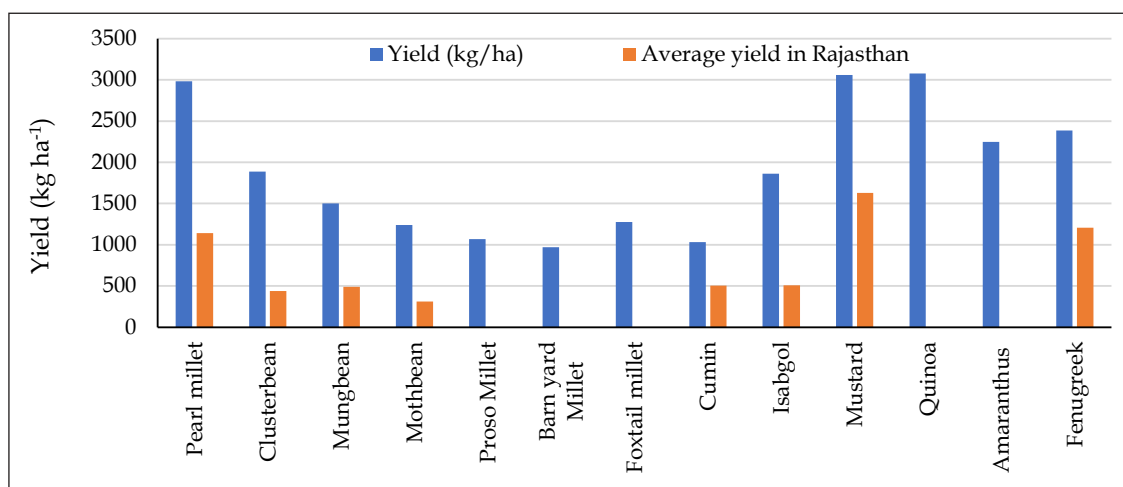


Fig. 4. Mean yield of crops realized in the Integrated Farming Cafeteria during 2022-2025 in comparison to their mean yields in Rajasthan during 2022-2024 (no data of proso millet, barnyard millet, foxtail millet, quinoa and amaranthus is available in Rajasthan) (Source: Agricultural Statistics, Govt of Rajasthan. 2024).

Table 2. Choice of horticultural crops for rainfed and irrigated conditions with yield and income potential

Crop	Variety	Growing conditions (Rainfed/irrigated)	Average fruit yield (kg plant ⁻¹)	Potential income plant ⁻¹ (Rs.)
Pomegranate	Bhagwa CAZRI Vishal	Irrigated under solar operated drip system	25	1000-1200
Ber	Gola Seb	Rainfed	65-70	1500-2000
Fig	Diana	Irrigated under solar operated drip system	12	1800
Date palm	ADP-1 Khuneji Navbat Sultan	Irrigated	80-100	6000-8000
Gonda	Maru Samridhi	Partially irrigated	60	1200

Yield levels obtained in various crops were higher than the state-level average yields (Fig. 4). Realized yields of crops in the IFC were 2-3 times higher than average yield in the region underscoring the scope of further increasing the yield by adopting new cultivars and good management practices as demonstrated in the IFC. This would certainly allow farmers to achieve much higher yields than conventional approach of farming in the region using available land resources. Better management practices and right choice of crops/cultivars would produce marketable surplus and enhance their income. This, in turn, would be a great motivation to switch to new crops and cultivars with suitable management practices.

Horticultural crops

The selection of appropriate horticultural crops plays a crucial role in enhancing farm productivity, income stability, and efficient utilization of land and water resources. In the IFC, a diversified system has been envisaged by including both irrigated and rainfed fruit plantation along with boundary plantation of high-value crops under the best management practices. Overall, the integration of suitable horticultural crops with improved management practices is essential to enhance farm productivity, resource efficiency, and farmers' income in a sustainable manner. Pomegranate being a high-value fruit crop offers assured market demand. Ber is a hardy and climate-resilient crop that thrives even under poor quality soils and low rainfall conditions, thereby providing nutritional and economic security to farmers. Fig, being a high-nutrient and commercially important fruit, contributes to crop diversification and income enhancement due to its premium market value

and suitability for processing. Date palm and gonda, as boundary plantation, serve as effective windbreak, enhances land use efficiency, and provide an additional source of income without compromising the productivity of main crops. The average fruit yield per plant is 12 kg, 25 kg, 65 kg, 80 kg, and 60 kg in fig, pomegranate, ber, date palm and gonda, respectively (Table 2).

Fodder crops

The fodder crops included bajra-napier hybrid (BNH), thornless cactus, moringa, guinea grass as perennial crops; fodder pearl millet and fodder jowar as rainfed during kharif; and oat and lucerne under irrigated conditions during rabi as seasonal crops. Various crops differed in their production potential depending upon their nature (annual *vis-à-vis* perennial) and availability of irrigation. BNH and guinea grass provided a high amount of green fodder (350-375 t ha⁻¹) (Fig. 5) through multiple cuts (6-8) throughout the year. The fresh cladode yield of thornless cactus was also very high (190 t ha⁻¹). On the other hand, rainfed pearl millet and sorghum and irrigated oats and lucerne could provide green fodder of 40-60 t ha⁻¹. Moringa, which is gaining popularity in the region yielded 5 t ha⁻¹ of dry leaf from four harvestings of leaf. The average fodder production was 25.5 tons from the block of 2500 m² area, which can sustain 5.1 adult cattle units (ACU) annually. These alternate fodder crops are very critical in providing green fodder under semi-intensive management of livestock.

Multi-purpose agro-forestry

Silvi-pasture type of agro-forestry is an important component of the IFC consisting of grass *Cenchrus ciliaris* intercropped with multipurpose tree species to enhance the

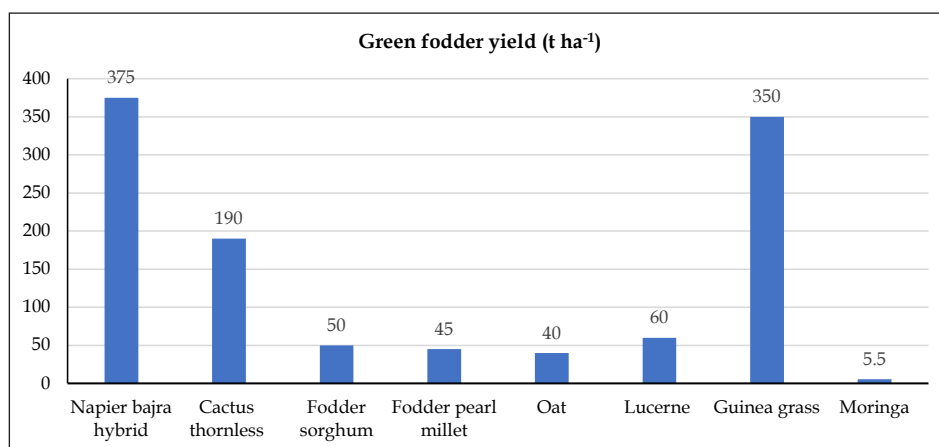


Fig. 5. Green fodder yield of alternative fodder crops in Integrated Farming Cafeteria. The data of moringa is of dry leaf powder (data for moringa is dry leaf weight).

production of fodder, timber, gum and seed. It comprises of four components. The grass serves as the primary source of green fodder. When planted at a row spacing of 140 cm, the grass can be harvested 2-3 times in a year with a yield of 2280-2500 kg ha⁻¹ and can also be used for controlled grazing by livestock.

The tree component includes Thar Shobha variety of Khejri (*Prosopis cineraria*) developed through budding technique with distinct advantages like short height, being thornless with early and uniform pod production. Trees are planted at 4 m × 4 m spacing. Nutritious pods harvested during April are used as vegetable after drying. A single tree provides 5-6 kg of fresh pod yield. Lopped branches also provides nutritious green fodder (6-8 kg tree⁻¹ for a five-year-old tree) for livestock. Moreover, this trees species, adapted to harsh environments of arid regions, contributes to improving ground cover and soil health.

Acacia senegal, planted along the boundary at a spacing of 4 m, serves as a live fence while generating additional income from its gum and seeds under rainfed conditions. Gum tapping is carried out on mature trees (generally 5-6 years old) during the dry season using CAZRI gum inducer with 400-500 g gum yield per tree, while seed collection (5-6 kg tree⁻¹) is done after pod maturity. Gum of the species have wide application in food and pharmaceutical industries as it has very excellent binding properties while dried seeds are used as an ingredient of famous off-season vegetable known as *panchkuta*.

Melia dubia has been included as a fast-growing commercial timber species, primarily aimed at plywood and veneer production, thereby enhancing medium-term economic returns from the system. *Melia dubia* is harvested for timber at 6-8 years of age, when trees attain suitable diameter (>15 cm) for plywood and veneer production. It yields 15-20 cubic feet (CFT) plywood per tree if planted in 4 m × 3 m spacing.

Precision farming and cultivation of high value crops

Two crops could be successfully grown in a year in natural-ventilated polyhouse. The average yield of cucumber varied in two seasons (Table 3). While 4 kg plant⁻¹ was average yield in autumn-winter crop, the mean yield per plant was only 2.5 kg in the summer crop, highlighting lower yields in challenging environments of summer season, though average selling price of cucumber in summer was higher as compared to winter season crop. Nonetheless, fruits of value of Rs. 1,66,000 were produced in two seasons. In other polyhouses/net-houses established in the adjacent fields, crops of coloured capsicum, tomato, cherry tomato and seedless brinjal could also be grown with high margins of profits.

Rainwater harvesting and its use

In the recent years, a few rainy storms of extreme intensity occurring in the arid region of the country result in generation of a significant runoff in a short period of time. The rainfall intensity of such storms usually exceeds infiltration rate of soil, which leads

Table 3. Average yields of cucumber hybrids in summer and winter seasons in naturally-ventilated polyhouse

Variety	Produce (No. of plants × yield)	Income
Fadia F ₁ (Summer: April to July)	2375 kg (950 plants × 2.5kg)	Rs. 71,250 @ Rs. 30 kg ⁻¹
Gurka F ₁ (Winter: September-January)	3800 kg (950 plants × 4 kg)	Rs. 95,000 @Rs 25 kg ⁻¹

to overland flow of excess water. Under these circumstances, harvesting of rainwater is of paramount importance.

The location of farm pond in the IFC was selected considering general land slope and computing elevation difference at different points on the land. Storage capacity of the pond was decided based on comparative evaluation of total available water and required water demand. Accordingly, a trapezoidal-shaped pond was designed. Side slope of the pond was kept as 0.66:1, which is steeper than that recommended for sandy soils (2.5:1) as pond was to be lined using high-density polyethylene (HDPE) sheet of 300-500 μ thickness.

A two-chamber sedimentation tank was constructed at the entry point of the farm pond to allow silt and sediments, carried from the catchment with flowing water, to settle down inside the sediment collection tank. Size of each sedimentation chamber was kept 3 m × 2 m × 1 m with a vertical wall in between two chambers and a rectangular notch at mid-point of the wall to allow water to enter from first chamber to second chamber. Velocity of the runoff water in the first chamber gets reduced permitting suspended silt to settle down at bottom. The runoff water then enters in the second chamber where some portion of the silt further gets settled down and is thus checked from entering in the pond that can be removed periodically. As the water flowing over the agricultural fields carries nutrient-rich topsoil that gets deposited in the sedimentation chambers, the deposited silt is beneficial for maintaining fertility of the catchment soils.

Seepage/percolation loss of stored water from the pond was totally checked by lining the pond with HDPE sheet (500 micron thickens). However, loss of water due to evaporation may sometimes be significant and large amount of water gets lost especially in arid regions. In order to overcome the problem of evaporational water losses from small reservoirs, thermocol balls (combination of two sizes: 4 and 8 mm diameter in 1:3 ratio) were spread over the entire water surface of farm pond, reducing evaporation

losses by 40%-60% under different situations and seasons. Cost of 4-8 mm diameter balls for a water surface area of 20 m × 12 m (240 m²) is Rs. 4,000/- and the balls work satisfactorily up to 2 years. These balls make bondage with the water and also among themselves creating a stable and continuous layer over water surface. The white surface created through thermocol (polystyrene) balls, effectively creates an albedo effect, which reduces water temperature and slows evaporation losses.

The rainwater stored inside the farm pond was utilized for irrigating vegetables and orchard crops. The water lifted through the submersible pump was passed through two-stage filtering system, consisting of sand filter and disk filter. Sand filter removes the dirt and other coarser particles from the water. Afterwards, the water passes through a disk filter where a series of disks removes silt, clay and other finer particles from the water. This filtering is necessary to check sediments from the lifted water of the pond to avoid clogging of drippers/emitters on a drip line. Further, entry of dirt and silt particles may also choke the foggers, if the harvested water is used for cooling the polyhouse during extreme summer (May-June). The sand filter is to be cleaned through back-flushing at regular intervals to avoid any drop in the water pressure. Likewise, the disk filter is to be opened and cleaned for maintaining proper flow of water through the pipeline towards the fogger line or drip line in the polyhouse.

Residue recycling

The composting block of IFC is important in recycling crop and farm residues into valuable black gold (organic manure - humus). The use of composts as plant nutrient-sources or as soil conditioners in agricultural fields and for environmental rehabilitation represents an age-old practice. Soil microbes play a very crucial role in decomposition of organic matter/crop residues into manure. The farm yard manure and other compost are having less nutrients, and therefore nutrient enriched compost is environmentally conscious and sustainable

option for enhanced nutrient supply with higher availability.

Enriched compost is prepared using residues of available mustard, weeds, grasses and leaf-litter of BNH grass along with chopped pruned twigs of horticultural plants in combination with rock phosphate and potassic feldspar. The biophos (P solubilizing microbes) and K solubilizing fungi (KSF - *Femitopsis melei*) were used for fast decomposition of residues and also mineralization/solubilization of P and K minerals by producing various enzymes during composting process. The wide C:N ratio of different grasses, wheat, mustard and napier grass residues were managed using leguminous weeds which have a narrow C:N ratio.

All residues are composted using the aerobic pit wherein the biomass is chopped into small pieces and arranged in layers with fresh cattle dung slurry and soil litter from dairy animals. The rock phosphate and K feldspar powder were applied to these layers at 10% of the total biomass. Adequate moisture (approximately 60%) and aeration are maintained. Residues are turned periodically (first turning after 2 weeks, second turning after 4-5 weeks and third turning after 8-9 weeks) to ensure uniform and efficient decomposition. The mature compost may contain N, P and K approx. 0.6-0.7%, 2.5-3.0% and 1.5-2.0 %, respectively. After 12-14 months of composting, the composted material is having earthy smell and can be used for field application.

Well decomposed composts are applied as basal organic manure in field crops, fodder crops, and orchards to enhance soil organic carbon, nutrient availability and microbial activity helping in sustainable crop production and improved soil physical, chemical and biological health. The use of enriched compost also enhances the nutrient/fertilizer use efficiency in the field and horticultural crops.

Exposure visits

The visitors to the IFC represented a diverse group of stakeholders including farmers; extension personnel working in outreach and education; researchers and technical personnel; policy makers; research managers; personnel involved in the agricultural business and supply chain, such as seed producers, input dealers; entrepreneurs and students. Visits

of farmer groups were planned to coincide with crop stages from flowering to maturity during both rabi and kharif seasons while other stakeholders visited the cafeteria during their scheduled visits to the institute.

Farmers, either in group or as individuals, were encouraged to spend at least 3-4 hours in the IFC visiting each block of cafeteria. This approach allowed farmers to observe specific agricultural practices, crop health, and yield potential of individual food, fodder and horticultural crops and other practices of modern farming. Experts were available during entire visit to guide and address farmers' queries and questions. These open-ended and semi-structured interactions facilitate knowledge sharing and promote the adoption of modern farming practices. Relevant literatures were also provided to farmers regarding new technologies and ongoing government schemes to support modern farming. Information on the availability of quality planting material and improved seed was also shared with visitors.

More than 5800 farmers visited IFC (Fig. 6) during *Kisan Mela/ Agri-Innovation Day* organized in the kharif and rabi seasons from 2022 to 2025 with a well-defined purpose to personally witness and compare the advantages of management practices, new crops and improved crop varieties over their traditional methods and thus encouraging the adoption of these beneficial interventions. Farmers represented more than 35 villages having diverse growing conditions from rainfed to irrigated crops cultivating different crop with variable levels of management.

The common queries raised by farmers were about the availability of quality seed of new varieties and crops, planting material of horticultural and fodder crops and multi-purpose trees; government schemes supporting agriculture; water requirements of crops and water saving technologies; and the marketing potential of new crops. Since availability of quality seed and planting material was indicated as the most critical factor in the adoption of new cultivar or crop, 2642 q of seed of new varieties of field crops, 4,21,000 seedlings of horticultural plants and multi-purpose trees, and 9,36,200 cuttings of Napier Bajra Hybrid have been sold on actual cost-basis since 2022. Supply of the improved seed and



Fig. 6. A view of farmers visiting the Integrated Farming Cafeteria at the Central Arid Zone Research Institute during rabi 2023-24.

quality planting material plays a crucial role in enabling the adoption of integrated farming by providing resilient, high-yield foundational elements for diversified agricultural practices.

The IFC included a comprehensive set of agricultural interventions that are being supported at the farmer fields through various government schemes, aimed at promoting sustainable, resource-efficient, and diversified farming practices. Key interventions (water harvesting, solar pump, micro-irrigation, seed mini kits, composting units, polyhouse, high value horticultural crops, fencing) demonstrated in the IFC align with initiatives like the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), PM-KUSUM and Mission for Integrated Development of Horticulture (MIDH). Relevant literature and details of schemes were provided to the visiting farmers. It was great motivation for farmers to observe very closely these interventions. Details and procedures of establishing the Farmers Producer Organizations (FPOs) were shared and connected with the Institute's KVKs.

Different components of IFC attracted the attention of different stakeholders and accordingly, various capacity building programmes and bankable projects on alternate fodder production, rainwater harvesting and solar energy, precision farming, etc. were implemented for their benefits.

The interactions during visits to IFC highlighted several key benefits that are given under:

Self-customization: The cafeteria approach allows farmers to pick and choose components that best fit their specific land size, resources, and needs, enabling a personalized approach to sustainable farming.

Learning new techniques: The cafeteria served as a live demonstration site where scientists explained the specific agronomic practices, seeding methods, spacing, and other management techniques that contributed to enhanced yields and resource use efficiency.

Observing the comparative performance: Farmers could see firsthand how different improved varieties and hybrids performed relative to each other and to conventional methods under similar conditions.

Knowledge and experience transfer: The IFC facilitates direct interactions between farmers and scientists, providing a mechanism for co-learning, feedback, and the efficient transfer of knowledge and quality planting materials (seeds, saplings).

Visual evidence: Farmers can see the real-time performance of various crops, varieties, and technologies, which is more persuasive than abstract information and encourages adoption.

Risk minimization: By observing different interventions, farmers can identify practices that provide multiple income sources and

year-round employment, thus minimizing risks associated with single-crop failures, market fluctuations, or climatic variability.

Resource efficiency: IFC demonstrates how by-products of one enterprise can serve as inputs for another (e.g., livestock manure for crops), improving nutrient recycling, soil health, and overall resource use efficiency.

Assessing potential profitability: By observing the clearly visible effects of good management on crops nearing maturity, farmers could better estimate the potential for increasing their own farm income and profitability, which is a core goal of integrated farming systems.

Understanding resource recycling: The site showcased how farm waste is effectively recycled within an integrated system to reduce the use of external inputs (like fertilizers and pesticides), reduce costs, and improve soil quality, which is more evident as the season progresses.

Mitigating risk and improving sustainability: Seeing diverse components

in practice helps farmers understand how integrating various components (crops, livestock, boundary plantation, water harvesting and its recycling, etc.) can provide stable income sources year-round and build resilience against climate variability and market risks.

Conclusions

Close observations of modern and sustainable interventions in IFC, relevant literature and details of government schemes provided to visiting farmers would go a long way to enhance farmers understanding of modern agricultural interventions and foster adoption of integrated farming. IFC which is an innovative extension approach can be followed by the national agricultural research and extension (e.g. KVKs) system to bridge the gap between technology and field-level implementation.

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About the Authors

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