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Resource Efficient Horticulture Technologies for Livelihood Improvement of Farmwomen

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Introduction

Despite 70 per cent of the population being engaged in agriculture and allied activities, declining food grains production and lack of food security remain the two biggest problems confronting our country. Horticulture play a unique role in country's economy by improving the income of the rural people, ensuring livelihood security. Studies show that farmers engaged in the production of fruits and vegetables often earn higher farm incomes than farmers that are engaged in the production of cereal crops only. Also, horticultural crops are labour intensive and hence, generates lot of employment opportunities for the rural population. Fruits and vegetables are also rich source of vitamins, minerals, proteins, and carbohydrates etc. which are essential in human nutrition. Hence, these are referred to as protective foods and assumed great importance as nutritional security of the people. India is the second largest producer of fruits (89.80 million tonnes) and vegetables (162.98 million tonnes) in the world with an area of 24.19 mha during 2013-14 (NHB, 2014). Despite of significant growth of horticulture, there is huge gap between present production and availability. Consumption of fruits and vegetable per capita in India is only about 120 and 250 g/day/ person, which is less than the minimum dietary requirement of 200 and 300g/day/person. Forty per cent of the world's malnourished children are in India and 60 per cent of Indian women are anaemic. Moreover, the productivity of fruits (12.3 t/ha) and vegetables (17.30t/ha) are very low in our country as compared to other country. It has also played a significant role in the women empowerment, providing employment opportunities and income through mushroom cultivation, floriculture, processing, value addition, production of quality planting materials, vegetable seed production. Horticulture has emerged as an indispensable part of agriculture, offering a wide range of choices to the farmers for crop diversification. It also provides ample opportunities for sustaining large number of agro-industries which generate substantial employment opportunities. The horticulture sector contributes about 24.5% of the GDP from about 8% of the area. Participation of women is more than 90 percent in some of the horticultural activities . Various activities like mixture preparation, filling of polybags, planting of seedlings in polybags, sowing of seeds, watering, transplanting, manuring, harvesting, grading, processing and marketing are perform by women. It is projected that India needs to produce 350 mt vegetables and 125 mt fruits by 2030 to meet the demand of the growing population. Since, there is not much scope for area expansion, the productivity enhancement is envisaged through adoption of good management practices including techniques of high density planting, rejuvenation of old and unproductive

orchards, INM, IPM and improved post-harvest handling and management systems for reducing post-harvest losses. In this backdrop horticulture technologies/ models with new enterprises and crop diversification will act as a potential tool to improve the income of the rural people and generation of employment opportunities. The technologies/ models will be developed considering the resource availability to ensure more income per unit of area and time. The horticulture technology/ model will act as a tool to enhance income sustainability of farmers through technological interventions, crop and enterprise diversification.

Scope of horticulture

1. Source of livelihood generation: Horticultural crops are high value crops and are highly remunerative and profitable than the cereal crops. Small scale cultivation or homestead gardening of fruit, vegetable, flower, medicinal and aromatic plant crops, nursery raising, orchard maintenance, employment in agro-chemical industries, small scale processing, marketing of fresh fruits & vegetables and processed products are various alternatives for livelihood generation and nutritional security for women.

2. Enterprise development: There is a tremendous scope for urban and peri-urban women for developing several horticultural enterprises by organising themselves into women Self-help groups (SHGs), Farmer Producer Organisations (FPO), Women Empowerment Groups and various cooperatives. In India there are several successful enterprises in fruit crops, for instance in mango, 'Mahamango', is a co-operative society established with the support of Maharashtra State Agricultural & Marketing Board (Pune) for boosting the export as well domestic marketing of Alphonso mangoes. A similar type of association named 'MANGROW' has been formed for the export of Kesar mangoes from Aurangabad district of Maharashtra. These mango industries are highly lucrative and profitable.

In case of banana, the Agriculture Marketing Board has established 'Mahabanana', a farmers' marketing organization with headquarters at Jalgaon. There are 26 co-operative societies registered under Mahabanana and each such member society has 300-350 small and marginal farmers. The organization was formed to boost export as well as domestic marketing.

3. Processing and value addition: Processing and value addition of fruit and vegetable crops are highly remunerative on account of increasing demand of processed products by the consumers. Women have an active role in several post production activities starting from harvesting, sorting, grading and processing. Orientation of women to this sector can be highly profitable not only to processing industries but also to the farming community. The

fruit & vegetable processing industry in India is still in its infancy and only around 1-2 % of its total production is processed as compared to 70 % in Brazil and USA, 78% in Philippines, 80% in South Africa, 83% in Malaysia and 30 % in Thailand. Thus, a great scope exists in expanding the food processing and value addition, which will in turn also help in employment generation and better returns.

4. Export potential: India's diverse climate ensures the bulk availability of various fruits and vegetables round the year. There is a tremendous export potential for both fresh as well as processed horticultural products in International market. During 2014-15, India exported fruits worth Rs 2771.32 crores out of which major share was occupied by fruits like mango, walnut, grape, banana and pomegranate. The major destinations for Indian fruits are UAE, Bangladesh, Malaysia, UK, Netherland, Pakistan, Saudi Arabia, Sri Lanka and Nepal (APEDA, 2015).

5. Industrial uses: Fruit crops can be exploited for several industrial uses and landless rural women can be actively involved in such industries. Papain is extracted from papaya can be taken up on commercial scale to obtain additional income. Papain is used as a meat tenderiser, manufacture of chewing gum, in tanning industry and for degumming natural silk. Similarly, bromelin, a proteolytic enzyme is extracted from pineapple. Banana fibre is used in making items like bags, rope and good quality paper. Latex from sapota also has several industrial uses.

6. Germplasm conservation: India has a rich biodiversity of horticultural crops. On account of global warming and climate change, there is a constant genetic erosion of valuable germplasm of several plant species. On-farm conservation of biodiversity can prevent loss of these valuable resources.

Horticulture is one of the important components of agriculture which covers 14% of area and shares more than 30% of agricultural GDP. The focused attention on horticulture has paid dividend and resulted in increased production which enhanced employment opportunities and minimized the nutritional gap. However a viable, sustainable and intensive horticulture model is required to enhance income generation capability of farm women for their resilient livelihood. The low per capita income and subsistence production system aggravate the situation of poor livelihood. In this backdrop horticulture model with new enterprises and crop diversification will act as a potential tool to improve the income of the rural people and generation of employment opportunities. The model will be developed considering the resource availability to ensure more income per unit of area and time. The horticulture model will act as a tool to enhance income sustainability of farm women through

technological interventions, crop and enterprise diversification which will have the potential of replicability among farm women. Moreover, the model is expected to enhance income, nutrition, food security and empowerment outcomes. Additionally the capacity building programme, training and exposure visits will not only upscale the knowledge and attitude of farm women but also income generation capability which in turn will improve the quality of life. The proposed horticulture model will make a synergy between resource utilization, nutrient requirement and return through incorporation of new viable enterprises and crop diversification.

Here some of the resource efficient horticulture technologies are discussed which will be helpful in improving the livelihood security of farming communities.

Protray seedling production technology developed: Vegetables play a significant role in Indian Agriculture by providing food, nutritional and economic security leading to improved livelihoods of farmwomen. To achieve higher production levels, productivity has to be increased through the adoption of improved high yielding varieties and improved production technology. Availability of quality seeds/ seedlings of vegetables to the farmwomen is the main cause of the adoption technology. Pro- tray seedling production technology is the best option to produce healthy seedlings of vegetable for quality produce. It is portable, easy and suitable for women. The seedling tray (pro tray) is filled with the growing medium (coco pith). A small depression (0.5 cm) is made with fingertip in the centre of the cell of the pro tray for sowing. Coco pith with 200 to 300 per cent moisture is used and hence no immediate irrigation is required until germination. After that, the trays are irrigated lightly every day depending upon the weather conditions. Spraying of 0.3 per cent (3g / litre) water soluble fertilizer (19 all with trace elements) twice (12 and 20 days after sowing) is done to enhance the uniform growth of the seedlings. The seedlings at right stage of planting are hardened by withholding irrigation and reducing the shade before transplanting or selling to the growers. Systemic insecticides are sprayed 7 - 10 days after germination and before transplanting for managing the insect vectors.

Application of mulching: In the present scenario of globalization and health consciousness demand for horticultural crops has increased world over. Excessive competition has not only compelled us to produce more but also to produce quality fruits and vegetables for sustaining in the international market. Apart from using high yielding varieties and good agricultural practices, there is a need to utilize environmental/biological energy for higher production. At present high tech interventions for quality enhancement are expensive and unaffordable for the producers to compete in the market. Therefore, effective and economical utilization of natural resources by low cost technologies and adaptable should be used. Mulch, being a natural resource, has become one of the most effective technologies for optimum yield and quality enhancement of crops besides reducing the cost of production. Mulching generally forms a protective layer around the plant for the benefit of its growth and productivity by modifying in the soil microclimate. It also helps in improving the overall plant health. The naturally available mulch materials include fallen leaves, twigs and other organic materials etc. Alternatively, different kinds of plastic films can be used as inorganic mulch . Mulching is also an important practice for establishing new plantation as it helps to conserve moisture in the root zone of the new plant until the roots have grown out into the surrounding soil.

Thickness of film

The thickness of film to be used in mulching determined by type and age of the horticultural crops (Table 1).

Table 1. Thickness of film

Crop duration	Thickness		Area coverage per kg	Weight per m^2
	Micron	Gauge	m^2	gram
Annual crop	25	100	42	23
Biennial crop	50	200	21	46
Perennial crop	100	400	11	93

Source: NCPAH, New Delhi

Table. Increase in yield of vegetable crops

Crop	Yield (t/ha		Increase in yield (%)
	Unmulched	Mulched	
Brinjal	36.73	47.06	28.12
Tomato	69.10	94.85	37.26
Chilli	16.79	19.71	17.39
Cabbage	14.3	19.90	39.16

Time of mulching: The best time of mulch crop is just after planting as it checks germination of weeds. In vegetable crops mulching should be done at the time of bed preparation but in fruit crops it should be done before planting. Replacement of mulch largely depends on the mulching material. Grass clippings and leaves decompose very fast and replenished frequently.

Study on mulching in tomato, brinjal, chilli and cabbage: In tomato, brinjal, chilli and cabbage four different mulches viz., M_0, M_1, M_2 and M_3 representing no mulch, mulching with transparent polythene, black polythene and with locally available *Glyricidia* leaves. Observation revealed that black polythene (0.25 mm thickness) was found most effective, as it registered significantly higher fruit yield 4. 42 kg/plant in tomato, 3.84 kg in brinjal, 312 gm in chilli and 654g weight of head in cabbage with negligible weed growth (1.97g/m^2 dw) than the other mulches. Number of fruits/ head weight and water use efficiency under black polythene mulch and *Glyricidia* leaves was statistically at par. It has been observed that mulched with blackpolythene plot registered significantly lower weed dry weight (67.3% less) than control.

Table: Effect of different mulching on yield and weed growth and weed control efficiency in tomato, brinjal, chilli and cabbage

Treatment	Yield (per plant)	Weed growth (g/m^2 dw)	Weed control efficiency (%)
Tomato			
M_0 -No mulch	3.60	75.60	-
M_1-Mulching with transparent polythene,	3.58	34.80	61.43
M_2- Mulching with black polythene	4.42	1.97	87.54

M_3- Mulching with locally available *Glyricidia* leaves	4.25	2.60	75.60
Brinjal			
M_0 -No mulch			-
M_1-Mulching with transparent polythene,	2.18	78.60	64.35
M_2- Mulching with black polythene	2.57	44.80	82.30
M_3- Mulching with locally available *Glyricidia* leaves	3.84	2.98	77.28
Chilli	3.59	4.60	-
M_0 -No mulch	210	82.60	64.75
M_1-Mulching with transparent polythene,	246	34.80	85.10
M_2- Mulching with black polythene	312	3.57	78.46
M_3- Mulching with locally available *Glyricidia* leaves	296	5.47	-
Cabbage			
M_0 -No mulch	370	73.50	58.37
M_1-Mulching with transparent polythene,	410	31.26	90.60
M_2- Mulching with black polythene	654	3.46	84.60
M_3- Mulching with locally available *Glyricidia* leaves	626	5.84	

Evaluation of cucumber, tomato, broccoli and capsicum under protected condition and open field condition

Low cost protected cultivation technology has been developed for tomato, cucumber, broccoli and capsicum under the hot- and humid tropical climate of Odisha. Crops and seedlings can successfully grown during February and March in the shed net houses, which

is, otherwise, not possible outside due to prevailing high temperature. Package and practices for growing vegetables under low cost shed net have been developed and standardized. Tomato, cucumber, broccoli and capsicum are very important high value vegetable crops and having good market demand. With this objective an experiment was conducted to evaluate the performance of tomato, cucumber, broccoli and capsicum under protected conditions and open field condition. Observations revealed that higher yield (4kg/ plant) was recorded in tomato var Avinash-3, 2.5 kg/ plant in cucumber var Kion, 1.5kg/plant in capsicum var Swarna and 569 g in broccoli var Pusa KTS1 under protected condition against 1.3kg/ plant in tomato, 600 g/ plant in capsicum and 337 g/plant in broccoli in open field condition. Duration of tomato, capsicum and broccoli in protected condition was extended about 45 days as compared to open field condition. It has been observed that 40 percent mortality was recorded in tomato under open field condition due to wilting and blight as compared to protected condition. Moreover, fruit quality in terms of size, shining, colour, taste and shelf life of these vegetables was better under protected condition as compared to open field condition.

Fertigation scheduling in tomato: Experiment was conducted on various major and micro nutrients viz., N,P,K ,Ca , Mg, S , Fe B,Cu ,Mn, Zn and Mo on different stages: S_1 - transplanting to ist cluster, S_2 - ist cluster to 2^{nd} cluster, S_3- 2^{nd} cluster to 3^{rd} cluster, S_4 - 3rd Cluster to 5th Cluster and S_5- 5th cluster to termination stage of tomato**.** It was observed that doses of N, K, Ca, Mg and S were as the increasing of plant growth increased. The doses of rest of nutrients viz., P 50 ppm , Fe 2.8 ppm, B 0.7, Cu 0.2, Mn 0.8, Zn 0.2and Mn 0.05 ppm were applied from transplanting to termination of crop.

3. Evaluation of protected cultivation of cucumber and capsicum: Under the hot- and humid tropical climate of Odisha, vegetables cultivation is difficult in summer and rainy seasons. Cucumber and capsicum are very important vegetable crops and having lot of demand. To evaluate the performance of cucumber and capsicum under protected conditions, an experiment was conducted on two promising varieties of Kion and Hilton of cucumber, and Swarna and Natasa of capsicum. Observations on number of fruits and yield were recorded. Among these varieties, highest yield was recorded in Kion (4kg/ plant) variety of cucumber and Swarna (1.5kg/ plant) variety of capsicum.

Raised bed and drip irrigation for vegetable production: Raised beds can help solve many problems. In areas where the soil contains too much sand or clay, or is too alkaline for

plants to grow well, raised beds are a good option. Soil that is poorly aerated because of compaction or poor drainage also will benefit from a raised bed. Raised bed can help improve the health and productivity of vegetable crops. Many farmers are stuck with soil types that have poor nutrient status, are too wet, compacted and have poor drainage, or infested with nematodes and other soil-borne pests. Such soils hinder seed germination, root growth, root establishment, nutrient supply and eventually affect plant growth. There are situations when it is more desirable to grow plants in raised beds because of less bending and crawling involved. Micro irrigation is a low pressure, low volume irrigation system suitable for high-return value crops such as fruits (pineapple and papaya) and vegetable crops (cowpea, French bean, tomato, brinjal, chillies and capsicum). Micro irrigation can increase yields and decrease water, fertilizer and labour requirements. Micro irrigation applies the water only to the plant's root zone and saves water because of the high application efficiency and high water distribution uniformity. It is observed that all plants of vegetable crops were healthy and almost disease free. It may be due to that application of water through drip as par requirement to the nearby root zone of plants.

Utilization of interspaced between fruit plants

Intercropping in banana: Longer gestation period of orchard crops is a major constraint towards crop diversification by small and marginal farmers. This constraint can be overcome by cultivating intercrop . It is revealed from the several studies that intercropping is more resilient and more profitable than monocropping. The crop should be such which can be economically grown under the shade else the opportunity time of the crop should be short. Thus need was felt to identify a crop which can grow under the shade as well as can be irrigated through existing system. To fill this gap, a study was carried out on different intercropping i.e. cowpea, amaranth (leafy vegetable) and elephant foot yam and radish in banana along with a control (Banana sole crop) were evaluated. Among the intercrops, banana + gave the maximum bunch weight (21.32 kg) and yield per ha (52.84 MT). Maximum additional income could be earned from elephant foot yam about Rs. 80000/- per ha/year, followed by cowpea (Rs 45000/-.).

Table Yield And economics of banana based intercropping system

Treatment	Fruit yield (t/ha)	Intercrop yield (t/ha)	Gross return	Total cost of cultivation	Net return (Rs/ha)

			(Rs/ha)	(Rs/ha)	
Rs/ha)Banana (Sole)	51.24	-	118110	82540	35570
Banana + cowpea	52,17	7.20	143190	98190	45000
Banana + Amaranth	52.84	8.45	129204	88560	40644
Banana + Elephant foot yam	54.53	22.12	286543	206543	80000
Banana + Radish	55.40	13.67	160700	118200	42500

Intercropping in drumstick: Drumsticks (*Moringa oleifera*) is an important multipurpose vegetable grown widely in Odisha for nutritional purpose and have good local demand. Different intercropping i.e. French bean, cow pea, amaranth (leafy vegetable), elephant foot yam and pineapple in drumsticks along with a control (drumstick sole crop) were evaluated. Among the intercrops, drumstick + French bean gave with maximum fruit yield per ha (45.50 t). Maximum income (Rs 190000/- per ha per year) could be earned from drumstick+ pineapple cropping system followed by drumstick+ elephant foot yam (Rs 135000/-.).

Table: Yield and economics of drumstick based intercropping system

Treatment	Fruit yield (q/ha)	Intercrop yield (q/ha)	Gross return (Rs/ha)	Total cost of cultivation (Rs/ha)	Net return (Rs/ha)
Drumstick (Sole)	150.00	-	150000	70000	80000
Drumstick + cowpea	132.50	64.00	196000	100000	96000
Drumstick + Amaranth	138.40	54.24	192000	88500	103500

Drumstick + Elephant foot yam	145.30	160.45	305000	170000	135000
Drumstick + French bean	144.00	56.30	200000	110000	90000
Drumstick + Pine apple	130.40	240.60	370000	180000	190000

Intercropping in lime: In Odisha, limes (*Citrus spp.)* are grown for nutritional purpose and have good market demand throughout the year. Different intercropping i.e. French bean, cow pea, amaranth (leafy vegetable) and colocasia in lime along with a control (lime sole crop) were evaluated. Among the intercrops, lime + cowpea gave with maximum fruit yield per ha (28.30q/ ha). Maximum income (Rs 138000 per ha/year) was earned from lime + French bean cropping system followed by lime+ colocasia (Rs 128000/- per ha per year).

Table: Yield and economics of lime based intercropping system

Treatment	Fruit yield (q/ha)	Intercrop yield (q/ha)	Gross return (Rs/ha)	Total cost of cultivation (Rs/ha)	Net return (Rs/ha)
Lime (Sole)	30.00	-	60000	40000	20000
Lime + cowpea	28.30	64.00	120000	70000	50000
Lime + Amaranth	22.45	72.20	116000	65000	51000
Lime + colocasia	24.10	220.53	268000	140000	128000
Lime + French bean	27.56	82.67	218000	80000	138000

5.Nutrient management in banana :A field experiment was conducted to find out the effect organic and inorganic inputs on growth, yield and quality of banana variety G-9. Seven treatments viz.T_1- fresh cow dung @ 500g/ plant; T_2- fresh cow dung @ 250g/ plant +

pond soil@ 250 g; T_3-fresh cow dung @ 500g /plant + 5g urea; T_4 - 500g fresh cow dung +5 g ammonium sulphate, T_5- 500g fresh cow dung + 10g sulphate of potash, T_6-fresh cow dung @ 500g/ plant + 5g ammonium sulphate and 10g sulphate of potash T_7- removal of male bud after completion of female phase (control) were applied to the selected plants. An application of 5 g ammonium sulphate and 10 g sulphate of potash blended with 500 g of fresh cow dung to the distal end of bunch showed 20% higher fruit yields and 22 days earlier fruit maturity in fruit yields as compared to control in G-9 variety of banana. The cost of treatment worked out to be Rs. 5 per plant as compared to Rs 10 per plant in soil application of recommended dose of NPK indicating cost effectiveness and easy of adoption by women. This technology is suitable for homestead cultivation of banana.

Table- Effect of organic and inorganic inputs on fruit yield and quality of banana variety Grand Naine (G-9)

Treatments	Number of fruits/ bunch	Weight of fruit (g)	Fruit size (cm)		Yield (kg/ bunch)	Maturity period (days)
			Length	Breadth		
500g fresh cow dung	67.34	104.24	11.02	3.31	18.80	115.20
250g fresh cow dung + 250 g locally available pond's soil	72.42	116.30	11.31	3.41	20.46	110.67
500g fresh cow dung + 5g urea	113.	123.96	12.20	3.55	20.08	110.56
500g fresh cow dung +5 g AS	89. 46	177.33	13.11	3.70	18.03	94.45
500g fresh cow dung + 10g PS	49.68	106.06	10.10	3.29	17.46	106.36
500g fresh cow dung +5 g AS +10g PS	46.79	96.75	10.02	3.12	22.10	100.20
Control	42.54	52.43	9.35	3.04	17.38	122.76

Note: AS (Ammonium sulphate), PS (Sulphate of potash)

6.Development of high density and meadow orcharding of guava: Guava is an important fruit crop in tropical and subtropical regions of the country due to it hardy nature of its tree and prolific bearing. Its cultivation requires little care and inputs. The traditional system of cultivation has often posed problems in attaining desired levels of productivity due to large tree canopy. Hence, a need felt to improve the existing production system, besides increasing its productivity. Currently, there is a worldwide trend to plant fruit trees at higher density or meadow orcharding to control tree size and maintain desired architecture for better light inception and ease in operations such as pruning, pests control and harvesting. The high density or meadow orcharding facilitates enhance production and quality of fruits besides the ease of plant management. In this method planting of guava accommodates 5000 plants /ha at 1.0x 2.0 m spacing. The plant canopy was managed judiciously with regular pruning. Plants were topped after 2 months of planting i.e. in the month of October. After appearance of new shoots, 50% of the shoots were pruned again in December- January for further induction of new shoots. Growth was initiated, flower differentiates and well spread plant canopy was attained by the end of May. An average fruit weight (140.00g) and yield of 1.5 kg/plant was recorded in second year of experiment. It is found very much suitable technology for women in horticultural crop production as women can easily perform cultural operations due to manageable height of the plants. Moreover, guava is a hardy

crop and requires little care and inputs for cultivation fetches remunerative price in market too .

Sl No	Parameter	Number
1.	Plant intensity	5000/ha
2.	Plant spacing	(1.02 x 2.0)m
3.	Pruning	50%
4.	Fruit weight	140.00gm
5.	Yield	1.5 kg/ plant

Comparison between traditional and meadow orchard system of guava growing

Attributes	Traditional system	Meadow system
Bearing of fruits	After two years	From first year
Production	Average yield is 15- 20 t/ha	Average yield is 40- 50 t/ha
Labour requirement	Require more labour	Require more labour
Production cost	Higher cost of production	Lower cost of production
Harvesting	Difficult	Easy
Quality	Large canopy, poor sunlight penetration and poor quality of fruits	Small canopy, better air and sunlight penetration, minimum disease incidence and high quality of fruits
Management by women	Women cannot manage due to large tree size	Women can manage easily due to small tree size

Economic feasibility of model : A resource efficient horticulture model was developed for 2000 m2 area with different components like high density planting of banana, papaya,

pineapple, lime and meadow orcharding of guava, different green leafy vegetables viz., coriander, menthi, palak and amaranth; roots and tuber crops viz., elephant foot yam, yam and colocasia and other vegetables viz., tomato, brinjal, cauliflower, chilli, cowpea, French bean. The main objective of the model is to increased crop productivity and profitability with increased resource use efficiency. After the cyclone *phylin and Hudhud* in October, 2013and 2014 respectively this model gave 790 kg fruits (banana, pineapple, guava and lime); 350 kg green leafy vegetables (amaranth, coriander leaves, fenugreek leaves and palak), 340 kg root and tuber crops (radish, elephant foot yam, yam and colocasia) and 1740kg other vegetables (bitter gourd, bottle gourd , cauliflower, cabbage, capsicum, okra, tomato, brinjal, chilli, cowpea, French bean, onion broccoli, knolkhol and cauliflower). Net income of Rs 34770/ with BCR of 2.94 were estimated from this model (1660m^2) during the second year.

Economic analysis of fruits and vegetable crops

Table: Economic feasibility of horticultural crops

Crops	**Total area (m^2)**	**Yield (kg)**	**Total Expenditure (Rs.)**	**Gross Income (Rs.)**	**Net Income (Rs.)**	**BCR**
Perennial fruits	420	900	5500	18000	12500	3.27
Vegetables						
Green leafy vegetables	185	350	990	3500	2510	3.54
Roots and tubers	195	340	1320	5100	3780	3.86
Other vegetables	860	1740	10120	26100	15980	2.58
Total	**1660**	**3330**	**17930**	**52700**	**34770**	**2.94**

Nutrient contribution from different fruits and vegetables/ day

Crops	Yield/day	Protein (g)	Calcium (mg)	Iron (mg)	Carotene (µg)	Vitamin C (mg)
Fruits	2.16	22.11	358.36	9.10	4964.38	1634.79

Green leafy vegetables	0.75	27.93	2520.00	21.95	42107.67	709.18
Roots and tubers	0.77	3.95	98.63	1.97	101.92	16.44
Other vegetables	4.08	68.22	1081.92	35.32	5763.01	1219.18
Total	**7.77**	**122.21**	**4058.90**	**68.33**	**52936.99**	**3579.59**
RDA	**-**	**250**	**5000.00**	**140**	**12000**	**200.00**
% of RDA contribution	**-**	**49**	**81**	**49**	**441**	**1790**

Development of coconut based multi-storey cropping model

Coconut is the important plantation crop grown in coastal area of Odisha. Cultivating intercrops in coconut provide higher productivity and income per unit area. Thus an integrated system with several crop combinations to maximize the production along with more income and employment generation would ensure a sustainable development of farmwomen and additional employment opportunities to farm families. Therefore an effort was made to standardize suitable intercrops in coconut based multistory cropping model with banana, papaya and guava as second storey crops. Different ground storey intercrops like cowpea, turmeric, elephant foot yam, colocasia and pineapple were cultivated in the interspaces of the main crop. Observation revealed that among the different intercropping combinations, highest yield were recorded by colocasia var Muktakesi (240 q/ha), followed by turmeric (208 q/ha) and elephant foot yam (170q/ha). Highest income (Rs 3,42,000) were estimated with the combination of coconut + banana + colocasia var Muktakesi as compared to sole crop of coconut (Rs. 1,50,000.ha). The care of ground storey crops is taken by the farmwomen.

Coconut based multi-storey cropping model at ICAR-CIWA

Table - Yield and income of multi- storey cropping model in coconut orchard

Crop	Yield	Income (Rs/year/ ha)

Traditional method (200 plants /ha)	**30 nuts/plant at 6 year age**	**60000**
With intercrop		
Top storey (main crop)	25 nuts/ plant	50000
Second storey		
Banana	3600 kg	54000
Papaya	4000 kg	60000
Guava	160 kg	32000
Ground storey		
Pine apple	140 q	210000
Turmeric	208q	312000
Elephant foot yam	170q	170000
Cowpea	43q	43000
Colocasia	240q	240000
Total income (Main crop+ banana+ pineapple)	-	**312000**
Main crop+ banana+ colocasia	-	**342000**
Main crop+ banana+ elephant foot yam	-	**272000**
Main crop+ banana+ cowpea	-	**225000**

Effect of pinching in marigold :

Marigold (*Tagetes erecta* L.) is very useful and easily grown flower by farmwomen which has exclusive use in religious and ceremonial functions. It is also grown as annual in pots and beds and blooms for 3-4 months in a year. The economic yield is depend upon varieties and pinching which play an important role in plant growth and flowering production. An experiment was carried out to identify varieties and standardize pinching for optimum flower yield with better flower quality in marigold during *Rabi* season. The treatments comprised of the four varieties *viz.*, Spun Gold (V1), Spun Yellow (V2) Sutton's Double Orange (V3) and Sutton's Double Yellow (V4) and three pinching treatments *viz.*, no pinching, 30 DAT, and 45 DAT. Maximum number of primary branches (20) and spread of plant (35 cm) were recorded with Spun Gold and pinching at 30 DAT. As regards yield parameters, the maximum number of flower (16) and flower yield (448 g/plant) were recorded by Sutton's Double Orange and pinching at 30 DAT followed by Spun Gold at 45 DAT .

Marigold cultivation at ICAR-CIWA

Table- Performance of different varieties and standardization of pinching for optimum flower yield in marigold

Treatment	Flower yield (g/plant)
Spun Gold (V1)	
No pinching (T1)	364
30 DAT (T2)	380
45 DAT (T3)	424
Spun Yellow (V2)	
No pinching (T1)	350
30 DAT(T2)	383
45 DAT(T3)	320
Sutton's Double Orange (V3)	
No pinching (T1)	316
30 DAT(T2)	340
45 DAT(T3)	430
Sutton's Double Yellow (V4)	
No pinching (T1)	275
30 DAT(T2)	360
45 DAT(T3)	330

Performance of different varieties of gladiolus for flower yield

The purpose of the study was to evaluate the performance of most suitable cultivar under the climatic conditions of Odisha. In gladiolus (*Gladiolus grandiflora* L), cv. Rose Supreme took minimum day (60 days) for flowering, while maximum florets (20) were produced by cultivar White Prosperity. Pusa Kiran recorded maximum length of rachis (38.8 cm). Maximum (90 cm) spike length was observed in cultivars Nova Lux and remained attractive for longer period and obtained spike life of 21 days followed by Applause (18.50 days) and Rose Spire (17.45days). Based on floral characteristics, cultivars Rose Supreme, White Prosperity, Nova Lux and Pusa Kiran were found promising for floral characters in Odisha condition.

Gladiolus cultivation at ICAR-CIWA

Table- Performance of different varieties of gladiolus for flower yield

Varieties	Number of floret / plant)
Rose Supreme	16
White Prosperity	20
Pusa Kiran	15
Nova Lux	18
Applause	14
Rose Spire	17

Performance of Chrysanthemum at different planting density

Chrysanthemum (*Chrysanthemum species)* has earned tremendous popularity as an ornamental flower due to its wide range of colour. In the standard types, usually the crown bud is allowed to bloom, but the single flower does not fetch appreciable market due to its large size. In cut flowers, two most important criteria for acceptable blooms to be assessed are the size of flowers and their stalk length. Considering the above facts, an experiment was

Chrysanthemum cultivation at ICAR-CIWA

conducted to evaluate the performance of chrysanthemum var. Chandrima at different spacing. The results revealed that spacing 25x30 cm (plant density12 plants/m^2) was better in respect to all the growth and flowering parameters and recorded maximum number of flowers / plant (42) . Unpinched single stemmed plants showed early flowering (33 days) and produced larger flower (10 cm) and maximum shelf- life (43 days).

Insect pest management:

India is a large producer and consumer of vegetables, many of them are highly vulnerable to frequent attacks of pests and diseases. At the time of such pest attack, farmers have a tendency to resort to indiscriminate use of chemicals and pesticides, which may be harmful to human health as well as to ecology. IPM is an alternative to such a scenario, which is cost effective and needs to be promoted among farming communities for quality production and environmental sustainability. Major insect pest infestation of different vegetable crops are observed during the experimental period and their management are given below.

TOMATO

Fruit Borer (*Helicoverpa armigera* Hubner) The adult is stout and medium-sized moth and has a dark circular spot in the centre on the forewing. They lay small, single, and whitish round eggs on the trifoliate leaves beneath the topmost flower cluster. Eggs hatch in about 3-4 days and the first instars larvae initially feed on the leaves and migrate to the developing green fruit later. The larvae bore into the fruits with the posterior end outside the hole. Full grown caterpillars show characteristic whitish and dark brown longitudinal stripes.

Management: Effective management can be done by adopting marigold as trap crop. Giving sprays of Ha NPV @ 250 LE /ha at 28,35 and 42 days after transplanting. Mechanical collection and destruction of bored fruit at periodic intervals (3-4 times) brings down the borer incidence to less than 2 per cent.

Serpentine Leaf Miner (*Liromyza trifolii* Burgess) The tiny, metallic fl y punctures the leaf lamina and feeds on the oozing sap. It lays eggs on the outer margin of leaves. Within 2-3 days, whitish maggots hatch out of these eggs and start mining the leaves and pupate in 6-10 days. Pupation takes place in the soil and occasionally on the leaf surface itself. Typical serpentine shaped tunnels are formed in the leaf lamina indicating the path of feeding by the **Management**: Often the incidence starts from nursery itself. Hence, remove infected leaves at the time of planting or within a week of transplanting maggots. Apply neem cake to

furrows (open)/beds (polyhouse) @ 250 kg/ha at planting and repeat after 25 days. Spray neem seed powder extract 4% or neem soap 1% at 15-20 DAPS. If the incidence is high, remove infected leaves and spray Triazophos 40 EC (1ml) mixed with 7.5 g neem/litre.

Whiteflies (*Bemicia tabacii*) White fly is a well-known vector, which transmits tomato leaf curl virus. It has piercing and sucking mouthpart and both nymphs and adults feed on lower surface of the leaves causing deformation of young leaves. White flies also excrete honeydew, causing sooty mold.

Management; Use virus resistant hybrids. Raise nurseries in seedling trays under nylon nets or polyhouses. Spray Imidacloprid 200 SL (0.3ml/l) in nursery at 15 days after sowing. Remove the leaf curl infested plants as soon as disease symptoms are expressed. This helps in reducing source of inoculums of the disease. Drench the base of the seedlings with Imidacloprid 200 SL (0.03ml/l) before transplanting. If protreys are used for raising nursery, drench the protreys with the chemicals one day before transplanting.

BRINJAL

Shoot and Fruit Borer (*Leucinode orbonalis* Guen): This pest has developed resistance against all groups of insecticides and management is very difficult. The adult moths lay tiny white eggs singly on flower buds and other plant parts. Eggs hatch into small light brown larvae. Caterpillars feed inside the tender shoots before flowering and cause wilting of the affected shoots. When the incidence is high, unopened flower buds swell and harbour the borer.

Management: Use nylon net barrier for raising nurseries to eliminate pest incidence coming from nursery to main field. Cut and destroy wilted insect damaged shoot tips during pre-flowering and flowering period at regular intervals. Regularly destruction of larvae in swollen damaged flower buds and fruits after each harvest is essential for control the infestation. Grow all round barrier crops like maize to save the crop from insect. Use of water traps loaded with pheromone @ 30 /Acre can reduce the pest incidence to minimum level. Apply neem cake @ 250-500 kg/ha to ridges at flowering and repeat 2 more times at 30-45 days interval. Grow varieties like Punjab Barsati, (moderate resistant cultivar) Pusa Purple Round, Punjab Neelam found to be resistant to brinjal fruit borer.

Leafhopper (*Amrasca biguttula* Ishida): Both adults and nymphs suck the sap from leaves. The eggs are inserted into the midrib or veins. During hatching the nymphs move along the

veins and nymphs suck the leaf sap. On the older leaves, the damage is seen as yellowish-green mosaic patches followed by brown necrosis and curling along the leaf margin.

Management: Soil application of neem cake 250 kg/ha followed by sprays of NSKE 4% at 10 days interval. Spray of systemic insecticides like Imidacloprid 200 SL @ 0.3ml/l or Acephate 75 SP (1 g/l) at pre-flowering stage. The varieties such as Kalyanpur, Punjab Chamikila, GB-1, and GB-6 reported as resistant to Jassids, Aphids and Whitefly. Use yellow sticky traps to control the sucking pests.

Root-knot Nematodes (*Meloidogyne incognita,* M. javanica): The root-knot nematodes cause root galls on the feeder roots which sometimes affect the entire root system showing heavy galling. This affects the uptake of nutrition and water and the plant show wilting during warmer part of the day. Later, stunting of plants with yellow foliage and reduction in yield is very common.

Management: Seed treatment with bio-pesticide *Pseudomonas fluorescens* @ 10 g/kg seed. Apply 2 tons of farmyard manure enriched with *T. harzianum* per acre before planting, along with 100-200 kg of neem cake. Trap cropping marigold *Tagetus sp* are effective in controlling *Melidogyne incognita.* Apply Carbofuran 1G @ 1kg ai/ha at the time of transplanting.

OKRA

Leafhoppers (*Amrasca biguttula* biguttula) Hoppers lay pear shaped, elongated and yellowish white eggs in the veins on the under surface of leaves. Both the adults and nymphs suck the cell sap. Nymphs move diagonally when disturbed. Plants loose their vitality and affected leaves turn yellow and curl upwards. When the infestation is high during summer, leaves turn brick red and show large necrotic spots.

Management: Apply neem cake @ 250 Kg/ha to soil immediately after germination and repeat after 30 days. In the initial stages of crop before flowering spray ™systemic insecticide like Acephate 75 SP (1ml/l) or Imidacloprid (0.3 ml/l). Once the fruit harvest starts avoid systemic insecticides. Spray neem seed powder extract (NSPE) 4% at the lower surface of the leaves to control insect damage.

Aphids *(Aphis gossypii)*: This is a polyphagous pest, feeding in colonies and completely covers the shoot tips, buds and lower surface of leaves. Both nymphs and adults suck the sap. They also excrete honeydew on which sooty mould develops.

Management: If aphid population is limited to just a few leaves or shoots then the infestation can be pruned out to provide control. Use tolerant varieties if available; reflective mulches such as silver colored plastic can deter aphids from feeding on plants; sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves. Thoroughly spray neem soap (1%) or pulverized neem seed powder extract (NSPE) 4%. During pre-flowering period spray systemic insecticides like Dimethoate 30 EC (2ml/l).

Whitefly (*Bemesia tabaci*): It is a polyphagous vector transmitting yellow vein mosaic disease (YVM). It lays eggs on the lower surface of leaves. Both the adult and the nymph feed by sucking leaf sap. They excrete honeydew, which results in sooty mould.

Management: Grow resistant varieties cultivars viz. Parbhani Kranti, Makhmali, Tulsi, Anupama-1, Varsha Uphar, Hisar Unnat, Arka Anamika and Arka Abhay to control (YVMV).™Apply neem cake @ 250 kg/ha at germination and ™again at 30 DAP followed by sprays of neem oil 1%. Set up yellow sticky and delta traps for control of whiteflies. Spray Imidacloprid 200 SL @ 0.3ml/l (should not be sprayed after flowering stage).

CABBAGE

Leaf Webbers (*Crocidolomia binotalis* Zeller): The moths lays eggs in clusters of 40-100 on leaf surface, which hatch in 5-7 days. Young larvae feed gregariously and later web the leaves together and feed within. This results in rotting of cabbage head. The larval period lasts for 25-20 days while pupation occurs in soil, which varies from 15-40 days.

Management: Collect and destroy egg masses and gregarious larvae. Spray neem seed kernel extract 4% or pulverized neem seed powder extract (NSPE) 4%.

Diamond Back Moths (*Plutella xylostella* L.): This is a major pest of cruciferous crops, particularly cabbage and caulifl ower during January-June and also during dry periods in monsoon. Eggs are yellowish white, and are laid singly on tender leaves. A single female may lay about 40-60 eggs. Incubation period is 3-6 days.

Management: Sow mustard as a trap crop.™Spray neem seed powder extract @ 4% thoroughly coverage to the crop canopy. Install light traps (3-4 with 60 or 100 Watt bulbs /

acre) to control adults. For one acre plot use 3-4 light traps (60 or 100 Watt bulbs) by hanging above a bucket half filled with water. Alternatively, hang the bulb above a gunny bag (slating below) smeared with grease or oil. Illuminate the bulbs for full night. Adults of DBM will get attracted to light and get trapped in the water/oil. Use the light traps for 3-4 days for effective control of DBM adults.

CUCURBITACEOUS VEGETABLES

Red Pumpkin Beetle (*Aulacophora foveicollis* Lucas) The adults are small, elongated yellow and defoliate the leaves immediately after germination. The larvae feed on roots and plant parts.

Management: Mechanically collect and destroy the pest if incidence is low. If the pest incidence is very severe, spray Indoxacarb 14.5 SC @ 0.5 ml/l or Chlorpyriphos 20 EC2.5ml/l.

Serpentine Leaf Miner (*Liriomyza trifolii* Burgess) This is an introduced pest occurring on many cucurbit vegetables. Heavy incidence is observed in pumpkin and cucumber. However, bitter gourd seems to be resistant.

Management: Soil application of neem cake @ 250 kg/ha immediately after germination. Destroy cotyledon leaves with leaf mining at 7 days after germination. Spray neem formulation with 10000 ppm or more (2ml/l) after 15 days sowing and repeat after 15 days, if necessary. If the incidence is high first remove all severely infected leaves and destroy.

Fruit Fly (*Bactocera cucurbitae* Coquillett). This is the major pest of cucurbits. The damage by maggots results in rotting of young and ripened fruits or drying and shriveling of fruits before maturity. Sometimes even the base of the plant gets attacked and plant start wilting. The incidence of insect is high in humid climate.

Management: Use resistant varieties like Arka Suryamukhi and other genotypes like KP-3, KP-19, KP-32, KP-38. Soil application of neem cake @ 250 kg/ha immediately after germination and repeat at flowering followed by sprays of neem soap 1% or PNSPE 4% at 10 days interval after flowering. Crush pumpkin 1 kg and add 100 gm jaggery and 10 ml Malathion and keep in the plot (4-6 places per acre). Adults are attracted to the fermenting pumpkin and lay eggs and get killed. Repeat the process 2-3 times in the cropping season.

Erect cuelure (para pheromone trap) 3 per acre to attract and trap male fruit flies. Spray Carbaryl 50 WP @ 3 gm/l.

LEGUMINOUS VEGETABLES

Bean Fly (*Ophiomyia phaseoli*): This species is serious in French beans and peas but can also be noticed on dolichos beans. This pest is serious during dry periods of Kharif (June-August) and after January-February when temperature increases above 30^0 C and can cause more than 70% mortality of the plants. The adults are small flies and lay eggs in the unifoliate leaves that come immediately after germination. It punctures the leaf, lays eggs under the leaf epidermis which turn into white spots, often confused with disease. The incidence is high during prolonged dry spells between rains, particularly in June-July months. When the incidence is early and high, plants invariably die. This mortality is noticed only after 25-30 days, when the plants are about to flower. Any control measures taken at that time is not useful.

Management: Apply neem cake 250 kg/ha immediately after germination. Monitor the plants for adult activities, puncture marks and petiole mining soon after germination. As soon as a few adults are observed over the crop, spray Acephate 75 WP @ 0.75 g/l or neem formulation with 10000 ppm Azadirachtin 2 ml/l. The botanicals get washed away by rain and become ineffective if it rains within 1-2 days of spray. Give second spray after 12-20 days of sowing if 5 leaves show petiole mining symptoms per 10 leaves.

Pod borer (*Muruca testulalis, Lampides boeticus*): The pyralid moth lays eggs on small flower buds as soon as flowering starts. Caterpillars bore flower and buds Flower buds can be examined for holes caused by young larvae.

Management: Remove the affected plants as soon a possible and spray Chlorpyriphos @ 0.05% at flower- bud stage.

ONION

Thrips (*Thrips tabaci* Lindeman): Thrips feed on a wide range of cultivated plants and weeds. Leave have shining silver streaks or have brown spots. Some of the alternate hosts include cabbage, cotton, tomato, cucumber, melons, pumpkins, and many flowering plants. Thrips are pestiferous in diverse ways. They cause direct damage to leaves and bulbs.

Management: Grow commercial varieties, N-2-4-1, Pusa Ratnar, B-780, Pusa Red and N-53 were found resistant to thrips. Good crop management practices can be readily manipulated to the disadvantage of thrips. Field sanitation techniques such as removing alternate weed host on bunds and destruction of culls of onion bulb are helpful to some extent in bringing down thrips population. Avoid successive planting of onion and garlic or other preferred host. By making adjustments in transplanting dates, onions can be made tolerant to early thrips attack and satisfactory yields can be obtained with minimum chemical intervention. Thrips being colour-sensitive, coloured mulches may be employed for their control. Sprinkler irrigation reduces thrips population considerably compared to drip and surface irrigation. Insects would be washed off or drowned in the water accumulated in the leaf bases. Plant two rows of maize surrounding the onion plots for effective control of thrips. Demeton (0.05%) and Cypermethrin at 60 g ai/ ha are recommended for control of this pest.

Conclusion

There is no doubt that horticultural crops are labour intensive and needs a care for making profitable for the farming community. Horticulture sector generates lot of employment opportunities for the rural population. Fruits and vegetables are also rich source of vitamins, minerals, proteins, and carbohydrates etc. which are essential in human nutrition. Despite of significant growth of horticulture, there is huge gap between present production and availability. Moreover, India needs to produce 350 mt vegetables and 125 mt fruits by 2030 to meet the demand of the growing population. Since, there is not much scope for area expansion, the productivity enhancement is envisaged through adoption of good management practices including techniques of high density planting and adoption of resource efficient horticulture technologies because of our natural resources are limited. Therefore, it is need of hour that judicious use of resources is the best option for improving productivity and natural resources conservation. The effective and efficient utilization of resources will reduce the cost of crop production thereby increasing farmers' profits and reduction of environmental pollution.

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