

MiniReview

Ensuring food security through golden revolution: prospects, achievements, and bottlenecks

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Abstract

The horticulture sector pondered as the most dynamic and sustainable segment of agriculture, which covers wide spectrum of crops (fruits, vegetables, flowers, spices, condiments, plantations etc.). Inclusion of some important and fast upcoming groups like medicinal and aromatic plants, mushroom, bamboo, and bee keeping has further reinforced sustainability to this sector. Shifting food pattern in wake of increasing income and health awareness of the populace has transformed Indian Horticulture as a vibrant commercial venture with 5-6 percent annual growth rate during last decade. This significant growth undoubtedly attributed to the organized and planned horticultural policies under aegis of “Golden Revolution”. However, this revolution is still seeking a backbone support in the form of efficient post-harvest management system. In this article, the authors go over the *pros* and *cons* of horticulture sector in India highlighting the worldwide importance of post-harvest technology and its role for sustainable food safety and security.

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Introduction

India is bestowed with varied soil and agro-climatic conditions, which is highly favourable for growing a large number of horticultural crops from tropical to temperate throughout the year and often termed as natural reservoir of horticultural biodiversity. Besides, existence of such a favourable biodiversity, ensuring the food security for around 120 crores of population is the major challenge for the agricultural sector of the country. The agrarian community of the country has efficiently exploited this natural endowment and achieved a significant leap in horticultural production after post independence with seven times jump.

Presently horticultural crops occupy around 10 per cent of the gross cropped area in India and contributing 12.5 percent and 14.0 percent in world's fruit and vegetable production respectively (NHB Database-2011). Within the last 19 years (from 1991-92 to 2010-11), horticultural cropped area in India has increased from 12.8 million ha to 21.83 million ha and production from 96.6 million tonnes to 240.53 million tonnes, recorded sharp increase of 70.6 percent and 149 percent, respectively (NHB Database-2010-11). Presently, the horticulture sector of country has recorded significant growth rate of 5-6 percent

during last decade (Singh, 2007) and contributing more than 29 per cent in agricultural GDP (Gross Domestic Product). The credit for outstanding leap in horticulture sector goes to the multi-dimensional but united approach of policy planners and researchers associated with various organizations especially National Horticultural Board (NHB), Indian Council of Agricultural Research (ICAR), Agricultural and Processed Food Products Export Development Authority (APEDA) and Agricultural Universities under the aegis of Ministry of Agriculture, Government of India (GOI) and marked as “Golden Revolution” for the country.

However, fast increasing population has dimmed the impact of revolution in mitigating the projected problems i.e. starvation, malnutrition and poverty. The past efforts in the investment have been rewarding and India is fast emerging as a horticultural hub and reckoned as a leader in the global arena. The projected research and development has made quantum jump in production, productivity, availability, and export. Several nutritionally potent horticultural crops like kiwi, olive, gherkins, kinnow, oil palm etc. were also introduced for commercial cultivation. Besides, “Golden Revolution” several other revolutions are also going on in India and other countries related to specific fields (Table 1).

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Table 1. Major revolutions in India and other countries

Revolution	Associated to
Black Revolution	Petroleum production
Blue Revolution	Fish production
Brown Revolution	Leather/non-conventional(India)/Cocoa production
Golden Revolution	Overall Horticulture development/ Honey Production
Golden Fiber Revolution	Jute Production
Green Revolution	Food grain (Cereals, Wheat & Leguminous plant) production
Grey Revolution	Fertilizer production
Pink Revolution	Onion production/Prawn production/ Pharmaceutical (India)
Red Revolution	Tomato/ Meat production
Round Revolution	Potato production
Silver Fiber Revolution	Cotton production
Silver Revolution	Egg/Poultry production
White Revolution	Milk/Dairy production (In India - Operation Flood)
Yellow Revolution	Oil Seeds production
Evergreen Revolution	Overall Agricultural Development

The world's populace is projected at 9 billion by the year 2030 and majority of inflation will be confined in the developing countries, where chronic food shortages and malnutrition persist (Chopra, 2010). This projected inflation of populace will certainly squeezed the per capita availability of natural resources, and may hinder the equilibrium and sustainability of agricultural systems due to over exploitation of natural resources, which will ultimately aggravate the menace like poverty, starvation, malnutrition and increase in food prices. Regrettably, unlike other horticulture rich countries, average Indians do not get the basic daily requirement of fruits and vegetables and our Human Development Index is very low. This is because a substantial amount of this valuable produce is lost due to improper post harvest management and lack of processing facility. To achieve our target of a hunger free country and reduce poverty, prominence needs to be given to loss reduction (post-harvest technology) that is essential to make available more fruits and vegetables and give better economic return from the existing level of production.

Potential of horticultural crops for ensuring food and nutritional security

Horticultural crops form an important part of the daily diet as effective nutritional supplements and the most prominent source for nutritional security, despite their well-known significance from the economic viewpoint (Siddiqui *et al.*, 2013a). Its significance further amplified in the countries like India where majority of population is vegetarian and undernourished. The fruit and vegetable sectors of horticulture are most potent to fulfil food requirements of the country and elevate the nutritional and economic status of people (Rana, 2010). In general, antioxidants, vitamins, minerals, and fibres are considered as main nutrients contributed by horticultural crops to a balanced diet, and thus special attention should be addressed to this group of nutrients (Siddiqui *et al.*, 2013a and b). Higher productivity, wider adoptability towards soil

Table 2. Productivity (t/ha) gap of important horticultural crops (2010-11)

Crops	Productivity (t/ha)			Gap (t/ha)/ Potential for improvement
	India	World	Highest Potential (Country)	
Fruits	11.7	10.9	24.4 (USA)	-12.7
Mango	6.6	7.7 (mango+guava)	15.8 (Brazil)	-9.2
Guava	12.0	14.9	42.8 (France)	-32.8
Apple	10.0	10.8	59.5 (Indonesia)	-23.4
Banana	35.9	17.6 (orange)	35.0 (Indonesia)	-26.2
Citrus	8.8	9.3	16.3 (U.S.A.)	-5.2
Grapes	11.1	NA	NA	NA
Pomegranate	6.9	24.7	85.8 (Indonesia)	-46.2
Papaya	39.6	22.3	69.5 (Indonesia)	-53.6
Pineapple	15.9			
Vegetables	17.3	18.8	37.2 (Spain)	-18.6
Potato	22.7	17.7	44.3 (U.S.A.)	-21.6
Onion	14.2	19.1	30.3 (Turkey)	-16.1
Tomato	19.1	32.8	81.0 (USA)	-61.9
Brijjal	17.5	25.0	49.2 (Egypt)	-31.7
Cabbage	21.5	27.7	66.1 (Japan)	-44.6
Cauliflower	18.3	16.9	24.8 (Pakistan)	-6.5
		(cauliflower+ broccoli)		
Spices	1.8			
Plantation crops	3.6			
Flowers Loose	5.4			
Productivity of Horticultural Crops	11.0			

(Source: National Horticulture Board Database-India for the years 2010-11)

and climatic conditions and lower cost of cultivation makes horticultural crops as an ultimate choice for sustaining livelihood and nutritional security to a large section of people in India having very meagre share of land holding. Productivity of fruits like banana (37 t/ha), grapes (23.6 t/ha), papaya (37.1 t/ha), pineapple (16.0 t/ha), and vegetables like potato (18.8 t/ha), onion (16.3 t/ha), cabbage (22.1 t/ha) are much higher than the wheat paddy rotation i.e. only 8 t/ha. These productivities have ample potential to ensure food security under ever squeezing per capita availability of natural resources (Table 2).

The horticultural crops offer unique advantage to nutritional security as well. Fruits and vegetables provide substantial amount of nutrients, important for human health and can play significant role for improving the nutritional intake especially of predominantly vegetarian population. They are important source of micronutrients, vitamins, minerals and folic acid (Siddiqui and Dhua, 2010). Fruits have proved to be essential for a balanced diet as a rich source of vitamins, protein, minerals, organic acids, carbohydrates, and antioxidants (Siddiqui *et al.*, 2013b). Whereas, the nutritional value of vegetables as a vital source of essential minerals, vitamins and dietary fibres has well recognized. Vegetables play an important role in human nutrition as a neutralizing agent for acid substances produces during digestion of high-energy foods (Siddiqui *et al.*, 2013a). Due to their high water content and fibre, leafy vegetables and roots probably aid in digestion and utilization of more concentrated food in human diet (Chopra, 2010). Man needs a wide range of nutrients to perform different metabolic functions and to lead a healthy life and their deficiency leads to a number of diseases in children and adults. Fruits and vegetables contain nutraceutical substances that provides medical and health benefits and their daily consumption have been strongly associated with reduced risk for some forms of cancer, heart disease, stroke, and other

Table 3. A glance of all India area and production of horticultural crops (Area- 000 ha, Production- 000 tonnes)

Crop	2008-09		2009-10		2010-11	
	Area	Production	Area	Production	Area	Production
Fruits	6100.90	68465.53	6477.83	73525.51	6383	74878
Vegetables	7980.71	129076.78	8214.58	136189.53	8495	146554
Spices	2629.40	4144.90	2466.8	4018.7	2940	5350
Plantation crops	3217.3	11336.4	3258.7	11249.3	3306	12007
Flowers						
Loose	166.5	987.4	176.1	1016.8	191	1031
Cut		113618.0		50759.0		69027
Total horticultural crops	20661.6	214715.9	21155.7	226872.1	21825	240531

(Source: National Horticulture Board Database 2010-11, India)

chronic diseases (Siddiqui and Dhua, 2010; Siddiqui *et al.*, 2013a and b). Some components of fruits and vegetables (phytochemicals) are strong antioxidants and function to modify the metabolic activation and detoxification/disposition of carcinogens, or even influence processes that alter the course of the tumour cell. It is better to consume a variety of commodities rather than limiting consumption to a few with the highest antioxidant capacity as it varies greatly among fruits and vegetables (Kalt, 2002). Nutritive constituents of fruits and vegetables that have a positive impact on human health and their sources are present in Table 4.

The fruit crops

The fruit plants have immense ability to withstand various soils and climatic stresses, which make them suitable to rehabilitate degraded and wastelands, which are abandoned due to unfit for cultivation of cereal and food grains. India is the second largest producer of fruits after China and contributes 12.5 per cent in global fruit production (Table 3) (NHB Database-2011). The country has wide ranges and varieties of fruits in its basket namely mango, banana, citrus, pineapple, papaya, guava, sapota, jackfruit, litchi, and grape, among the tropical and sub-tropical fruits. Similarly, apple, pear, peach, plum, apricot, almond and walnut count among the temperate fruits. The aonla, ber, pomegranate, annona, fig, phalsa are among the arid zone fruits are the important fruit species (Singh, 2010). India is the world's largest producer of mango, banana, sapota and acid lime. About 39.5 per cent of the world's mangos and 23 per cent of world's banana are produced in India. Country has achieved laurels as highest productivity in the world for banana, grapes, citrus fruits, litchi, papaya and acid lime (Singh, 2010).

Besides all above achievements in fruit production, the actual potential of the country has yet not fully exploited. The major fruit growing belts are confined in subtropical and tropical parts of the country and a limited area has been harnessed in the temperate region. Productivity and fruit quality of several fruit crops in the country are much below to their actual potential and the losses during

Table 4. Bioactive substances present in some horticultural crops

Commodity	Bioactive substances	Commodity	Bioactive substances
Aonla	Vit. C, Polyphenols	Beans	Genistein, isoflavonoid
Apple	Flavonoids, polyphenols	Broccoli	Glucosinolate, selenium
Citrus	Vit C, bioflavonoids, Chalcone	Carrot	α -carotene, lycopene
Grapes	Flavonoid, phenols	Chilli	Capsaicin, capsanthin
Strawberry	Flavonoid, phenols	Ginger	Gingerol
Tomato	Lycopene	Turmeric	Curcumin
Onion	Quercetin	Radish	Iso-thiocyanate

(Rana, 2010; Ayala-Zavala *et al.*, 2011; Siddiqui *et al.*, 2013b)

harvesting, packing, storing, transportation and marketing are very high, sometimes more than 30 percent. The poor post harvest handling and lack of adequate infrastructures has significantly reduced the per capita availability of fruits, which is merely 70 g/day against the dietary recommendations of WHO, which is 120 g/day (Dhillon, 2005). Very negligible proportion of fruit production is being exported from the country in form of fresh as well as processed fruit products.

There is ample possibility to cover-up this gap through integrated approach projected to harness maximum productivity potential of fruit crops through efficient and sustainable utilization of natural resources under precision farming practices. The Government of India has introduced several schemes in form of techno-financial assistance for the development of tissue culture units, vegetable seed production farms, protected cultivation, Hi-tech nurseries, rejuvenation of senile orchards, promotion of INM and precision farming, organic farming, bee keeping, mushroom production etc. under National Horticultural Mission. All these programmes are projected to increase production of quality fruits and reduction in processing and transportation losses. This effort have rewarded in terms of increase in fruit production of the country, however the achievement is much below than the actual potential. The harnessed productivity of major fruit crops is much below to their actual potential, which can be further improved through scientific orchard management.

The vegetables crops

Vegetables play a vital role in the nutritional security of Indian populace that is dominantly vegetarian. Its role becomes more pertinent considering the medicinal and protective attributes for various diseases. Higher productivity and economic return in vegetable cultivation attracted attention of farmers' specially small and marginal farmers who are having very small land holdings. India is a treasure house of wide vegetable biodiversity, which inhabited 175 types of vegetables including 82 leafy vegetables, and 41 root (tuber and bulb) crops cultivated in varied agro climate ranging from tropical to temperate (Singh *et al.*, 2006). However, vegetable sector of the country is mainly concentrated in the cultivation of

potato, onion, tomato, brinjal, okra, peas, cabbage and cauliflower, which jointly contributes 66.3 percent to total vegetable production. Potato alone contributed 28.9 percent in total vegetable production during year 2010-11 (Table 3) (NHB Database-2011). India is the second largest producer of vegetable and contributed 14 percent to the world's vegetable production during year 2010-11 (NHB Database-2011) from 8.5 million ha of cultivated area. However, per capita availability at the farm-level is around 210 g/day, compared to the recommended level of 280 g/day (Singh *et al.*, 2006). Data in respect of the highest productivity potential and actual productivity of the country reveal ample potential for improvement of productivity through use of quality hybrid seeds under scientific cultivation practices like precision farming, integrated nutrient, and pest management and post harvest value addition to reduce various losses (Table-2).

Spices and plantation crops

Spices are high value and low volume export oriented commodities, which yield aromatic and pungent principles commonly used for flavouring and seasoning of food and beverages and also used in Ayurvedic medicines. India is the centre of origin and diversity for major spices like black pepper and cardamom and possibly for ginger and turmeric and occupies a pre-eminent position in production and global trade of spices and foreign exchange earnings. About 60 different kinds of spices can successfully be grown in India but spice sector of the country is mainly concentrated on the cultivation of chillies, garlic, turmeric, ginger, coriander, cumin, and pepper, which covers about 89 percent of the total cultivated area under spice and jointly contributed to 91 percent of total spice production (Table 3) (NHB Database-2011). Productivity level of the India in respect of spices is also considerably low in comparison to other countries. For example average yield black pepper in India is only around 290 kg/ha, which is much below to the Malaysia average yield which is 2925 kg/ha (more than 10 times higher). Similarly, In case of cardamom, India's average yield is 120 kg/ha while in Guatemala it is 200 kg/ha. In India, even the gap between national average and the realizable yield is very wide. Realizable yield for pepper and cardamom is around 2445 kg/ha, and 1625 kg/ha, respectively, whereas, the national productivity of pepper and cardamom is merely 290 kg/ha and 120 kg/ha, respectively. The focal cause of poor crop productivity is unscientific crop management practices and lack of knowledge of precision farming. Bridging this gap through effective implementation of various extension tools like site specific crop demonstration, precision

farming practices, information and communication technology (ICT) etc. is the thrust need and having potential to increase country's production many fold (Vision-2020, IISR).

Plantation crops constitute a large group of crops including coconut, areca nut, oil palm, cashew, tea, coffee, rubber, and cocoa. The major plantation crop of the country is coconut, which covers 57.4 percent of area and share more than 90 percent in total production (Table 3) (NHB Database-2011). India is the largest producer, processor, consumer and exporter of cashew in the world. India is also the leading producer of areca nut in the world with 53 per cent share of global output. Coconut, cashew nut, areca nut and cocoa are the major plantation crops of India that jointly cover 15.5 percent of total cropped area under horticulture and contribute only 5.3 percent to the total horticultural production of the country. Traditional cultivation practices and small farm holdings are the major causes of poor productivity of plantation crops. However, they play an important role in view of their export potential as well as domestic requirements and in employment generation and poverty alleviation programs particularly in rural sector.

Postharvest management of fresh produce as a backbone for developing countries

The ultimate goal of crop production is to provide quality produce to the consumers at reasonable rate. Most of the horticultural crops are highly perishable and post harvest losses are very significant under present scenario of post harvest management, which is insufficient to meet the requirement of the country. The break-up of these losses, which occur due to poor post harvest management facilities and practices are poor handling (30%), poor storage (30%), poor transportation (30%), presence of large number of intermediaries (5%) and the lack of knowledge about better preservation techniques (5%) (Maheshwar and Chanakya, 2006).

The Golden revolution was mainly focused on the production of horticultural crops, which was achieved significantly. However, the development of needful storage infrastructure for post harvest storage was neglected in revolution programmes. This infrastructural lack imposes various post harvest losses and causes a significant gap between the gross production and net availability. Along with the increasing production of horticultural crops particularly fruits and vegetables there post harvest loss is increasing counting about 30- 35% of total production in the absence of proper post-harvest handling/storage, preservation, and cold

chain infrastructure (Kitinoja *et al.*, 2011). There is an urgent need for food processing technologies and packaging equipment, especially in areas of value-added fruit and vegetable processed products. Ready-to-eat/serve snacks and convenience foods segment, which is growing at the rate of 20 percent, also offers good potential. Business in handling, packaging, and storage equipment sector for Horticultural-products also offers good prospects in India. The existing storage and handling system for fresh horticultural produce is traditional and there is an urgent need for modernization and creation of infrastructure to reduce large-scale wastage. A study jointly conducted by the management consultancy firm, McKinsey & Co. and the Confederation of Indian Industry (CII), determined that at least 50% of the production of fruits and vegetables in the country is lost due to wastage and value destruction. The cost of wastage is estimated at Rs. 23, 000 crores (US\$4.6 billion) on an annual basis (Rolle, 2006). This urgently necessitates developing an integrated approach right from production to post harvest management and processing in order to ensure increased income and employment for all sections of the rural people be economically sustainable and contribution towards food and nutrition security of the people. The growth potential for food business in India, however, is very promising. In recent times, factors such as changing food consumption patterns, increased spending on value-added products, increase in income levels, rapid urbanization, increasing number of women joining the workforce and changing lifestyles has brought about a marked shift among consumers for processed food items.

Amenities that could be created to all the important production centres as well as in large markets include post-harvest handling infrastructure viz., humidified storage apparatus for fresh produce; sorting and grading equipment; technology to reduce microbial contamination; cooling systems, cargo transport air-conditioning and refrigeration systems for railways; refrigerated containers/trailers; and vans for transport of perishable products. Reduction of loss would mean increasing food availability in fresh or processed form. There is a need for adequate support for establishing Cold Chain facilities and modern markets, including setting up of Terminal Markets and creating modern humidified storage facilities at the Ports and the Airports also. Development of cold chain infrastructure is essential to exploit the potential of the horticulture sector in distant both global and domestic markets. Support to the growing organized retail sector through efficient supply chain systems could also boost domestic consumption, encourage

value addition, and reduce loss (Maheshwar and Chanakya, 2004; Kitinoja *et al.*, 2011).

A further dilemma is that fruits and vegetables are not uniformly available throughout the country and some areas suffer from scarce supply even when there is a glut in other parts. Marketing, storage and packaging of both fresh and processed products would play a vital role in price permanence of delicate horticultural produce. An immense force to food processing and storage will add value to the product. It will increase the income of farmers, create employment, and promote rural industrialization.

Infrastructure for handling of perishable commodities has been inadequate. Recently, initiative has been made to develop the requisite infrastructure, improvement in the Port facilities, setting up of Quality Testing Labs, Cold Chain facilities etc. Reduction of moisture loss from the product is the major quality of packaging materials. A solution to moisture loss problems from produce appeared with the development and wide distribution of semi permeable plastic films. Airflow through the ventilation holes allows hot fruit or vegetable to slowly cool and avoid the build-up of heat produced by the commodity in respiration. Holes are also important in cooling the fruit when the packages are placed in a cold storage, especially with forced air-cooling. Ventilation holes improve the dispersal of ethylene produced. Research and development effort is required to develop edible films and coatings that have good packaging performance besides being economical. Improved packaging will become more essential as International trade expands after globalization. Better packaging should be of immediate value in reducing waste. Much background research on packaging of perishable products and flowers is needed simulating the actual handling conditions expected during marketing (Murthy *et al.*, 2009).

Losses of fresh produce take place at the levels 1/3 between the farm and road head, another 1/3 between road head and wholesale markets and the remaining 1/3 between wholesale market and retailer. There is need to train the self-help groups, unemployed/under employed youth, and growers including house wives on scientific pre-harvest and post-harvest management including processing and preservation. The introduction of training young boys and girls in the field of "Preservation of fruits and vegetables" is to yoke the widely expanding horizon of job opportunities in the area. Extension personnel engaged in horticultural developmental activities either in government sector, agricultural universities or in food science and technology centres should be delegated the duty to provide the

required training to growers/producers and training the trainers for thorough orientation in maturity determination, grading and packing standards for all commodities. There is need to improve packing containers, method of handling during transport and marketing. Application of correct techniques can reduce the losses by about 70 to 80%. There is also need to improve the skill in handling of preservation equipment for large scale, working in hygienic manner, maintaining sanitation, preparation of preserved products, and identification of spoilage and application of remedial measure. Besides, the concept of supply chain management should be followed in this sector for over all development because supply chain management (SCM) represents the management of the entire set of production, manufacturing/transformations, distribution, and marketing activities by which a consumer is supplied with a desired product.

At last, investments are needed to develop necessary infrastructure in this sector including setting up of research and development laboratories and pilot scale plant in the agricultural universities and grant for setting up/expansion/modernization of existing food processing industries in the state. Appropriate policies and schemes for development and transfer of new technologies are urgently needed to propagate non-polluting, cheap technologies e.g., irradiation and biotechnology for preservation of horticultural produce. The efforts are needed to capitalize our strengths like long growing-season, diverse soil and climatic conditions and removing gaps/constraints to meet the goal of moving towards an alarming horticultural growth in India.

Conclusion and future directions

The investments especially in the postharvest horticultural technology can have a major impact on reducing post harvest losses and increasing the food security, ultimately, improvement in the incomes with the use of existing production techniques without increasing production. The formulation of Postharvest Working Group in each states of the country would be very useful in providing a forum for communications among all those concerned with postharvest biology and technology research and extension. The future research and extension activities must be toward the maintaining quality especially flavour and nutritional content and ensuring safety (avoiding chemical and microbial contamination). A major attention and funding for postharvest research and extension efforts should be given to different governmental as well as private organisations. The fruitful postharvest

research may be realized via internships, faculty exchanges, and human resource development for staff in university laboratories and research centres, laboratory upgrades, improved access to web-based information.

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