Chapter - 1

Introduction
The world's most urgent need is to increase the production of nutritious food in a sustainable manner and improving farm family income in order to ensure household food security, while at the same time conserving the natural resource base. Vegetables are vital source of mineral, vitamins and dietary fibers and play an important role in human nutrition in supplying certain constituents in which other food materials are deficient. A large number of studies have shown that the consumption of vegetables is inversely associated with the risk of cancer, particularly of alimentary canal and respiratory tract.

Agriculture in India accounts for nearly 65% of the country's employment, 18% of the total GDP and about 18% of total export earning and a major supplier of raw material to industries. Agriculture is not only the backbone of Indian economy and food security but also a way of life, a tradition and anchor of overall livelihood opportunity for about 700 million of over one billion populations. Agriculture, therefore, is and will continue to be central to all strategies for planned socio-economic development of the country.

In India, production and productivity of major agricultural commodities have improved over the last few decades. With total vegetable production of 125.88 million tons, country occupies first position in production of cauliflower and peas, second in onion and
third in cabbage\textsuperscript{1}. During the last decade, vegetables have achieved promising increase in production i.e. 33.93 per cent followed by coarse cereals 26.71 per cent, oil seeds by 17.81 percent, wheat by 9.68 percent, pulses by 8.85 percent and rice by 6.36 percent. During 2003-2004, India produced 93.92 million tones of vegetable from 6.24 million ha of land with productivity of 15.0 t/ha, which increased to 125.88 million tons from an area of 7.8 million hectares with a productivity of 16.1 t/ha during 2007-08. Presently, India's share in world vegetable production is about 16 per cent. Our country will need to produce 215 million tones of vegetables by 2015 to meet the demand of domestic and export markets. The increase in vegetable production by increasing area under vegetable production is limited due to the continued decrease of land holding and depleting natural resources. Hence, more emphasis has to be given on productivity enhancement to fulfill country's requirements for food and nutritional security and poverty alleviation.

In India, solanaceous vegetables constitute a major bulk of the total vegetable production. During 2007-08, tomato accounted for 8.9 % (10260.6 thousand tons) of the total vegetable production of 125887 thousand tons with productivity of 17.9 t/ha. The production of tomato increased from 7462.3 thousand tons from and area of 458.1 thousand ha during 2001-02 to 10260.6 thousand tons from an area of 571.7 thousand ha during 2007-08\textsuperscript{1}. The major tomato producing states within India are Andhra Pradesh, Orissa, Karnataka, West
Bengal, Bihar, Uttar Pradesh, Gujarat, Maharashtra and Chhattisgarh. Similarly, 9596 thousand tons of brinjal was produced in India from an area of 566 thousand ha with average productivity of 17 t/ha during 2007-08. In India, the important brinjal producing states are- West Bengal, Orissa, Bihar, Gujarat, Maharashtra, Andhra Pradesh, Jharkhand, Karnataka, Chhattisgarh, Madhya Pradesh, Uttar Pradesh and North-eastern states. India is the largest producer and consumer of chilli among other major producers in the world and is at the top in terms of international trade, exporting 20% of its total production. In India, dry chilli production rose by nearly 43 % from 8.7 lakh tons in 1997-98 to 12.5 lakh tons in 2007-08. The production of chilli in India is dominated by Andhra Pradesh with 53% of the total production, followed by Karnataka (9%), Orissa (6%), West Bengal (6%), Maharastra (5%), Madhya Pradesh (4%) and others (17%).

Agricultural productivity is demanded at a faster pace than ever before to meet the demands of increasing population, besides other compelling factors including global climatic changes, global market competition and consumer choices. India is the second largest producer of vegetables in the world, next to China. These are grown on 7.8 million hectares forming about 4% of the total cropped area. The limited cultivable area can be best utilized for growing vegetables, which are known to give higher yields per unit area and time. Vegetable growing being labour intensive can substantially
increase employment avenues too. Our country is gifted with a wide range of agro-climatic conditions, which enables the production of vegetables throughout the year in one part of the country or the other and then maintaining a continuous supply of fresh vegetables throughout the year. Off-season vegetables are in great demand in home market as well as in the neighboring countries. In recent years, keen interest has developed in vegetable cultivation on larger farms that are distantly placed from consuming centres. Various varieties of vegetables, including solanaceous vegetable crops, have been released in the recent past, for table and processing purposes.

Based on the climatic condition prevailing in different parts of the country, 8 agro-climatic zones for vegetable crops have been formed, viz. I. Humid western Himalayan region (J&K, Himachal Pradesh and Uttarakhand), II. Humid Bengal –Assam basin (West Bengal and Assam), III. Humid eastern Himalayan and bay islands (Sikkim, Meghalaya, Manipur, Nagaland, Mizoram, Tripura, Arunanchal Pradesh and Andaman & Nicobar Islands), IV. Sub-humid Sutlej Ganga Alluvial plains (Punjab, Uttar Pradesh and Bihar), V. Sub-humid eastern and south eastern uplands (Chhatissgarh, Orissa and Andhra Pradesh), VI. Arid western plain (Rajasthan, Gujarat, Haryana and Delhi), VII. Semi arid plateau and central highlands (Madhya Pradesh and Maharashtra) and VIII. Humid to semi arid western ghats and Karnataka plateau (Karnataka, Tamil Nadu and Kerala).
Vegetable export has more than tripled by volume in the decade from 1995 to 2005\textsuperscript{3}, and now represent about 2.5\% of production\textsuperscript{4}. The value of exports of vegetables and spices almost tripled from 1999 to 2005. ITC (Indian Tobacco Co.) data on export and import value for India 2001-2005 are generally higher than the data of FAOSTAT (perhaps ITC is capturing more of processed vegetable data also) and suggest export value has doubled between 2001 and 2005 while imports have remained static, representing less about 5\% of the value of exports in 2005\textsuperscript{5}. India is planning a proposed productivity increase of 5\% for the horticulture sector to contribute 19\% of agricultural GDP for its 11\textsuperscript{th} 5 year plan\textsuperscript{6}. The adoption of policies, including a focus on high-value horticulture such as vegetables coupled with trade and market reform, could contribute substantially to several of the plan's socioeconomic targets.

The agriculture sector is changing throughout the world. Cereal farmers are adding vegetables to their crop rotations in response to increased consumer demands. Assuming a 3.5 and 5.5 percent GDP growth rate in India, the projected demand for vegetables in the year 2030 for India alone is 151 and 193 million tons, respectively. Without increasing the area to achieve this target, the yield increase should be 190 to 200 per cent. The future of vegetable production in the country seems very bright with the adoption of better production technologies developed by the public as well as private organizations. However, there are certain issues that hinder a smooth adaptation of
the technologies and also in realizing the full potential of the vegetable sector of India, e.g., lack of education and awareness about opportunities, lack of market knowledge and marketing skills, lack of professionalism and small holding, falling water levels and lack of irrigation facilities, expensive credits, many intermediaries who increase cost but do not add much value, controlled prices and poor infrastructures are important impediments hindering full exploitation of the potential.

The market reforms in agricultural commodities have so far been limited mainly to food grains. The marketing of vegetables has so far received little attention of the government. At present, there are large number of intermediaries in this trade between the producer and consumer which has resulted in a wide gap in the producer and consumer’s price of these commodities which needs to be reduced to enable farmers receive remunerative prices for their produce and boost their production and consumption in the country. The union government has not made any common regulation for the marketing of vegetables applicable all over the country; however, some of the state governments have enacted laws and Acts. The marketing of vegetables is under regulation in Rajasthan, Maharashtra, Bihar, Delhi, Uttar Pradesh and Karnataka and outside any regulatory purview in Tamil Nadu, West Bengal and Jammu & Kashmir. At present, the wholesale markets for vegetables on a country-wide basis are concentrated in 10 large cities i.e. Delhi, Calcutta,
Bangalore, Chennai, Mumbai, Jaipur, Nagpur, Vijayawada, Lucknow and Varanasi. These cities account for the arrival of 75 per cent of vegetables marketed in major urban areas in India. Delhi, Calcutta, Mumbai and Pune alone account for the arrival of 55 per cent of vegetables.

The growth in horticulture is driven by consumer demand and the need for farmers to enhance incomes through high-value crops. In India between 1983 and 1999/00, per capita availability of vegetables has doubled, while cereal consumption has declined by 10%\textsuperscript{7}. But based on projections to 2010, further increase in vegetable production will be needed to meet demand. Most of the supply increase could be achieved through higher per unit productivity and reduction in post-harvest losses. Production also needs to be boosted in non-irrigated areas, and in home and village gardens, especially in remote and mountain areas (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007) where availability levels are particularly low. Income from staple crops is inadequate, so farmers supplement with off-farm and non-farm income, and increasingly grow high-value crops such as vegetables.

Horticultural crops including vegetables generate more jobs per hectare, on-farm and off-farm, than staple based agricultural enterprises. This benefits farmers and landless laborers in both rural and urban areas. Value-addition to horticultural crops generates
further employment in the associated agri-businesses and further down the commodity chain from the producer to the consumer. Although the costs of inputs such as labor can be higher, the profits are higher and the income thus generated can be used for many different purposes in terms of eradication of hunger and affording access to education and health care. General aspects of cultivation and proper management of solanaceous vegetables is being given hereunder:

**Tomato**

Tomato is one of the most popular and widely grown vegetables in the world ranking second in importance after potato in many countries. The fruits are eaten raw or cooked. Tomato in large quantities is used to produce soup, juice, ketchup, puree, paste and powders, it supplies vitamin C and adds variety of colour and flavours to the food. Green tomatoes are also used for making pickles and preserves. By virtue of its many attributes, tomato is considered as a favourite crop for research in physiology, genetics, cytogenetics, molecular biology, etc. all over the world.

**Origin**

Two areas namely Peru and Central Mexico have been indicated as sites of early domestication. Evidences for the origin of tomato
indicate that it originated in Peru-Equador-Bolivia region of South America.

**Soil and Climate**

Tomato is grown in many types of soil from sand to heavy clay. A well drained fairly fertile loam with a fair moisture holding capacity is ideal for growing a good crop of tomato. Tomato being a warm season crop requires relatively long season to produce a profitable crop. High temperature along with high humidity favours development of foliar diseases, whereas dry wind results in dropping of flowers.

**Importance and uses**

Tomato universally treated as ‘protective food’ is being extensively grown as annual plant all over the world. It is a rich source of minerals, vitamins and organic acids. The total sugar content is 3 - 5 percent in ripe fruit and amount of ascorbic acid varies from 16-65 mg/100 g of fruit weight. The total amino acid is 100-350 mg/100g of fruit weight. Tomato are used directly as raw vegetables in sandwiches, salad etc. Several processed item like paste, puree, juice, ketchup etc. are prepared on a large scale. Tomato is a very good appetizer and its soup is said to be a good remedy for patients suffering from constipation.
Export potential

The specific requirements of tomato for export are round, medium sized and red coloured for Middle East, while cherry tomato is preferred for export in European countries. Processed products of tomato especially puree and pastes have great demand in export. For encouraging export potential of tomato and its products, there is an urgent need of development of suitable varieties, proper packing procedure and long term and consisted export policy. Pre cooling units and cold storage for fresh tomato should be established for prolonging the shelf life and minimizing the losses in post harvest handling.

Improved varieties/hybrids

A large number of tomato varieties/hybrids have been evolved by the various organization of the country. These varieties are having desirable attributes like earliness, high yield, good fruit size, and colour and disease resistance. Some of the popular varieties are Sel-7, Kashi Amrit, Kashi Vishesh, Co 3, Arka Vikas, Roma, etc. An average yield of about 500 q/ha can be obtained through cultivating high yielding varieties.

Planting season

The tomato can be grown almost throughout the year in the country. The number of crops grown varies from region to region.
Scheduling of time for tomato cultivation

<table>
<thead>
<tr>
<th>Area</th>
<th>Season</th>
<th>Time of nursery sowing</th>
<th>Transplanting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern India</td>
<td>Autumn winter</td>
<td>July - August</td>
<td>August-September</td>
</tr>
<tr>
<td></td>
<td>Late autumn</td>
<td>August-September</td>
<td>September - October</td>
</tr>
<tr>
<td></td>
<td>Spring summer</td>
<td>November-December</td>
<td>December-January</td>
</tr>
<tr>
<td>Hills</td>
<td>March-April</td>
<td>April-May</td>
<td></td>
</tr>
</tbody>
</table>

However, the number of crops and the time of seed sowing depend entirely on climatic conditions of the region.

Preparation of field

The field is first ploughed with soil turning plough followed by 4-5 ploughing with country plough and/or harrow. Leveling should be done after ploughing. At the time of soil preparation, raising of the planting bed above ground level facilitates drainage during rainy season and if this practice is followed during winter season, it enhances plant growth by conserving the soil heat apart from several other advantages.

Cropping system

Tomato is well fitted in different cropping systems. Cauliflower-tomato-okra, sunflower-cabbage-tomato, maize-tomato-watermelon and paddy-peas-tomato have been found remunerative under varied weather conditions around Bangalore. Other cropping systems like
rice-tomato, okra-potato-tomato, and tomato-onion are also popular in several parts of the country. Under sequential intercropping system palak or radish can be grown as inter crop in tomato successfully, which gives maximum profit over tomato alone.

**Storage and marketing**

Tomatoes can be stored in low temperature and evaporative cool storage. In India, tomatoes are not commercially stored in cold storage at large scale. Pre-cooling of tomato after harvest and prior to storage and transportation are reported to prolong their storage life. Tomato fruits at mature green stage could be stored successfully at 10-12°C in polythene bags of 100 gauge thickness for 4 to 5 weeks. Storage life of tomatoes could be increased by keeping in evaporative cool storage (Zero energy cool chambers). It was found that tomato at breaker stage stored in zero cool chambers during summer extended shelf life by 4 to 5 days. The cool chamber has been found effective in maintaining fruit acceptability for longer period and minimizing weight loss considerably.

Usually bamboo basket and wooden boxes of various size and shapes are used for packing of tomatoes. Wooden boxes are generally used for packing for long distance markets. Use of polythene for prepackaging of tomatoes could reduce the physiological losses in weight and increases the shelf life.
Brinjal

Brinjal or eggplant is one of the most common, popular and principal vegetable crops grown in India and other parts of the world. It can be grown in almost all parts of India except higher altitudes all the year round. A number of cultivars are grown throughout the country depending upon the yield, consumer preference about the colour, size and shape of the various cultivars. Brinjal is of much importance in the warm areas and is being grown extremely in India, Bangladesh, Pakistan, China and the Philippines. It is also popular in France, Italy and the United States. In India, it is being consumed as a cooked vegetable in various ways.

Origin

Brinjal is normally self-fertilized annual crop. The cultivated brinjal is undoubtedly of Indian origin and has been in cultivation from long time.

Importance and uses

The unripe fruits are primarily used as cooked vegetable for the preparation of various dishes in different regions of the world. It has got good potential as raw material in pickle making and dehydration industries.

High anthocyanin content and low glycoalkaloids content are considered essential. For processing, fruit should have a high dry
matter content and low level of phenols. The round types of brinjal have high polyphenol activity and glycoalkaloids content. The bitterness in brinjal is due to glycoalkaloids. The glycoalkaloids present in most of the cultivated varieties range from 0.37 to 4.83 mg/100 g fresh weight whereas glycoalkaloids content of about 20mg/100g fresh weight produces bitter taste.

**Cultivars**

Brinjal varieties are preferred on the basis of their colour, fruit shape and size. The selection of variety depends on the climatic conditions and consumers preference. In West Bengal, North UP, Orissa regions green fruited brinjal is more preferred. The preference vary according to the season also as the white fruited brinjal is mostly used in summer months as there is very less bitterness and fiber at that time. There are a number of varieties and hybrids developed by the public and private sector for the cultivation but the most popular and higher yielder are- Pusa Purple Long, Pant Samrat, Punjab Sadabahar, Pant Rituraj, Kashi Sandesh, Hisar Shymal, Kashi Prakash, etc.

**Soil and Climate**

Brinjal can be grown practically on all soils from light sandy to heavy clay. Light soils are good for early crop, while clay loam and silt loam are well suited for high yield.
Brinjal is a warm season crop and susceptible to severe frost. A long and warm growing season is desirable for successful brinjal production. Cool nights and short summers are unfavorable to its proper yield. A daily mean temperature of 13 - 21 °C is most favourable for its better growth and yield. It has been observed that the variety and temperature interaction on their effect on leaf size also.

**Raising seedlings**

The time of seed sowing and transplanting the seedlings in various agroclimatic situations primarily depend upon the temperature, rainfall and availability of irrigation facilities. In northern India, following periods of nursery raising are in vogue.

<table>
<thead>
<tr>
<th>Time of seed sowing</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>June-July</td>
<td>Autumn crop</td>
</tr>
<tr>
<td>November</td>
<td>Spring-summer crop</td>
</tr>
<tr>
<td>March</td>
<td>Rainy season crop</td>
</tr>
</tbody>
</table>

**Seed rate**

To transplant 1 hectare of land, about 500 to 750 gram of seeds are sufficient for sowing. For hybrids, 350 to 400 gram seeds are enough for one hectare planting.

**Transplanting**

The seedlings are ready for transplanting when they attain a height of 15 cm after about 25-30 days of sowing with 4 leaves in 4-6 leaves.
Plant population density

The planting distance depends on the fertility status of the soil, growing season and cultivars. According to nature of cultivars, following distance is recommended.

Brinjal varieties and their planting distance

<table>
<thead>
<tr>
<th>Variety</th>
<th>Row to row distance (cm)</th>
<th>Plant to plant distance (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long fruited cultivars</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>Round fruited cultivars</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>Bush/non-spreading cultivars</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Spreading cultivars</td>
<td>90</td>
<td>75</td>
</tr>
</tbody>
</table>

Harvesting

The brinjal fruits should be harvested when they attain a good size and colour, its surface should not lose its bright and glossy appearance. At full maturity, fruits become yellow or dull in colour. It is an indication of over maturity and loss of quality. The maturity can be tested by pressing the thumb on the front skin. If the pressed portion springe back to its original shape, the fruit is too immature. Timely harvesting of tender fruits increases the total growing period and number of pickings and yield.
**Yield**

The yield of the brinjal fruits depends on the cultivar, season of growing, fertility status of the soil and application of manures & fertilizer etc. On an average yield of open pollinated varieties varies from 300-500 q/ha. Hybrids are having very high yield potential provided that good nourishments and plant protection measures are adopted. Yield of hybrids ranges from 600-800 q/ha.

**Storage**

Brinjal fruits can be stored for more than 28 days at 8.3 to 10.0°C with 87 to 90% relative humidity. Green brinjal has comparatively longer shelf life of four weeks on the basis of physiological loss in weight, discolouration, spoilage and CO$_2$ injury during storage at 8 to 10°C under controlled atmosphere with initial concentration of 5% CO$_2$. For transportation, pre treatment with fungicidal wax emulsion and packaging in perforated polythene bag enhances shelf life.

**Chilli**

Chilli or hot pepper is one of the most valuable commercial crops grown in India and belongs to the family Solanaceae. Chilli is rich in vitamins A, C, E & P. Capsaicin is responsible for pungency and has good medicinal value. Sweet pepper is often called as bell pepper because majority of sweet pepper cultivars grown worldwide have bell shaped (four lobbed) fruits. Chilli is cultivated for various market
types and exhibits wide range of genetic and morphological diversity in terms of fruit size, shape and their consumption patterns. In India, *C. annuum* is cultivated for fresh fruits (both sweet & hot types), oleoresin/colour extraction (paprika type) and processing (pickle type). The major chilli producing countries are India, China, Korea, Hungary, Spain, Nigeria, Thailand, Turkey, Kenya, Sudan, Uganda, Japan, Ethiopia, Indonesia, Pakistan, and Mexico. India has immense potential to export different types of chillies required by various markets around the world.

**Origin**

The centre of diversity for the genus *Capsicum* is in southern part of South America. The primary centre of origin for domesticated *C. annuum* is in semi-tropical Mexico, while India is considered to be the secondary centre of diversity of capsicum.

**Cultivars**

A large number of high yielding varieties having better yield, resistance to major pests and diseases, seed content, colour and capsaicin content have been evolved and recommended for different parts of the country. Some of these varieties are dual type e.g. Pusa Jwala, LCA-235, CCH-2, etc. The cultivars are selected based on the region and the local requirements like fruit type, size, shape, colour, pungency, resistance to pests and diseases, etc.
Soil and Climate

Well-drained loamy soils are most suitable for chilli cultivation. Sandy loam soil is ideal to get early yield, while loam soils are preferred to get high yield. Quality of fruits is better in light soils than in heavy soils. The crop can be grown over a wide range of altitudes from sea level up to nearly 2100 meters. It is generally a cold weather crop, but can be grown throughout the year under irrigation. Chillies are better adapted to warm weather than the sweet pepper (capsicum), but it does not set fruit well when night temperatures are greater than 24°C and below 10°C. The optimum soil temperature for seed germination is 25°C and the maximum is 30°C and the optimal temperature for productivity is between 18°C - 30°C.

Growing season

The major season for growing chillies in India is kharif season. In northern India, generally two crops, i.e., kharif and Rabi crops are taken. In southern India, the three crops i.e., kharif, rabi and summer season crops are grown. Kharif crop is sown/transplanted in the month of June to July, rabi crop in the month of October to November and summer crop in the month of January to February. Sweet pepper is transplanted in August–September for autumn–winter crop and in November-December for the spring-summer crop in plains. In the hills, seeds are sown during March to April.
**Input Use Efficiency**

In order to get maximum return from any crop with the available resources, the inputs or the resources has to be efficiently and judiciously utilized. The important inputs for growing chillies are seed, manures & fertilizer, water and safe protective measures.

Good quality seed is the most critical input in any crop cultivation including chillies. It is always better to treat the seeds while storing or sowing. Seed treatment refers to the application of fungicide, insecticide or a combination of both to seeds, so as to disinfest them from seed-borne or soil-borne pathogenic organisms and crop pests both in field and in storage. Seed treatment helps in prevention of spread of plant diseases, protects seed from seed rot and seedling blight, improves germination, and provides protection from insect pests.

It is universally accepted that the use of chemical fertilizers is an integral part of the package of practices for raising the agricultural production to a higher place. Studies conducted by the Food and Agricultural Organization (FAO) of the United Nations have established beyond doubt that there is a close relationship between the average crop yields and fertilizer consumption level. Moreover, the nutritional requirement of chillies could not be fully met with the use of organic manures like FYM and other manures like neem cake, castor cake, groundnut cake, etc., for want of their availability in
adequate quantities. Hence, there is need for an efficient use of fertilizers as major plant nutrient resource in enhancing the chilli productivity. Other resource of plant nutrients like organic manures, bio-fertilizers etc., also should be integrated to get the maximum agricultural output from every kilogram of applied nutrient in the form of fertilizers. The recommended doses of manures in chilli crop is 20-25 tons of FYM, 120-150 kg nitrogen, 80 kg each of phosphorous and potassium per hectare. In addition to FYM, addition of neem cake @ 4-5 q/ha at the time of last ploughing is beneficial. Whenever an insecticide is sprayed on crop, addition of 1% urea along with protective measures is useful for proper growth and development of plants.

The critical stages of irrigations under chilli crop is just after transplanting, at active flowering and fruit setting stage, failing which results in the non-establishment of plants, flower/bud drop and hence the reduced yield. Number of irrigations, interval between two successive irrigations depends on type of soils, age of crop and climatic conditions, such as for light soils: 7-10 days interval, heavy soils: 10-15 days interval and during summer: 5-6 days interval. After prolonged drought, if irrigation is provided at flowering and fruiting stage, lot of flower and fruit drop will be seen.

All other management practices of crop husbandry will be futile if the crop is not protected against the ravages of pests. Experts'
assessments reveal that around 22 per cent of yield losses in major chillies can be attributed to insect pests. In absence of crop protection the yields may be drastically declined.

A large number of growth substances have been used to regulate growth and flowering in chilli. From the findings of several workers on the use of different growth regulators and its effects on chilli, a comprehensive report has been made on these aspects. In addition to the above, timely intercultural operations like weeding, hoeing and earthing up is essential for a good crop return.

**Nursery Management**

The quality of seedlings used in planting exerts great influence on ultimate crop performance. Recent years have seen many developments in the methods of raising transplants. One of these includes precision production of transplants in peat blocks/pro-trays under protection especially in case of F hybrids. More precision and control are possible when plants are raised under protected structures. Seedlings raised in pro trays offer an alternative to bare-root plants. It has been recognized that these new systems can provide: a means of controlling seedling growth, faster transplanting, improved crop establishment particularly under dry conditions and subsequent crop uniformity. Plants raised in containers are usually grown in specially prepared growing media. Many different media composts are available but there is an increasing trend of soil-less
media based on peat, sand, grit, vermiculite, perlite, polystyrene or other materials and combination of these materials in different proportions.

**Quality Planting Material**

Quality seed is the most important and crucial factor for a good crop husbandry. Better the quality of the seed, better is the assurance for productivity. Chilli grower use the seeds purchased from the markets (made available either through public organizations or private sectors), exchange from among the growers or their own-saved seeds of the last crop harvest. In India, the acreage under improved/notified/identified/ released varieties of chilli pepper is lesser which needs utmost attention. The F₁ hybrids or the open pollinated (OP) varieties marketed by the private organizations are costlier and sometimes render the farmers to use unimproved local varieties. Seed production of chillies requires sufficient isolation distance (about 500 m) to maintain the purity. The cross-pollination in chillies ranges up to 90 percent. Bagging or netting of individual plants or whole plot is essential to get the true to type seeds. Public sectors in our country have already developed a large number of open pollinated and hybrid varieties of chilli. The public organizations contributing towards varietal research and development are notably, IIVR Varanasi, IIHR Bangalore, RARS Lam, PAU Ludhiana and IARI New Delhi.
Harvesting

Pepper fruits can be harvested either at the green immature or red mature stage. For vegetable use, green fruits are harvested. For pickles, picking is done at ripe or green stage. For the preparation of dry chilli, the chilli fruits should be in fully red condition or more than 80% red stage. Under well manage situation 10-12 picks can be harvested as green chilli or 7-9 picks as red chilli stage. Harvested red mature fruits should be kept under room temperature for two days for the uniform development of red colour of partially red fruits before expose to sunlight for drying. Laying material like, mats or gunny bags should be used to dry the pods under sunlight. Good quality dry chilli can be produced 5-6 days after drying under sunlight.

Though India has acquired a position of prominence as a producer and supplier of vegetables, there is scope to strengthen the position further as it has suitable agro-climatic conditions for production of all types of vegetables throughout the year in one or the other part of the country. It is estimated that around 20-25% of the total vegetables is lost due to poor post harvesting practices. Less than 2% of the total vegetables produced in the country are commercially processed as compared to 70% in Brazil and 65% in USA. Vegetable growers and specialists have not equipped themselves with the qualitative aspects of production and pre- and post-harvest care, which play a vital role. The required infrastructure facilities should be
in position in producing areas to facilitate grading, packing and movement of produce from the field to the final consumer in the shortest possible time. This requires governmental intervention and also sizeable investment in research and development. Setting up of 20 agri-export zones in the new EXIM (export-import) policy 2002-2007, is one of the major steps the Government of India has taken to promote export.

Keeping in view the situation discussed above and the need of a planned appraisal of the current economic scenario, particularly of solanaceous vegetables, the present work entitled 'Economic Appraisal of Production and Marketing of Solanaceous Vegetables in Different Agro-climatic Zones of India' was planned with the following objectives:

1. To study the resource-use pattern and its efficiency in production of solanaceous vegetables on sample farmers.

2. To estimate the comparative profitability of solanaceous vegetables in different agro-climatic zones of the country.

3. To study the marketing and temporal price behaviour and supply-price relationship in solanaceous vegetables.

4. To study the export performance of solanaceous vegetables.
5. To identify the constraint faced by vegetable growers in the field of production and its marketing and to suggest suitable measures to overcome them.

**Research Methodology**

1. **Sampling design and collection of primary data**

For collecting the primary data under the present study, two-stage stratified random sampling were used. State, district and villages were selected in first stage and growers and other stakeholders were selected in second stage of sampling. Thus a total of sixteen states, i.e. two from each agro-climatic zone were randomly selected. Further two districts were selected from each state and two villages from each district making a total of 32 district and 64 villages. Under the present study, five farmers growing solanaceous vegetables from each identified villages of all the zones were selected making a total 320 farmers. The data were collected through a pre-tested questionnaire developed for the purpose.

2. **Collection of secondary data**

The desired secondary data were collected from the Statistics department and Horticulture department of the district as well as states. Apart, the data were also collected from various secondary sources viz. APEDA, FAO, NHB and Spice Board.
3. Analytical Framework

Besides simple statistical tools such as averages, percentages and standard deviations, the regression technique will be used to establish input output relationship and production function for each of the crop in all the agro-climatic zones where these are cultivated. Comparative profitability of different solanaceous vegetable in all the agro-climatic zones will be assessed by farm business analysis. Different costs like Cost A1, Cost A2, Cost B1; Cost B2, Cost C1, Cost C2 and Cost C3 will be estimated using methodology given by CACP, New Delhi, to arrive at different farm efficiency measures to compare the profitability of the crops.

The mathematical model of vegetable production function will be as follows:

\[ Y = f (X_i) \]

where, \( Y \) = Total vegetable production

\( X_i \) = Inputs used in the production of vegetables like, seed, fertilizers, irrigation, plant protection measures, human labour, machine labour, bullock labour, etc.

Resource Use efficiency

To estimate resource use efficiency in solanaceous vegetables production, the marginal value products of inputs for these crops were compared with the acquisition cost of the inputs.
Estimation of marginal physical product

Marginal physical product (MPP) of a particular resource is calculated by taking the order partial derivative of the output (Y) function with respect to the concerned input Xi which is given below:

\[ Y = a X_1^{b_1} X_2^{b_2} \ldots X_n^{b_n} U \quad i = 1, 2, \ldots, n \]  

(1)

The first order partial derivative of output with respect to input Xi is calculated as

\[ \frac{\delta Y}{\delta X_i} = b_i \left( \frac{y}{X_i} \right) \]

(2)

\[ = APP_i \cdot b_i \]

where, \( APP_i = \frac{Y}{X_i} \)

By substituting the geometric mean values of Y and X_i in the equation (2), we obtain the MPP of the input X_i.

Estimation of marginal value product

By multiplying the MPP of an input by the price of the output, we obtain the Marginal Value Price (MVP) of each input, which can be written mathematically as:

\[ \text{MVP of } X_i = \text{MPP of } X_i \cdot P_y \]  

(3)

where \( P_y = \text{Per Unit Output Price} \)

In order to study the resource-use efficiency of an input, the ratio of MVP of the input to its price per unit was calculated. If the ratio is less than unity, it indicates the input is over-utilized. If MVP/price
ratio is greater than unity, the resource in question is under-utilized and if the ratio is equal to one, it indicates that the relevant input is being optimally used.

**Export performance of Solanaceous vegetables**

The time-series data on production and trade of solanaceous vegetables and their products for India vis-a-vis world were obtained from NHB and FAO database. To study the performance and composition of exports of different solanaceous vegetables, only the data of tomato and its products were collected through secondary sources and per cent shares were worked out on a decade basis to take into account the problems of wide fluctuations in the value of export and imports. The Export Performance Ratio (EPR) was estimated to examine the comparative advantage of India in tomato export, using the method suggested\(^\text{12}\). Accordingly, the EPR of India in tomato and tomato products was estimated by equation (3):

\[
\text{EPR} = \frac{S_{\text{it}}}{S_{\text{wt}}} \quad \ldots (3)
\]

where,

\( S_{\text{it}} = \text{Share of tomato in India's total export, and} \)

\( S_{\text{wt}} = \text{Share of tomato in the total world export.} \)

Since EPR is based on observed pattern of trade flows, it is also called Revealed Comparative Advantage (RCA). If EPR/RCA is greater than
unity, the country has the comparative advantage in export of the concerned commodity and vice versa. As suggested\textsuperscript{13}, RCA was made symmetric by obtaining the index as \((\text{RCA}-1/\text{RCA}+1)\). This index is known as Revealed Symmetric Comparative Advantage (RSCA) and varies from -1 to +1. The data from the trade yearbook of FAO were used for the analysis. Annual compound growth rate (ACGR) and coefficient of variation were computed to examine the trends in tomato trade and instability in export of tomato and tomato products. The growth rates and coefficient of variation were calculated for the two periods, viz. before the commencement of WTO (1985 to 1994) and after WTO (1995 to 2004) for a better understanding of trade performance of India vis-à-vis world.

The factors influencing the export of tomatoes were identified using Cobb-Douglas type of demand function\textsuperscript{14}.

\[
Y = a Q^{b_1} T^{b_2} (PR)^{b_3} (ER)^{b_4} U \quad \text{... (4)}
\]

where,

- \(Y\) = India’s export of tomato (Mt)
- \(Q\) = Tomato production in India (Mt)
- \(T\) = Volume of international trade in tomato (Mt)
- \(PR\) = Ratio of Indian export price and non-Indian international prices of tomato
ER = Exchange rate (Rs/US$)

a = Intercept

brs = Elasticity of respective variables, and

Uj = Random-error terms, uj \sim \mathcal{N}(0, \sigma^2_u).

The Indian export and international prices of tomato and its products have been represented by their respective unit values. The unit value of Indian export was derived from the data on quantity and value of tomatoes export available in the FAO trade yearbook.
References


