3. Farming System

Farming system signifies optimization of various agricultural components and their integration in multi-enterprise development for sustainable farm practices under diverse situations and farm categories.

Conservation agriculture: Conservation agriculture has emerged as a new paradigm to achieve goals of sustainable agricultural production. The farmers are able to sow wheat in about 0.4 ha area per hour by using conservation agriculture technologies of zero, strip and rotary till drills and bed planter. These technologies save 60 to 80% of the precious resources of time, labour, diesel, cost and energy; and also 9 to 37% irrigation water compared with conventional sowing. These technologies are cost-effective (24-27%)

Wheat-crop sown using conservation agriculture technology at farmer's field

and energy efficient (34-37%) as well as give higher wheat yield (15-22%) with greater net returns (26-31%); reduced *Phalaris minor* (43-76%) as compared with conventional sowing. Bed planting, and zero and strip till drilling in rice-wheat cropping system also improve soil health through improvement in soil organic carbon (15-38%) and mean weight diameter of aggregates (18-72%) after continuous practising for nine years.

Multiple cropping systems for rice-fallow of Jharkhand: An alternative system of intensive cropping, namely rice-potato+wheat (grown in 1:1 row ratio)-greengram has been identified for irrigated medium land situations of Jharkhand to enhance production almost four times, employment generation 174% over conventional rice-fallow system. It fetches higher profitability (₹ 330/day/ha), additional income (₹ 98,123/ha), B : C ratio (1.46), energy output (218.7 KMJ/ha), net energy return (148.4 KMJ/ha) and land-use efficiency (96%) along with better nutrient uptake, maintenance of soil health and lesser weed population.

Integrated farming for managing coastal salinity: Integrated crop-fish cultivation through land shaping showed substantial scope in coastal agriculture. It increased productivity of land and water, income of farmers, irrigation facility and resulted in reduction of salinity build up in soil and improved drainage condition. The land shaping technologies also reduced the salinity build up in soil of raised lands during dry months due to increased height of land from the brackish groundwater and stored the rain water (freshwater) in the field. The economics of various land shaping models calculated by CSSRI, RRS, Canning town revealed that the farm pond model emerged as the most profitable land shaping model with highest B:C ratio of 2.33 followed by paddy-cum-fish, deep furrow and high ridge, shallow furrow and ridge and paddy-cum-brackish water fish. The most preferred rice varieties identified were CSRC (S) 21-2-5-B-1-1 and Gitanjali for *kharif* and Bidhan 2 and Canning 7 for *rabi* season.

Resource conservation in shifting cultivated degraded lands of Eastern Ghats: *Gliricidia* plantation with ragi and upland paddy in *kharif* season under rainfed conditions on alley cropping in shifting cultivation areas of Eastern Ghats gave higher grain (2.10 tonnes/ha) and straw yield (3.46 tonnes/ha) of ragi over control (1.36 tonnes/ha) with lowest runoff (14.4%) and soil loss (5.37 tonnes/ha). Similarly, in case of upland paddy, maximum grain (2.21 tonnes/ha) and straw yield (4.78 tonnes/ha) was recorded with *Gliricidia* trench planting in comparison to 1.50 tonnes/ha obtained under control.

Ragi and paddy cutivation under alley cropping system

Makhana cultivation under shallow water table depth: Traditionally, makhana is grown in the natural water-bodies like ponds, lakes, swamps and ditches. In these water-bodies, the average depth of stagnant water is generally 1.2-1.8 m. Due to high water depth of water-bodies, the agronomic management of the crop is very tedious and as a result, the productivity of this crop is very low (0.8-1.0 Mg/ha). Further, no other crop is possible in these water-bodies. Keeping this fact in view, an experiment was conducted to find out the possibilities of makhana cultivation in lowlying fields.

A heavy texture lowland field was well prepared by two deep ploughings and addition of farmyard manure @ 3.0 Mg/ha. After ploughing, a bund of 0.45 m height and 0.6 m width was constructed along the borders of each plot. The plots were filled with water up to the height of 0.15 m and direct sowing of makhana seeds was done at a spacing of 1.25 m × 1.25 m by putting 3 healthy seeds at 4 cm depth. A seed yield of 2.84 Mg/ha was obtained compared to 1.0 Mg/ha in traditional systems, indicating the potential of the systems.

Bamboo plantations in gullied lands: Bamboo plantations on extremely degraded ravinous lands located along three major Indian rivers, namely Mahi, Chambal and Yamuna, with supportive staggered trenches could consume 80% of rainfall with higher survival percentage and plant growth. The system can generate income of about ₹ 27,000 to 36,000/ha/year.

Intercropping and tillage practices under rainfed conditions in Bundelkhand: Madhya Pradesh is the largest soybean producing state in India but the yield levels in Bundelkhand region are very low. The rainfall is very erratic and uncertain and is mainly responsible for creating moisture scarcity, and crop failures under rainfed conditions. Evaluation of various soybean-based systems indicated that intercropping was more beneficial than sole cropping of soybean in red and black soils. Under red soils, soybean + castor intercropping system recorded the highest soybean equivalent yield (548 kg/ha) followed by soybean + clusterbean (347 kg/ha). In black soils, soybean + sesame (750 kg/ha) system recorded the highest soybean equivalent yield, followed by soybean + clusterbean (536 kg/ha).

Micropropagation of *Pongamia* and bamboos: Micropropagation technique for rapid and mass multiplication of bamboos (*Bambusa balcoa*, *B. vulgaris*) and *karanj* (*Pongamia pinnata*), have been achieved on Murashige and Skoog (MS) medium supplemented with different concentrations of growth regulators. Nodal segments of 2-3 cm size containing auxillary buds from field grown bamboos and *karanj* were used as explant. The maximum number (100%) of aseptic cultures were established by treatment of 0.2% $HgCl_2$ for 15 minutes. Auxiliary buds collected from new flush of bamboo during July–August were best to culture. Maximum bud break response up to 96% in *B. balcoa* and 100% in *B. vulgaris* was recorded on MS medium supplemented with cytokinin. During first to third sub-culture, an average shoot multiplication rate of 3-4 fold in *B. vulgaris* and 2-3 fold in *B. balcoa* was obtained in the MS medium supplemented with 2.0-5.0 mg/litre benzylaminopurine (BAP). These were sub-cultured and multiplied on MS + 5.0 mg/litre BAP medium. Regular (four week's interval) sub-culturing of shoot propagules increased the multiplication rate. After 4-6-cycles of shoot multiplication, the rate of shoot multiplication increased and later a consistent 4-6 fold average multiplication rate was obtained. Rooting was obtained when shoot propagules were sub-cultured on MS medium supplemented with 1.0-5.0 mg/litre naphthalene acetic acid (NAA) or indole butyric acid (IBA). Best rooting (80-85%) was obtained within 30-35 days of subculture on MS + 4.0 mg/litre NAA and on MS + 5 mg/litre IBA. Generally 4-8 roots emerged from the basal end of the propagule. Healthy root and shoot system developed in four weeks old culture on rooting medium. Hardening procedures were also developed. Survival of hardened plantlets was 65%.

Multitier rice–fish–horticulture-based farming system model: Viable multitier rice–fish–horticulture-based farming on 0.8 ha for enhancing farm productivity and income in the substantial part of 4 million ha of deep-water areas (50–100 cm, maximum 150 cm of water depth) of the country, more particularly in the 3 million ha of eastern India, has been developed. This system model integrates short-term and long-term fruit crops, tuber crops and vegetables in the uplands (Tiers I and II); rainfed lowland rice, followed by various crops in the Tier III; deep-water rice, followed by rice and/or vegetables in the Tier IV of the field; fish and prawn in the rice field and ponds; and poultry, duckery, fruits, plantation crops, flowers, agroforestry and others on the bunds of the system.

Success story

Sapota/mango–teak-based agroforestry system for peninsular India

A multi-component agroforestry system with sapota as the base crop, teak in the sapota line and agricultural crop in the interspace was developed for high rainfall areas having irrigation facilities. Broad spacing provided to this crop provided an opportunity to cultivate an intercrop in the initial years. Demonstrations were initiated during 1996, in two farmers fields at village Kyarakoppa, district Dharwad. Sapota was planted at a recommended spacing of 10 m × 10 m in rows across the slope. Three teak plants were planted at distance of 3 m – 2 m – 2 m – 3 m in between two sapota trees. Field crops, viz. horsegram, *jowar* and *bajra*, were grown in the interspaces of sapota + teak alleys. Sapota crop served as an insurance against failure of field crops. The same technology was adopted by another farmer with a modification, i.e. sapota being replaced by mango. Fruit bearing in sapota and mango started from the seventh and eighth year respectively. Presently, the sapota is yielding 30 to 40 kg/plant which fetches for ₹ 22,000 to 25,000/ha. The fruit yield from mango is 30-50 kg/plant and that fetches ₹ 36,000 to 60,000/ha. The income generated from field crops in both the cases is about ₹ 2,500 to 3,500/ha. The value estimation of teak reveals that each teak pole costs about ₹ 120. With age, the crown size of perennial component (sapota/mango and teak) increased and consequently of field crops was not in cultivation from 2007 onwards. The system generated employment to an extent of 180 man days per year. The socio-economic status of the farmers improved as farmer is earning on an average of ₹ 23,500/ha/year with sapota and ₹ 48,000/ha/year with mango based system as against ₹ 3,000/ha/year only during initial period from the same land.

Multitier rice-fish-horticulture-based farming system

This system could produce annually about 14–15 tonnes of food crops, 1 tonne of fish and prawn, 0.5–0.8 tonne of meat and 10,000–12,000 eggs, in addition to flowers and 3–5 tonnes of animal-feed from a hectare. Productivity of food crops would increase further to 16–17 tonnes, besides, 10–12 tonnes of fibre/fuel-wood from eighth year onwards owing to addition of produce from perennial fruit-crops and agroforestry components. The net income from this system was around ₹ 100,000/ha in the first year, and is expected to increase to ₹ 150,000 or more from the eighth year onwards.

The system can increase farm productivity by 15–17 times and net income by more than 20-fold over the traditional system of the rice farming in the deep-water areas. It generates additional farm employment up to 300 man-days/ha/year. And additional benefits of the rice–fish farming are carbon sequestration of rice fields, improvement of soil-nutrient status, providing life-saving irrigation to crops during drought as well as drainage of water from field due to in-built micro-watersheds, and biocontrol of weeds and other pests because of gainful interspecific interactions among rice, fish, duck and other biological components. This system has been adopted in some areas of Odisha.

Stale-seed bed technique: For irrigated cotton at Coimbatore, a new method of managing weeds has been standardized. In this technique, two weeks in advance of cotton sowing, ridges and furrows were prepared and irrigated, leading to germination of weed seeds. One week after irrigation, mixture of Pendimethalin and Glyphosate was sprayed; the former killed germinating weeds up to one month by the residual action, and the germinated weeds were killed by glyphosate. Thus, both cotton and intercrops could escape weed competition. By combining one manual weeding at 35–40 days after sowing could provide weed-free situation up to the critical period for weed competition. The method recorded seed-cotton yield equivalent to 5,682 kg/ha.