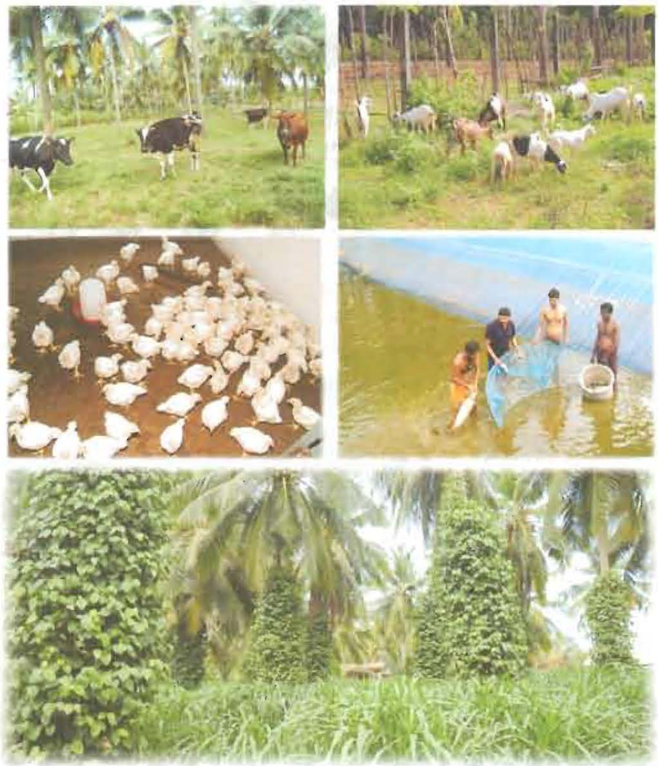
COCONUT BASED INTEGRATED FARMING SYSTEM



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1. Introduction

Coconut is predominantly cultivated in small and marginal holdings in India and the major coconut growing states are viz., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. About 98 per cent of the coconut holdings in the country are less than two ha in area and more than 90 per cent of them are less than one hectare in extent. Most of these holdings neither provide gainful employment for the family labour round the year nor generate sufficient income to satisfy the family requirement. Coconut palm when grown as a monocrop, does not fully utilize the resources viz., soil, nutrients, moisture and solar radiation available in the garden. There is ample scope to exploit these resources for the integration of crops and animals in coconut garden for enhancing income and employment opportunities. Presently coconut growers are exposed to economic risks and uncertainties owing to the frequent price fluctuations for the produce. In this context, it is needless to emphasize the importance of crop/enterprise diversification in coconut gardens.

Integrated farming is a common whole farm management approach that combines the ecological care of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food. Coconut based cropping/farming systems, involving cultivation of compatible crops in the interspaces of coconut and integration with other enterprises like dairy, poultry and aquaculture offer considerable scope for increasing production and enhancing productivity per unit area, time and inputs by more efficient utilization of resources like sunlight, soil, water and labour. Coconut based integrated farming is an ecologically sustainable system which helps the farmer to realize more income. Sustainability is the objectivity of the integrated farming system where production process is optimized through efficient utilization of inputs in safeguarding the environment with which it interacts.

2. Agronomic feasibility of coconut based integrated farming system

A spacing of 7.5 m x 7.5 m is recommended for planting coconut in the square system. Experimental evidences have shown that a sole crop of coconut, at the recommended spacing of 7.5 m x 7.5 m does not fully utilize the available resources such as land space, aerial space, water and nutrients.

a. Rooting pattern

Coconut palm like all monocots has a typical adventitious root system. Under favourable conditions, as many as 4000 to 7000 roots are found in the middle-aged palms. About 74 per cent of the roots produced by a palm under good management do not go beyond 2 m lateral distance and 82 per cent of the roots were confined to the 31 to 120 cm depth of soil. Recent studies have confirmed that more than 80 per cent of the root activity was confined to a lateral distance of 2 m from the trunk (Fig.1).Thus, in a coconut garden the active root zone of coconut is confined to 25 per cent of the available land area and the remaining area could be profitably exploited for raising subsidiary crops.

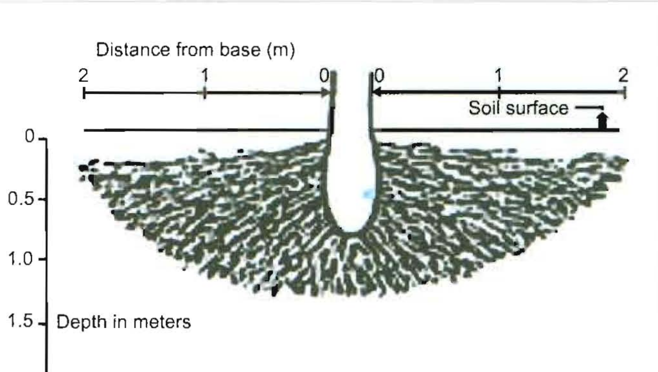


Fig. 1. Schematic presentation of the rooting spread pattern of an adult coconut palm

b. Canopy structure and light utilization

The venetian structure of the coconut crown and the orientation of leaves allow part of the incident solar radiation to pass through the canopy and fall on the ground. The leaves in a coconut palm crown are not randomly distributed, but clumped around few widely spaced growing points. It is estimated that as much as 56 per cent of the sunlight is transmitted through the canopy during the peak hours (10-16 hours) in palms aged around 25 years. The diffused sunlight facilitates growing a number of shade tolerant crops in the interspaces.Thus, canopy structure and light utilization pattern render coconut palm as the tree crop most suited to integration.

Based on the growth habit of the palm and the amount of light transmitted through its canopy, the life span of coconut palm can be divided into three distinct phases from the point of view of intercropping.

1. Planting till full development of canopy (about 8 years): Good transmission initially, but decreasing with age, suitable for growing annuals/biennials.
2. Young palms (8 to 20 years): Maximum ground coverage and low canopy height- poor light availability- not suitable for multiple cropping.
3. Mature trees (more than 20 years): Increase in trunk height; reduction in crown size - light transmission increasing with age - ideal for raising annual and/or perennial crops.

In general, fodder can be grown as intercrop throughout the life cycle of coconut palm. However, more fodder yield is realized under first part (upto 8 years) and third part (above 20 years) of the coconut life cycle.

3. Research on coconut based integrated farming system at Central Plantation Crops Research Institute (CPCRI)

Coconut based integrated farming system research was started at CPCRI in 1972. Initially experiments were conducted by intercropping fodder grass in a 60 year old coconut garden spaced at 7.5 m x 7.5 m with integration of dairy unit. The experiment was continued for a period of 16 years (1972-1988). Five milch animals of Jersey cross/Brown Swiss/Holstein were maintained by a family consisting of two adults (man and his wife) and two children in the mixed farming unit in an area of 1 ha. Subsequently, coconut based integrated farming system experiment was further intensified with the introduction of new enterprises viz., poultry, rabbitry, quail farming, fish farming and sericulture during the period from 1989 to 1999. During the period from 2000 to 2003, this experiment was maintained under the National Agricultural Technology Project (NATP) with the same components. From the year 2004 onwards the CBIFS experiment was continued with the fodder grass variety NB-21 replaced by Hybrid Bajra Napier CO-3 and introduction of azolla cultivation unit. A goatery unit was integrated into the system during 2013.

The components of the existing coconut based integrated farming system in one ha area under the experiment are furnished in Table 1 below.

Table 1. Components of coconut based integrated farming system

Sl. No.	Component	Area (ha)/numbers
1	Coconut (WCT)	175 nos.
2	Fodder grass (BN CO-3) and guinea grass/Fodder sorghum, fodder maize, (Stylosanthes - annual and perennial), fodder cowpea	1.00 ha
3	Black Pepper (Panniyur-1) planted in coconut basin and trailed on the coconut stem	175 nos.
4	Banana (Njali poovan variety) planted on border areas	195 nos.
5	Dairy (Holstein Friesian and Jersey cross breed cows)	0.02 ha* / 8 nos
6	Poultry (Broiler birds 4-6 batches/year)	100/batch
7	Japanese quails	100 layers
8	Biogas plant (3 m^3)	1 no.
9	Azolla unit (4 m^2)	3 nos.
10	Aquaculture (Catla, Rohu, Mrigal, Grass carp) - 1000 fingerlings in the pond of 27.5 x 22.5 x1.5 m	0.062 ha
11	Goatery unit	60 sq. m./(20+1)

* includes space occupied by the pump house and farm house

Management and performance of different components viz. intercropping, dairy, poultry and aquaculture is explained in detail in the following section. The impact of these components on coconut and economics is also described.

4. Management of component crops and enterprises

4.1. Crop components

4.1.1. Coconut

Coconut palms were planted during 1972 in a spacing of 7.5 m x 7.5 m and the crop was maintained by proper integration with other components in the system. Cow dung, biogas slurry, cow shed washings, poultry manure and recycled water from fish pond were utilised in the coconut garden. Management of coconut and component crops in the system was done through four different treatments, viz.,

i) Coconut maintained as a monocrop with recommended nutrient management practices

ii) Coconut + black pepper + fodder grass + banana system maintained through application of 50 per cent organic manures produced in the system and remaining 50 per cent through inorganics

iii) Coconut + black pepper + fodder grass + banana maintained through 100 per cent organic recycling in the system

iv) Coconut + black pepper + fodder grass + banana maintained through 100 per cent recommended nutrients as inorganic fertilizer

Since grass was inter planted in the coconut garden, irrigation at the rate of 20 mm once in 4 days was practiced through sprinkler irrigation, which is equivalent to 100 per cent of open pan evaporation. This works out to be 2,00,000 l per irrigation per ha. Other regular cultural practices were adopted as per the package of practices. About 3.95 t of coconut leaves were obtained from the system per annum which was recycled into the system by vermicomposting and mulching.

4.1.2. Banana

In order to utilise the available land resource effectively and generate more income from the system banana was chosen as a component crop and it was planted around the periphery during 2011. In one hectare area of coconut plantation approximately 195 banana suckers were planted in an interval of 2 m under single row system (Fig. 2). Cultural practices were adopted as per the package of practices. From this crop component, 728 kg of biomass on dry weight basis was produced per annum, which was recycled in to the system.

Fig. 2. Banana along the border

4.1.3. Black pepper

Black pepper (variety Panniyur-1) was planted during 1999 in the coconut basin and trailed on the coconut palms (Fig. 3). Nutrient management practices were implemented as per treatment requirements as detailed above. Other cultural practices were adopted as per the package of practices.

Fig. 3. Black pepper vines trailed on coconut palm

4.1.4. Fodder grass

Intercropping of fodder grass in the interspaces of coconut is one of the major components of the coconut based integrated farming system. The fodder grass should be chosen on the basis of the following desirable qualities viz.

- Low competition with coconut for resources such as plant nutrients and soil moisture

- Ability to withstand shade
- Good response to fertilizer application
- Compatibility to grow with leguminous fodder plants
- Relished by cattle

Different species of fodder grass, besides some legumes were tried earlier as intercrops in coconut garden since the commencement of the integrated farming experiments. The results from these studies have shown that various pasture grasses (*Brachiaria miliiformis, B. brizantha, B. ruziziensis, B. mutica, B. dicotyoneura,* and *Digitaria decumbens*), fodder grass varieties viz., Guinea grass (*Panicum maximum*), Hybrid Napier Bajra: NB-21 and BH-18, Hybrid Bajra Napier (CO-2), Guatemala grass (*Tripsacum laxum*), Blue panic (*Panicum antidotale*), Rhodes (*Chloris gayana*), Sudan grass (*Sorghum sudanense*), leguminous fodder species viz., Brazilian lucerne (*Stylosanthes gracilis*), Cowpea (*Vigna unguiculata*), Centro (*Centrosema pubescens*) and Pueraria (*Pueraria javanica*) and grass + legume mixture species (Hybrid Napier + *Stylosanthes gracilis*), Hybrid Napier + *Pueraria javanica* and Hybrid Napier + *Centrosema pubescens* could be successfully cultivated in the coconut garden.

In the present model of coconut based integrated farming system maintained at CPCRI, Kasaragod (from 2004 onwards), Hybrid Bajra Napier CO-3, Guinea grass CO(GG)-3, Cowpea CO-5, fodder sorghum, fodder maize and stylosanthes were integrated. The details of management and performance of these fodder crops are presented as follows:

4.1.4.1. Hybrid Bajra Napier CO-3 fodder grass

The Bajra Napier hybrid CO-3 is an excellent fodder crop. This grass is highly leafy with long and broad leaves and very little stem portion (leaf to stem ratio is 0.7) and hence it has high palatability. Under the climatic conditions of Kerala, the best season of planting is with the onset of southwest monsoon during May-June. However, as an irrigated crop, planting can be done at any time of the year. The recommended fertilizer dose for Hybrid Bajra Napier CO-3 when grown as intercrop in coconut is 100:35:35 of N, P_2O_5 and K_2O kg/ha, respectively, and 50 kg of N after each cut.

In the coconut based integrated farming system (CBIFS) maintained at Kasaragod, stem cuttings of Bajra Napier hybrid CO-3 was used as planting material. However rooted slips can also be used for planting. Cuttings of moderately matured stems (3 months old), from the lower two thirds of the stem length, were used for planting for better sprouting and establishment. The cuttings were planted in a slanting position with the spacing of 60 cm x 60 cm. The cuttings with three nodes were inserted into the soil with the basal end down to such a depth that two nodes remained within the soil and one node above the soil surface. The underground nodes developed in to roots and shoots while the upper ones developed shoots

only. Planting during heavy rainfall period should be avoided. The field was provided with good drainage during the rainy season, as the crop cannot withstand water stagnation. Sprinkler system of irrigation was practiced at CPCRI with 20 mm of water at IW/CPE ratio of 1.00. About 2 lakh l water was applied and the irrigation was given at the frequency of once in four days. Two intercultivation were practiced to avoid weed growth in the initial period for better establishment and vigorous growth (Fig. 4). Subsequently, intercultivation was given as and when necessary. The grass was cut once in 45 days. The first cutting of the grass was done at 80 days after planting. Cutting was done close to the ground level leaving stubbles of 5- 10 cm height. This fodder grass showed quick regeneration capacity. The grass was maintained for a period of three years. Replanting should be done after three years. Leguminous green manure crops can be raised in the interspace and incorporated before replanting of grass.

Fig. 4. Hybrid bajra napier CO-3 as intercrop in coconut

To elucidate the effects of recycling of organic materials and organic manure obtained from the system on fodder yield, the nutrient management practices for fodder grass in the Coconut Based Integrated Farming System (CBIFS) experiment was done with the following treatments.

- T1: 50 per cent of recommended fertilizers through inorganics and 50 per cent through organics
- T2: 100 per cent organics
- T3: 100 per cent through inorganic fertilisers

Growth parameters viz., plant height, number of tillers and yield of grass were measured at every harvest stage. The experimental results revealed that growth parameters and fodder yield were higher (117 t/ha/year) in the treatment in which both inorganic fertilizer and organic manures was applied followed by the treatment in which nutrient requirement was met through 100 per cent organics (106 t/ha/year) and treatment having chemical fertilizers alone (96 t/ha/year) (Table 2). The crude protein content in the fodder ranged between 11.94 to 12.69 per cent. It was interesting to note that crude protein content was higher when the fodder grass was grown as intercrop when compared to monocrop (10.5%). This was mainly due to the higher nitrogen content of grass under shaded conditions. The quantity of fodder obtained is sufficient to maintain 10-12 milching animals.

Table 2. Effect of nutrient management practice on green fodder yield and crude protein content of hybrid bajra napier CO-3

Nutrient management practice	Green fodder yield (t/ha)			Mean yield (t/ha)	Crude protein content (%)
	1st year	2nd year	3rd year		
T1 50 per cent organics + 50 per cent chemical fertilizers	137	110	105	117	12.19
T2 100 per cent organics	110	100	103	106	12.69
T3 100 per cent chemical	120	83	85	96	11.94
CD (P =0.05)	15	26	17	20	NS

In the field situation, staggered planting of fodder grass is to be practiced, depending on the number of cattle to be fed, to avoid wastage of fodder grass. Based on the experimental results at CPCRI, Kasaragod, the recommended pattern of staggered planting of fodder grass to meet the requirement of cattle as part of CBIFS is furnished in Table 3.

Table 3. Recommended pattern of staggered planting of fodder grass

No. of milch animal	Area in cents	Area of staggered planting in cents					
		Days of planting in the first month					Days of planting in the second month
		1st	7th	14th	21st	28th	5th
1	24-25	4.2	4.2	4.2	4.2	4.2	4.2
2	48-50	8.3	8.3	8.3	8.3	8.3	8.3
3	72-75	12.5	12.5	12.5	12.5	12.5	12.5
4	96-100	16.6	16.6	16.6	16.6	16.6	16.6
5	120-125	20.8	20.8	20.8	20.8	20.8	20.8
6	144-150	25.0	25.0	25.0	25.0	25.0	25.0
7	168-175	29.2	29.2	29.2	29.2	29.2	29.2
8	192-200	33.3	33.3	33.3	33.3	33.3	33.3
9	216-225	37.5	37.5	37.5	37.5	37.5	37.5
10	240-250	41.6	41.6	41.6	41.6	41.6	41.6

(Cent = 40 sq. m)

4.1.4.2. Guinea grass

Guinea grass is an important perennial bunch fodder grass species of the tropics. It is an excellent fodder, much valued for its high productivity, palatability and good persistence. This grass tolerates shade and grows under trees and bushes and is best suitable as an intercrop in coconut gardens. It can perform well under rainfed conditions also. The grass is adapted to a wide range of soil conditions. It usually grows on well-drained light textured soil, preferably sandy loam or loam. The field should be ploughed two to three times to obtain a good tilth. The best season of planting is at the onset of southwest monsoon during May-June. Under irrigated conditions, planting can be done at any time of the year. Since seed germination is poor, vegetative propagation is preferred.

In the CBIFS at CPCRI, Kasaragod guinea grass variety CO (GG)-3 was tried as intercrop in coconut. Rooted slips were planted at the spacing of 50 x 50 cm and the crop was planted in the trenches of 30 cm width and depth. A basal dose of 10 tonnes of FYM, 35 kg N, 35 kg P_2O_5 and 25 kg K_2O per ha was applied. In addition, 20 kg of nitrogen/ha applied after each cut. Under rainfed conditions, fertilizer application should be carried out only when there is sufficient moisture. Sprinkler system of irrigation was practiced at CPCRI with 20 mm of water at IW/CPE ratio of 0.75. Cowshed washing from the dairy unit and water from fishpond were also used for irrigation, especially during the initial stage for better performance of the grass. Cutting was done at 10 cm above the ground level and the first cutting was done about 9-10 weeks after planting and subsequent cuts were taken at 45 to 60 days intervals. Seven harvests were made in a year and guinea grass has to be replanted after 3-4 years. The performance of guinea grass variety CO (GG)-3 was evaluated and a yield of 85 t/ha /year was obtained (Fig. 5).

Fig. 5. Guinea grass variety CO (GG)-3 as intercrop in coconut

4.1.5. Fodder legume

4.1.5.1. Cowpea

Legumes are palatable and proteinaceous fodder crops, which have pivotal role in animal production systems. Legume fodders may be mixed with straw or other grasses to prevent the occurrence of bloat and indigestion. For higher productivity of milk, the animal should be fed with balanced amount of grass with leguminous fodder in the ratio of 3:1. In the CBIFS, cowpea seeds of CO-5 and C 152 were sown with a spacing of 30 cm x 15 cm. Fertilizer dose of 16 kg N, 24 kg P_2O_5 and 12 kg K_2O was applied. Harvesting was done 50-60 days after sowing when it had attained 50 % flowering. From one ha of coconut garden, CO-5 and C 152 recorded 15.75 and 13.2 t green fodder yield, respectively. Sowing should be avoided during heavy rainfall. Intercropping of fodder cowpea in the coconut garden can be done in three ways: first, the entire inter space can be utilized for growing only fodder cowpea or combination of grass + cowpea in the ratio of 3:1 or by using 75% of inter space for fodder grass and 25% inter space for cowpea as shown in the figure (Fig. 6). Cowpea for fodder purpose can be sown in any month under irrigated conditions.

Fig. 6. Fodder cowpea as intercrop

4.1.5.2. Stylosanthes

Stylosanthes is a fodder cum leguminous cover crop, which is suited for intercropping in coconut gardens, either alone or in combination with fodder grasses.The plant thrives well in light soils due to its deep rooting system. The crop is suited for growing in warm, humid tropical climate. It is fairly drought resistant and shade tolerant. Sowing is to be done at the onset of southwest monsoon during May-June. Different species of stylosanthes suitable for cultivation include perennial types viz., Brazilian lucerne *(Stylosanthes guianensis),* Shrubby Stylo *(Stylosanthes scabra),* short-lived perennial legume Caribbean stylo *(Stylosanthes hamata)* and annual type Townsville stylo *(Stylosanthes humilis).*

In the CBIFS, three species of stylosanthes viz., *Stylosanthes guianensis, Stylosanthes hamata* and *Stylosanthes scabra* were evaluated. Sowing was taken up during the month of June and the seed rate of 3 kg/ha was used for intercropping in coconut garden. Seeds were broadcast and covered with a thin layer of soil, such that the depth of sowing was 5-10 mm. Seeds start to germinate within a week. Fertilizer dose of 20 kg N, 60 kg P_2O_5 and 30 kg K_2O /ha was applied for both annual and perennial stylosanthes. For perennial crops 60 kg P_2O_5 and 20 kg K_2O was applied in subsequent years. Application of lime @ 375 kg/ha is also recommended in acid soils. Gap filling was done 15 days after sowing. First weeding was given 45 days after sowing. A second weeding and hoeing were also carried out after the first harvest. Gentle raking of the interspace after the application of fertilizers in the subsequent years was done. First harvest was taken 3-4 months after sowing and subsequent harvest at 45 days intervals or according to the growth of the crop. For perennial stylosanthes, five harvests were taken in a year and crop was retained in the field for three years (Fig. 7). The green fodder yield obtained per year from different stylosanthes species viz., *Stylosanthes guianensis, Stylosanthes hamata* and *Stylosanthes scabra*, when grown in the interspaces of coconut, were 23.2 t/ha, 26.3 t/ha and 27.9 t/ha, respectively.

Fig. 7. Stylosanthes as intercrop

4.1.6. Fodder cereals

4.1.6.1. Fodder maize

Maize is mainly grown for grain purpose. However, it can be cultivated for fodder purpose because of its good quality green fodder and high yield. Maize is the most ideal crop for silage making too. In irrigated areas, one crop of maize for fodder purpose may be taken up before monsoon, i.e. from January to May to get green fodder during summer. The optimum season for sowing as rainfed crop is the first week of June to last week of June and September to October.

In CBIFS, maize variety African Tall was tried as an intercrop in coconut. Maize seeds (50-60 kg) were sown at a spacing of 30 x 15 cm and sowing was taken up during the month of June as rainfed crop and during February as summer crop. Irrigation was given immediately after sowing and life irrigation was given on the third day and thereafter once in 10 days. Hoeing and weeding were done as and when necessary. Fertilizers at the rate of 45 kg N, 30 kg P_2O_5 and 30 kg K_2O per hectare was applied. 50% N and full P and K was applied at sowing time and the remaining 50 % N at 30 days after sowing as top dressing. Maize fodder which is upto three weeks old should not be fed to cattle. The crop was harvested when the cob is in the milky stage. The green fodder yield obtained from fodder maize (variety African Tall) under Kasaragod conditions was 26.2 t/ha from the summer season crop and 24.7 t/ha during monsoon season (Fig. 8).

Fig. 8. Fodder maize as intercrop

4.1.6.2. Fodder sorghum

Fodder sorghum is quite soft, palatable and fast growing annual fodder crop adapted for cultivation up to an altitude of 1500 m. Under irrigated conditions, two crops of sorghum may be taken in one year, one during February to June and the second during monsoon season, i.e. June to October. It should be harvested for fodder purpose after flowering. If harvested at early stage, there is risk of hydrocyanine (HCN) poisoning.

In CBIFS, the fodder varieties viz., CO-27 and CO FS-29 (multicut variety) was tested as intercrops under coconut with a spacing of 30 x 10 cm. Irrigation was given immediately after sowing and life irrigation was given on the third day and thereafter once in 10 days. Hand weeding was done on the 20th day of sowing. N, P_2O_5 and K_2O fertilizers were appiled at the rate of 45, 30 and 20 kg per ha, respectively for CO- 27 variety of fodder sorghum and for variety CoFS 29, 45 : 40 : 40 kg N,P, K/ha was applied as basal dose and 45 kg N as top dressing 30 days after sowing followed by the application of 45 kg N/ha after every cut. After

4[th] cut, 40 kg P_2O_5 and 40 kg K_2O along with 45 kg N was applied to sustain the fodder yield and quality. Harvesting for fodder was taken up at 50% flowering. CO-27 recorded green fodder yield of 22 t/ha and CO FS-29 variety recorded a green fodder yield of 36 t/ha/year (Fig. 9).

Fig. 9. Fodder sorghum CO-27 as intercrop

4.2. Dairy

Dairying is an important source of subsidiary income to small and marginal farmers and agricultural labourers. Dairy farming has three dimensional benefits i.e., quick and regular cash return, milk as an excellent food and only source of animal protein to the vegetarian population and supply of manure for the maintenance of soil fertility. The manure from animals provides a good source of organic matter for improving soil fertility and crop yields. The gobar gas, if generated from the dung, can also be used as fuel for domestic purposes and also for running engines for drawing water from well. The surplus fodder and agricultural by-products are gainfully utilised for feeding the animals. Since agriculture is mostly seasonal, there is a possibility of finding employment, throughout the year, for many persons through dairy farming. Thus, dairy also provides employment throughout the year. A dairy building should be located at a higher elevated area with good drainage facility (Fig. 10). It should be located in such a way as to have maximum exposure to the sun in the north and minimum exposure to the sun in the south and protection from prevailing strong wind currents whether hot or cold. Buildings should be placed in such a way that direct sunlight can reach the platforms, gutters and mangers in the cattle shed. As far as possible, the long axis of the dairy shed should be set in the north-south direction.

In the CBIFS unit at CPCRI, Kasaragod, eight cows (seven number of Holstein Friesian and one Jersey cross breed) were maintained so that at least five animals could yield milk throughout the year. The cowshed space provided per animal was 40 sq.ft. Each animal was provided 1-1.2 m width and 1.5-1.7 m length as standing space. The floor of the cow shed should be non slippery, free from holes and crevices and should have proper slope. Cows were maintained under face out (tail to tail) system. The walls of the shed was 1.5 meters in height (Figs.11 & 12). The roof was maintained at 3 metres height. Proper shade and cool drinking water in summer was provided. Proper sanitary condition was maintained around the cowshed. Cowdung and urine was properly disposed.

Fig. 10. Cow shed

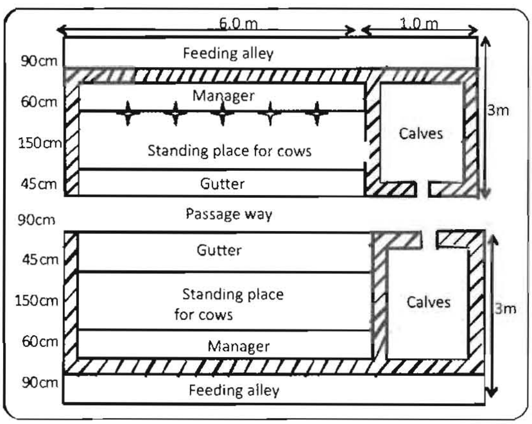
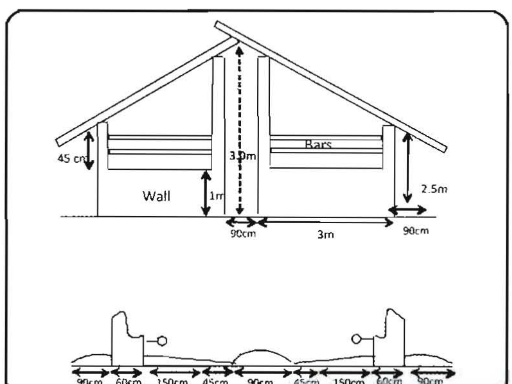


Fig. 11. Cross section of the cow shed

Fig.12. Elevation of the cow shed



Pregnant cows were segregated from others about 15 days prior to delivery. Necessary care was given for the pregnant cows before and after delivery and also for the new born calf. Male calves were disposed off through auction and female calves were reared. A resting yard/ exercise yard with proper fencing was made available to the animals for outdoor grazing to facilitate proper animal health (Fig. 13). For this purpose, animals were let out of the cow shed and allowed to graze in the resting yard after morning milking and evening milking.

Fig.13. Dairy animals in the resting yard

Feed is the major input component in dairy farming, accounting for 55-60 per cent of the total cost of milk production. Therefore, judicious feeding is the most important pillar of remunerative dairying. The dairy animals were fed on an average 25-30 kg green fodder daily, supplemented with concentrates as per schedule given in the Table 4. The daily ration was usually made up of a concentrate mixture and one or two roughages. It is desirable to use a balanced mixture of several feed ingredients or a compounded feed than using one or two ingredients since the mixture will be more palatable and reduce chances of nutrient deficiencies. The concentrate mixture can be made up of protein supplements such as oil cakes (coconut cake, groundnut cake, soyabean meal, gingelly cake), energy sources such as cereal grains (maize, jowar), tapioca chips and laxative feeds such as brans (rice bran, wheat bran, gram husk). Mineral mixture containing major and all the trace elements is to be included at a level of 2 per cent. Ready made concentrates can be purchased from market and used for feeding cattle. However to economize on the cost of feeding, the concentrate mixture can be home made as the concentrate mixtures available in the market are costlier and their quality in most cases leaves much to be desired. The feed ingredient selected should be unadulterated and free of fungal toxins. Such a mixture should have 14-16 % digestible crude protein (DCP) and about 70 % total digestible nitrogen (TDN). Some of the recommended concentrate mixtures (approx. 15% DCP, about 70 %TDN) which were tried in CBIFS are presented in the Table 5.

Table 4. Feed schedule for dairy cattle

Animals	Concentrate	Green grass (kg)	Paddy straw (kg)
Dry cows (maintenance)	1.25 kg	25-30	1
Milking animals	1 kg for every 2.5 to 3.0 litre of milk + maintenance allowance	30	2
Pregnant animals	1 kg concentrate mixture plus ½ kg energy supplement (rice gruel/ ground maize tapioca/ tamarind seed meal/jack fruit seed meal) from 6 month of pregnancy in addition to the maintenance and production allowance.	30	2
Calves	1 kg	5	1

Any one of the mixture can be used depending upon the availability of the material. Balanced quantity of fodder grass and concentrates should be included in the feed for optimizing production of milk and reducing the cost of milk production.

Table 5. Ingredient composition of concentrate mixtures (%)

Ingredient	Concentrate mixture I	Concentrate mixture II	Concentrate mixture III
Coconut cake	10	15	25
Gingelly cake	-	20	-
Groundnut cake	30	-	10
Cotton seed cake (decorticated)	-	-	20
Rice bran	30	-	-
Wheat bran	-	30	12
Maize	27	32	30
Mineral mixture	2	2	2
Salt	1	1	1

Drinking water was made available to the cow at all times. Regularity in feeding was followed. Concentrate mixture was fed before milking – half in the morning and the other half in the evening. Half the roughage ration was fed in the forenoon after watering and

cleaning the animals and the other half in the evening, after milking and watering. High yielding animals may be fed three times a day (both roughage and concentrate). Increasing the frequency of concentrate feeding will help maintain normal rumen motility and optimum milk fat levels. Abrupt changes in the feed should be avoided. Long and thick stemmed fodders such as Napier should be chopped and fed. Highly moist and tender grasses were allowed to wilt or mixed with straw before feeding. Legume fodders were mixed with straw or other grasses to prevent the occurrence of bloat and indigestion. Concentrate mixture in the form of mash was moistened with water and fed immediately, while pellets were fed as such. All feeds were stored properly in well ventilated and dry places. Mouldy or otherwise damaged feed should not be fed the animal.

The udder should be milked out regularly from the day of calving. Milk can be used for usual human consumption from the 3rd or 4th day onwards. Animals producing more than 12 kg of milk per day were milked 3 times a day, keeping the intervals between milking almost equal (once in 8 hrs). Care was taken to have clean milking practices. Milking of cows was done by milking machine (Fig. 14), which work on the principle of negative pressure, with a vacuum pump sucking air out of the system. The teat cups are attached to the teats after letting down. Due to sucking action of the machine, negative pressure is produced around the teat and milk flows out. From the teat cups the milk is drawn into milk tanks or milk cans through tubes. The main advantage of the milking machine is that labour can be saved. As the milking can be done quicker, the high yielders can be milked completely. Contamination of milk can also be reduced as the milk does not come in contact with outside objects.

During the period from 2005 to 2013, the annual milk production from the system ranged from 12,137 to 17,457 l with the average of 14,977 l per annum. On an average, 60 tonnes of fresh cow dung per year was produced in the system, which was available for recycling.

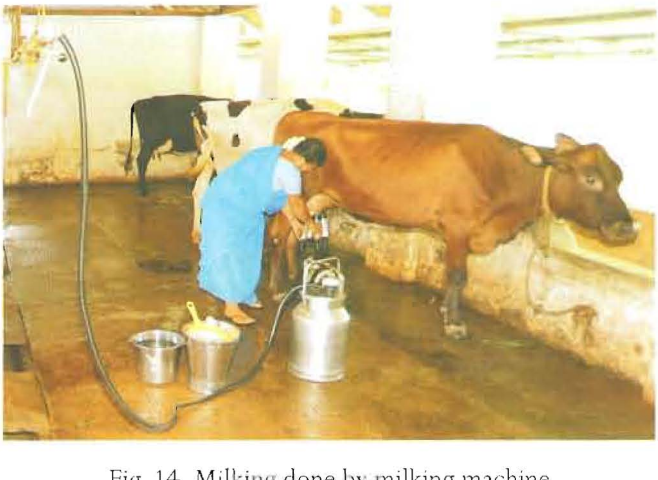


Fig. 14. Milking done by milking machine

4.3. Biogas

A biogas plant is an anaerobic digester that produces biogas from animal wastes. In CBIFS, floating dome type plant was constructed. It was observed that about 50 kg cow dung is necessary to generate 3 m^3 biogas (Fig.15). With an average daily biogas requirement of 0.56 m^3 per person, the total biogas required to meet the fuel needs of a family consisting of five members will be 2.85 m^3. The slurry obtained from the biogas unit was applied to grass and coconut palms.

Fig. 15. Biogas unit

4.4. Poultry

4.4.1. Broiler

As a component of the CBIFS experiment at CPCRI, a poultry unit of 100 broilers per batch was reared in the deep litter system and a floor space of 1 sq. ft. was provided per bird. (Fig.16). Three birds per square meter is an absolute maximum. The shed was provided with good ventilation for free flow of air. Under poor ventilation, the chicks will not only be weak but also more predisposed to respiratory diseases. Coir pith (waste material obtained after extraction of coir from husk) was spread on the floor, evenly to a height of 5 cm, to form a bedding and conserve the droppings and to prevent loss of nutrients. A very shallow layer of litter on concrete floor was maintained to maximize any cooling effect that the concrete floor may have on the birds through absorption of body heat. Growing houses were thoroughly cleaned and disinfected prior to the transfer of the growing stock. Birds were transferred only during good weather. Clean fresh drinking water was provided at all times. A separate brooding chamber was fabricated to take care of chicks in the initial stages. Brooding is the process of supplying artificial heat to the chicks from the time they are taken out from the incubators and up to the time their bodies can control their heat requirements and they are covered with feathers. Day old broiler chicks were kept in brooding chamber for 14 days and then transferred

Fig. 16. Broiler birds in the unit

to the shed. Chicks should have uniform size and color. The weight of a day old chick should not be less than 33 g. Broiler birds were given concentrates in the following feeding schedule (Table 6).

Table 6. Feed requirement of broiler (g/day)

Age	Upto 3 days	4-7 days	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
Feed requirement (g/day)	10	20	40	60	80	100	120	120	120

Vitamins, minerals and antibiotic supplements may be added to the drinking water during the first few days. The immediate burning or burying of dead birds is an important part of the good sanitation programme. Broilers are normally marketed at 45-60 days of age, on attaining the average weight of 1.75 kg/bird.

In the CBIFS unit, 4-6 batches of birds in the unit with 100 birds per batch were maintained. On an average, 1.5 t of coir pith enriched with poultry droppings was obtained per annum from the CBIFS unit at CPCRI, Kasaragod. The enriched coir pith obtained from the system was recycled. Coir pith, a waste material obtained after extraction of coir from husk, is not easily amenable for decomposition since it is very rich in lignin and cellulose and has a high C:N ratio. Besides, large quantities of coir pith available from the coir industrial units create difficulty for its disposal and also result in environmental problems. One of the ways to overcome these difficulties is to compost the coir pith. It is observed that coir pith can be composted faster if it is enriched with poultry droppings, as deduced from the data presented in Table 7.

Table 7. Nutrient content of coir pith enriched with broiler droppings vs. raw coir pith

Contents	Raw coir pith	Coir pith enriched with poultry droppings
Lignin (per cent)	30.2	13.2
Cellulose (per cent)	29.3	16.2
Total N (per cent)	0.34	1.96
Total P (per cent)	0.02	2.04
Total K (per cent)	0.48	2.01
Total Mg (per cent)	0.36	0.54
Total Ca (per cent)	0.87	0.96
Total Mn (ppm)	128	295
Total Fe (ppm)	1299	1982
Total Zn (ppm)	126	247
Total Cu (ppm)	68	148
pH	6.4	7.2
Organic carbon (per cent)	28	19.2
C: N Ratio	97:1	11: 1

4.4.2. Japanese quail

Japanese quail is a hardy bird that thrives well in cages or deep litter system of rearing and is inexpensive to rear. Hence, it can be integrated successfully as a component of the CBIFS. The brown coloured Japanese quail is bred for commercial quail production. They are relatively small in body size and are adaptable to intensive systems of poultry husbandry. The unique characteristics of fast growth, early sexual maturity, high rate of egg production, short generation interval and shorter incubation period makes it very suitable as an alternative farming animal. They are fairly resistant to diseases. With shorter reproduction cycle and earlier marketing age, it offers fast monetary circulation, ultimately yielding quicker returns. Egg production starts when the female quail reaches six to seven weeks of age and it touches 85 per cent production by the end of 10 weeks. Sexing is not done in one day old quail chicks. Only after 4 weeks of age, the female can be differentiated from the males. Females are larger than males and they have black spots on face, neck and in the breast region. Male/female ratio in the parent stock should be 1:2 or less. Quails lay most of the eggs during evening hours i.e., between 3 to 6 PM. Eggs should be collected very frequently and carefully, as shells of

eggs are very thin and they break very easily. With proper care, hens should lay 200 eggs in their first year of lay. Life expectancy is two years.

In the CBIFS, hundred numbers of quail layers were integrated and a floor space of 0.5 sq. ft. was provided per bird (Fig.17). Adult Japanese quail consumes 14-18 g of food per day. Clean, fresh water was provided at all times. Layers were provided 14-18 hours of light per day to maintain maximum egg production and fertility. This means that supplementary lighting must be provided in the monsoon and winter seasons.

Fig.17. Japanese quail in the unit

Nutrition is one of the most important factors required to maintain quails in good physical condition and to obtain normal growth and egg production. Since feed constitutes 60-70 per cent investment at the farm, for deriving maximum benefit out of quail farming it is necessary to feed a balanced ration which will have all the nutrients in balanced proportion (Table 8). Japanese quails were given 20 g concentrates per bird per day.

Table 8. Nutrient requirement for layer quails

Nutrient	Starter (0-4 weeks)	Grower (4-5 weeks)	Layer (> 6 weeks)
Energy (kcal /kg)	2750	2750	2700
Protein per cent	24	20	19
Calcium per cent	0.8	0.6	3.0
Phosphorus per cent	0.3	0.3	0.45

On an average, 7000 eggs and 625 kg organic manure was obtained annually from the Japanese quail unit comprising of 100 layers integrated in the CBIFS unit. Enriched coir pith obtained from the quail unit was applied to coconut palms.

4.5. Aquaculture

Aquaculture as an enterprise can effectively be integrated with the coconut based mixed farming system. In the semi-intensive aquaculture system as the natural food available in the pond will not be sufficient for the fish, it is necessary to supplement it with cowdung and artificial feed. Hence, cowdung and fodder grass available in the CBIFS were used as supplementary feed material for the fish. In the CBIFS unit, a fishpond of 27.5 m length, 22.5 m width and 1.5 m depth was constructed (Fig. 18). As the soil is sandy and porous the pond was lined with silpaulin sheets to curtail percolation loss. Clayey/laterite soil was filled upto 10 cm at the bottom of the pond. This soil layer will help to facilitate natural recycling of the food material and arrest the temperature fluctuations during hot days. The pond water was maintained with the help of internal water source. To facilitate draining of water from the pond whenever needed, an outlet pipe is provided at 1 ft below the embarkment so as to drain the excess water. Both the outlets and the drainpipes are fixed with strainers so that fish does not escape. As the pond was lined with silpaulin sheet, natural ecosystem will not be there and hence artificial aeration is a must. For this, 1 HP blower was installed through which air is pumped into the pond at 12 different points for proper aeration throughout the pond.

Fig.18. Fishpond

First installment of the supplementary feed was supplied into the pond about 24 hours before releasing the fingerlings. Care was taken to prevent algal growth. About 4-6 cm fingerlings of four selected species viz. catla (*Catla catla*), rohu (*Sebeo rohita*), mrighal (*Cirrhinus mrighla*) and grass carp (*Cteneopharyngodon idellus*) were released in the pond. Generally 1000 fingerlings can be accommodated in 625 m^2 area. The density of the population depends on the level of management and the number of species of fish.

Use of concentrates helps in quick growth of fish. A mixture of groundnut cake and rice bran was provided in 1: 1 ratio at the rate of 1 to 3 per cent of body weight of fish. These materials were mashed thoroughly and made into ball with the help of water and suspended at minimum four places in the pond. Since poultry droppings were available in the system, around 1 kg of poultry droppings were also applied everyday to the pond. This also helps to provide ready-made food for the fish. For grass carp variety, green grass was applied every day.

Fish was harvested from pond at two times (10 months and 12 months). Maximum weight of the fish at the end of one year varied between 830 to 1300 g per fish depending upon the variety. The weight ranged from 830 g in case of mrighal to 1300 g in the case of grass carp (Table 9). It is desirable to harvest the fish at periodical intervals so that the remaining ones in the pond can attain good weight.

Table 9. Growth of different varieties of fish [average weight (g)/length (cm)]

Varieties	After 1 month	After 3 months	After 5 months	After 8 months	After 12 months
Rohu	14/8.5	88/17	155/24	480/32	870/35
Catla	16/6.6	89/16	255/24	555/31	920/45
Mrighal	12/5.2	84/14.8	150/21	460/26	830/32
Grass carp	27/8.6	92/19.8	285/21	960/37	1300/44

On an average, 400 kg fish was harvested per year from the aquaculture pond in the CBIFS unit at CPCRI, Kasaragod (Fig.19).

Fig. 19. Harvested fish from the fishpond

4.6. Goatery unit

Goat, popularly known as the poor man's cow is one of the most remunerative enterprises which was integrated with the existing coconut based integrated farming system during 2013. Initially four females and one male of the Malabari breed was introduced and integrated with the system. Presently twenty females and one male are maintained in the system. Goats are sensitive to rain and wetness as these make them prone to pneumonia. Hence, care should be taken to protect the goat from hot and cold wind, humidity, solar radiation and rain. The goat house was constructed in east-west orientation. Since goats prefer sleeping in elevated platforms, stair type arrangement house was constructed on a raised platform (about 1 meter height from ground level), by establishing concrete pillars (Fig. 20). The house was well ventilated and drained, and easy to clean. Separate pens were provided for lactating and dry does, kids, growers and bucks. Roof was thatched with Mangalore pattern tiles. The adult, kids and bucks were provided with the floor spacing of 1.0, 0.4 and 3.4 sq. m, respectively. The wooden floor was provided with 1 cm space between wooden planks to allow passage of dung and urine to the ground. A fenced loafing area beside the goat house was provided (3 m^2 /adult) to allow animals to loaf freely.

Feed management: Concentrate mixture should have minimum 14 to 16% crude protein with sufficient energy, minerals like calcium, phosphorus etc. and vitamins. Immediately after birth, kids were allowed to drink colostrums and thereafter up to 5 days, to develop better immunity. Up to 2 months kids were provided does milk @ 1/10th of their body weight. The concentrated mixture at the rate of 300-400 g, 200-300 g and 400-500 g, respectively was provided for 6-12 months old growers, adult and bucks, in addition green fodder of 2-3 kg, 3-5 kg and 5-7 kg, respectively.

Fig. 20. Goat shed

On an average, 1.2 t of goat manure was obtained per annum from the floor of the goat shed in the CBIFS unit at CPCRI, Kasaragod.

Fig. 21. Goats in the system

4.7. Azolla

One of the major components of maintenance cost involved in dairy and poultry under the CBIFS is cost of concentrate feed. To reduce the maintenance cost it is necessary to find alternate low cost feed material. Azolla is a floating fern, which can be used as an alternative to concentrate feed for livestock and poultry in the coconut based integrated farming system. Azolla is very rich in proteins, essential amino acids, vitamins (vitamin A, vitamin B12 and Beta-carotene), growth promoter intermediaries and minerals like calcium, phosphorus, potassium, iron, copper, magnesium etc. On a dry weight basis, it contains 25 - 35 per cent protein, 10 - 15 per cent minerals and 7 - 10 per cent of amino acids, bioactive substances and biopolymers. Azolla can be cultivated by following simple and low cost management practices.

Azolla was introduced in the CBIFS experiment during 2007. A water body was made in the interspace of coconut, with the help of a silpaulin sheet. Silpaulin is a polythene tarpaulin, which is resistant to the ultra violet radiation in sunlight. A pit of 2 x 2 x 0.2 m was dug as a first step. All corners of the pit were maintained at the same level so that a uniform water level was maintained. About 10 - 15 kg of sieved fertile soil was uniformly spread over the silpaulin sheet. Slurry made of 2 kg cow dung and 30 g of super phosphate mixed in 10 liters of water, was poured onto the sheet. More water was poured to raise the water level to about 10 cm. About 0.5 - 1 kg of fresh and pure culture of azolla was placed in the water. This resulted in rapid growth and filled the pit within 10 - 15 days. A mixture of 20 g of super phosphate and about 1 kg of cow dung was added once in every 5 days in order to maintain rapid multiplication of the azolla and to maintain the daily yield of 500 g. A micronutrient mix containing magnesium, iron, copper, sulphur etc., was also added at weekly intervals to enhance the mineral content of azolla. Three such units of azolla cultivation were maintained in the CBIFS plot (Fig. 22).

Azolla was harvested with a plastic tray having holes of 1 cm^2 mesh size to drain the water. Azolla was washed to get rid of the cow dung smell. Washing also helps in separating the small plantlets, which drain out of the tray. The plantlets along with water in the bucket was poured back into the original bed. In case of severe pest attack, the entire bed was emptied and fresh lay out was made in a different location. Azolla feed was fed to layers, broilers and cows. It was observed that 10 per cent of the concentrate feed for poultry can be substituted with azolla under the CBIFS.

Fig. 22. Azolla

5. Component integration and resource flow in CBIFS

Integrated farming system is a closed system and it requires less off farm inputs. It gives importance to recycling of produces/wastes among the components in the system. The end product of such recycled material is always used as organic manure. It facilitates high input use efficiency and energy efficient practices by proper linking of different components that resulted in intelligent management of available resources to attain acceptable profits and sustained production levels. In the system, integration is mainly done through organic recycling and linkage between components occur where products or by products of one component serve as a resource for another. In addition, linkage of components of varied nature enabled different sources of nutrition. Component integration of coconut based integrated farming system maintained at CPCRI is depicted in figure 23.

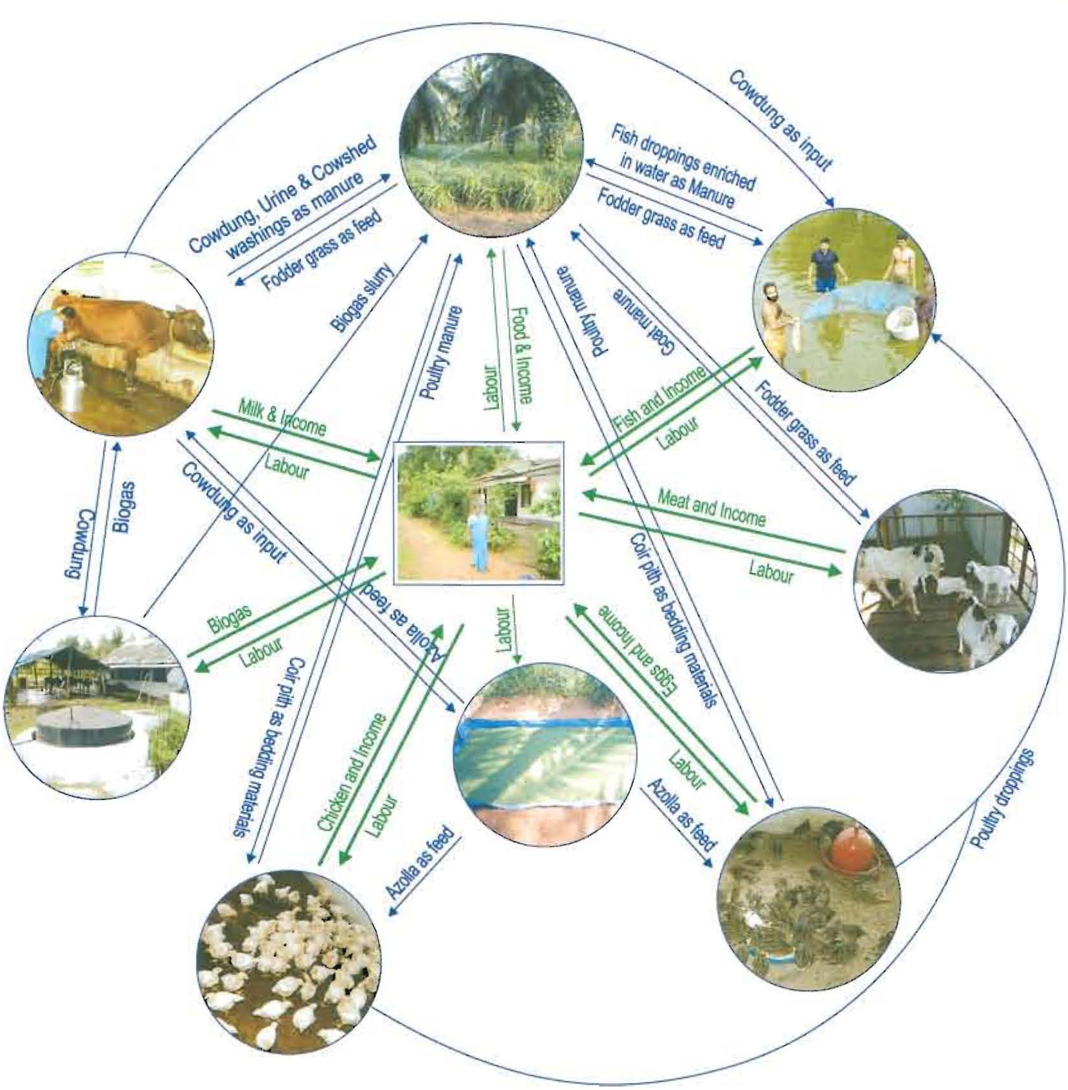


Fig. 23. Component integration and resource flow of CBIFS

6. Impact of Coconut Based Integrated Farming System

6.1. Effect on coconut yield

In CBIFS, coconut recorded higher yield compared to monocropping. The coconut palms maintained under CBIFS receiving integrated nutrient management practices i.e., combined application of organic and chemical fertilizer recorded significantly higher yield which was followed by other treatments under CBIFS (Table 10).

Table 10. Effect of CBIFS on coconut productivity (nuts/palm)

Treatments	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Monocrop + recommended fertiliser	97	94	81	102	98	108
CBIFS: 50 % organic + 50 % inorganic	113	106	108	122	126	137
CBIFS: 100 % organic	91	81	92	103	107	126
CBIFS: 100 % inorganic	100	96	107	110	116	108

6.2. Effect on foliar nutrient levels

The major, secondary and micro nutrient status of coconut palms under the CBIFS was monitored and it was found that there is a positive influence of the organic nutrient source application on the nutrient content of coconut leaves (Table 11 and 12). In general, leaf nutrient status were higher under CBIFS treatments compared to monocropping. Among the treatments, CBIFS : 50 per cent organic + 50 per cent inorganics recorded higher macro nutrient content followed by 100 per cent organics and 100 per cent inorganic fertilizer. Iron and manganese contents were higher under monocropping of coconut. Copper content was higher under 50 per cent organic + 50 per cent inorganics and higher zinc content was recorded under 100 % organic treatment.

Table 11. Effect of CBIFS on plant macro and secondary nutrient status (%)

Treatments	N	P	K	Ca	Mg
Monocrop + recommended fertilizer	1.83	0.12	1.01	0.39	0.187
CBIFS – 50 per cent organic + 50 per cent inorganic	1.97	0.14	1.14	0.52	0.211
CBIFS – 100 per cent organic	1.95	0.12	1.04	0.49	0.201
CBIFS – 100 per cent inorganic	1.84	0.13	1.01	0.50	0.189

Table 12. Effect of CBIFS on plant micro nutrient status (ppm)

Treatments	Fe	Cu	Zn	Mn
Monocrop + recommended fertilizer	176.00	7.10	8.60	297.50
CBIFS: 50 per cent organic + 50 per cent inorganic	157.20	8.20	10.80	245.50
CBIFS: 100 per cent organic	148.00	7.42	15.80	188.50
CBIFS : 100 per cent inorganic	174.20	7.35	12.00	242.50

6.3. Effect on soil nutrient status

The soil nutrient status under different treatments in the CBIFS is given in Table 13. In general, soil nutrient status in terms of organic carbon and available N and P were higher under CBIFS treatments as compared to monocropping. However, the potassium content was low in the CBIFS treatments compared to monocropping because of the rigorous potassium uptake by both coconut and grass components.

Table 13. Soil nutrient status in the CBIFS (average of two depths 0-25 and 25-50 cm)

Treatments	Organic carbon (per cent)		Nitrogen (kg /ha)		Phosphorus (kg/ha)		Potassium (kg/ha)	
	Coconut basin	Inter space	Coconut basin	Inter space	Coconut basin	Inter space	Coconut basin	Inter space
Monocrop + recommended fertilizer	0.38	0.27	291	197	213	138	162	92
CBIFS: 50 per cent organic + 50 per cent inorganic	0.44	0.39	301	214	232	198	144	87
CBIFS: 100 per cent organic	0.45	0.37	284	202	172	165	126	52
CBIFS :100 per cent inorganic	0.39	0.32	298	214	197	174	112	66

N,P,K: Mineralizable nitrogen, available phosphorus and available potassium

6.4. Effect on soil physical properties

The soil physical properties under different treatments in CBIFS are given in Table 14. CBIFS with organic manure recycling recorded higher water holding capacity, hydraulic conductivity and reduction in bulk density when compared to monocropping of coconut. The reduction in the bulk density is due to the application of organic manures, which increased the soil aggregation and pore space, where as in the treatment where only the inorganic fertilizers were applied, the bulk density was very high due to natural compaction of the red sandy loam soil. This particular limitation of the red sandy loam soil is very well managed when the organic farming practices are followed. Similarly due to the reduced bulk density with high micro pores in the favourable soil structure developed by the application of organic manures, the water holding capacity of the soil is also increased and it was found highest in the treatment where 100 per cent organic nutrient sources were applied followed by the 50 per cent organic and inorganic sources were integrated and it was least in the 100 per cent inorganic application. The hydraulic conductivity of the soil was highest in the treatment of 100 % inorganics application but it was less in the treatment of 100 per cent organic nutrient source application. Hydraulic conductivity was very low in monocropping of coconut than in the treatments with fodder grass intercropping.

Table 14. Effect of coconut based integrated farming system on soil physical properties

Treatments	Water holding capacity (per cent)	Bulk density ($g\ cm^{-3}$)	Hydraulic conductivity ($mm\ second^{-1}$)
Monocrop + recommended fertilizer	17	1.58	0.0037
CBIFS: 50 per cent organic + 50 per cent inorganic	20	1.42	0.0064
CBIFS: 100 per cent organic	21	1.43	0.0054
CBIFS: 100 per cent inorganic	18	1.56	0.0073

6.5. Effect on soil microbial population

The distribution of soil microbial groups was investigated under various treatments in CBIFS and monocropping (Table 15). Microbial population indicated that the soil biological activity was more in the farming system when compared to the monocrop of coconut. All the three microbial population viz., bacteria, fungi and actinomycetes were found to be very high in the 100 per cent organic farming treatment followed by the 50 per cent organic substituted treatment. The microbial population was low in treatments receiving only inorganics both under coconut + fodder grass intercropping and monocropping of coconut. The organic manures served as a good medium for the microbial growth due to the growth promoting substances and enzymes present in them. Microbial population was comparatively high in the interspaces where the grasses were grown than the coconut basin due to high root biomass available in the grass cropped area. The root turn over in the rhizosphere and root exudates provided a highly conducive environment for the microbial population to multiply.

Table 15. Microbial distribution in coconut based integrated farming system

Treatments	Bacteria 10^5 cfu/g soil		Fungi 10^3 cfu/g soil		Actinomycetes 10^5 cfu/g soil	
	Coconut basin	Inter space	Coconut basin	Inter space	Coconut basin	Inter space
Monocrop + recommended fertilizer	13.45	10.00	6.86	4.16	9.62	6.16
CBIFS: 50 per cent organic + 50 per cent inorganic	18.22	21.64	16.6	17.23	7.83	12.35
CBIFS:100 per cent organic	23.17	29.22	18.16	19.31	11.33	14.26
CBIFS : 100 per cent inorganic	11.76	14.66	7.12	8.35	7.00	10.24

6.6. Economic analysis of mixed farming system

Coconut based integrated farming is an ecologically sustainable system which fetch higher income to cultivators when compared to coconut grown as monocropping. To assess the economic viability of CBIFS, the average cost and returns for a period of two years (2011-2013) were analysed. The total cost involved in maintaining the system under CBIFS with integrated nutrient management practices was Rs. 3,89,700/-. The total returns realised from the system was Rs. 6,75,212/- and net returns was Rs. 2,85,512/-. The average annual input out put details of the CBIFS for the period 2011-2013 are furnished in Tables 16 and 17.

Table 16. Input details of CBIFS (Rs./ha - average of 2011-13)

Component		Cost (Rs.)
1.	Feed cost	2,77,824
2.	Cost of purchasing birds	4,253
3.	Veterinary medicine	6,789
4.	Fertilizer cost	11,250
5.	Labour cost	60,000
6.	Miscellaneous	6,884
7.	Cost of fingerlings	1,500
	Total variable cost	3,68,500
	Annuity value	21,200
	Total cost	**3,89,700**

Table 17. Output details of CBIFS (Rs/ha - average of 2011-13)

	Component	Output	Amount (Rs)
1.	Coconut (nos.)	23,800	1,31,250
2.	Milk (litres)	12,770	2,85,491
3.	Broiler birds (kg)	238	20,371
4.	Quail eggs (nos.)	6,095	6,095
5.	Fish (kg)	224	17,920
6.	Banana (kg)	2,087	33,696
7.	Biogas (m^3)	500	6,000
8.	Pepper(kg)	365	98,859
9.	Elephant foot yam (kg)	2,433	24,330
10.	Sale of calf/old cow (nos.)	1	21,200
11.	Cow dung (t)	30	30,000
	Total income		**6,75,212**
	Net income		**2,85,512**

The economic analysis of CBIFS clearly indicates the economic viability of the system.

6.7. Employment generation

The annual labour requirement of a pure coconut plantation of one hectare was about 150 man days, of which about 50 per cent labour was diverted for harvesting of coconuts. Under CBIFS, total employment generation in a normal year was about 780-830 man days, and in years when grass slips were to be planted/replanted, their employment potential rose to about 1000 mandays. It indicates that under CBIFS not only the farm family (husband and wife) was getting employment round the year, but also it could provide 50-100 man days work for outside labour.

7. Conclusion

The experience of maintaining coconut based integrated farming system at CPCRI clearly indicates the scope for the integration of crops and animals in the coconut garden for enhancing income and providing employment throughout the year. Resources like sunlight, soil, water and labour were efficiently utilized. Subsidiary income was realized from all the component units. Besides enhancing coconut yield, there was substantial improvement in soil and plant health status, soil physical properties and soil biology, there by making CBIFS more economically feasible and ecologically sustainable than monocropping.