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RESEARCH ARTICLE

INTEGRATED HORTICULTURE PRODUCTION SYSTEMS FOR NE REGION OF INDIA

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ABSTRACT

Recently horticulture crop production has shifted from rural confinement to commercial venture to attract young entrepreneurs and economically viable and socially acceptable.In the North Eastern Region, the total area under horticultural cropsis around 822.5 thousand hectare which is around 3.14 percent of the total geographical area of the region and it givestotal production of 6818.4 thousand tonnes. Within the horticulture sector in the NE Region, fruit crops occupy 40.14%, vegetables51.83% and spices 8.03% area.Among fruits, citrus has the largest area under cultivation (34%), followed by banana (24%),pineapple (17%), apple (4%), papaya, mango, litchi, passion fruit (3% each), guava (2%) and kiwi (1%).Among vegetables, potato has the maximum area (27%) under cultivation followed by cabbage (10%), peas (7%), cauliflower (6%), tomato and brinjal (5%), okra and chilli (4%),onion (2%) while other vegetables have 30% of the total area under vegetable cultivation.Efforts have been made to develop an integrated fruit production systems including selection of location specific fruits crops and variety, production of quality seeds and planting materials, high density planting, identification of rootstocks for H.D.P, INM based on soil and leaf nutrient status, crop regulation. Integrated weed management development of horticulture based cropping systems for different agro-climatic region, organic farming for export oriented fruit crops, modern approaches of horticulture technologies like crop diversification, conversion of gray to green land, contract farming, precision farming, water resource management, protected cultivation, integrated weed management, integrated pest and disease management, improved post harvesting management and processing for value addition.

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INTRODUCTION

In India, out of 23.4 million hectares area under horticultural crops, fruits are grown in an area of 6.87 million ha with the production of 77.7 million MT (2012-13). Among fruit crops, banana leads in production share (32%) whereas mango is cultivated in maximum area (2.48 million ha).In India, vegetable crops are cultivated in an area of 9.07 million ha with the production of 159.5 million MT. Among vegetable crops, potato leads in production share (28%) with maximum area (1.97 million ha) and highest production (44.7 million MT) (2012-13). India has emerged as the largest producer of coconut, are canutcashewnut, ginger, turmeric, black pepper and the second largest producer of fruits and vegetables. Recently, the new crops, kiwi, olive crops, strawberry and oil palm have been successfully introduced for commercial cultivation. Govt. has identified horti-cultural crops as a means of diversification for making agriculture more profitable through efficient land use, optimum utilization of natural resources and creating skilled employment for rural people.

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Recently horticulture crop production has shifted from rural confinement to commercial venture to attract young entrepreneurs and economically viable and socially acceptable. Efforts have been made to develop an integrated fruit production systems including selection of location specific fruits crops and variety, production of quality seeds and planting materials, high density planting, identification of rootstocks for H.D.P, INM based on soil and leaf nutrient status, crop regulation. Integrated weed management development of horticulture based cropping systems for different agro-climatic region, organic farming for export oriented fruit crops, modern approaches of horticulture technologies like crop diversification, conversion of gray to green land, contract farming, precision farming, water resource management, protected cultivation, integrated weed management, integrated pest and disease management, improved post harvesting management and processing for value addition. In the NEH Region. The total area under horticultural crops is around 822.5 thousand hectare which is around 3.14 percent of the total geographical area of the region and it gives total production of 6818.4 thousand tonnes. Within the horticulture sector in the NE Region, fruit crops occupy 40.14%, vegetables51.83% and spices 8.03% area.

Crop wise area, production and productivity of different horticultural crops of NE region (2010-11) is given below

Crops	Area (ha)	Production (MT)	Productivity (MT/ha)
Fruits	344,379	2950,328	8.57
Vegetables	444,603	4502,091	10.13
Spices	68,858	363,527	5.28
Grand Total	857,840	7,815,946	9.11

Source: NHB and State Departments (2010-11)

From the production point of view, fruit crops contributed37.75%, vegetables 57.60% and spices 4.65% to the horticulture production basket of theNE Region. Considering the excellent climatic conditions, abundant rainfall and fertile soil(high organic content) of the region, the productivity of different horticultural crops is quitelow as compared to national productivity. Among fruits, citrus has the largest area under cultivation (34%), followed by banana (24%), pineapple (17%), apple (4%), papaya, mango, litchi, passion fruit (3% each), guava (2%) and kiwi (1%).

Statewise area, production and productivity of horticultural crops of NE Region (2010-11) is listed below

State	Area (ha)	Production (MT)	Productivity (MT/ha)
Arunachal Pradesh	101,967	417,849	4.10
Assam	401,009	4,545,288	11.33
Manipur	78,349	671,854	8.58
Meghalaya	73,076	552,104	7.56
Mizoram	69,786	490,936	7.03
Nagaland	27,473	251,145	9.14
Sikkim	44,375	188,290	4.24
Tripura	66,953	802,211	11.98

Source: NHB and State Departments

Other fruits have 6% of the total horticulture area under cultivation. In terms of production, banana has the largest share (34%), followed by pineapple (24%), citrus (21%), papaya (6%), mango, guava, passion fruit (3% each), litchi (2%), grapes andapple (1% each).

In N.E.H. Region, state wise priority Horticultural crops are listed below

States	Horticultural crops
Assam	Banana, Citrus, Guava, Pineapple, Papaya, Jackfruit, Arecanut, Potato, Guava, Litchi, Cabbage, Cauliflower, Brinjal, Pea, Tomato, Ginger, Turmeric
Nagaland	Citrus, Pineapple, Banana, Papaya, Potato, Tomato, Cabbage, Okra, Ginger
Tripura	Citrus, Banana, Litchi, Pineapple, Peach, Papaya, Brinjal, Potato, Cauliflower, Tomato, Okra
Meghalaya	Pineapple, Citrus, Banana, Papaya, Guava,, Passion fruits, Strawberry, Kiwi, Peach, Potato, Tomato, Brinjal, Cabbage, Cauliflower, Ginger, Turmeric
Arunachal Pradesh	Apple, Citrus, Banana, Pineapple, Guava, Kiwi, Peach, Passion fruits, Large cardamom, Black pepper, Ginger, Potato, Tomato, Cabbage
Manipur	Pineapple, Papaya, Banana, Jackfruit, Citrus, Peach, Kiwi, Passion fruit, Cabbage, Pea, Tomato, Cauliflower, Chilli, Ginger, Turmeric
Mizoram	Citrus, Banana, Passion fruit, Grape, Peach, Papaya, Chayote, Bitter gourd, Bean, Brinjal, Ginger, Turmeric, Birds Eye Chilli
Sikkim	Citrus, Kiwi, Banana, Potato, Tomato, Cabbage, Broccoli, Cauliflower, Pea, Okra

Among vegetables, potato has the maximum area (27%) under cultivation followed bycabbage (10%), peas (7%), cauliflower (6%), tomato and brinjal (5%), okra and chilli (4%), onion (2%) while other vegetables have 30% of the total area under vegetable cultivation. In terms of production, potato has the highest production and contributes 22% to vegetableproduction in NER followed by other vegetables (22%), cabbage (18%), tomato (11%), cauliflower (9%), brinjal (7%), okra (4%), peas and chilli (2% each) and onion (1%). Fruits crops like *Prunusnepaulensis, Myricanagi, Eleagnuslatifolia, Docyniaindica, Citrus medica, Citrus assamensis, Averrhoeacarambola, Citrus macroptera, Musa sikkimensis, Baccaureasapida, Castanopsisindica* etc. which are rich in vitamins, protein, minerals and valued for raw fresh fruits or preserved products and components in food diet during off season for poor people.

Identified varieties of fruit crops for NEH Region

Citrus: Khasi mandarin, Assam lemon, Acid lime, Sweet orange
Pineapple: Kew, Queen
Guava: Allahabad Safeda, L-49 and H-7
Banana: Jahaji, Borjahaji, Chinichampa, Sabri, Malbhog.
Peach: TA-170, Floridosun, Shan-e-Punjab, Sharbati
Plum: Santarosa, Alton, Titrok
Pear; Bartlett, Baghughosa, Sandpear, Patharnakh
Apple: Royal Delicious, Rich-A-Red, Red Delicious, Golden Delicious.
Kiwi: Abbot, Allison, Bruno, Hayward
Strawberry: Sweet Charle, Chandler, Ofra
Passion fruit: Purples, Yellow, Kaveri
Litchi: Sahi, China, Bedana, Rose scented
Mango: Amrapalli
Papaya: Honey Dew, Co_2, Solo, Taiwan

Product of quality planting materials

Being true to type and uniform growth nucellar seedlings of polyembryonic varieties of mango and citrus have become popular. Root stocks of various fruit crops like apple, mango, citrus, Guava, Sapota, peach, pear etc. Plum have been identified for raising budded or grafted planting materials to produce early and good yield and quality fruit produce.Soft wood grafting has been standardized for mango, sapota, custard apple and jack fruit. Shoot tip grafting techniques in citrus and veneer grafting in mango are practiced commercially. Patch budding in guava and tongue grafting in peach have become successful. In banana, suckers of 700g-1000g have been found optimum. Micropropagation protocols for apple, banana, grapes, pineapple, papaya and strawberry are available in the country. Use of low cost polyhouse may be advised for multiplication and rearing of propagated plants in this region.

High Density Planting (H.D.P)

Recently high density planting have been found successful in banana, pineapple, citrus, guava, apricot, peach, apple and plum. H.D.P accommodates more number of plants per unit area, provide high yield (>double), with high fruits quality, control of alternate bearing, proper weed management, reduced cost of production and use of growth substances to control flowering and fruiting. In H.D.P. tree size is controlled by using dwarfting rootstocks, growth retardants like daminozide, paclobutrazol, maleic hydrazide and enthephon and by canopy management through pruning.

Crop Regulation in fruit crops

In mango, soil application of pactobutrazol @5g/l during July-August enforces annual fruiting.

Crop	Rootstock/variety	Spacing	Population	Yield (t/ha)
Apple	M-9, 27	1.5m x 1.5m	4444	50-60
Pear	Quince	3.5m x 1.0m	2285	50-60
Cherry	Colt	4m x 4m	625	10-12.5
Peach	Local peach	3m x 3m	1111	8-10
Banana	Basrai	1.5m x 1.5m	4444	140.0
Papaya	PusaNanha	1.25m x 1.25m	6400	103.6
Guava	Allahabad Safeda	3m x 4m	833	16.5
Pineapple	Kew	0.25m x 0.6m x 0.90	63,758	118.8
	Queen	0.3m x 0.6m x 0.90m	43,500	55.0
Litchi	Shahi	2.0 mx 1.5m	333	5.82
Mandarin	Troyer citrange	1.8m x 1.8m	3000	60.0
	Khasi mandarin	4.5m x 4.5m	500	50.0
Mango	Amrapali	2.5m x 2.5m	1600	22.20

Spray with NAA (200ppm) in October controls malformation. At mature stage fruit drop can be controlled with NAA spray (20ppm). In grapes, application of dormex (1.5%) induces early repining. Pruning to a particular bud strength controls bearing. Double spray of 10% and 20% urea on cvs Allahabad Safeda and L-49, twice at bloom eliminate poor quality rainy season crop and increases winter season yield by 3-4 times, respectively. Concurrent pruning has been found successful for producing multiple crops in high density plantation in Guava. In pineapple, Staggering of fruits harvest throughout the year is possible by using different planting material, adopting sequential planting methods and by using flower inducing chemicals like application of 50ml of a mixture containing ethephon (25ppm) + 2% urea + 0.04% calcium carbonate on the plant with 30-35 leaves.

Integrated Nutrient management

Fertilizer schedule management based on analysis of leaf and soil nutrient status through appropriate diagnostic tools, use of soluble organic fertilizers through drip irrigation system, improvement of soil fertility through addition of green manures, composts, liquid manures, cowdung, cowurine, vermicompost, vermiwash and use of biofertilizer like VAM (Glomusfasciculataum G,mossseae) and other phosphate solubilizers like microphos and phosphobactrin @200g/tree/year enhances phosphorus availability and improve fruit yield and quality.

Integrated soil and water management

Mulching, preparation of half- moon terraces, bench terraces, contour bunding, planting of double row of herbaceous fruits crops across the slope and fruit trees on the contour line, use of drip irrigation system for high value fruit crops and construction of water storage tank (Jalkund) for life saving irrigation have been observed as proven technologies for soil and water management.

Development of horticulture based cropping system

Suitable land use systems such as Agrihorti, Agri-horti-silvi pastoral, mixed horti, pure horti, horti-silvi-patoral and multi-tier horticulture system should be developed based on agroclimate zones, crop priority, topography and socio-economical factors.

Organic farming

It is the production system, which avoids or excludes use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. In general, organic farming system rely upon crop rotation system, crop residues, animal manures, legumes, green manures, off farm organic wastes, mechanical cultivation, minerals bearing rock and aspects of biological pest control to maintain soil productivity and tilth to plant nutrients and to control insects pests and diseases and weeds. In world total area under organic farming is approximate 24 m ha out of which India contribute 20.6 mha only. In 2001,Indian organic fruits and vegetables were exported for an amount of US 11 million dollars. Major horticultural commodities have been put under organic horticulture in India are fresh fruits (Pineapple, cashew nut, passion fruit, banana, mango), fresh vegetables (tomato, Cole crops), processed fruits, juices, processed vegetables, tea, coffee, spices etc.

Traditional organic cultivation

- Agnihotra farming: Growth promoter, insecticide
- Panchagavya: Quality banana production, yield increase in cole crops.
- Cowdung: Insect pests & disease control, seed germination.
- Tobacco leaf extraction: Insect control.
- Neem or karaglate: Soil borne disease control.
- Alder agriculture in Nagaland: Growing of colocassia, pumpkin, chilli.
  Alder agriculture in Sikkim: Large cardamom.
- Intercropping/mixed cropping: Rice + Cucurbits
  Rice+ Banana.A.P.
  Maize+ French bean
- Temperate Horticulture in Sikkim: Apple+ Potato Radish
  Cabbage.
  Mid hill Horticulture in Sikkim; Mandarin+ Ginger+ Sweet potato.
- Contour trench farming in Mizoram: Pineapple planting.

Principle and Practices of Organic Horticulture

Marketing and Economic consideration:

- Protection, volume, size, quality and reliable marketing strategy**.**
- Processing of unsuitable fruits for fresh markets to make up production cost.
- To meet buyers expectation of volume, quality and timing.
- Cost-benefit analysis of markets.

Planning and planting of an organic orchard

- Site selection based on topography, soil type, water filtration rate, frost pattern, maximum and minimum temperature, length of growing season, rainfall pattern, availability of irrigation water, possibility of water table and wind velocity.
- Crops and varieties suited for the region.
- Crops species selection.
- Small size short-term investment: Strawberries, Kiwi, grapes, vegetables, ornamentals.
- Big size long term investment; Apple, peach, orange, papaya, pears, sapota
- Selection of variety: based on ~ early, mid ,late;
  ~ adaptability, chilling requirement
  ~ Water requirement, dwarf, semi dwarf or standard
  ~ resistance to insects pests and diseases.

Procurement of planting materials of organic stock from reputed nurseries a heady certified by inspectors.

Site preparation through

- Adjustment of soil P^H through soil test
- Nutritionally balanced soil with addition of organic matter.
- Well planned sequence of tillage
- Soil solarization by using plastic film on moist soil for 1 to 2 months.

Orchard layout and design

Based on topography, species, stature, maturity time, weed prevalence.

Orchard management through

- Covering cropping using grasses or legumes.
- Crop rotation with annuals or perennials.
- Pest management through IPM.
- Nutrient management through compost mixing with soil using shallow tillage, addition of organic manures like leaf manure, cowdung, vermicompost, biodynamic field sprays, cow pat pit manures, liquid manures, hybrid compost, vermiwash, biofertilizers etc.
- Organic weed management through cover crops, organic mulches (straw, spoiled hay, leaves, wood dust, sugarcane trash etc.), use of geotextiles, sheet mulch, use of weed harrowing, Implements or heel hoe, use of allowed herbicides like vinegar, citric acid in each terraces.
- Water management through drip irrigation, half moon terracing, full moon terracing; planting across the slope, vegetable barriers etc.

Post harvest management starting from washing, grazing, packing and storage should be practiced carefully to prevent contamination.

Organic farming in N.E.Region

North Eastern States where fertilizer consumption is less than 25 kg/yr are suitable for organic farming. The region is rich in biodiversity and blessed with gene centers for citrus, banana, cucumber, brinjal, 3000 numbers of indigenous crop germplasms; 1600 species of orchid, 9 genera of medicinal plants and five genera of aromatic plants. North East States are selected because the land is almost virgin and the crops are virtually organic. The use of inorganic fertilizers and chemicals is meagre in the region. All the households are maintaining livestocks producing sufficient quantities of on-farm manures. The region is receiving very high rainfall leads to production of biomass including weeds, shrubs, and herb which could be efficiently used in organic production. The region has the potential of about 47 mt of organic manure including 37mt from animal excreta and 9 million tons from crop residues. The region is home to some niche crops like Assam lemon, Joha rice, medicinal plants and passion fruits. North Eastern Region (NER) accounts for 45% of total pineapple production in India. Sikkim is the largest producer of large cardamom in the world. NER is the fourth largest producer of oranges in India. Extent of chemical consumption in farming is less than the national average. Besides, eighteen lakh ha of land in NER can be classified as 'Organic by Default'. In January, 2016 , Sikkim has been declared as "First Organic State of India".

Priority Crops	Pineapple (Assam, Meghalaya, Tripura)
	Passion fruit (Mizoram, Nagaland, Manipur, Sikkim)
	Kiwi (Sikkim, Arunachal)
	Apple (Arunachal, Sikkim)
	Orange (Assam, Meghalaya, Sikkim, Arunachal)
	Radish (Meghalaya)
	Ginger (Meghalaya, Mizoram, Sikkim, Nagaland)
	Turmeric (Meghalaya, Assam, Mizoram)
	Large cardamom (Arunachal, Sikkim)
	Potato(A.P.,Meghalaya)
	Colocasia(Assam, Meghalaya)
	Orchid(Sikkim, Arunachal)
	Gladiolus(Meghalaya, Tripura, Nagaland)
	Blackpepper,Arecanut(Assam, Tripura)

EXPERIMENTAL RESULTS

Integrated weed management

Crop	Nutrient requirement	Yield
Cabbage	Poultry manure10t/ha+Panchagavya	460 t/ha
Cauliflower	FYM (20t/ha)	348 t/ha
	Poultry manure (10t/ha)	342 t/ha
	FYM + Panchagavya	333 t/ha
Broccoli	Poultry manure@10t/ha	190 t/ha
	FYM (20t/ha)	182 t/ha

It involves both preventive methods like use of clean seeds, sanitation, clean cultivation, use of well rotten organic manures such as pre-plant and post-plant tillage, soil solarization, crop rotation, adjustment in planting and chemical controls by using glyphosate, diuron, paraquat, 2,4- D, butachlor etc. as well as biological control with parasitoids and insects.

Name of weed	**Biocontrol agent**
Parthenium	Zygograma (beelle)
Chromolena	Cecidochares (Tephritid fly)
Mikania	Puccinia (rust fungi)

Protected cultivation

Protected cultivation practices is defined as a cropping techniques wherein the microclimate surrounding the plant body is controlled partially/fully as per the requirement of plant species during their period of growth. Among protected

cultivation practices, glass/green house/ polyhouse cum net house is common. The green house is generally covered by a glass or plastic which generally reflects back 43% of the net solar radiation incident upon it allowing the transmittance of the " photosynthetically active solar radiation" in the range of 400-700 nm wave length. The sunlight admitted to the green house is absorbed by the crops, floor and other objects which in turn emit long wave thermal radiation in the infrared region for which the glazing materials has lower transparency. As a result the solar energy remains trapped in the greenhouse, thus raises the temperature and this condition of natural rise in greenhouse air temperature is utilized in the cold regions to grow crops successfully.

There are various types of green houses used for growing of horticultural crops.

- Hi-tech greenhouses are constructed to achieve higher degree of climate control: The temperature, humidity and light are automatically controlled. Evaporative cooling devices and heaters are used to maintain temperatures inside. Such types of greenhouses are used for high value vegetable crops like tomato, capsicum, carrot, lettuce, cucumber and flowers like rose, orchids etc.
- Medium cost greenhouses are constructed at the cost half that of climate controlled greenhouse with 15 mm bore GI pipes, only exhaust fans and cooling pads are used for maintaining temperature and humidity during summer. These greenhouses have single layer covering 800 gauge UV stabilized LDPE film and suitable for vegetable cultivation during mild winter and mild summer and for cut flower production.
- Low cost or naturally ventilated greenhouse is a zero energy chamber made of polythene sheet of 700 gauge supported on bamboo, GI pipes or steel pipes without any heating and cooling device. The temperatures within poly house increase by 6-10^{o}C more than out side. Low cost greenhouses are mainly used for the production of cucumber, tomato, off-season muskmelonetc. and cut flower production.

Advantages of greenhouse technology

- To raise crops anywhere in the world any time of the year.
- The crop yields are at the maximum level per unit area, per unit volume and per unit input.
- Production of quality products free from insects, pathogens and chemical residue.
- High value and high quality crops could be grown for export markets.
- Increase of the income from small and marginal land holding maintained by farmers.
- To generate self-employment for the educated rural youth in the farm sector.
- At high altitudes, especially Ladakh, low cost polyhouse is useful to grow vegetables round the year.

Commercial application

High cost greenhouses

- Seed production of high value vegetable crops.
- Vegetative propagation of chrysanthemum, roses, carnations, gladiolus etc.
- Quality cut flower production of rose, carnation, lily, chrysanthemum, and gerbera.

Medium cost green houses

Vegetable forcing like growing of tomato, capsicum, brinjal, chilli during cold winter months.

- Raising of off season nurseries of cucurbits and solanaceous vegetable crops for crops in spring-summer.
- Maintenance of propagating materials of asparagus, sweet potato and pointed gourd.
- Raising potted plants and seedlings plants in the nursery.

Low cost green houses

- In NEH region, low cost green houses of bamboo frame structure are useful for off-season cultivation of vegetable crops.
- In temperative region, low cost green houses are useful to grow vegetables round the year.

Integrated pest and Disease management

IPM is a broad ecological pest control approach consisting of all types of. pest control measures such as cultural, mechanical, biological and chemical methods to keep the pest population below economic thresh hold level. It is an economically justified and sustainable system of crop production that leads to a maximum productivity with the least adverse impact on the total environment. In Horticulture, IPM packages are available in Potato, onion, tomato, cruciferous vegetables, leguminous vegetables, cucurbitaceous vegetables, brinjal, okra, and chilli/capsicum.

Approaches

Cultural control

- Deep summer ploughing exposes and destruct soil borne pathogens, insects and weeds.
- Crop rotation alters the environment both above and below ground to break the availability of plant hosts for disease causing organisms.
- Intercropping of various combination helps in harbouring the parasites and predators in the field.
- Mixed cropping helps in harbouring honeybees for making easy for cross pollination
- Strip cropping help to disguise the crop from pests.
- Sanitation for removing and destroying breeding sites of the pest as well as preventing from anew pest establishing on the farm.

Mechanical and physical control

- Flooding, heat or steam sterilization of soil.
- Use of insect screens to control aphids, thrips, mites and other pests.
- Use of multi-row vacuum machines.

Chemical control

- Use of chlorinated insecticides like dermet, dichlorovos for soil borne insects.

- Use of contact insecticides for sucking insects
- Use of systemic insecticides for chewing type insects

Botanicals

They are simply pured plant leaves, extract of plant parts or chemicals purified from plants. Pyrethrum, neem formulation and rotenone are examples of botanicals. Traditional botanical pesticides like leaves of Jatropha, Pangania, Tubi, Bael, Karanj and castor are also used. Besides, sprays of cow silica and Bio dynamic pesticides through fermentation of cow dung, cow urine, neem, panjamia, calotropis, castor or nettle leaves along with B.D. have shown very effective against pests and diseases.

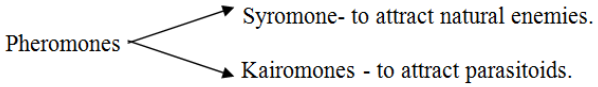
Bio pesticides

Bio pesticides are the products derived from biological resources and emerging as new crop protection strategy. These are classified into three broad categories.

- Biochemical pesticides (Neem,pheromones)
- Microbial pesticides (bacteria,fungi,virus)
- Biocontrol agents.

Biochemical pesticides (Neem based)

- Azadirachtin
- NeemagonNeem based
- Neematex
- Neemagold



Microbial pesticides

Fungi	Beacebassiana-	To control lepidopteran pests
	Aspergilluscandidus -	To control bark eating caterpillar
	Verticilliumlecanii-	To control scale and white fly
	Trichoderma spp.-	Soil antagonist
Bacteria	*Bacillus thuringiensis*-	To control lepidopteran pests
Virus	Nucleopolyhedro virus-	Fruit borer of tomato Spodopteralitura of cole crops
	Baculo virus-	Rhincerosbettle
Nematode	Biovector(commercial)-	To control citrus root weevil

Hi-Tech post harvesting handling of fresh horticultural produce and processing for value addition

A considerable amount fruits and vegetables produced in India is lost due to improper post- harvest operations. To achieve our target to feed the population as well as meeting the requirements of the processing industry and export trade, only increasing production is not enough, rather we shall have to adopt advanced technologies in the sector of post-production management of highly perishable horticultural produce.

Establishment of packing station: Farmers, cooperatives and other private agencies should be encouraged to establish packing stations at nodal points to carry out post- harvest operations like washing, sorting, grading, fungicidal dip, surface coating, degreening, ripening, conditioning, vapour heat treatment and packing.

Vapour heat treatment: (VHT) VHT is popular in mango to control oriental fruit fly. It helps in ripening and uniform colour development of fruits. In VHT machine, heated air at 95% RH is circulated through crates of freshly harvested fruits.

Food irradition: Gamma irradition enhances keeping quality of fresh produce by inhibition of sprouting and dessication in case of vegetables like potato (100Gy), onion (60-90Gy) and delay in ripening and senescence and reduction in fungal decay.

Prepackaging: It means packaging the produce in consumer size packs which reduces the transportation cost and increases shelflife, reduces the shopping time of the consumers. Experimental evidences have shown that shrink crop packaging of individual, grape fruit, oranges, mandarins, tomato, brinjal, and capsicum with 10μm high-density polyethylene film increases the storage life over unpackaging. Polymeric film or Hm film delays ripening and increases shelf life of fresh fruits and vegetables during transportation.

Packaging: Packaging provides the essential link between producers and consumers through marketing of fresh horticultural produce. Various types of Packaging materials are commonly used in bamboo baskets, gunny bags, wooden boxes and plastic crates. Recently, a ventilated Corrugated Fibre Board (CFB) box has been developed with ventilated partition for packaging and transportation in mango, keno, apple, peach etc.

Palletization: Post harvest losses of produce can be reduced by using pallets. All the subsequent handling operations become very easy once the boxes are placed on the pallets. It is also important to introduce mechanical loading and unloading with use of forklift trucks while handling pallets.

Precooling: It is the process of removal of field heat from commodities and practiced before packaging or storage or transportation. It is done through room cooling, hydro cooling, package icing and vaccum precooling. Precooling is essential in the post harvest handling of grapes. Precooling of mangoes at 12-15^{o}C with 500ppm bavistin increases shelf life and reduces spongy tissue, by reducing respiration and delay in ripening. Low cost evaporative cool chamber can be used for pre cooling of citrus fruits.

Storage: The low cost, environment friendly cool chamber developed by IARI, New Delhi can solve storage problem of horticultural crops, where electrical availability is not proper. Cotrolled/modified atmospheric storage increases post -harvest life of produce at reduced oxygen level and elevated CO_2 concentrations through retardation of ripening, senescence and chilling injuries. A gas blending system has been designed and fabricated at IARI for generation of CA condition for post-harvest treatment of horticultural produce. By modified atmosphere and packaging and storage, mangoes can be stored up to 6 to7 weeks.

Containerization: Introduction of refrigerated containers as well as controlled/modified atmosphere containers are useful for shipment of fruits, vegetables and flowers. In India, low cost containers can be designed and fabricated to suit our requirement with introduction of ventillation and evaporative cooling.

Cold /Cool chain: Maintenance of low temperature of various stages of handling through cold chain reduces losses and retains the quality of produce. In our country, the development of cool chain by adopting the principle of evaporative cooling and other non -conventional methods of cooling.

Hi-Tech. value added products of Horticultural crops: Value added process products, especially fruits and vegetables improve national economy by reducing post harvest losses at one end and on the other end, provide quality nourishment to millions of consumers at affordable costs. Present day processed value added innovative horticultural products include pre-cut minimally processed vegetables, fruit juice concentrates, semi concentrates, improved dehydrated fruits and vegetables, freeze dried fruits and vegetables, IM (Intermediate mixture) and Ht fruits and vegetables.

Minimally processed fruits and vegetables: In this method the trimmed, peeled, cut pieces and shreds of fruits and vegetables are non thermally treated by dipping them in the solution of Potassium metabisulphate (0.01-0.09%), Sodium benzoate (0.03-0.08%), Citric acid (0.5-1.2%), Ascorbic acid (200-300ppm) and salt (3-6%) at 20-25^{o}C for few hours or at 5±1^{o}C for several hours. Soaked products are drained and surface moisture is removed in a basket centrifuge operating at1000 rpm. The product is subsequently exposed to ultraviolet light for 10 minutes in a clean room, packed in flexi polymeric sachets and stored at 5±1^{o}C.Sweet potato, yam, raw papaya raw mango, bottle gourd, ridge gourd, cabbage, carrot and mango could be stored up to 40-60 days, while cow pea seed, bitter gourd showed keeping quality up to20-25 days at the same temperature. Ionizing radiations used at 1-5 Kr is used to check food borne pathogens in precut fruits, vegetables and juices.

Fruit juice concentrates: Fruit juice are processed into concentrates or pulps by using unit operation like vacuum evaporation, freeze concentration and membrane processing techniques like osmosis, reverse osmosis and ultra filtration. Fruit juice concentrates can be used as semi finished intermediate products for production of fruit juices, beverages and fruit juice powders. Generally fruit juices are concentrated into 4 folds, 6 folds or 8 folds fruit juice concentrate in the trade increasing solid concentrate 35-75% in the final products. Fruit juice concentrates in the of21-27oB are available in orange, pineapple, mango, guava, pomegranate, tomato, carrot and watermelon.

Improved dehydrated fruits and vegetables: In this method, vegetables like cauliflower (blanched), are treated with 3% salt and 6% sucrose for 12-16 hour at 4^{o}c to reduce shrinking and to improve rehydration with afficling palatability and keeping quality. In another way, soak treatment of vegetables in 20% sucrose for 1 hour followed by4% salt for one hour along improves colour developments. Blanched precooked carrots treated with 14% sucrose and 1% salt at 40^{o}C followed by overnight freezing at –20^{o}C matrix fracturing and FB dehydration at 60^{o}C to a moisture content of 8% improves rehydration.

Freeze-dehydrated fruits and vegetables: Freeze-dehydration consists of two processes freezing and drying. In the former case, products are frozen to temperature of –10^{o}C to 40^{o}C and then moisture is removed from the frozen solid matrix under high degree of vacuum at a relatively low temperature (40-60^{o}C) without melting. Fruits and vegetables containing 85-95% moisture can be freeze dried into puree or pulp with 24to30 h. to a final moisture content of 2 %. Usually polymeric films with aluminium foil resistant to oxygen, water and light ingress are suitable for packaging freeze- dehydrated fruits and vegetables. Mango, pineapple, citrus, apple, banana, papaya, guava, plum, tomato, watermelon and avocado are suitable for successful freeze dehydration. Besides, freeze dried ready to constitute beverage mixes of pineapple, mango and mousambi; puree forms of vegetables and mushroom soup powders are also popular.

IM fruits and vegetables: Moist infusion of fresh fruits and vegetables in a soak solution containing ingredients such as glycerol, sucrose, salt, potassium sorbate (antimycotic), potassium/sodium metabisulphite, dextrose, pectin ampled with or without partial dehydration is attributed to IM technology in obtaining shelf-stable products through osmotic process. A number of IM fruit slices(guava, pineapple, mango, banana, jack fruit, apple and sapota) and IM fruit bars (based on fruits with soft gel like texture like mango, banana, guava, papaya, jamun, pineapple, jack fruit and apple) have been developed with final moisture contents of 30-40% and 12-13.5% and water activities of 0.70-.080 and 0.58-0.68 respectively. IM carrot slices and cauliflower florets with moisture content of 47-49 and 0.80-0.83% having fresh cooked appearance have also been developed. The IM products have a minimum shelf life of 6 moths under ambient conditions when packed in paper aluminium foil-polyethylene laminated pouches.

HT stabilized fruits and vegetables: Hurdle technology (HT) stabilization is a combined approach of processing techniques such as freezing, refrigeration, dehydration, irradiation, pulse electric fields, high pressure processing, ultra sonication, use of chemical preservatives, P^{H} and air control are used in unison in a synergistic fusion to bring about desired microbial safety. Heat lethality, process temperature, chill temperature, P^{H}, acidity, radiation dose, redox potential, preservation, micro flora and storage temperature are considered as Hurdle factors. Usually two or more of the hurdles are used in combination to effect hurdle stabilization. The HT stabilization provides an avenue for preserving surplus and seasonal fruits and vegetables with value addition and commercial exploitation at cottage, small, medium and large scale. The products have long shelf life and can be stored in flexi-polymeric packs without refrigeration.

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