UNIT 12 VEGETABLE PRODUCTION

Structure

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12.0 OBJECTIVES

After studying this unit, you will be able to:

- to discuss the importance of vegetable crops for food and nutritional security;
- to elaborate on the area, production, and productivity of major vegetable crops; and
- to explain the role of vegetable crops as an agro-industry in the Indian economy.

12.1 INTRODUCTION

Vegetable crops are the most sought crops the world over as they are essential items of food and nutrition both for rich as well as poor. Their role in our diet needs no emphasis as they are a rich source of carbohydrates, proteins, fats, minerals, and vitamins and are regarded as protective foods well equipped to combat malnutrition. Although there has been a tremendous increase in the production and consumption of vegetable crops since independence in the country, there exists a gap between the optimum needs and their present proportion in the average Indian diet due to ever increasing population which has already touched 1.3 billion. Increasing vegetable production, therefore, continues to be the main goal vis-à-vis the quality of the produce. A systematic approach towards increased vegetable production and consumption is essential.

Progress made in the development of improved varieties of major vegetable crops concerning maturity periods, growth habits, resistance to diseases and insect pests, and the extreme temperature has been remarkable. Besides, agro-techniques for getting maximum production have been standardized and enough progress has also been made in the management of diseases, insect pests, nematodes, and weeds. However, there has been a gap in the full dissemination of this knowledge to the vegetable growers, therefore, there is a need to compile recent advances in major vegetable crops concerning varieties, agro-techniques, integrated pest management for the benefit of vegetable growers, researchers, teachers, and students.

Presently, vegetable production in India is more than 188 million tonnes from an area of around 10 million hectares with productivity of 18.26 metric tonnes per hectare (2019-20). With the rising population pressure, this productivity further needs to be increased to meet the dietary recommendations of 300 g of vegetables per capita per day. This is possible by following an improved package of practices for scientific vegetable cultivation. Besides, to reduce post-harvest losses, it is essential that on-farm primary processing, grading, and packaging are encouraged which will go a long way in value addition and improving the quality of the produce.

12.2 RELEVANCE OF VEGETABLES TO AGRO-INDUSTRY

Major solanaceous vegetable crops like potato, tomato, brinjal, chilli, sweet pepper have the potential not only for fresh market but potato, tomato and chili have special utility for developing agro-industry. Likewise, cole crops (cauliflower, cabbage, broccoli, knolkhol, Brussels sprouts, and kale), bulb and root crops (onion, garlic, carrot, radish, beetroot, turnip, *etc*.), leafy vegetables (beet leaf, spinach, amaranth, Chenopodium, vegetable mustard, *etc*.), legume vegetables (garden pea, French bean, winter bean, cowpea, cluster bean, and dolichos, *etc*.) and cucurbits (cucumber, muskmelon, watermelon, bitter gourd, pumpkin, bottle gourd, *etc*.) have great potential in the domestic fresh market, export market, processing industry and emerging functional and fusion food industry for the balanced food for tackling malnutrition. This is because these vegetable crops are rich sources of various bioactive compounds that can be extracted and used in balanced food development. Besides, these are potent sources of edible colour and various anti-oxidants. Thus, their suitability is not limited to the domestic cottage industry for chips, ketchup, puree, and pickle making but for the multinational nutraceutical industry.

12.3 FRUIT AND LEAFY VEGETABLES

The importance of fruits and leafy vegetables in human nutrition is well known. These vegetables are rich and comparatively cheaper sources of vitamins and minerals. Their consumption in sufficient quantities provides sufficient immunity to the human body against certain degenerative diseases. Solanaceous fruit vegetables, okra, and leafy vegetables are therefore important human diet for good human health. In general, they provide different minerals like iron, calcium, phosphorus, potassium, iodine, *etc*. and different nutraceuticals like beta carotene, lycopene, lutein, capsaicin, and capsanthin which have antioxidant activity. Thus, the consumption of these vegetables protects our body from exposure to free radicals which cause degenerative diseases like cancer, *etc*. It is therefore essential to produce a large quantity of these types of vegetables to supply our constantly growing population in ample amounts to protect our population from degenerative diseases. So growers should have sufficient knowledge of production practices and plant protection of these vegetables without hampering their quality and consumer acceptability, especially during this organic era. Fruit vegetables are transplanted crops *i.e.* their seeds should be sown in the nursery and then transplanted depending upon the crop at three or four weeks' age.

12.3.1 Tomato

Tomato (*Solanumlycopersicum L.)* is an important fruit vegetable widely cultivated the world over. Tomato is a diploid species with 2n = 2x = 24 chromosomes. It belongs to the family Solanaceae. It can be consumed raw, boiled, stewed, as a sauce, or in combination with other foods. These can be used as an ingredient in the kitchen or can be commercially processed whole or as a paste, juice, and powder. The red colour of the tomato is due to lycopene, which has anticancer activity. Its culture extends from the tropics to a few degrees in the Arctic Circle.

Fig. 12.1: Tomato

12.3.2 Brinjal

Brinjal, eggplant, or aubergine (*Solanummelongena* L.) is one of the most grown vegetable crops in India. It belongs to the family Solanaceae. The somatic chromosome number of the brinjal is 2n=24. It is adapted to a wide range of climatic conditions. It has a long bearing period when grown under a mild climate of southern states but its bearing is shortened under hot climate. Its fruits are a fairly good source of calcium, phosphorus, iron, and vitamins, particularly B groups. Brinjal is reported to stimulate the intrapeptic metabolism of blood cholesterol. White brinjal is said to be anti-diabetic.

Fig. 12.2: Brinjal

12.3.3 Chilli

Chilli is known as hot pepper, was introduced to India from Brazil in the 16th century by the Portuguese. The botanical name of Chilli is *Capsicum annum* and belongs to the family Solanaceae. The basic chromosome number of chilli is x=12. Within over four centuries, it has spread to an area of around 0.39 million hectares and production of 4.12 million tonnes covering almost all the states of the country (2019-20). Chilli is mainly used in culinary adding flavour, colour, vitamins, and pungency. Therefore, chilli is indispensable to India and many African and Asian countries. In the food and beverage industry, chilli is being used in the form of an oleoresin. In India, no dish is complete without chillies.

Fig. 12.3: Chilli

12.3.4 Okra

The cultivated okra (*Abelmoschus esculentus* L. (Moench) is an important vegetable crop throughout the tropical and subtropical regions of Asia and Africa. The most frequently observed somatic chromosome number is 2n=130. It belongs to the family Malvaceae. It is valued for its mature, tender, and green fruits. Okra fruits are rich in calcium (90 mg/100 g fresh weight) and provide a valuable supplementary item in the tropical diet. The young fruits are consumed as cooked vegetables, mostly fresh but sometimes sun-dried or frozen. The fruit is fairly rich in protein and minerals. Its seed contains 13–22% edible oil and 20–24% edible protein and is viewed as an alternative source for edible oil. In the Far East countries like Papua New Guinea, Fiji, and Solomon Island, a wild relative of okra known as *Abelmoschus manihot* is used as a leafy vegetable.

Fig. 12.4: Okra

12.3.5 Amaranth

Amaranths are primarily used as potherbs. It is the most common leafy vegetable grown during the summer and rainy seasons in India. It fits well in crop rotation as it is a short-duration crop and produces more biomass per unit area. Leafy amaranth is said to be native to India. Among leafy types, *Amaranthus tricolour* is the main cultivated species in India.

Fig. 12.5: Amaranth

12.3.6 Beet Leaf or Spinach Beet or Indian Palak

Beet leaf is one of the most common leafy vegetables in tropical and subtropical regions. The states popularly growing this crop include Uttar Pradesh, West Bengal, Maharashtra, and Gujarat. However, it is not very popular in southern states. Botanically, Palak is known as *Beta vulgaris* var. *bengalensis*. Palak has a chromosome number 2n=2x=18. It is a native of the Indo-Chinese region.

Fig. 12.6: Beet Leaf or Spinach Beet or Indian Palak

Check Your Progress Exercise 1

Note: a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

i. Vegetables are called as…………………food.

ii. Dietary recommendation of……………..g vegetables per capita per day.

iii. Lycopene antioxidant compound is found in………………………..crop.

iv. Botanically, Indian palak is known as……………………………………………

v. Amaranthus…………….is the main cultivated species of India.

vi. White brinjal is said to be anti…………………….

vii. Botanically okra is known as……………………………..

viii. Chromosomes number of tomato and chilli……………

ix. Family of brinjal……………………………………

12.4 COLE AND BULB CROPS

12.4.1 Cole Crops

The word 'Cole' originated from the Latin word 'caulis' meaning stem. Cole crops are a group of highly differentiated plants originating from a single wild species *Brassica oleraceavar sylvestris*. *Brassica oleracea*is a versatile species that under human selection has generated several crops each targeted to a different organ of the plant (leaves along the stem: kales; leaves surrounding the terminal bud: cabbage; enlarged axillary buds: Brussels sprouts; inflorescences: cauliflower and broccoli; swollen stem: kohlrabi and marrow stem kale). Cauliflower (*Brassica oleracea L. var. botrytis* L. 2n = 2x = 18) is one of the most popular vegetables after cabbage. It is grown for its highly suppressed 'prefloral fleshy apical meristem' branches called "curd." This is cultivated worldwide in different climatic conditions, ranging from temperate to tropics during most cropping seasons, and is available round the year in the market.

Cabbage (*Brassica oleracea var. capitata*) is another important vegetable of the cole crops group. It is a rich source of vitamins A, B, C, and minerals. It covers about 4% of the total area under vegetables. India comes next to China in cabbage production. It is now grown almost throughout the year. Odisha, West Bengal, Bihar, Karnataka, Maharashtra, Gujarat, and Punjab are major cabbage-growing states. Commonly grown cabbage in India is white. Red and Savoy cabbage is not so popular. The heads of cabbage vary from flat-topped to long-oval. The tender leaves are primarily used as a cooked vegetable, more in raw than in processed form.

Knol-khol (*Brassica oleracea var. gongylodes*) is known by many names in India. It is popular in Kashmir, West Bengal, Maharashtra, Assam, Uttar Pradesh, Punjab, and some parts of South India, but it is not cultivated commercially. It is characterised by the formation of a knob which arises from a thickening of the stem tissue above the cotyledons. The fleshy turnip-like enlargements of the stem develop entirely above the ground. This knob is harvested for human consumption as a raw or cooked vegetable, though in some parts, young leaves are also used. All the cole crops are transplanted and require extra care during nursery raising and transplanting and for a month after.

12.4.2 Bulb Crops

Onion (*Allium cepa L.*) is an important vegetable crop the world over. Onion is consumed in the form of fresh, frozen, dehydrated powder and green bunching onions. As a culinary ingredient, it adds to the taste and flavour of a wide range of food preparations and it is also used as a salad. India produces all three varieties of onion – red, yellow, and white. In some parts of the country, onion is grown in all three seasons. In the northern part of the country, onion is usually grown in the winter (*Rabi*) season. However, in the southern and western states of Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat, and Maharashtra, it is grown in the winter (*Rabi*) as well as in the rainy (*Kharif*) seasons. Currently, *Kharif* onion is gaining ground in the northern part of the country. The top five onion producing states include Maharashtra, Karnataka, Gujarat, Bihar, and Madhya Pradesh accounting for about 70 per cent of the total production.

Garlic (*Allium sativum*) is the second most important bulb crop after onion in India. Garlic is used as a spice or condiment throughout India. It is also an important foreign exchange earner for India. It has a higher nutritive value than other bulb crops. It is rich in proteins, phosphorous, potassium, calcium, magnesium, and carbohydrates. India has become one of the biggest exporters of garlic worldwide. Madhya Pradesh, Gujarat, Uttar Pradesh, and Rajasthan contribute 73 % area and 78 % of the production of garlic in India.

12.5 TUBER AND ROOT CROPS

12.5.1 Potato

Potato (*Solanum tuberosum*) is one of the major food crops grown in a wide variety of soils and climatic conditions in nearly 150 countries. It is the most important dicotyledonous source of human food. It ranks as the fourth major food crop in the world, exceeded only by wheat, rice, and maize. The dry matter production of potatoes per unit area of land, total potato production has increased in both developed and developing countries in the past 40 years. Potato is a versatile, carbohydrate-rich food highly popular worldwide and prepared and served in a variety of ways.

The year 2008 was declared the International Year of Potato (IYP) by the United Nations. The declaration of IYP reflects the importance of potato in food security, nutrition, poverty alleviation, environmental conservation, and sustainable development.

Area and Production

Potatoes are grown in about 150 countries throughout the world and more than a billion people worldwide consume potato. About 370.4 million tonnes of potatoes were produced in the world over an area of about 17.3 million hectares in 2019 (FAO STAT 2021). The top ten producers in the world are China, India, Russia, USA, Ukraine, Poland, Germany, Belarus, Netherlands, and France. These together contribute about 70% of the total production. India ranks second, contributing around 13.18 % to the world's production after China. Production-wise India has always remained in the top ten for the last twenty years. Europe is the largest per capita consumer, followed by North America and Latin America

Potato is produced in an area of 2.05 million ha with a production of 48.56 million tonnes and productivity of 23.68 t/ha (2019-20) (agricoop.nic.in). Indian processing industry consumes less than 2% of the total production in the country. Out of the total area of vegetables, potato occupies 19.9%, the production was 25.8% share of the total vegetable production (2019-20). Potato is grown almost in all states of India.

The states of Uttar Pradesh, West Bengal, and Bihar account for 61.4 % area and 68.4 % of the potato production in the country. The highest area and production is from Uttar Pradesh, followed by West Bengal and Bihar. The highest productivity (2019-20) of the crop is in Gujarat (30.6 t/ha), followed by Bihar (29.9 t/ha). Potato is one of the principal cash crops. Other major potato growing states are Gujarat, Madhya Pradesh, Punjab, Assam, Jharkhand, and Haryana. About 90% of the potato crop in India is cultivated in Indo-Gangetic Plains from October to March. About 10% of the area lies in the hills where the crop is grown during long days of summer months from April to September.

Nutritive value

Apart from starch, potato provides body-building substances such as vitamins, minerals, and proteins. Carbohydrates constitute about 80% (range 63-86%) of the total solids found in potatoes. Freshly harvested, it contains about 80 per cent water and 20 per cent dry matter. About 60 to 80 per cent of the dry matter is starch. On a dry weight basis, the protein content of potato is similar to that of cereals and is very high in comparison with other roots and tubers. In addition, the potato is low in fat. Potatoes are rich in several micronutrients, especially vitamin C - when eaten with its skin; a single medium-sized potato of 150 g provides nearly half the daily adult requirement (100 mg). The potato is a moderate source of iron, and its high vitamin C content promotes iron absorption.

Potato is a good source of vitamins B1, B3, and B6 and minerals such as potassium, phosphorus, and magnesium, and contains folate, pantothenic acid, and riboflavin. Potatoes also contain dietary antioxidants, which may play a part in preventing diseases related to ageing, and dietary fibre, which benefits health.

Potato is a low energy density food. Potato starch contains amylase and amylopectin. The amylase content in starch ranges from 18.5-32.0. Sucrose, glucose, and fructose comprise the major sugars of potato. The dietary fibre content ranges between 1-2% in fresh potatoes. Potatoes contain a higher concentration of lysine (4.2-5.7mg/g) than cereals, potato is a supplement for the cereal-based diet.

12.5.2 Sweet Potato

Sweet potato (*Ipomoea batatas*) is widely grown in the tropics and warm temperate regions of the world. It is the third most important tuber crop in India after potato and cassava. The root tubers are mainly used as a subsidiary food. The crop is grown in all the states of India except the states of Jammu and Kashmir, Himachal Pradesh, and Sikkim.

Sweet potato ranks as the most important food crop on a fresh weight basis in developing countries after rice, wheat, maize, and cassava. It is predominantly cultivated as a rainfed crop in eastern India, especially in Odisha, Bihar, West Bengal, and Jharkhand. Odisha is the leading state in area and production, followed by Uttar Pradesh and West Bengal. Even in eastern India, the crop is concentrated in a few districts only, Koraput, Sundargargh, Keonjhar, Ganjam, and Bolangir are the major sweet potato growing districts covering 50% area under crop in Odisha.

Area and Production

Sweet potatoes are grown (2019) in about 7.77 million hectares area, yielding 91.82 million tonnes, with an average yield of about 11.82 tonnes/ha (FAO STAT, 2021). It is mainly grown in developing countries, which account for over 97% of world output. Sweet potato is a poor man's crop in Africa, with most of the production done on a small or subsistence level. China is the largest producer of sweet potatoes, accounting for more than 80% of the world's supply.

In India, it is grown on a 0.13 million ha area with a production of 1.50 million tonnes and productivity of 11.5 tonnes/ha (2017-18). Odhisa is a leading producer with 0.38 million tonnes production, followed by Kerala 0.34 million tonnes, Uttar Pradesh 0.23 million tonnes, and West Bengal 0.22 million tonnes.

Food value and uses

Sweet potato roots (orange and non-orange) are a valuable source of vitamin C (20-30mg/100g), vitamin B complex and E. Vine tops have excellent micronutrient contents and adequate protein content (2-4%) for use as a food. The roots are rich in carbohydrates (starch, cellulose, hemicelluloses, pectins, and sugars). Starch accounts for 60-70% of the dry matter. The total sugars in cultivars show wide variations; with a usual range of 0.38-5.64%, sucrose is the most abundant sugar in raw roots. It accounts for around 80-90% of the total dry matter content.

The dry matter content varies depending on the cultivars, cultural practices, climate, *etc.* and is reported to range from 13- to 48%. The vine tops are a rich source of vitamin A (5580IU/100g, and calcium (74mg/100g). The most studied nutraceuticals in sweet potatoes are carotenoids and anthocyanins. The purple-fleshed sweet potatoes (variety Ayamurasaki) are a rich source of anthocyanins, which have medicinal value as an anti-oxidant and cancer-preventing activity. Besides, in Japan, the coloured roots are used for extracting the pigment, which is further used in various food products. The β-carotene is the most abundant pigment in sweet potato orange-fleshed varieties and yellow-fleshed varieties.

The yellow and orange colour in tubers is due to β-carotene. Orange fleshed sweet potato (OFSP) has more advantages than other cultivars. The OFSP can supply significant amounts of vitamin A and energy simultaneously helping to address both VAD and undernutrition. The intensity of the orange colour reflects the amount of beta-carotene present. Generally, the orange flesh varieties have the range of 250- 800 RAE/100g of fresh weight basis (FWB) 30-95µg/g. The current guidelines recommend that the pro vitamin A activity be expressed in retinol activity equivalents (RAE). The RAE definition is based on the assumption that 16.7% of the ingested beta carotene is observed and 50% is converted to retinol. This results in an average conversion factor of 12 units of beta carotene to form 1 RAE. OFSP is an example of a bio-fortified crop in which the mineral nutrient status of staple foods is enhanced through plant breeding to the point where the impact on micronutrient status can be achieved.

12.5.3 Cassava

Cassava (*Manihot esculenta* Crantz) is the most important crop among the tropical root and tuber crops. Cassava is one of the most important sources of food energy in several tropical countries. An estimated 70 million people in Africa and N.E. Brazil get more than 500 calories/day from cassava. The crop is frequently identified as a famine reserve due to its tolerance to drought and infertile soils, and its ability to recover from disease and pest attacks. Cassava also offers the advantage of a flexible harvesting date, allowing for farmers to keep the roots in the ground until needed. The area of cassava under marginal environments has been continuously increasing, particularly for regions with poorer soils and long dry seasons.

Cassava is consumed either directly as cooked tubers or as products prepared from cassava. Cassava in India is mainly used for human consumption, industrial, and animal feed sectors. In India, nearly 60% of cassava is used industrially in the production of sago, starch, and dry chips. Tapioca sago is generally known as Sago (Sabudana in Hindi) in India. Sago is a produce, prepared from the milk of cassava root. The added value realized from industrial cassava makes this crop one of the most profitable choices for farmers.

Area and Production

Cassava is cultivated in an area of 0.17 million ha producing 6.06 million tonnes (2019-20) in India. Tamil Nadu accounted for an area of 0.09 m ha, Kerala 0.05m ha, and Andhra Pradesh (0.01 mha). Cassava is grown as a rainfed crop in Kerala and Andhra Pradesh. But in Tamil Nadu, it is grown both as an irrigated and rainfed crop. The north-eastern region of Thailand is the world's biggest exporter of dried cassava. About 60% of the total planted area is in this region.

Cassava generally refers to the roots of the plant, whereas tapioca to starch and other processed products. The large central pith of the cassava roots is considered the starch-reserve flesh (30 - 35% starch). More than 800 starch and sago industries operate in and around the Salem and Namakkal districts of Tamil Nadu. The added value realized from industrial cassava makes this crop one of the most profitable choices for farmers. In India, Sago was produced first in Salem (Tamil Nadu). During 1943-44, sago production started on a cottage scale basis in India by pulping the tapioca roots, filtering the milk extract, and after settling the milk, forming globules and roasting these globules. Tapioca Root is the basic raw material for Sago and starch. India is one of the leading countries in tapioca production. It is a very nutritious product as it contains carbohydrates and an appreciable amount of calcium and vitamin C.

12.5.4 Carrot

Carrots (*Daucus carota,* 2n=2x=18) are grown all over India. It is taken in raw as well as cooked form. It is made into pickles and sweetmeat. A sweet preparation called *Gajarhalwa* is a very famous dish in north India. Carrot juice is a rich source of β-carotene and is sometimes used for colouring butter and other foods. Black carrot is a rich source of anthocyanins and is used for the preparation of a beverage called *Kanji* considered to be a good appetizer. The carrot contains about 87% water, rich in minerals and vitamins (B, C, D, and E). Raw carrots are an excellent source of vitamin A, potassium, vitamin C, vitamin B6, thiamine, folic acid, and magnesium.

12.5.5 Radish

Radish (*Raphanus sativus*) is a root vegetable suitable for tropical and temperate climates. The leaves and roots are consumed both as salad and as cooked vegetables. The radish roots are a good appetizer. The different preparations of radish are useful in curing liver and gall bladder problems. Roots are used in treating urinary complaints and piles. The juice of fresh leaves is useful as a diuretic and laxative.

Check Your Progress Exercise 2

Note: a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

i. The edible part of cauliflower is………………… a pre-floral fleshy apical meristem.

ii. The year………….. was declared as the International Year of Potato by the United Nations.

iii. …………….. largest producer country of sweet potato.

iv. In, India nearly 60 % of cassava is used industrially in the production of ………..

v. Botanically carrot is called as……………………………………………

vi. Black carrot is the rich source of…………………………………………

vii. ………………. is a wholesome food in terms of protein and energy.

viii. Family of cabbage is………………………………………….

12.6 LET US SUM UP

The total production of vegetable crops has jumped six times after independence in the country. Important vegetables are tomato, brinjal, okra, beans, peas, cucurbits, melons, and cole crops. Solanaceous vegetable crops include tomato, potato, brinjal, chilli, and sweet potato. Tomato has wider coverage in comparison to other vegetables. Brinjal is adapted to a wide range of climatic conditions. In hilly regions, it is grown only in summer. Leafy green vegetables have more nutrition per calorie than any other food. Greens make up a significant source of vitamins A, C, E, and K as well as several B vitamins. Cole crops include cabbage, cauliflower, broccoli, Brussels sprouts, kale, and kohlrabi. The *Brassica* family is well adapted to cool-season production. Onion and garlic are grown as bulbs vegetables and spices, used for flavoring the dishes. In contrast to developed countries, where potato is a staple food crop, it is a vegetable in many developing countries including India. Cassava is an important starchy staple crop in India. Besides being a staple food crop, cassava can be used as raw material for the production of industrial starch and ethanol. Root crops carrots and radishes are also consumed as vegetables providing nutritional security in the human diet.

12.7 KEYWORDS

Anthocyanin: Anthocyanin pigments are responsible for the red, purple, and blue colours of many fruits, vegetables, cereal grains, and flowers.

Bulb crop: A storage organ usually formed underground. The swollen portion consists mostly of fleshy, food-storing scales attached to a short flat stem and cloves. Onion and garlic are grown as bulbs vegetables

Cole crops: Cole crops originated from the word caulis (Latin), meaning stem or stalk of a plant.

Lycopene: Lycopene is a carotenoid and phytonutrient found in red fruits and vegetables such as tomatoes, pink grapefruits, watermelons, and papayas. It is the compound that is responsible for the red colour in these foods.

Sago: Sago is a product prepared from the milk of cassava root.

12.8 SUGGESTED READINGS/ REFERENCES

1. B. Chaudhary (2006).Vegetable: National Book Trust of India. New Delhi
2. Chadha, K. L. Hand Book of Horticulture (eds.), I.C.A.R, New Delhi.
3. M. S. Dhaliwal (2012). Handbook of Vegetable crops by Kalyani Publishers, Ludhiana.
4. S.P. Singh (2009). Principles of Vegetable Production by, Agrotech Publishing Academy, Udaipur.
5. Thamburaj S. and Singh Narendra Textbook of Vegetables Tubercrops and Spices (eds.) (2004). I.C.A.R., New Delhi.

12.9 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

i. Protective

ii. 300g

iii. Tomato

iv. Beta vulgaris var. bengalensis

v. Amaranthus tricolor

vi. Diabetic

vii. Abelmoschus esculentus

viii. 2n = 24

ix. Solanaceae

Check Your Progress Exercise 2

i. Curd

ii. 2008

iii. China

iv. Sago

v. Dacus carota

vi. Anthocyanins

vii. Potato

viii. Brassicaceae

12.10 UNIT END QUESTIONS

1. Why vegetables are called protective food?
2. What are the major causes of the low productivity of bulb crops in India?
3. "Potato is a wholesome food", justify.
4. Write a short note on the role of cassava in the agro-industry.
5. Comment on the nutritional value of sweet potato.
6. Which are the major potato-growing states of India?
7. What are the uses of carrot and radish?
8. How can we increase the productivity of vegetable crops to meet the dietary recommendations?