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Hi-tech Horticulture : Pros and Cons

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Abstract

Horticulture is an integral part of food and nutritional security. It is an essential component of economic security of the stakeholder. Hi-tech horticulture is a technology which is modern, less environment-dependent and capital-intensive but with a capacity to improve productivity and farmers' income. In the new era of changing climate, hi-tech horticulture has become necessity so as to sustain productivity and economic stability of the Indian farmers. Hi-tech horticulture is useful not only for production of fruits, vegetables and flowers but also for conservation, plant protection, post-harvest management including value-addition. The present article reviews various aspects of hi-tech horticulture hinting future prospects.

Key words : Hi-tech, horticulture, fruits, vegetables, flowers, post-harvest management

Introduction

Agriculture and allied sectors contributed 18% of the India's gross domestic product (GDP) in the year 2014-15 (Anonymous, 2017). A large proportion of this contribution comes from the horticulture sub-sector. Fruits and vegetables constitute the second largest category among agricultural crops in terms of gross value of output (GVO) with 25% contribution in 2014-15 (**Table 1**). It is second only to the cereals but has recorded a steady increase over 2011-12 (**Figure 1**). On the contrary, cereals have recorded a decline in GVO (Anonymous, 2017). Thus, horticulture under which fruits and vegetables are counted has been consistently emerging as a mainstay of Indian economy. And rightly the budget outlay for horticulture increased to 4.6% in the XII Five Year Plan to support this encouraging sector (Anonymous, 2016).

As per the United Nations' estimates, the world population will grow to 9.7 billion by the year 2050. Of this, as per different estimates, India will host nearly 1.6 to 2 billion (Ghosh, 2012). The demand for horticultural produce is expected to rise at an annual rate in excess of 3% (Chand, 2008; Ghosh, 2012). On the contrary, the year-on growth in production of horticultural crops is dwindling from a peak of 7.8% in 2010-11 to 2.1% in 2015-16 (**Table 2**, **Figure 2**). These trends, if not checked, will create a big gap in the demand and supply of horticultural crops. The only solution to such a situation

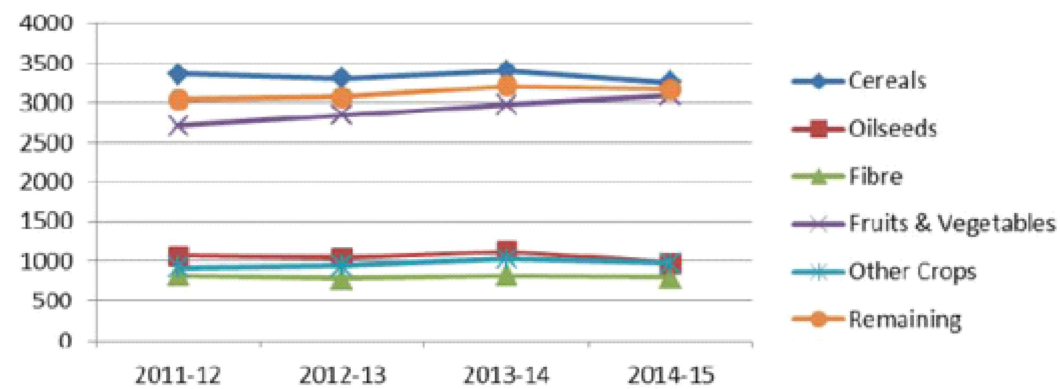

Figure 1. Trends in gross value of output (GVO, ' '00 crore) of major subsectors at constant prices. Of the two top sectors, fruits and vegetables have shown steady increase
Source: Anonymous (2017)

Table 1. Gross Value of Output (GVO) of major subsectors of agriculture at constant prices

Item	Gross value of output at constant prices (Rs. '00 crore)			
	2011-12	2012-13	2013-14	2014-15
Cereals	3364	3305	3400	3260
Oilseeds	1067	1041	1124	973
Fiber crops	819	780	825	802
Fruits and vegetables	2705	2840	2983	3098
Other crops	915	945	1029	973
Remaining	3045	3075	3210	3172

Source: Anonymous (2017)

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Table 2. **Growth trends of area and production of horticultural crops, 1991-92 to 2015-16 (values in per cent)**

Crops	2010-11 over 2009-10		2011-12 over 2010-11		2012-13 over 2011-12		2013-14 over 2012-13		2014-15 over 2013-14		2015-16 over 2014-15	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
Fruits	-1.4	4.4	5.0	2.1	4.1	6.4	3.4	9.5	-11.9	-0.2	-0.9	1.5
Vegetables	6.4	9.6	5.8	6.7	2.4	3.7	2.1	0.4	1.5	3.3	5.5	0.4
Flowers	4.4	1.0	33.0	60.2	-8.3	4.7	9.5	1.5	24.4	0.4	10.5	-0.8
Aromatics	0.2	5.6	-0.8	-6.4	10.1	62.2	-11.4	-2.5	1.2	3.4	10.5	-0.8
Plantation crops	1.3	0.7	8.2	36.2	1.8	3.8	0.9	-4.0	-3.7	5.1	3.8	-2.8
Spices	19.3	33.2	9.3	11.2	-4.2	-3.5	2.8	2.9	0.0	0.0	8.9	15.4
Total horticultural crops	4.5	7.8	6.5	7.0	1.9	4.5	2.1	3.2	-3.2	2.2	7.9	2.1

Source: Anonymous. (2016)

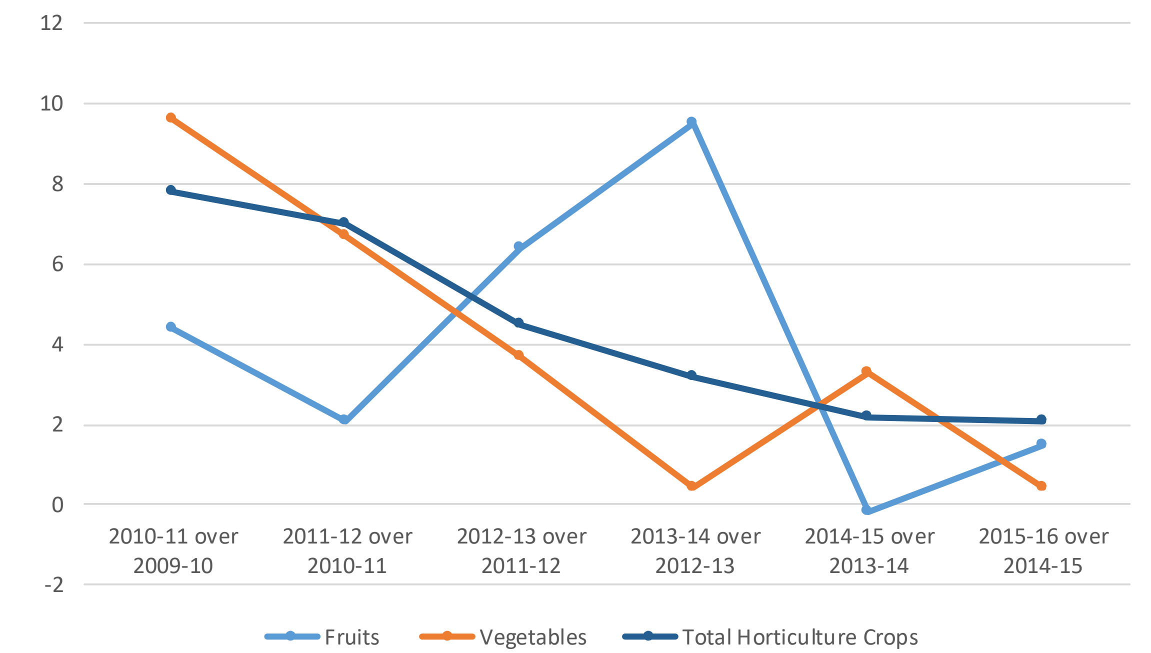

Figure 2. The trends in year-on growth in production of horticultural crops in India. Despite different crop categories reaching peaks during this period (see Table 1), the trend in total horticultural crop production is declining

Source : Anonymous (2016)

will be adoption of hi-tech horticulture as forecasted in a NAAS policy paper (Chadha, 2001) and subsequently in the report of working group on horticulture, plantation crops and organic farming for the XI Five Year Plan (Planning Commission, 2007).

The present scenario of horticulture sector in India is encouraging. And although annual growth in production has dampened in recent years, the production itself has witnessed tremendous increase in the past two decades (**Table 3**). Even the productivity has increased substantially although not to the desirable extent (Anonymous, 2016). In 2015-16, horticultural crops were grown on an area of 23.79 million hectares (Mha) with the production showing 283.36 million tonnes (Mt) (**Table 4**).

Hi-tech Horticulture in India

In the recent era, horticulture is not merely a means of diversification but forms an integral part of food and nutritional security and is also an essential element of economic security. Adoption of horticulture has brought prosperity in many states *viz.*, Maharashtra, Karnataka, Andhra Pradesh and Kerala (Singh, 2014). Judging by the burgeoning increase in population, there is a great pressure on natural resources added with global warming and climate change, decreasing land holdings, and high demand of quality horticultural fresh produce. Situation demands a shift towards modern technologies of crop production in which hi-tech horticulture has already taken a lead.

Term hi-tech horticulture refers to the precise production techniques for efficient use of inputs at the appropriate time and quantity for maximization of yield and quality in different horticultural crops. It is an adoption of any technology

Table 3. Decadal growth (%) in area and production of horticultural crops in India				
Crops	2001-02 over 1991-92		2010-11 over 2001-02	
	Area	Production	Area	Production
Fruits	28.3	33.4	37.1	42.5
Vegetables	9.1	33.9	27.5	39.5
Flowers	-	-	44.5	48.1
Aromatics	-	-	44.5	48.1
Plantation crops	23.1	22.6	9.7	19.2
Spices	37.7	22.9	9.5	29.6
Total horticultural crops	24.55	28.2	28.8	37.8

Source: Anonymous (2016)

Table 4. Area and production of horticultural crops in India in 2015-16

Crops	Area (Mha)	Production (Mt)
Fruits	6.405	91.443
Vegetables	9.575	166.608
Flowers and aromatics	0.860	3.392
Plantation crops	3.683	15.477
Spices	3.264	6.350
Total horticultural crops	23.787	283.360

Source: Anonymous (2016)

which is modern, less environment-dependent, capital-intensive and has the capacity to improve productivity and quality of horticultural crops (Chadha, 2001). Hi-tech horticulture has also been defined as a modern environment-friendly, acceptable, intensive technique to capacitate farmers for obtaining high productivity and quality products to fetch more money. It is a chain system of culturing fruits, flowers, vegetables and spices with a proper linkage from selection of seed/variety to the finished product through the process of modern technique of crop production through post-harvest management techniques. Hi-tech horticulture has overcome a barrier of agro-climates making most of the vegetables and other horticultural products available to the consumers in all calendar months although at a premium price.

The technologies encapsulated in hi-tech horticulture include use of genetically modified (GM) crop varieties derived from bio-technology and genetic engineering, micro-propagation, integrated nutrient, water, weed and pest management, protected cultivation, organic farming, use of modern immuno-diagnostic techniques for quick detection of viral diseases, post-harvest technologies, including cold chain (Chadha, 2001).

Hi-tech Germplasm Conservation

India is a rich region for extant diversity of horticultural crops owing to it being one among eight Vavilovian Centers of crop plants origin (NBAP, 2008). This diversity exhibits preponderance of variable land races or primitive types belonging to different crops including horticultural crops. Around 80 species of major and minor vegetables, apart from several wild/gathered kinds occur in India (Peter and Abraham, 2007; Sheshadri, 1987).

The need for intensification of collection and conservation activities in horticultural crops has been highlighted in the past. However, when we follow it traditionally, it involves lot of space which is a constraint. Hi-tech technology-intensive methods like *in vitro* conservation and cryo-preservation would help conserve genetic diversity for indigenous plants. In fact, of the total 4.3 lakh collections held in the National Gene Bank (NGB) less than 10% constitute those of horticultural crops (NBPGR, 2017). A low cost and highly beneficial conservation technology like ultra-dry storage needs to be harnessed for improving the scenario (Ashok et al., 2017). For example, zeolite-based desiccants were found to be very effective for ultra-dry storage of tomato seeds. Cryo-preservation has a great potential which is unutilized for horticultural plants. Protocols are being developed for cryo-preservation of pollen and vegetatively-derived explants of horticultural crops (Benelli, 2013).

Hi-tech Cultivars of Horticultural Crops

Conventional breeding in horticultural crops especially fruit-tree and plantation crops is difficult and time-consuming. Molecular approaches can be used for reducing the time-lag and inducing favourable traits in the varieties. There is great scope for somaclonal varietal development in horticultural crops. Somaclonal variation provides a new and alternative tool to the breeders for obtaining genetic variability relatively rapidly and without any sophisticated technology in the horticultural crops (Krishna et al., 2016). Gene-editing is an emerging area which can be explored. Traits which need to be focused include dwarfing, herbicide resistance, pest resistance, long shelf-life, and improved nutritional quality.

Hi-tech Propagation

Availability of quality planting material is the basic need for expansion of truthful horticulture industry. However, unorganized sector is the source of more than 60% planting material. Further, most of the nurseries in production of horticulture planting material are engaged in ornamental plant production and are concentrated in the vicinity of towns and cities. As per the star-rating programme of the National Horticulture Board (NHB), of the 689 nurseries rated none was 5-star rated and only 25 were 4-star rated (www.nhb.gov.in/nursery). This reflects on poor status of adoption of modern technology by the horticultural nurseries.

Micro-propagation is an important tool for quick production of large number of plants. It is already being exploited in crops like banana (*Musa* spp.), bell capsicum (*Capsicum annum*), tomato (*Solanum lycopersicum*), chilli (*C. annum*) and several ornamental plants. There is an enormous scope for micro-propagation of crops especially ornamental crops in India. The protocols, therefore, need to be further refined for higher efficiency (Chadha, 2001; Sahiijram and Rao, 2017).

The plug-plant propagation of horticultural crops is taking roots in India, for example, on a large scale in Chhattisgarh where it is working. Plug-plant propagation is advantageous for production of healthy, virus-free seedlings which reduce pre-bearing period, provide uniform crop growth and facilitate harvest. Among various crops vegetables [tomato, chilli, brinjal (*Solanum melongena*), bell capsicum, cole crops (*Brassicaceae*), cucurbits (*Cucurbitaceae*), beet root (*Beta vulgaris*), lettuce (*Lactuca sativa*), parsley (*Petroselinum crispum*), celery (*Apium graveolens*) and onion (*Allium cepa*)], fruits [papaya (*Carica papaya*), strawberry (*Fragaria ananassa*), tree tomato (*Solanum betaceum*) and raspberry (*Rubus idaeus*)], flowers [rose (*Rosa* spp.), gerbera (*Gerbera jamesonii*), chrysanthemum (*Chrysanthemum* spp.), carnation (*Dianthus caryophyllus*), dahlias (*Dahlia* spp.) and orchids (*Orchidaceae*)], and medicinal plants [stevia (*Stevia rebaudiana*), aloe (*Aloe vera*)] are suitable for plug plant production (Chadha et al., 2017).

Table 5. Nutrient removal by different horticultural crops

Crop	Yield (t ha^{-1})	Uptake (kg ha^{-1})		
		N	P_2O_5	K_2O
Banana	40	250	60	1000
Citrus	30	270	60	350
Grapes	20	170	60	220
Mango	15	100	25	110
Papaya	50	90	25	130
Pineapple	50	185	55	350
Passion fruit	15	60	15	75
Apple	25	100	45	180

Source: Ganeshamurthy et al. (2011)

The development and standardization of grafting in fruit crops namely mango, guava and grapes have revolutionized the planting and production scenario in India. Hi-tech techniques are useful for grafting. Computer-aided commercial grafting is available in Japan for mass production of certain plants (Chadha, 2001). Such machines may be developed indigenously. Presently the foot-operated grafting machines are used in India. Grafting in vegetable crops especially in watermelon (*Citrullus lanatus*), capsicum and brinjal is a newly emerging new hi-tech method. In states, like Chhattisgarh, large scale vegetable grafts are produced.

Nutrient Management in Hi-tech Horticulture

Hi-tech horticulture relies heavily on judicious application of irrigation and nutrients to horticultural crops. Adoption of drip irrigation has resulted in high yields and better quality in fruits (banana, grape, papaya, pomegranate, mandarin, coconut, arecanut and cashew), vegetables (cabbage, cauliflower, tomato, gherkin, baby-corn), cut-flowers (rose, carnation and gerbera), and plantation crops (tea, coffee and rubber). Fertiliser schedules and leaf nutrient guides have been developed for several horticultural crops (Planning Commission, 2007). However, with advancement in biotechnology, planting practices and novel fertiliser application techniques, it is necessary to revisit the recommended doses and schedules. The concepts of site-specific, orchard-specific, tree-specific and phenophase-specific application of nutrients are taking roots in scientific discourse.

Enhancing Nutrient Use Efficiency (NUE)

Fruit crops are highly nutrient-exhaustive due to their perennial nature, and since these act as major sinks of absorbed nutrients (Srivastava and Shirgure, 2017). Fruit crops can remove 500-1000 kg N+P+K ha^{-1} year^{-1} which needs replenishment with better management practices (Tandon, 1991; Ganeshamurthy et al. 2011) (**Table 5**). As a corollary, nutrient removal under hi-tech horticulture of fruits may be higher.

High density planting (HDP) increases the plant population per unit area. It increases the yield of fruit crops considerably. At the same time, it increases the amount of nutrients removed from soil. To compensate for these losses, it is necessary to increase the per hectare doses of fertilisers (Haldankar et al., 2013; Reddy, 2004). Typical cases in mango and guava are shown in **Table 6**. Similar findings have been recorded in banana (Naik et al., 2016).

As a result, HDP is always recommended with fertigation. Fertigation with drip irrigation results into 30-50% water saving. It also maintains salt concentration. Moreover, it helps in maintaining higher yield levels. For example, in banana, HDP and

Table 6. Comparison of traditional and hi-tech horticulture (High density planting) for yield and nutrient management					
Spacing	Plant population ha^{-1}	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Yield (t ha^{-1})
Mango					
Regular 10 m x 10 m	100	150	50	100	5
HDP 5 m x 5 m	400	600	200	400	15
Guava					
Regular 8m x 8 m	156	93	46	46	15
HDP 6m x 2 m	833	299	149	149	47

Source: Haldankar et al. (2013); Reddy (2004)

Table 7. Effect of fertigation method on vegetative growth of newly planted pomegranate

Treatment	RGR of shoot (%)	Average plant spread (m)	Plant height (m)	Leaf area (cm^2)
100% RDF + HW	7.5 (16)	1.5	1.5	54
100% RDF + DI	11.9 (20)	1.6	1.8	57

RDF: Recommended dose of fertilisers (100:250:500 g N:P:K plant^{-1})
HW: Hand watering
DI: Drip irrigation
RGR: Relative growth rate
Source : Dhakar et al. (2013)

Table 8. Fertigation technology and schedule under high density planting (HDP) in mango (%)

Nutrient	Stage of application				
	Immediately after harvest (2 months)	Preflowering (2 months)	Flowering to fruit set (2 months)	Fruit development (4 months)	Total
N	25	40	20	15	100
P	50	30	20	-	100
K	25	20	30	30	100

Recommendation: 1.0:0.5:1.0 kg of NPK/ bearing tree/year through drip fertigation
Source: TNAU (2013)

fertigation in combination resulted into higher yields (Badgujar et al., 2004; Reddy et al., 2004; Naik et al. 2016). Similarly, Dhakar et al. (2013) found that, in pomegranate, recommended doses of fertilisers showed superior performance when applied through drip irrigation compared with conventional irrigation (**Table 7**). Keeping this in mind, scheduling of fertiliser doses needs to be provided through drip irrigation (TNAU, 2013) (**Table 8**).

Hi-tech Production

Protected cultivation of horticultural crops is the ultimate form of hi-tech horticulture in India for today. In most of the states in India protected cultivation of horticultural crops is common. Among the various protected structures, fully-automatic polyhouses help for cultivation even under unfavourable climatic conditions. However, they are costly and economically viable only in limited parts of India. The cost-effective structures such as net houses and low poly-tunnels are popular and are rapidly increasing in proportion.

Although initial costs are high, ultimately the high value fetched by high-quality produce brings much higher income to the farmers. A comparative statement worked out by TNAU justifies this amply (**Table 9**). In frequent climatic aberrations these are useful for obtaining appropriate yields with better quality. Protected cultivation provides scope for less soil-dependent cultivation. The use of coco-peat and vermin-compost helps not only to increase yield but also to reduce soil-borne diseases. Presently the protected cultivation for horticultural crops in India is commercially practiced for plant propagation and commercial cultivation.

Fruits

In India, fruit crops are conventionally grown and the production potential of such cultivation is far below the potential which can be enhanced through hi-tech approaches. These methods involve high density planting, soil and leaf-analysis-based integrated nutrient management, micro-irrigation, fertigation, proper integrated pest, disease and weed management, appropriate mechanization and essential innovations such as pre-harvest bagging and use of growth regulators. In India hi-tech technology has transformed the scenario of fruit crops like banana, pineapple (*Ananas comosus*) and grapes (*Vitis vinifera*) (**Figure 2**).

One of the foremost technologies for fruit orchards is high density planting (HDP). By the end of Tenth Five Year Plan, the HDP technology was successfully tried in banana, apple, papaya, mango, guava and citrus (Planning Commission, 2007). Aonla and sapota can also be added to this list (Chadha et al., 2017).

High density planting has a potential to increase yields and reduce cost of production of several horticultural crops. It has already been exploited successfully in kinnow, orange (*Citrus sinensis*), pineapple, banana and to some extent in apple (*Malus pumila*) and mango (*Mangifera indica*) (Dalvi et al., 2010). There are several ways of achieving this objective such as selection of dwarf cultivars and scions, use of dwarfing rootstocks/interstocks, pruning and growth regulators for canopy management (Haldankar et al., 2013), (**Figure 3**). Constraints in HDP are poor availability of dwarf varieties planting material, lack of standardized technology, higher initial establishment cost, professional and scientific competency, and intensive management to avoid negative effects of high density (Goswami, 2014).

Vegetables

It includes not only protected cultivation of vegetables under greenhouse, net house or poly house but also includes use of precision farming technology *viz.* integrated nutrient management (INM), fertigation and mulching. Hi-tech cultivation of vegetables offers distinct advantages of quality, productivity and favourable market price to the growers. High-valued vegetables such as capsicum, cherry tomato and tomato are often cultivated in either polyhouses or net houses. For summer cultivation of vegetables, net houses are preferred which not only improve yield and quality of produce but also save considerable amount of water (Chadha, 2001).

Vegetable growers can increase

Table 9. Comparative statement of cost, yield and net income from horticultural crops grown conventionally and using hi-tech practices.

S.No	Crops	Cost of cultivation (‘Rs.ha^{-1})		Yield (t ha^{-1})		Percent yield increase over conventional system	Net income (Rs. ha^{-1}) (at the lowest price)		
		Conventional	Hi-tech	Conventional	Hi-tech		Conventional	Hi-tech	Market price range (Rs. kg^{-1})
1.	Tomato	61000	99800	50	150	200.00	39000	275200	2-30
2.	Chilli	46000	68000	22	35	59.09	64000	142000	5-15
3.	Paprika	49000	72000	37	60	62.16	136000	288000	5-20
4.	Capsicum	49000	72000	18	25	39.00	95000	153000	8-25
5.	Brinjal	50000	82000	60	150	150.00	70000	293000	2-30
6.	Bhendi	40600	62000	10	16	60.00	19400	50000	2-30
7.	Cabbage	51500	78000	75	110	46.00	173500	252000	6-15
8.	Cauliflower	51500	78000	32000 flowers	44444 flowers	38.89	108500	1442000	3-10
9.	Tapioca	30000	49000	30	45	50.00	54000	140000	2.8-5
10.	Water melon	50000	72000	40	60	50.00	50000	108000	2.5-10
11.	Musk melon	56000	76000	22	34	55.00	54000	128000	5-25
12.	Ribbed gourd	42000	74000	20	30	50.00	38000	76000	4-15
13.	Bottle gourd	42000	74000	40	66	65.00	78000	157000	3-15
14.	Gherkins	48000	72000	20	35	42.86	72000	208000	6-12
15.	Turmeric	45000	70000	5	8	37.50	55000	90000	20-40
16.	Coriander	32000	48000	87000 bundles	125000 bundles	43.68	55000	77000	1-2/bundle
17.	Banana	56000.00	115000.00	75	110	46.67	319000	655000	5-12
18.	Chrysanthemum	55000	78000	20	25	25.00	245000	297000	15-25
19.	Golden rod	77000	97200	15000 bunches	25000 bunches	66.67	73000	177800	10-14/bunch

Source : Directorate of Extension Education, Tamil Nadu Agricultural University, Coimbatore.222. www.agritech.tnau.ac.in their income substantially by protected cultivation of vegetables during off-season by using a variety of structures ranging from simple shade-nets to hi-tech automated polyhouses (Rai, 2012). Protected cultivation with precision farming is the foremost hi-tech approach in vegetable cultivation. At high altitudes, especially in Ladakh, polyhouses with low-cost technology have been employed successfully to grow vegetables round the year in spite of adverse climate (Mishra et al., 2010). However, the demand is for low-cost indigenous materials for constructing affordable structures. Off-season cultivation of cucurbits under low plastic tunnels is one of the most profitable technologies in North India. Walk-in-tunnels are suitable and effective to raise off-season nursery and vegetable cultivation. Insect-proof net houses are used for virus-free cultivation of tomato, chilli and capsicum. Polytrenches have proved extremely useful for growing vegetables under cold desert condition in upper reaches of the Himalayas of India (Singh, 2012). Exotic vegetable cultivation, hydroponics, aeroponics (soil-less cultivation), terrace gardening, use of plastic low tunnels, walk-in-tunnels, vertical gardening technologies for production of leafy vegetables in protected structure, aquaponics (production of fish and

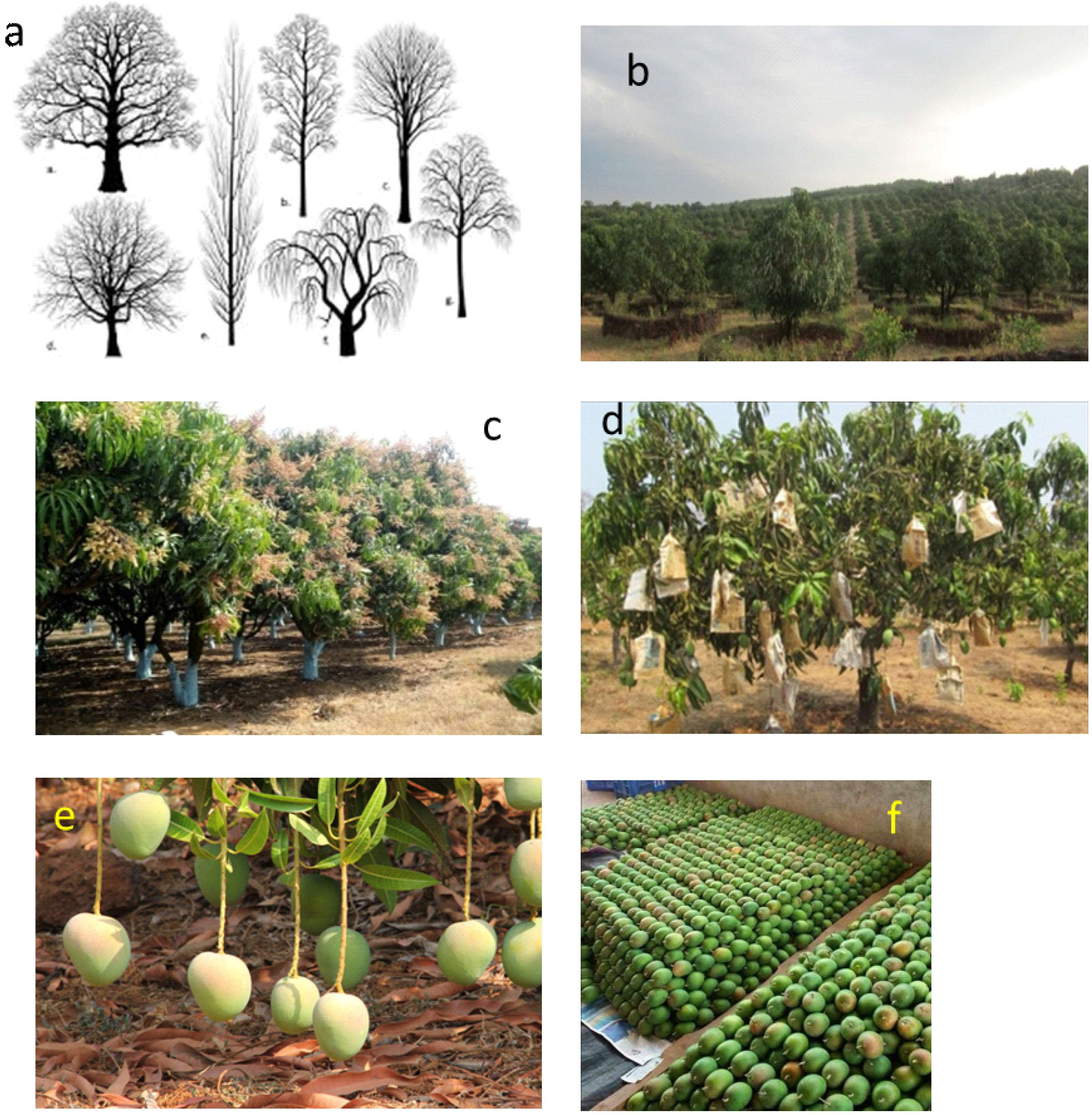

Figure 3. High density planting (HDP) as a component of hi-tech horticulture. a) Canopy architecture in fruit crops suitable for HDP (Source: www.fruitsandnuteducation.ucdavis.edu), **b) High density planting orchard** (**Source**: DBSKKV, Dapoli, personal communication), **c) Flowering in high density planting orchard** (**Source**: DBSKKV, Dapoli, personal communication) **,** **d) Pre-harvest Bagging** (**Source**: DBSKKV, Dapoli, personal communication), **e) Bearing of mango fruits** (**Source**: DBSKKV, Dapoli, personal communication)**, f) Graded mango fruits** (**Source**: www.indiamart.com)

Figure 4. Cultivation of vegetables using hi-tech methods. a) hi-tech vegetable seedling in production (**Source**: www.kvknashik.com)**, b) vegetable cultivation in polyhouse** (**Source:** DBSKKV, Dapoli, personal communication)**, c) capsicum as an important hi-tech vegetable** (**Source**: DBSKKV, Dapoli, personal communication)**, d) staking in vegetables** (**Source**: DBSKKV, Dapoli, personal communication)**, e) bearing of capsicum** (**Source**: www.israel21c.org)**, and f) packing in corrugated fibreboard boxes (CFB)** (**Source**: www.agric.wa.gov.au)

vegetables together) are the futuristic innovative ventures in hi-tech vegetable production (**Figure 4**).

Flowers

The commercial floriculture has emerged as hi-tech activity under controlled climatic conditions inside greenhouse, net house and/ or polyhouse. Floriculture in India is being viewed as a high growth industry (Mohan, 2016). Commercial floriculture is becoming important since it has a tremendous export opportunity to earn foreign exchange. India exported 22,086 MT of floricultural products to the world which corresponds to Rs. 548.74 crore (~ 82 million US$) in 2016-17 (www.apeda.gov.in). Floricultural products consist of cut flowers, pot plants, foliage plants, seeds, bulbs, tubers, rooted cuttings and dried flowers or leaves. The important floricultural crops in the international cut flower trade are rose, carnation, chrysanthemum,

Figure 5. Cyclic steps of production of cut flowers as component of hi-tech horticulture. a) polyhouse structure (**Source**: www.indiamart.com)**, b) rose cultivation in polyhouse** (**Source:** www.agrifarming.in)**,** **c) carnation cultivation in polyhouse** (www.indiamart.com)**, and d) packaging of flowers** (**Source**: www.krishisewa.com)**.**

gerbera, gladiolus, gypsophila, orchids, anthurium, tulip, and lilies. Flowers like rose, gerberas and carnation are grown in polyhouses. Maharashtra, Karnataka, Andhra Pradesh, Haryana, Tamil Nadu, Rajasthan, and West Bengal have emerged as the major floriculture centers (Mohan, 2016). Economically and ecologically sustainable polyhouse structures suited to different agro-climatic conditions need to be evolved indigenously.

The cut flowers, which are presently being exported from India, mostly come from hi-tech floricultural units. Protected cultivation, although in limited area (5% of total flower crop area), contributes significantly to total flower exports. India has several advantages and a huge potential to increase the acreage under intensive flower production to further increase the floricultural exports. This requires more number of low-cost units in strategic locations with sound technological back-up (**Figure 5**).

India is native to wide array of ornamental plants. Many of these have potential as ornamental for use of loose flower, cut-flower, potted plant as well as medicinal and other commercial uses. If strategies are formulated to utilize them optimally by keeping essential norms of biodiversity conservation of these unutilized species can yield great economic benefits to farming community. Some of the potential unutilized species and their values are shown in **Table 10**.

Value Addition in Floriculture for Neutraceuticals

Flowers not only excel for aesthetic value but are also rich sources of neutraceuticals. In future, hi-tech horticulture possesses potential for such new avenues. The variety of different pigments in a well-balanced diet is a key to prevention and therapy for a range of chronic human diseases (**Table 11**).

Exploitation of Natural Colour and Dyes from Horticultural Crops

Many countries are now focusing on natural colourants which can be used as raw materials for food, cosmetics, pharmaceuticals, and textile industries. Natural

Table 10. Potential unutilized species and their values

Species	Scientific name	Potential values
Jasmine	*Jasminum nitidum*	Year round flowering, off-season flowering
Rose	*Rosa brunani*	Flower are fragrant and ornamental suitable for attars and marmalades.Also used in soothing cough syrups with high vitamin contents
Periwinkle	*Vinca minor*	Attractive garden plant, producing purple green flowers used in herbal medicines to treat diarrhea and dysentery

Source: Jawaharlal (2017)

Table 11. Flower crops and their neutraseutical properties

Species	Neutraceutical values
Rose, anthurium, gladiolus, gerbera, lilium	Anthocyanins
Marigold	Yellow carotenoids
Bougainvillea	Betalains
Calendula, marigold	Lutein, Zeaxanthin, Beta carotene
Orchids	Anthocyanins, anthoxanthins, and plastid pigments

Source: Prasad et al (2017)

Table 12. Selected crops and their natural colourants

Natural colourants	Source(s)	Colour
Curcumin	*Curcuma longa*	Yellow
Riboflavin	Nuts, brocolli, wild rice, whole grains, mushrooms, soybeans	Yellow, orange
Lycopene	Tomato, watermelon	Orange, yellow
Zeaxanthin	Paprika, corn spinach, lettuce	Orange, red
Betanin	Beet root	Red, purple
Saffron oleoresin	Saffron	Saffron

Source: Walia (2017)

colourants may also be used in color medicines (tablets, pills, facials and nail enamels). Better solid-liquid extractions, processing and formulation techniques are required so that farmers themselves can adopt it (Walia, 2017) (**Table 12**).

Post-harvest Management

The huge post-harvest losses particularly in perishable horticultural produce in tropical environment and unorganized market system require developmental attention on priority. Public-private partnership and massive investment in infrastructural development in post-harvest handling and modernization of marketing systems of perishable products are essential.

There is a need to reduce losses by culminating multiple handling of fresh produce by sorting, grading, waxing, precooling and improving storage, packaging and transportation systems. It will help in providing better economic return to the growers. A network of farmers' service centers is required to be set up in major production areas to evolve collaboration between the producer and end-user. Establishment of primary processing centers at farm gate is essential.

Hi-tech Mechanizing and Post-harvest Handling

Mechanization especially with reference to harvesting and post-harvest handling is gaining momentum. Hydraulically-operated elevators are available to facilitate harvesting in the field. Sorting through gadgets based on photometry, acoustic response, short wave radiation, machine vision and laser technology hold promise (Kumar, 2017). Appropriate field heat removal techniques, *viz*., cold air system, hydro-cooling, vacuum cooling or slush system, need to be adopted at the field level (*in situ*) to reduce post-harvest losses of horticultural produce significantly (Chandra and Upadhyay, 2017).

Processing and Value Addition

Appropriate processing not only adds on value but is also beneficial to reduce post-harvest losses. Minimal processing for quick cooking of vegetables and their products, which are prepared with intermediate moisture, has great potential in the civil sector besides the defense sector. These convenient foods can be stored without refrigeration and can be marketed in both domestic and international markets (Singh and Singh, 2017).

Cold-chain

A cold chain or cool chain is a temperature-controlled supply chain. An unbroken cold chain is an uninterrupted series of refrigerated production, storage and distribution activities, along with associated equipment and logistics, which maintain a desired low-temperature range. The cold-chain sector is part of India's second Green Revolution and high value products such as fruits, vegetables, meat, fish, poultry and dairy are critically dependent on it. A study by National Centre for Cold Chain Development (NCCD) has underlined the missing links in agri-logistics and will help devise long-term plans and policies to improve cold-chain networks. In future, development focus needs to be more on modern pack-house and refrigerated transport, which are important for initiating the appropriate logistics chain from villages to city centers. A holistic approach to cold-chain is part of hi-tech horticulture as it evaluates all the necessary logistic components, including modern cold stores as distribution platforms and ripening chambers. The gap in India's cold-chain is not as much due to a lack of cold storage capacity but has more to do with various other components, necessary to implement farm-to-fork connectivity (Balyan, 2015).

For the current consumption of the urban clusters, India needs about 70,000 pack-houses, each equipped with a pre-cooler and dispatch room for onward transport links. Currently, the country has only about 250 such pack-houses. The gap in cold store capacity is projected at only about 3.5 million tonnes (MMT) in space. Lack of pack-houses and transport connectivity breach the integrity of cold-chain. This also results in most of the cold storage capacity being used to store only crops like potato, dried chillies and pulses which do not need onward cold-chain connectivity (Balyan, 2015).

Hi-tech Horticulture in Konkan Region of Maharashtra

Konkan region is a highly dynamic and vibrant part of the **Western Ghats range** of Maharashtra having favourable agricultural climate of the tropics. Geographically this hilly region with a long coastal sea shore is gifted with a wide range of horticultural potentials. It is a coastal strip of land bounded by the *Sahyadri* hills on the east and the Arabian Sea on the west. Maharashtra's Konkan region comprises of Raigad, Ratnagiri, Sindhudurg and Thane districts (Bhattacharyya et al. 2017). Konkan region is specially known as horticultural zone; mango, cashew, kokum (*Garcinia indica*) and spices are the major crops in south Konkan zone while sapota (*Manilkara zapota*), flowers, and vegetables are major crops in the north zone.

The HDP technology in mango for this region has been developed and standardized (Dalvi et al., 2010). Further, hard-rock planting of mango has emerged as a practice adopted by farmers using advances in mechanization (Bhattacharyya et al., 2017). Standardization of paclobutrazol (PBZ) doses for early and regular flowering and fruiting in mango cv. Alphonso in Konkan has been recognized as a pioneering high-tech intervention (Burondkar and Gunjate 1993; Planning Commission 2007). This technology is applied covering >10,000 ha (20,000 – 25,000 liters) in Konkan (Murad Burondkar personal Communication). However, the cost of the chemical is a constraint behind further extension of this hi-tech intervention.

Vegetable cultivation and floriculture are commercial ventures in Palghar, Thane and Raigad districts. In this region hi-tech horticulture is practiced for various crops but authentic statistical data is not available. Capsicum is commercially grown on around 200 ha. area (Parag Haldankar Personal Observation). Mulching and shade-net houses are used for cucurbits, water melon and betel vine cultivation. Recently, modern social media technology was used by vegetable growers in a cluster in Ratnagiri district to substantially expand the area under vegetables and effectively market their produce. Improved packaging for flowers, vegetables and spices are adopted to reduce post-harvest losses. Farmers have started practicing canopy management and pre-harvest bagging in mango (Haldankar et al., 2013).

Hi-tech Horticulture: Way Forward

Hi-tech horticulture is a powerful tool for doubling productivity of horticultural crops and can well be used for doubling farmers' income (DFI). The broad themes to carry forward the goal of hi-tech horticulture may include i) climate-resilient production technology through hi-tech interventions, ii) conservation of existing germplasm and exploitation of underutilized plant and land use with development of new varieties/ hybrids suited for hi-tech horticulture, iii) application of biotechnology and nano-technology, iv) precision farming oriented to targeted yield, crop and region-specific nutrient management and irrigation resource conservation, and v) development of a chain for post-harvest management to reduce post-harvest losses and to impart value addition.

To keep pace with the modern information-based decisions, it is necessary that real-time data is recorded from the crops and communicated to the decision-makers immediately as a profitable hi-tech horticulture entrepreneurship. Considerable advances have been made in the developed nations with respect to new types of sensor technologies, decision-support tools, and automated irrigation control technologies. These have significantly improved the efficiency and reliability of the technologies and decreased purchase and operating costs (Lea-Cox, 2012).

Use of wireless sensor based irrigation network (WSIN) has potential benefits in terms of reduced use of water and decreased CO_2 emissions. But more importantly, it will help in reducing application rate of nutrients considerably (up to 40%) and also the runoff rates of applied nutrients (up to 40%) (Majsztrik et al., 2013). In Japan, cloud-based vegetable production and distribution systems are being developed. The cutting edge technologies that can be harnessed for hi-tech horticulture include sensor networks, cloud computing, augmented reality, unmanned air vehicles, and control area network (Ahrary and Ludena, 2015). Use of such technologies added with indigenous knowledge will have a far-reaching consequence to see that hi-tech horticulture reaches a new high.

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