B.Sc. Ag III Sem

Production Technology for Vegetables and Spices

Credit - 2(1+1)

As per ICAR 5TH Dean Syllabus

E – COURSE CONTENT

Production Technology for Vegetable and Spices
HVS 212

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	techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders, of Tuber crops such as Potato	
11.	brief about origin, area, climate, soil, improved varieties and cultivation practices such as time of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders, of; Leafy vegetables such as Amaranth, Palak.	
12.	Perennial vegetables	

Lecture: 1

Importance of vegetables & spices in human nutrition and national economy

Introduction

After green revolution, our country has made a tremendous progress in vegetable production. India is now, the second largest producer of vegetables in the world after China.

Vegetables form an integral part of staple diet in India where about 42% population is vegetarian and being a rich sources of daily requirement of nutrients, vitamins and minerals Now days the whole world is converting into vegetarian. Its need of hour to supplement our food bowls with vegetable and move towards attaining a healthy nation. From the last few years, the use of vegetables has received remarkable large adoption. The vegetables not only grow quickly but also give higher yields in comparison to other crops. Realizing the worth of vegetables in human health, Indian Council of Medical Research (ICMR) recommends that an average man with vegetarian or non vegetarian food habit should consume total 300 gram (125 g leafy vegetables, 100 g roots and tubers and 75 g others vegetables) per capita per day. Consumption of adequate amount of vegetables helps in maintaining health and vigour of an individual.

Vegetable: Vegetable is an herbaceous plant or plant part which is mostly consumed in the unripe form after cooking. These are grouped according to plant part used that is leaves (lettuce, chauli, palak), stem (celery), tuber (potato), bulb (onion, garlic) etc.

Importance of vegetables in human nutrition

Olericulture has been one of the most important branches of horticulture. In the past, vegetables were considered to be the luxury but now these are being considered as an asset providing a vital constituent of human diet and a good source of income to the growers. Vegetables, which are mostly short duration crops enable a farmer to take larger numbers of crops from a given area of land as compared to other agronomical crops. Due to urbanization, industrialization and shrinkage of agricultural land, cultivation of vegetable crops will be more economical.Vegetables are considered as “Protective supplementary food” as they contain large amount of amino acids, which are required for proper functioning of various metabolic processes in human body. They are rich source of minerals like phosphorus, iron and calcium,

vitamins and other nutraceutrical substances, which are essentially required for maintaining good health and vigor of human body.

They produce taste, increase appetite, maintain good health and protect against degenerative diseases. The nutrient source and deficiency symptoms are shown in Table 1 & 2

Table 1: Nutritive value of vegetables

Nutrients	**Vegetables**	**Quantity present in vegetable**
Vitamin A	Bathua leaves Colocassia leaves Beet leaves	11300 IU/100 g 10278 IU/100 g 9770 IU/100 g
Vitamin B_1 Thiamine	Chillies Colocassia leaves Tomato (Red)	0.55 mg/100 g 0.22 mg/100 g 0.12 mg/100 g
Vitamin B_2 Riboflavin	Fenugreek leaves Amaranthus	0.31 mg/100 g 0.3. mg/100 g
Vitamin C Ascorbic acid	Drumstick leaves Coriander leaves Chillies Broccoli Tomato	220 mg/100 g 135 mg/100 g 111 mg/100 g 109 mg/100 g 31 mg/100 g
Carbohydrate	Tapioca Sweet potato potato	38.1 % 28.2 % 22.6 %
Protein	Lima bean Peas Cowpea	7.9 g/100 g 7.2 g/100 g 4.3 g/100 g
Fat	Potato	118 mg/100 g
Fiber	Potato Chilli Amaranthus Beet leaf Spinach	752 mg/100 g 6.8 g/100 g 1.0 g/100 g 0.7 g/100 g 0.6 g/100 g

Calcium	Agathi Curry leaves Amaranthus and fenugreek leaves	1130 mg/100 g 813 mg/100 g 395 mg/100 g
Phosphorus	Amaranthus Garlic	800 mg/100 g 187 mg/100 g
Iron	Agathi Amaranthus	83.9 mg/100 g 22.5 mg/100 g
Potassium	Spinach Amaranthus	605 mg/100 g 230 mg/100 g

Table 2: Functions and deficiency symptoms of various nutrients

Nutrients	**Functions**	**Deficiency symptoms**
Carbohydrates	Supply energy (4 Kcal/g) and help in the assimilation of other nutrients. Fibres improve digestion, prevent constipation and reduce the level of cholesterol	Loss of energy and weakness
Proteins	Help in the formation and maintenance of tissues, body growth; provide energy (4 Kcal/g). Form enzymes and hormones to regulate various physiological processes in the body.	Retard growth of children, cause irritability, apathy and retard mental development. Skin and hair losses colour. The swelling of face, lower parts of legs and feet.
Fats	Supply essential fatty acids and energy (9 Kcal/g).in concentrated form	Lack of energy and weakness
Vitamins		
Vitamin A	Helps in growth and provides protection against infections and night blindness. It increases longevity	Night blindness, susceptibility to diseases and retardation of growth in young stage.
Vitamin B-		

Complex		
Thiamine B_1	Maintains appetite and keeps the nervous system healthy and helps in the release of energy.	Cause Beriberi, loss of appetite, enlargement of throat, loss of sensitivity of skin, loss in weight and fall of body temperature.
Riboflavin B_2	Helps in cell respiration, essential for growth, helps in maintenance of skin	Cracks at the corners of mouth, raw red cracked lips, soreness of the tongue, ulcers in oral cavity, swollen of the nose and redness of eyes.
Niacin or Nicotinic acid B_5	Essential for growth and release of energy	soreness of the tongue, pellagra and skin changes in hands, feet, legs and neck
Ascorbic acid or Vitamin C	Necessary for healing of wounds and absorption of iron. To make cementing substances to hold cells together and to strengthen walls of blood vessels to resist infection. Essential for calcification of bones and teeth.	Scurvy, bleeding in gums and mucous membrane, tooth decay and susceptibility to common cold
Vitamin D	Helps in building strong bones and teeth and essential for the absorption of calcium	Cause rickets and dental diseases
Vitamin E	Helps in normal reproduction	Cause sterility
Minerals		
Calcium	Essential for the formation of bones and teeth. Helps in the clotting of blood	Cause rickets and osteomalacia in women after repeated pregnancies
Iron	Acts as oxygen carrier in the body and helps the formation of haemoglobin	Anaemia, pale and smooth tongue, in paleness of lips, eyes and skin and spoon shaped nails
Iodine	To form thyroxin hormone	Cause goiter

Vegetables as general medicines:

Many of the vegetables have curative properties such as:

- Being a rich source of proteins, minerals, vitamins, water and low in fat vegetables helps in checking obesity.
- It is said that juice of cabbage act as an antidote against poisonous mushroom
- Bitter luffa juice is known as an effective anti-jaundice medicine.
- Carrot has a therapeutic effect on intestinal disorders in children due to the presence of chemicals in the terpene chain in the essential oils found in this plant.
- It is believed that the extraction of carrots from the carrots prevents pregnancy by preventing the implantation of a fertilized egg in the uterus.
- Onions, garlic, and other vegetable-containing sulfur have antiseptic properties. There is a triterpene compound, garlic inotoldiol, which is reported to inhibit fungal growth under vitro conditions.
- Sweetpotato contains a bitter substance known as ipomeamarone. Indigenous New Zealanders use these herbs as an antipyretic.
- Pungent extract (capsaicin) of red pepper has been used to treat neurogenic bladder
- The role of various ginger and turmeric treatments is well documented

Role of Vegetables in National Economy

Horticulture sector has proved beyond doubt its potentiality for gainful economy especially in most fragile ecosystem. Realizing the significance of services it renders to mankind, Horticulture has been projected high-up in the national agricultural scenario.To ensure livelihood security to the native population Vis-à-vis nutritional security to the mass at large, horticulture sector has been recognized as the best viable alternative. Vegetables are important constituents of Indian Agriculture and nutritional security due to their short duration, high yield, nutritional richness, economic viability and ability to generate on-farm and off farm employment.It is estimated that domestic demand for vegetables will rise. Therefore, increasing the production and productivity of vegetables is of paramount importance for meeting the ever increasing demand of vegetables at reasonable price. Vegetables played a significant role in improving land productivity, generating employment, improving socio-economic conditions of rural

peoples and providing nutritional security to people. The horticultural scenario of the country is fast changing in the recent years.

A large number of vegetable crops are being cultivated in India in temperate, tropical and sub tropical regions.

Most vegetables grow fast, produce a lot and offer a very high income. Current production is not enough to meet the needs of 300 g of vegetables on an average per person per day. Currently the per capita intake is about 145g / day. By the end of 2030 on average we need 151-93 million tons of vegetables to meet our need. Since the daily supply of vegetables per person is very low, it is important that the production and consumption of vegetables in India should be increased three to four times. The vegetable industry contributes significantly to the country's economy. Millions of farmers, entrepreneurs (marketing) and industries (seeds, fertilizers, pesticides, herbicides, machinery producing etc.) rely directly or indirectly on vegetable farming. Vegetables have a great deal of direct impact on income, employment and nutrition. Due to its diverse local climate and favorable climates, India can grow into one of the world's leading exporters of fresh vegetables and seeds.Vegetables are increasingly seen as important for food safety and nutrition. Vegetable production provides a promising economic opportunity to reduce rural poverty and unemployment in developing countries and is an integral part of farm-segregation strategies. To affect the economic power of vegetables, governments will need to increase their investment in farm production (including improved varieties, alternative pesticides, and the use of protected agriculture), better harvest management, food security, and market access. To touch on the nutritious power of vegetables, consumers need to know how vegetables contribute to health, and get them at low prices or be able to grow them on their own. Vegetable consumption should therefore be nourished by a combination of supply side effects and behavioral change interactions that emphasize the importance of eating a healthy and healthy vegetarian diet. To fully tap into the economic and nutritional potential of vegetables, governments and donors will need to deliver vegetables much earlier than they currently receive. Now is the time to prioritize vegetables, provide increased economic opportunities for emerging farmers and provide healthy food for all.

Conclusion: The importance of vegetables in human diet is well known since time immemorial as they supply all main components of human diet. It is correctly said that **“Vegetables are friends of doctors and glory of cook”.** It is one of the important components of human diet and also the important component of horticulture; assume

great significance in providing food and nutritional security. Being effective supplements of nutrition, vegetables form a balanced diet of rich and poor people. According to UN food organizations, about 25 million people die from hunger and exhaustion every year. Under these circumstances of hunger and under nutrition, particularly in developing countries, vegetable crops acting as protective food, can play an important role in alleviating the malady by providing good amount of minerals, vitamins and energy in balance diet. Vegetable production also provides good opportunity for unemployed youths. These are highly beneficial for the maintenance of health as well as for diseases prevention. They contain valuable food ingredients which can be successfully utilized to build up and repair the body. Vegetables play a crucial role in crop diversification, employment generation and socio-economic upliftment of the farming society. Vegetable provides carbohydrate, protein, fat, vitamins, minerals and water along with roughages which are the essential constituents of balanced diet

Lecture: 2

Kitchen gardening/Home Garden/Nutritional Garden

Definition: It is the growing of vegetable crops in residential houses to meet the requirements of the family all the year around.

Importance of vegetables

1. Vegetables occupy an important place in our daily life particularly for vegetarians
2. Vegetables are the only source to increase not only the nutritive values of foods but also its palatability.
3. For a balanced diet, an adult should have an intake of 85 g of fruits and 300 g of vegetables per day as per the dietary recommendation of nutrition specialists
4. But the present level of production of vegetables in our country can permit a per capita consumption of only 120 g of vegetables per day

Why Kitchen Garden?

1. Considering the importance of vegetables, to produce our own vegetable requirements in our backyards using the available fresh water as well as the kitchen concept has emerged
2. This will only facilitate successful production of our own requirement of vegetables.
3. Cultivation in a small area facilitates the methods of controlling pests and diseases through the removal of affected parts and non-use of chemicals.
4. This is a safe practice, which does not cause toxic residues of pesticides in the vegetables produced.

Kitchen Garden Site Selection

1. There will be limited choice for the selection of sites for kitchen gardens and the final choice is usually the backyard of the house.
2. This is convenient as the members of the family can give a constant care to the vegetables during leisure and the wastewater from the bathrooms and kitchen can easily be diverted to the vegetable beds.
3. The size of a kitchen garden depends upon the availability of land and number of persons for whom vegetables are to be provided.
4. There is no restriction in the shape of the kitchen garden but wherever possible rectangular garden is preferred to a square one.
5. With succession cropping and intercropping, five cents of land would be adequate to supply vegetables for an average family of four to five persons.

Land preparation

1. Firstly a through spade digging is made to a depth of 30-40 cm.
2. Stones, bushes and perennial weeds are removed.
3. 100 kg of well decomposed farmyard manure or vermicompost is applied and mixed with the soil.
4. Ridges and furrows are formed at a spacing of 45 cm or 60 cm as per the requirement.

5. Flat beds can also be formed instead of ridges and furrows.

Sowing and planting

The main objective of a kitchen garden is the maximum output and a continuous supply of vegetables for the table throughout the year. By following certain procedures, this objective can easily be achieved.

1. Direct sown crops like bhendi, cluster beans and cowpea can be sown on one side of the ridges at a spacing of 30 cm. Amaranthus (meant for whole plant pull out and clipping) can be sown after mixing 1 part of seeds with 20 parts of fine sand by broadcasting in the plots. Small onion, mint and coriander can be planted/sown along the bunds of plots.
2. Seeds of transplanted crops like tomato, brinjal and chilli can be sown in nursery beds or pots one month in advance by drawing lines. After sowing and covering with top soil and then dusting with 250 grams neem cake so as to save the seeds from ants. About 30 days after sowing for tomato and 40-45 days for brinjal and chilli and big onion the seedlings are removed from nursery and transplanted along one side of the ridges at spacing of 30-45 cm for tomato, brinjal and chilli and 10 cm on both the sides of the ridges for big onion. The plants should be irrigated immediately after planting and again on 3rd day. The seedlings can be watered once in two days in the earlier stages and then once in 4 days later.
3. The perennial plants should be located on one side of the garden, usually on the rear end of the garden so that they may not shade other crops, compete for nutrition with the other vegetable crops.
4. Adjacent to the foot path all around the garden and the central foot path may be utilised for growing different short duration green vegetables like Coriander, spinach, fenugreek, Alternanthera, Mint etc

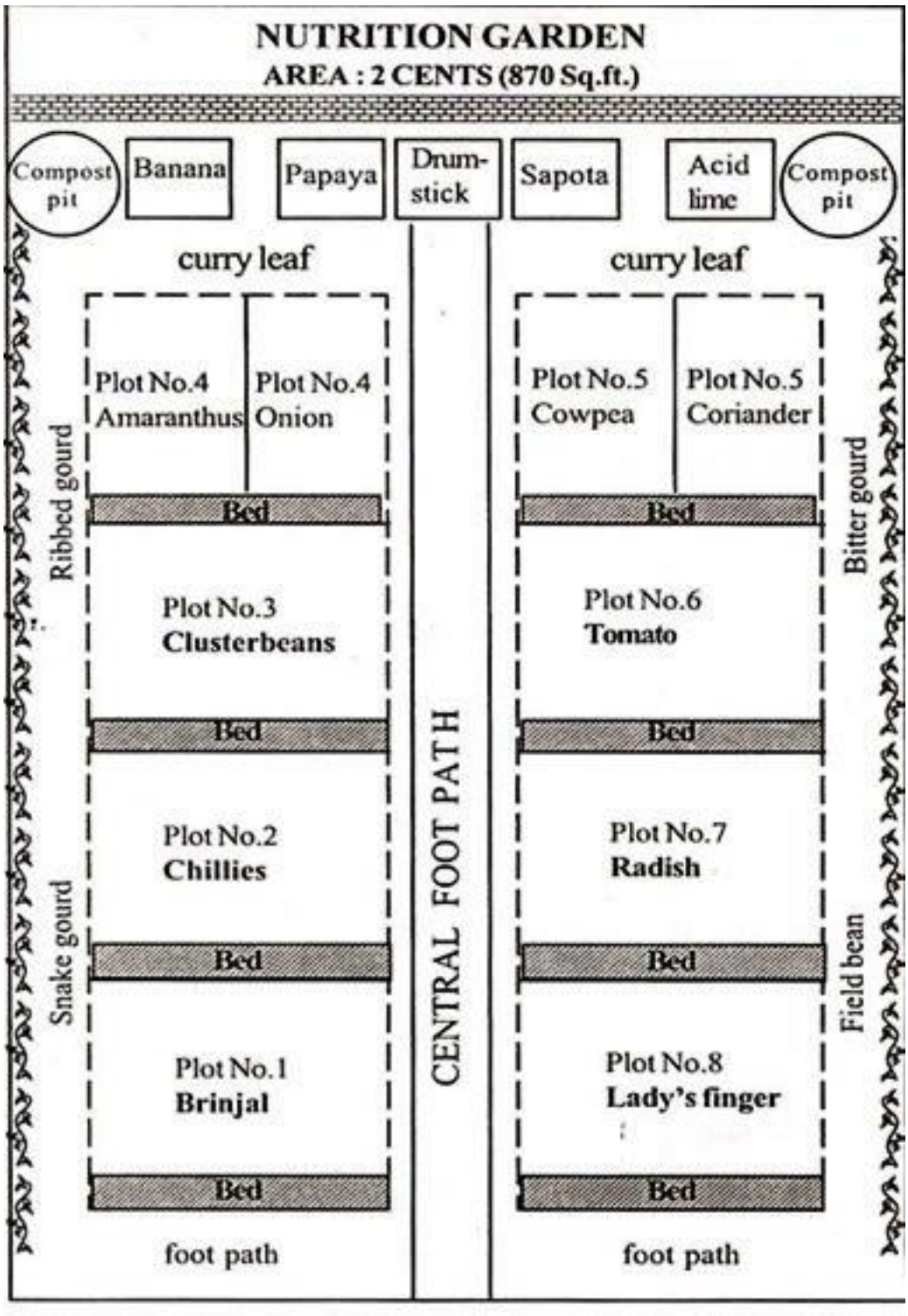
Vegetable Seeds Sowing Calendar

Name of Vegetable	Growing Season	Days to Maturity
Onion	May-Jun	150-160 days
Bottle Gourd	Feb-Mar Jun-Jul	55-60 days
Carrot	Aug-Sept-Oct	75-80 days
Tomato	Jun-Aug Nov-Dec	110-115 days
Melon	Feb-Mar Jun-Jul	70-85 days
Potato	Oct-Dec	70-120 days
Cabbage	Sept-Oct	90-100 days
Beans	Feb-Mar	45-50 days
Broccoli	Aug-Sept	90-100 days
Cauliflower (Late)	Aug-Sept-Oct	120-125 days
Cauliflower (Mid-season)	Sept-Oct	120-125 days
Apple Gourd	Feb-Mar Jun-Jul	70-80 days
Cucumber	Feb-Mar Jun-Jul	50-70 days
Corn	Oct-Nov	60-100 days

Lettuce	Sept-Oct	45-55 days
Radish	Aug-Jan	40-45 days
Pumpkin	Jan-Mar Sept-Dec May-Jun	70-75 days
Bitter Gourd	Feb-Mar Jun-Jul	55-60 days
Okra	Feb-Mar Jun-Jul	45-50 days
Cauliflower (Early)	Mid-June	120-125 days
Capsicum	Nov-Jun May-Jun	95-100 days
Spinach	Sept-Nov Feb	60 days
Peas	Sept-Oct-Nov	55-60 days
Beetroot	Oct-Nov	80-90 days
Turnip	Oct-Nov	40-50 days

Perennial plot

1. Drumstick, Banana, Papaya, Tapioca, Curry leaf and Agathi.
2. 2. It may be observed from the above crop arrangements that throughout the year some crop is grown in each plot without break (Succession cropping) and where ever possible two crops (one long duration and the other a short duration one) are grown together in the same plot (companion cropping).



Layout of Kitchen Garden

Lecture: 3

Tomato

Botanical name : *Solanum lycopersicum*

Primary centre of origin: Peru

Secondary centre of origin: Mexico

Popularly known as: Poor man‟s Orange

Importance and uses:

- The fruits are eaten raw or cooked
- Its large quantities is used to produce soup, juice, ketchup, puree, paste and powder
- It supplies Vitamin A, C, B1, B2 and dried tomato juice retains Vitamin C.
- It adds variety of colour and flavours to the food.

Area and production

The estimated world production of tomato is about 127.92 million tones and area of about 47.19 lakh ha. China ranks first with production of 33.64 million tones leaving USA to second place. The area and production of tomato in our country was about 6.34 lakh ha and 124.33 lakh tones respectively in 2009-10. The leading tomato growing states are UP, Karnataka, Maharashtra, Haryana, Punjab and Bihar.

Climate and soil

Tomato is a warm season crop. It thrives in temperatures between 1°-30°C and is neither tolerant to frost, nor to waterlogged condition. The optimum range of temperature is 20°-24°C, mean temperature below 16°C and above 27°C are not desirable. Lycopene, which is responsible for red colour, is highest at 21°-24°C while the production of this pigment drops off rapidly above 27°C. Soil which is well drained, fairly fertile, rich in organic matter with a fair water-holding capacity is ideal. For early crop, a sandy loam soil is the best, however, for higher yield

Description of popular varieties and hybrids

A large number of tomato determinate and indeterminate varieties have been evolved by various organizations of the country. According to the growth habit, tomato is characterized by two types of plant.

Determinate type dwarf or bush type:

Inflorescence occurs more frequently in almost every internode until terminal ones are formed and elongation ceases at this point, in otherwords, it may be defined as self topping and the main stem terminates with a flower cluster.

Indeterminate type tall type: Inflorescence cluster occurs at every third internodes and main axis continues to grow indefinitely.

Variety/Hybrid IARI, New Delhi	Salient Features Recommended	Areas
Pusa-120	Plants are semi determinate, spreading, late maturing with dark green foliage. Fruits are flattish round, attractive, medium to large, uniform red, less acidic, less seeded, resistant to nematode and suitable for winter and summer seasons.	All over India

	Average yield 300-320 q/ha.	
Pusa Ruby	This is an early maturing variety. Plants are indeterminate with a height of 80-85 cm and spreading habit with few hardy branches. Fruits are flat to round, slightly lobed (4 -5 locules), medium sized, uniform red at maturity with slightly acidic pulp, suitable for fresh consumption and processing. It is ideal for autumn, winter and spring summer seasons. Average yield 280-300 q/ha.	All over India
Pusa Sheetal	Plants are determinate, fruit set successfully under low night temperature (up to 8°C) and suitable for early spring season, fruits are flattish round with yellow stem end, smooth, attractive,medium size, red colour and uniform ripening. Harvesting starts from early March in northern plains. Average yield 350 q/ha.	Bihar, Punjab, Rajasthan, U.P., West Bengal, Delhi, Haryana, H.P. and J&K
Pusa Gaurav	Plants are dwarf, bushy with moderate foliage cover. Fruits are smooth, elliptical (egg-shaped) and borne in clusters. The unripe fruits are firm with thick flesh (0.6 cm) with twowell filled locules facilitating easy transportation over long distances. Whole fruit is suitable for processing and canning as it is without neck constriction and has higher TSS (6%) and better keeping quality at room temperature. It has average yield potential of 330-350 q/ha.	Punjab, U.P., Bihar, Rajasthan, Gujarat, Haryana and Delhi
Pusa Uphar	Plants are indeterminate, prolific bearer, upright, compactwith dark-green foliage; fruits in bunches with 4-6 fruitsper bunch, attractive, round, medium in size, thick skinned and uniform in ripening. Average yield 370 q/ha.	Punjab, U.P., Bihar, Rajasthan, Gujarat, Haryana and Delhi
Pusa Rohini	Fruits with thick pericarp, suitable for long distance transportation. Maturity in 80 days. Average yield 415 q/ha	NCR
Pusa Sadabahar	Determinate, thermo insensitive, fruit set takes place almost round the year, both hot and cold set, Maturity in 60 days. Average yield 350 q/ha.	NCR
Pusa Hybrid-2	Plants are compact, semi determinate with good foliage cover having prolific bearing. Fruits are round to flattishround, firm,	H.P., J&K, Uttarakhand (Garhwal and

	smooth and attractive with uniform red atmaturity. Plants are highly tolerant to root knot nematode. Average yield 600-625 q/ha.	Kumaon), Punjab, U.P., Bihar, Delhi, Goa, Gujarat, Maharashtra,Daman & Diu, Dadra & Nagar Haveli, A.P., Tamil Nadu, Karnataka and Haryana
Pusa Hybrid-4	Plants are determinate, compact with good dark green foliage. Fruits are attractive, round, smooth, average fruit weighing 70-80 g with three locules, thick pericarpand uniform ripening. It has field resistance to root knotnematode. Average yield potential of 425-450 q/ha.	Maharashtra, Jharkhand, Chhattisgarh, A.P., M.P., Odisha, Bihar, Karnataka,Rajasthan, Punjab, Gujarat and Tamil Nadu
Pusa Hybrid-8	Plants are determinate, with green compact foliage and heavy fruit bearer. Fruits are round, medium (75-80 g) withuniform ripening. Average yield 430-450 q/ha.	Punjab, U.P., Bihar and Jharkhand
Pusa Divya	It is a cross between Long style x Roma. Plants are indeterminate, profusely branched; fruits thick skinned,round to oval; first picking in 80 days after transplanting.Average yield 350 q/ha.	Punjab, U.P. and Bihar IIHR Bengaluru
Arka Ananya	High yielding F1 hybrid with combined resistance to Tomato Leaf Curl Virus (TLCV) and bacterial wilt. Fruits are oblate-round, medium (65-70 g), deep red, medium firm fruit suitable for fresh market. Average yield 65-70 t/ha in 140 days.	Punjab, Tarai region of U.P., Bihar, Jharkhand, Chhattisgarh, Odisha, Arunachal Pradesh, Rajasthan, Gujarat, Haryana, Delhi, M.P. and Maharashtra
Arka Vardan	High yielding F1 hybrid with root knot nematode resistance. Developed for fresh market. Average yield 75 t/ha in 160 days	H.P., J&K, Hills of U.P., Punjab, Tarai region of U.P., Bihar, Jharkhand, Karnataka, Tamil Nadu and Kerala
Arka Vishal	High yielding F1 hybrid for fresh market. Average yield 75 t/ha in 160 days.	Punjab, Tarai region of U.P., Bihar, Jharkhand, Karnataka, Tamil Nadu and Kerala
Arka Abhijit	High yielding F1 hybrid with bacterial wilt resistance. Developed for fresh market.	Chhattisgarh, Odisha,

	Average yield 65 t/ha in 140 days	Arunachal Pradesh, Rajasthan, Gujarat, Haryana, Delhi, Karnataka, Tamil Nadu and Kerala
Arka Vikas	Fruits are medium large (80-90 g), oblate with light green shoulder, which develop deep red on ripening. Developed for fresh market Adapted to both rainfed and irrigated conditions. Average yield 35 t/ha.	H.P., J&K, Hills of U.P., Punjab, Tarai region of U.P., Bihar, Jharkhand, Chhattisgarh, Odisha, A.P., Rajasthan, Gujarat, Haryana, Delhi, M.P., Maharashtra, Karnataka, Tamil Nadu and Kerala
Arka Abha	Fruits are oblate with light green shoulder. Fruits have stylar end scar with average fruit weight of 75 g. Develops deep red colour on ripening. Resistant to bacterial wilt caused by Ralstonia solanacearum. Developed for fresh market and average yield 43 t/ha.	All over India
Arka Saurabh	Fruits are medium large, (70-80 g), round with light green shoulder, deep red in colour, firm with nipple tip. Developed for both fresh market and processing. Average yield 30-35 t/ha.	H.P., J&K, Hills of U.P., Punjab, Tarai region of U.P., Bihar, Jharkhand, Chhattisgarh, Odisha, A.P., Rajasthan, Gujarat, Haryana, Delhi, M.P., Maharashtra, Karnataka, Tamil Nadu and Kerala
. Arka Alok	Fruits on the lower clusters square round, large in size, cluster oblong, firm with light green shoulder. Resistant to bacterial wilt. Developed for fresh market. Average yield 46 t/ha.	H.P., J&K, Hills of U.P., Punjab, Tarai region of U.P., Bihar, Jharkhand, Karnataka, Tamil Nadu

		and Kerala
Kashi Vishesh	This variety is resistant to TLCV and has been developed using L. hirsutum f. glabratum B'6013' as donor parent following backcross pedigree selection method. Plants are determinate, dark green, fruits are red, spherical, medium to large size. First harvest at 70-75 days after transplanting. Average yield 400-450 q/ha.	J&K, H.P., Uttarakhand, Punjab, U.P., Bihar, Jharkhand, Chhattisgarh, Odisha, A.P., Karnataka, Tamil Nadu and Kerala
Kashi Amrit	Fruits are round, attractive red and fleshy with an average weight of 108 g. Suitable for cultivation during TOLCV infested period. Average yield 620 q/ha.	U.P., Bihar and Jharkhand
Kashi Hemant	The plants are determinate, fruits are attractive red and round, weight varies from 80 to 85 g. Average yield 400-420 q/ha.	Chhattisgarh, Odisha, A.P. and M.P
Kashi Sharad	Plants are indeterminate, leaves broad, fruits are attractive red, slightly oval, firm, thick pericarp, longer shelf life, weight 90 to 95 g. Average yield 400-500 q/ha.	J&K, H.P. and Uttarakhand
Kashi Anupam	Plants are determinate, fruits are large, flattish round (slightly indented at blossom end of fruit), attractive red with 5-6 locules, medium maturity in 75-80 days after transplanting. Average yield 500-600 q/ha.	Rajasthan, Gujarat and Haryana HAU, Hisar
HS-101	Plant are determinate sturdy, multi-branched, fruit in clusters of 2-3, round, small to medium in size, red at ripening and suitable for winter season. Average yield 250-275 q/ha.	All over India
HS-102	Plant are determinate, fruit in clusters of 3-4, small to medium in size, uniform in ripening and suitable for winter and summer seasons. Average yield 250-275 q/ha.	All over India
Hisar Lalit	Plants are determinate, fruit maturity in 65-70 days after planting, average fruit weight 50 g, resistant to root knot nematode. Average yield 250-300 q/ha.	All over India
Hisar Arun	Plants are determinate, heavy bearer, early and high yielding. Average yield 275-300 q/ha.	All over India

Nursery raising

A net area of about 225m- may be required to raise the seedling for one hectare land. Generally the nursery beds are prepared in the size of 7.5m long, 1.00m width and 10-15cm height. Well decomposed farmyard manure is properly mixed into top soil of the bed at rate of about 3kg/mf. A fertilizer mixture of 0.5kg NPK of 15: 15: 15 per bed is mixed in the soil at least 10 days before sowing the seeds. Normally 400-500g and 125—175g seeds for open pollinated and hybrid respectively are required for the planting of one hectare land. For raising good and healthy seedlings, treatment of the seeds with fungicide like Captan or Cereson or Thiaram @2§/kg seed is essential. Similarly, the seed beds are also treated with steam or Vz litre of 40% formalin/m2 soil. Soon after fumigation the beds are covered with polythene for 24 hours. If the fumigation is not done in the nursery bed, solanzation should be done to minimize the attack of insect pests and diseases. For solarization, cover the nursery bed with a transparent, plastic sheet during the day hours for 10 days. If beds are not sterilized, drench with 0.2% Brassicol or Captan. The seeds are sown in bed either broadcast or in row, at a distance of 7.5cm between the rows. After the sowing, the rows are covered wnh a thin layer of the compost. Thereafter, the beds are irrigated with a rose can. Light watering is required daily in evening. Nowadays the nurseries are being raised in low tunnel and low-cost polyhouse. Use of transparent plastic sheet as low tunnel provides an ideal condi¬ tion for successful raising of seedlings than the conventional method. The utility of low-cost polyhouse for raising of seedling in winter months facilitates trans¬ planting in short time for spring planting in plains. The use of agronets protects the seedlings from insect and reduces the vector borne viruses infestation and damage by other insects. The beds are covered with straw or polythene sheet until the seed germinate. Every week, if required a fungicide such as Dithane M 45 or Difolation 0.25% should be sprayed to reduce the post-emergence damping off

Soil preparation and transplanting: Tomato should be planted in well pulverized field by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. Ploughing should be followed by leveling. Tomato is normally planted in raised beds of 60-75 cm width. Transplanting should be done during late afternoon and the seedlings are placed on side of the beds. This provides ample moisture for the plants to survive.

Seed Rate: Open pollinated varieties: 400-500g and Hybrids: 150-200g

Spacing: Determinate varieties should be transplanted at a spacing of 60cm between rows and 45cm between plants to plant. On the other hand, indeterminate varieties should be planted at a spacing of 90cm between rows and 30cm with in rows.

Manures and fertilizers: Apply well rotten/decomposed farmyard manure (FYM) @ 200-250 quintals per ha at the time of field preparation. In addition, apply 75-100 kg N, 50-75 kg phosphorus (P2O5) and 50-60 kg potassium (K2O) kg per hectare. Apply one third of nitrogen, full dose of phosphorus and half of potassium at the time of planting. Another one third of nitrogen is to be applied after one month of transplanting. Remaining half of potassium should be applied along with one third nitrogen after two months of transplanting.

Table: Recommended dose of N, P and K fertilizers and their time of application

Recommended	Farmyard	Nitrogen	Phosphorus	Potassium

dose				
Open pollinated varieties	250	75-100	50-75	50-60
Hybrids	250	150-180	100-150	80-120

Intercultural and weed control: Tomato is widely space planted crop. Hence, scope of weeds is more in initial stages. The most critical period of crop for weed competition is between 30-50 days after transplanting. Therefore, herbicides can be used to control weeds in initial stages of plant growth while hand weeding can be practiced in later stages of plant growth alongwith fertilizer top dressings. Application of Alachlor (Lasso) @ 2kg a.i./ha (4 litres/ha in 750 litres of water) before transplanting is beneficial for controlling annual and broad leaved weeds. Pendimethalin (Stomp) @1.2 kg a.i./ha (4 litres/ha) or Fluchloralin (Basalin) @ 1.32 kg a.i./ha (2.5 litres/ha) can also be used before transplanting if there is problem of annual weeds only.

Use of growth hormones:

 Flower cluster and whole plant sprays with GA3 **at** 50 and 100 ppm hastens fruit set and advanced harvesting by one week.

 Seedling treatment with NAA (0.1 ppm) gave better quality fruits. Seedling treatment by soaking them for 24 hours in dark in NAA at 0.1 ppm showed higher fruit set, early and increased total yield.

Irrigation: Careful irrigation is required for better growth of tomato crop which should be sapplied at right time. Both over-watering and insufficient irrigation is harmful. Insufficient irrigation in tomato arrests flower development, dropping of flowers and cease fruit growth. Flowering and fruit development are the most critical stages of irrigation.

Harvesting: Tomato fruits are harvested at different maturity stages depending upon the purpose for which it is used and distance over which they are to be transported. Fully developed mature green fruits are harvested for long distance transportation. Such fruits ripen after reaching the market and develop good colour under favourable conditions. The following stages of maturity have been recognized in tomato:

1. Immature green stage: Fruits are green but have attained the normal size. The seeds are not fully developed and not covered with jelly like substances. The fruits do not give the actual colour. The fruits are harvested at this stage when they are to be transported over a long-long distance.

2. Mature green stage: the fully grown fruits with a brownish ring at stem scar, removal of calyx, light green colour at blossom end changes to yellowish green and seeds are surrounded by jelly like substances filling the seed cavity. Fruits develop good colour when ripen under favourable conditions. Harvested for long distance transportation and ripen after reaching the market

3. Turning stage (breaker stage): 1/4th of the fruit especially at blossom end shows pink colour. These fruits are harvested for local market.

4. Pink stage: 3/4th of the surface shows pink colour

5. Hard ripe stage: Nearly all red or pink with firm flesh

6. Over ripe: Fully coloured and soft. Suitable for processing and ensure desired quality and red colour in product. Fruits at turning stage (1/4th of the fruit especially at blossom end shows pink colour), pink stage (3/4th of the surface shows pink colour) and hard ripe stage (nearly all red or pink with firm flesh) are harvested for local market. Over ripe fruits (Fully coloured and soft) are suitable for processing which ensure desired quality and red col.our in processed products.

Fruit Yield: Open pollinated varieties: 250 – 300 quintals per hectare

Hybrids: 500-800 quintals per hectare

Physiological disorders in tomato:

Physiological disorders differ from disease infestation as they are non-parasitic and are the result of abiotic stresses which may be due to adverse weather conditions or nutritional deficiencies or improper cultural practices.

1. Blossom End Rot: A very common and destructive disorder. Rotting of fruits starts at blossom end of the fruit. Deficiency of Mg and Ca is the main cause. It can be managed by spraying calcium chloride @ 0.5% at fruit development stage. Also apply balanced irrigation and ensure proper staking.

2. Cracking of fruits: Cracking of fruits at stem end is common and often results in large losses. Cracks appear to develop at maturity or ripening stage than mature green or turning stage. Deficiency of boron and long dry spell followed by heavy watering are the main reason of cracking. Soil application of 20-30 kg of borax per hectare is beneficial. Application of proper irrigation at right stage is also very important.

3. Puffiness/ Hollowness: The outer wall continues to develop but the growth of remaining internal tissues is retarded. This results in light weight fruits which lack firmness and are partially filled. High or low temperature, low soil temperature and high soil moisture are predisposing factors**.** Single application of 4-CPA @ 20mg/litre or CPPU @ 20-25mg/litre results in reduction of this problem.

4. Sunscald: Exposed fruits either green or nearing ripeness scald readily during extreme heat. White or grey colour appears on green or yellowish red fruits. More sun intensity cause injury to fruits in May & June (11-3 pm) during peak heat period. Grow varieties having heavy foliage which provide greater protection to fruits from sun rays.

5. Cold Injury or Low temperature injury: Tomato is very sensitive to frost. At near freezing temperature, vines freeze, get withered and desiccated. Fruits show much severe symptoms as they become soft, water soaked and dull coloured. Cover the fruits with foliage to manage this problem. Planting should be adjusted in such a way that it does not coincide with frost.

6. Blotchy Ripening: Ripening of fruits is not uniform as certain portion develop colour while in others greenish-yellow or whitish patches can be seen on ripe fruits particularly in stem end portion. The possible reasons are imbalance of N and K nutrition especially when K is deficient. Even, more days or weeks of alternate sun and cloud during fruiting also lead to blotchy ripening. Balanced fertilization and proper irrigation help in managing this problem.

Lecture: 4

Brinjal

Botanical name: *Solanum melongena*

Family: Solanaceae

Origin: South East Asia-India.

Brinjal is also known as "Poor man‟s crop". The other names of brinjal are "Aubergine", "Guinea squash", Egg plant. Bitterness in brinjal is due to Solasodine

Importance and uses

It is valued for its tender unripe fruits used as a cooked vegetable.

White brinjal is said to be good for diabetic patients.

It cures toothache if fruits are fried in sesamum oil.

It acts as an excellent remedy for those suffering from liver complaints.

It is rich in vitamin A and B.

Distribution, area and production

In addition to India, other major bnnjal producing countries are China,Turkey, Japan, Egypt, Italy, Indonesia, Iraq, Syria, Spain and Phillipines. India contributes 6, 44,3062mt to the global production of bnnjal and ranks second to China. Bnnjal covers 8.14/o of total vegetable area and produces 9% of total vegetable production in India.

In India it is well distributed in Orissa, Bihar, Karnataka, West Bengal, Andhra Pradesh, Maharashtra and Uttar Pradesh. The total area, production and productivity/ha as given in the Yearbook of National Horticultural Board, New Delhi is presented in Table

Soil: It can be grown practically on all soils from light sandy to heavy clay. Silt loam and clay loam soils are generally preferred. The soil should be deep, fertile and well drained. pH 5.5-6.8.

Climate: It is a warm season crop and susceptible to severe frost. A long and warm growing season is desirable for its successful cultivation. It grows best at a temperature of 21-29 oC. Temperature below optimum (21oC) affects yield and quality and result in deformed fruits. It can tolerate drought and excessive rainfall and remains vegetative under high temperature and humidity.

Improved varieties:

- IARI: Pusa Shymala, Pusa Purple Long, Pusa Purple Cluster, Pusa Kranti, Pusa Bhairav, Pusa Anmol (H), Pusa Hybrid 5 (long), Pusa Hybrid 6 & 9 (round),
- IIHR: Arka Sheel, Arka Shirish, Arka Kusumkar, Arka Navneet (Hybrid), Arka Nidhi, Arka Keshav, Arka Neelkanth
- IIVR :

  Long fruited: Kashi Manohar,Kashi Shyama,kashi Taru,Kashi green long,kashi ganesh

  Round Fruited: Kashi Vijay,Kashi modak,(Kashi sandesh F1)

(Kashi Himani-Oblong fruited)

- PAU: Punjab Chamkila, Punjab Sadabahar, Punjab Barsati, Punjab Neelam, PH-4, Selection-4,
- GBPUAT, Pantnagar: Pant Samrat, Pant Rituraj, Pant Brinjal Hybid-1
- Others: Hisar Jamuni, Hisar Shyamal Azad Kranti, T-3, Annamalai, Surya, Phule Hybrid 1, Aruna, Manjarigota

Nursery sowing and planting time:

Crop/region	**Spring-summer**	**Rainy**	**Autumn crop**
NI plain	Nov(mid Jan-Feb)	Mar-may(April-June)	June-July(July-Aug)
East and south Indian condition: year the round. Main season: July- August			

- Shoot and fruit borer- serious problem in Spring-summer crop
- Little leaf and Phomopsis blight- Autumn winter and much more serious in rainy season crop

Raising of nursery: As such Tomato

Soil preparation and transplanting: Brinjal should be planted in well pulverized field by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. Ploughing should be followed by leveling.
Seed Rate: 500-700g (OP), 350-400g (hybrids) 1g seed contains 250 seeds
Planting distance: Dwarf varieties- 60 × 45 cm, Tall variety- 90 × 60 cm

Manures and fertilizers: FYM @200-250 quintals per ha should be applied at the time of field preparation. In addition, apply 75-100 kg N, 50-60 kg phosphorus (P2O5) and 50-60 kg potassium (K_2O) kg per hectare. Apply half of nitrogen and full dose of phosphorus and potassium at the time of sowing and remaining nitrogen after one month of sowing.

Irrigation: Same as tomato crop. Apply Irrigation at an interval of one week in summer season and 10-15 days during winter. In rainy season, it depends upon the frequency and intensity of rain. About 100-110 cm of irrigation water is required.
Weed management: Like tomato, brinjal is also a widely space planted crop. Hence, scope of weeds is more in initial stages. The most critical period of crop for weed competition is between 30-50 days after transplanting.

Fruit set in brinjal is affected by flower type**.** Four types of flower are formed in brinjal based on style length such as
1. **True short style**: Ovary rudimentary, stigma is at the base of anthers- no fruit set.
2**. Pseudo short style:** Ovary is not well developed (rudimentary), stigma is half way up the anthers- no fruit set but can set if growth regulators are applied.
3**. Medium styled:** Ovary is well developed and pollination is normal. Stigma is near tip of anthers (30-40% fruit setting).
4**. Long styled:** Big size ovary, stigma proturate or exserted beyond the anther tip, more fruit set under natural conditions (50-60%).

Medium and long style flowers form fruit under natural conditions. Therefore, PGRs can be sprayed to enhance fruit set in brinjal *e.g.* NAA (50ppm) after 30-35 days of transplanting or PCPA (20 ppm).

Harvesting: Fruits should be harvested when they attain a good size, attractive colour and its surface should not loose its bright and glossy appearance. Timely harvesting of tender fruits increases the total growing period and number of pickings alongwith yield.
Yield: 300-500 q/ha (OP var.), Hybrids: 600-800 q/ha

PHYSIOLOGICAL DISORDER

1. Calyx withering
This disorder occurs between mid-February and mid - April. The affected fruits
become reddish brown in colour and lacking in normal luster and thus marketability of fruits
is hampered. The affected fruits have much higher calcium and nitrate content than healthy
Ones.

Lecture: 5

Chilli and Bell pepper

Botanical Name: *Capsicum annuum var. hortense* (chilli)
Capsicum annuum var. grossum (Bell pepper)
Family: Solanaceae
Origin: New world (American) – Mexico and surroundings of central America
Red colour of chilli fruit is due to capsanthin which is used as natural colourant. Oleoresin extracted from chilli is used in cosmetic products indicating its industrial importance

Types of Capsicum

a. **Hot pepper:** Pungent due to crystalline volatile alkaloid capsaicin, located mainly in the placenta of fruit, cultivated for vegetables, spices and pickles *etc.*, potential foreign exchange earning crop, and rich source of vitamin A and C.

b.Sweet Pepper (Shimla Mirch): Bears bell shaped, non pungent/mild and thick pericarp/fleshed fruit, used as vegetable

c. Paprika: Mild in taste and slightly pungent than sweet pepper. Used as spice in European countries, gives colour and mild pungent taste to food stuff, used in pickles and sandwiches

Importance and uses

Chillies

It is very important and indispensable items in every kitchen for its pungency, spicy taste and appealing colour which adds to the food. Its demand in the pharmaceutical industries is increasing day by day on account of its medicinal values since green chillies are rich in rutin. The fruits are rich in vitamins A and C.

Bell pepper or Shimla Mirch

Sweet pepper green, or red or yellow, may be eaten cooked or raw, sliced in salads and pizzas.

They are also used for pickling in brine, baking and stuffing.

Sweet pepper imparts a novel flavour in stews

Area and production

Chillies and capsicums both belong to the same capsicum species of Capsicum annuum. Chilli also known as hot pepper was introduced into India from Brazil in the 16th Century by the Portuguese. Within a span of over four centuries it has spread to an area of around 0.8 million covering almost all states of the country. The major chilli growing states are Andhra Pradesh, Karnataka, Maharastra, Orissa, Tamil Nadu, Madhya Pradesh, West Bengal and Rajasthan in that order and account for more than 80% of the total area and production. The area and production keeps varying depending on price in the previous year and the weather conditions. Area has been varying between 0.982-0.816 million ha and production 61,82,000 and 86,200 tonnes of dry chilli. Andhra Pradesh has been leading both in area and production contributing on an average of 25% of the total area and over 40-50% of the total production. The major chilli growing districts in different states are given in Table 1. Chillies have adapted very well to the Indian conditions so much so that India is considered as secondary centre of origin.

Climate: Chilli requires a warm humid climate and can tolerate extreme of climate better than tomato and brinjal. It is highly sensitive to frost. The most ideal temperature for its better growth and development is 20-25 oC. Temperature 16-32 oC is the most congenial for fruit set but maximum fruit set occurs at 16-21oC. It is mostly grown as a rainfed crop in areas having moderate rainfall with in the range of 60-120cm. Excessive rainfall results in poor fruit set, rotting of fruits and defoliation of plant.

Soil: Chilli can be grown practically on all type of soils except on saline soils provided the soil is well drained and well aerated. Sandy and sandy loam soils are generally preferred for an early crop or where season is short. The soil should be deep, fertile and well drained. It can be raised on the soil with a pH range of 5.8-6.5 for its better growth and development. It is not very sensitive to soil acidity.

Varieties

Chilli: G-3, Pusa Jwala, Pusa Sadabahar, Bhagya Lakshmi (G-4), HC-28, HC-44, Andhra Jyoti, Punjab Lal, Punjab Surkha, Punjab Guchhedar, NP-46A, Pant-C-1, Sindhur, Pant-C-2, X-235,

Chilli hybrids: CH-1, CH-3, Arka Meghana, Arka Harita, Arka Sweta, CCH-2, CCH-3

Bell Pepper: California Wonder, Yolo Wonder, Arka Mohini, Solan Hybrid 2, Arka Basant, Arka Gourav, Bharat (hybrid), Solan Bharpur, Pusa Deepti (hybrid)

Planting time under Indian condition:

Chilli	
In frost free areas	1.Autumn-winter(oct-Nov) 2.Spring –summer(Jan-Feb) 3.Rainy season(June-July)
Northern Indian plains	1.December sowing (Feb) 2.May-june(June-July)
Bell pepper	
North Indian	1.Autumn-winter(Sowing in Aug) 2.Spring –summer(Nov)
South Indian	Extreme of temperature does not prevail so can grown for quite long from June- Feb.

Transplanting techniques**:** Seedlings are ready for transplanting when they attain a height of 15cm with 4 leaves in 4-6 weeks. Plantation is done on flat or raised (rainfall prone areas) beds transplanting should be done during late afternoon

Seed rate:

Crop	**Seed rate**
Chilli	1kg/ha 2-3kg/ha for direct seeded
Hybrid	400-500gm/ha
Capsicum	1.25kg/ha seed is bold
Hybrid	700gm/ha

Spacing:

Chilli 45X45 or 60X45 cm

Capsicum: 60x45cm

Manures and fertilizers: Apply FYM @250q/ha, Nitrogen @ 75 kg/ha, Phosphorus @ 60-75kg/ha and Potassium @ 50 kg/ha. Full dose of farmyard manure, phosphorus and potassium and half of N should be applied at the time of transplanting. Remaining part of N should be top dressed in two equal parts at an interval of one month each.

Irrigation: Chillies are grown mostly as rainfed crop though crop should be irrigated when there is insufficient rainfall. A light irrigation is given during the third day of transplanting and thereafter at weekly interval. Gap filling is done during second

irrigation after 10 days of transplanting. The most critical stages for irrigation are blooming (flowering), fruit setting and development

Weed management: Weed intensity is generally more in red soils than in black soils in the same locality. Weed intensity is high when the crop is grown during kharif season than in Rabi or summer months. Though cultural methods of weed control is widely followed, with the increase in labour wage and scarcity of laborers and some times increased rains preventing these

operations, using herbicides or combination of both herbicide and cultural operations are becoming more popular. A large number of herbicides have been tried, both for transplanted and direct sown chilli crop. Among the herbicides tried, dephenamide, trifluralin, EPTC, Nitrofen had given good results in chilli crop. Various mulches such as saw dust, gravels, crop residues, plastic films etc are used to control weed population.

Harvesting

Chilli: The picking of fruits depends upon the type and purpose for which they are grown

1. Green fruits: Fruits are harvested when they are still green but fully grown. It needs 5-6 pickings for harvesting the whole crop.
2. Pickles: The fruits are harvested either green or ripe
3. Drying: Red when fully ripe fruits are picked at an interval of 1-2 weeks and harvesting continues for a period of about three months. The ripe chillies are dried under sun for 8-15 days, while commercially it is dried at about 54.4 oC in 2-3 days.

Bell peppers: Fruits are usually harvested and sold when they are of suitable market size and

are green, and are relatively firm and crisp. There is a limited demand for the mature red fruits. These are picked with an upward twist which leaves a piece of stem attached. Young, immature peppers are soft and yield readily to mild pressure of the fingers.

Lecture: 6

Cucurbitaceous Crops

Importance

- Cucurbits form an important and a big group of vegetable crops cultivated extensively during summer season.
- This group consist as of wide range of vegetables which are used either as salad, pickling (cucumber) or for cooking (all gourds) or candied or preserved (ash gourd) or as desert fruits (musk melon and water melon).

- All cucurbits belong to the same family cucurbitaceae but genera may be different.
- The cultural requirements of all crops in this group are more or less similar.

Soil: A well drained soil of loamy type is preferred for cucurbits. Lighter soils which warm quickly in spring are usually utilized for early yields while heavier soils are suitable for more vine growth and late maturity of the fruits. In sandy river beds, alluvial substrata and subterranean moisture of river streams support the cultivation of cucurbits. The soil should not crack in summer and should not be waterlogged in the rainy season. It is important that soil should be fertile and rich in organic matter. The most suitable pH range is between 6.0 and 7.0

Climate: Cucurbits are warm season crops. They do not withstand even light frost and strong winds though cucumber tolerates a slightly cooler weather than melons. Seed does not germinate below 11oC, optimum germination occurs at 18oC and germination increases with rise in temperature till 30oC. Cucurbits grow best at a temperature range of 18-24oC. Proper sunshine and low humidity are ideal for the production of cucumber. Melons prefer tropical climate with high temperature during fruit development with day temperature of 35-40oC. Cool nights and warm days give better quality fruits in melons.

Varieties:

Crop Name	**Botanical name& Chro.No**	**Origin**	**Varieties:**
Cucumber	(Cucumis sativus) 2n=14	India	Japanese Long Green, Pusa Uday, Pusa Barkha, Pant Kheera-1, Pusa Sanyog (F1 hybrid,) Poinsette,shetal.priya
Bottle Gourd	(*Lagenaria siceraria*) (2n = 22)	Africa	Pusa Naveen, Pusa Samridhi, Pusa Sandesh, Pusa Santushti, Pusa Hybrid 3, Punjab Round, Punjab Komal, Punjab Long, Arka Bahar
Bitter Gourd	(*Momordica charantia*) (2n = 22)	Tropics of the old world	Arka Harit, Pusa Do Mausami, Pusa Vishesh, Pusa Hybrid-2, Coimbtore Long, Kalyanpur Baramasi,
Sponge Gourd	(Lufa cylindrica) (2n = 26)	India	Pusa Sneha, Pusa Supriya, Pusa Chikni
Ridge Gourd	(L. acutangula) (2n = 26)	India	Pusa Nutan, Pusa Nasdar, Arka Sumeet, Arka Sujat, **Satputia** (hermophrodite flower)

Ash Gourd	(*Benincasa hispida*) (2n = 24)	Japan Pusa and Jawa	Pusa Ujjawal, Co-1, Co-2, S-1 (PAU),
Snake Gourd	(*Trichosanthes anguina*) (2n = 24)	India	Co-1, Co-4, TA-19, Chichinda
Water melon	(*Citrullus lunatus*) (2n = 22)	Africa	Arka Jyoti (F1), Arka Manik, Sugar Baby, Durgapur Meetha, Durgapur Kesar, Asahi Yamato
Musk melon	(Cucumis melo) (2n = 24)	North west India and hot valleys of Iran	Pusa Madhuras, Pusa Sharbati, Hara Madhu, Punjab Rasila, Punjab Sunheri, Punjab Hybrid, Arka Jeet, Arka Rajhans, Hisar Madhu, Durgapur Madhu, Kashi Madhu

Agronomic practices

Sowing Times:

- In northern plains, most of the cucurbits are sown during winter season *i.e.* in the month of November (in the riverbeds).
- In the garden soils, sowing is done in February.
- Melons are grown only when the weather is warm and dry during fruit development *i.e.* November to February.
- For rainy season, grow only those cucurbits which can tolerate rains. *e.g.* bitter gourd in June-July.
- In north-eastern states most of the cucurbits are sown from November to March when the weather is comparatively dry.
- In southern and central India, winters are not severe and long, therefore, these can be grown throughout the year. November sown crop is over by March-April
- In Northern Indian hills, sowings start from April-May and the crop is over by August-September.
- In western India, sowings are done from September upto February

Methods of planting: Mostly in cucurbits, *in situ* method of sowing is followed. But in certain areas of Northern India and hills where the main objective is to get early fruit harvest, the seedlings are raised in polythene tubes and plantation is done in the field when the conditions are favourable without disturbing the soil ball. Transplanting is done at 2 true leaves stage.

1. Furrow method: Furrows are made at 1 to 1.5 m in case of cucumber and bitter gourd. The sowing is usually done on the top of the sides of furrows and the vines are allowed to trail on the ground especially in summer season.

2. Bed method: In some regions, bed system is in fashion where the seeds are sown on the periphery of beds. The width of the bed is almost double to the row to row spacing.

3. Hill method or raised beds or raised point: The hills are spaced at a distance of 0.5-0.75m and 2-3 seeds are sown per hill, after germination retain only one or two plants per hill. This method facilitates proper drainage especially in heavy rainfall regions.

4. Pit Method: Generally, it is followed in southern India. The pit is lower than the normal bed surface. Training is done by Pargolla or Pandal system.

Seed rate, Spacing and yield:

Crop Name	**Season**	**Seed rat(kg/ha)**	**Spacing (m)**	**Yield (q/ha)**
Cucumber	Summer/rainy	2.5-3.5	1.5 × 0.60-0.90	250-300
Bottle Gourd	Summer/rainy	4-5	2-3 × 1-1.5	300-400
Bitter Gourd	Summer/rainy	4-6	1.5-2.5 × 0.60-1.20	150-200
Sponge Gourd	Summer/rainy	2.5-3.0	2.50-3.00 × 0.60-1.20	150-200
Ridge Gourd	Summer/rainy	3-3.5	2.50-3.00 × 0.60-1.20	150-200
Ash Gourd	Summer/rainy	3-3.5	1.5-2.5 × 0.60-1.20	200-250
Snake Gourd	Summer/rainy	5-7	1.5- 3 × 0.6-1.2	100-150
Water melon	Summer	3-4	2.5-3.5 × 0.90-1.20	300-500
Musk melon	Summer	1.5-2.0	1.50-2.0 × 0.60-0.90	150-200

Chow –Chow (*Sechium edule*) is a perennial crops propagated by viviparous single seed fruits. **Vivipary:** Seed germinates inside the fruit while still attached to the parent tree and nourished by it.

Manures and fertilizers:

Farmyard manure (q/ha)	**Nitrogen (N)**	**Phasphorus (P)**	**Potassium(K_2O)**
	Kg/ha		
200-250	60-100	50-75	50-85

Full dose of farmyard manure, phosphorus and half of potassium and N should be applied at the time of sowing. Remaining part of N should be top dressed in two equal parts after one month and at flowering stage while half of K is applied when good growth takes place.

Interculture and weed management: Thinning of plants should be done 10-15 days after sowing retaining not more than 2 healthy seedlings per hill. The beds or ridges are required to be kept weed free in the early stages before vine growth start. Weeding and earthing up are done at the time of top dressing of split application of nitrogenous fertilizers. Apply Fluchloralin or Trifluralin @ 0.75-1.0 kg/ha or Bensulide @ 5-8 kg/ha as preplant soil incorporation at 2 weeks before sowing. Butachlor @ 1 kg/ha or chloramban @ 2-3 kg/ha aspre emergence & Naptalam @ 2-4 kg/ha as post emergence after first weeding efficiently helps in controlling the weeds in cucurbitaceous crops. In general, vertical training is more helpful in increasing the yield of cucumber

Irrigation: In spring-summer crop, frequency of irrigation is very important, while in rainy season crop, well distributed rainfall between July to September reduces the frequency of irrigations. Ridges or hills or beds are to be irrigated a day or two prior to sowing of seeds and then light irrigation is to be given 4 or 5 days after sowing. Flooding of hills is to be avoided and crust formation of the top soil should be prevented. Irrigation once in 5 or 6 days is necessary depending upon soil, location, temperature etc. Irrigation water should not wet the vines or vegetative parts, especially when flowering, fruit set and fruit developments are in progress. Wetting will promote diseases and rotting of fruits, so it is essential to keep beds or inter row spaces dry as far as possible so that developing fruits are not damaged. In rainy season, therefore, these crops are trailed over supports to prevent rotting of fruits

Sex expression and sex ratio: It is of great significance in most of the cucurbitaceous crops
which have monoecious plants that means they bear male and female flowers separately on the same plant. In the beginning, monoecious plants bear only male flowers and female flowers appear late. The female to male ratio goes on increasing with the age of the plant. Though sex expression and sex ratio are varietal characteristics but they are influenced by environmental conditions. Low fertility, high temperature, and long light periods induce maleness.

- Gibberellic acid (GA) at higher concentration induces maleness but at lower concentration of 10-25 ppm increases the number of female flowers.

- Two sprays, first at 2-leaf stage and again at 4 –leaf stage with 100 ppm of NAA, 200 ppm of etheral, 3 ppm of Boron or 3 ppm of Molybdenum can suppress the number of male flowers and increases the number of female flowers, fruit set & ultimate yield.
- Silver nitrate sprays induces male flowers.

Harvesting:

- Harvesting of crop at right time is very important in cucurbits as in most cases, seed

development is undesirable.

- Harvest cucumber, bottle gourd, bitter gourd, snake gourd, ridge gourd and sponge gourd when they are still young, tender and have soft seeds inside.
- Harvest before fruit colour changes from green to yellow.

Musk melon: It is a climacteric fruit which ripe during transportation and storage. Hence, it should be harvested before it attains fully ripe stage. Full slip stage i.e. a crack develops around the peduncle at the base of the fruit and when fully ripe the fruit slips easily from the stem. Half slip stage: Only a portion of the disc is removed when the fruit is pulled out. The scar on the fruit is smaller than the full slip stage.

Water melon: It is harvested at fully ripe stage. Maturity signs are withering of tendril, change in belly color or ground spot to yellow and the thumping test produce dull sound on maturity and metallic sound in unripe fruits.

River bed cultivation

Cucurbits have following salient features which make them fit for river bed cultivation:

1. Long tap root system which makes use of subterranean moisture.

2. These are more space planted crops, less no. of plants per unit area are to be managed.

3. Hot & dry weather with maximum sunshine prevails right from March-June/July which is an essential requirement for melons.

It is kind of vegetable forcing being used in India where cucurbits are sown during winter season in the river beds.

- Pits or trenches are made during October-November.
- They are of convenient length, 30 cm wide and 60 cm deep or to a depth at which the sand is moist.
- A distance of nearly 2-3 m is kept between the trenches.
- Normally, 3-4 pre-germinated seeds are planted/hill in pits or trenches.
- Before sowing, the trenches are manured with FYM.
- Sprouted seeds are carefully sown. Spot watering during the initial stages is essential.
- Protection from low temperature/chilling winds during Dec-Jan (1-2 oC) is provided probably from *Saccharam* spp. on north side of the pit. It serves following purposes:

i. Checks the sand drifting on dug up trenches.

ii. Provide protection against chilly winds.

iii. This grass spread over the sand later on & vines spread over this grass.

iv. Sand does not blow off in hot months.

 Fruits from river bed are available 30-50 days before then the normal field sown crop.

Problems: Leaching of nutrients, Risk if floods due to winter rains, Occurrence of diseases & Fruits having undesirable quality due to inbreeding depression.

Lecture: 7

French bean

Phaseolus vulgaris

2n = 22

Brief about origin: South and central America

The French bean (Pbaseolus vulguns L.), also known as kindey bean, haricot bean, snap bean, navy bean, is one of the most important leguminous vegetable. It is grown for the tender green beans and dry beans (Rujmahy The pods are slender, 10-25cm long, straight or slightly curved with prominent beak. Seeds are kidney¬ shaped, elongated but somewhat compressed and white, red, purple or blackish in color or mottled. This vegetable is in great demand in citie's and is grown both commercially and in home gardens.

Brief about origin: Southern Mexico and central America are the primary centres of origin of french bean while Peruvian-Equadorian-Bolivian areas are considered to be secondary centres. Phaseolus aboriginens is the progenitor of Phaseolus vulgaris.

Climate:
Most of the french bean varieties are day neutrals except some semi-pole varie¬ ties which are short-day types. It is a cool weather crop but thrives well in the optimum temperature ranging between 15° and 25°C. The crop is sensitive to frost, high temperatures and high rainfall. The plants shed their blossom or young pods in very hot or rainy weather. The pole-types are generally grown in heavy rainfall areas of Chhotanagpur and Uttar Pradesh.
Soil:
French bean can be grown in all types of soils ranging from light sandy loam to clay soils but it cannot withstand water-logging. The highest yield is obtained in soils with a pH between 5.3 and 6.0. Extremely acidic and alkaline Soils are not suitable.
Improved varieties:

French bean cultivars are classified into string and stringless based on the ex¬ tent of fibre in the pod and into bush and pole-types according to the growth habit. Some commercially grown cultivars are given below.

Kentucky wonder: It is a pole type introduced from USA with long, flat, string less pods, yields 10-12.5 tonnes/ha.

Contender: Pods are round, green stringless, slightly curved, introduced from USA, yields 8-9.5 tonnes/ha, tolerant to powdery mildew and mosaic.

Pusa Parvati: Early bearing, string less, yield 8-8.5 tonnes/ha, resistant to mo¬ saic and powdery mildew.

Arka Kornal: Straight, flat, tender pods yield 9 tonnes/ha. Pant Anupama, Arka Suvidha (IHR 909), IHR 220, Top Crop and Tweed Wonder are some of the im¬ proved varieties cultivated in different states.

TKD 1: It is a hybrid derivative of a cross between two pole types, viz Sel 1 and PV 118. The green tender pod yield ranges from 5-6 tonnes/ha and matures in 90-100 days.

KKL 1: it is a pole type best suited for elevation of 1,800-2,400m. It has a potencial yield of 7 tonnes of pods or 3 tonnes of grains per hectare.

YED 1: It can give a green pod yield of 9.75 tonnes/ha. Seeds are bold, attrac¬ tive and dark-purple in colour.

Seed Rate: (kg/ha): 80-90 (Bush type) and 30-40 (Pole type)

Seed inoculation: Rhizobium culture can be used to inoculate the seed before sowing. This seed inoculation helps in quick nodulation on the roots which inturn fix atmospheric nitrogen

Time of sowing:

There are two main growing seasons for french bean in the plains of India. The first sowing is done in July-September and may even extend up to October. The second sowing is in early spring that is between January-February. In hilly regions, the sowing is done from March to the beginning of May.

Spacing (inter- row x intra-row) 45cm X 15 cm (Bush type) and 90cm X 10-15cm (Pole type)

Manures and fertilizers: Farmyard manure **@**200-250 q/ha is applied at the time of field preparation. The full dose of recommended fertilizers *i.e.* 30-50 kg N, 60-100 kg P2O5 and 30-60 kg K2 O /ha should be applied at the time of sowing.

Irrigation: French bean is a shallow rooted crop. Water-stress has marked influence on yield and quality of pods. About 6-7 irrigations during the growing season would be requied at regular intervals. Flowering and pod development periods are the critical stages. Depending on the atmospheric conditions, the seasonal water requirement may range from 300-350mm/ha of water. For higher yields, the crop should be irrigated as soon as the soil-moisture tension reaches 0.5cm in the top10cm of the soil.

Weed management: Shallow cultivation during the early stages of crop is necessary to check t e weeds and to facilitate earthing up. A pre-sowing application of Fluchloralin at the rate of 2 litre/ha checks the weed growth for 20-25 days. At least two hand weedings are required before earthing up. At the later stages of crop growth, the weeds are kept under check due to the thick canopy of the crop.

Harvesting: The crop is ready for first harvest in about 45 days after sowing. It takes about 7-12 days after flowering for the pods to be ready for picking. About three pick¬ ings in bush beans and five pickings in case of pole beans are taken. 1 he green pods are to be picked when they are immature and fully grown but still tender. As the harvest is delayed, the total yield increases but the quality falls rapidly due to over maturity of pods, fibre development and rough surface. Somtimes, fresh seeds from over mature pods can be shelled and used..

Yield: The yield of tender pods vary from 8-10 tonnes/ha in bush varieties and 12-15 tonnes in pole types

Physiological disorders:

1. Transverse Cotyledon Cracking: This is a major disorder in French bean. It is enhanced by planting dry seeds in wet soil. White seeded varieties are more prone. Hard seed coat is essential for resistance to this disorder and seed coat shattering. Therefore, seed containing 12% moisture has better germination.

2. Hypocotyl necrosis: It means death of hypocotyls tissues. It is associated with low Ca and Mg content in the seed.

Lecture: 8

Garden Pea
Botanical Name: *Pisum sativum L.*
Family: Fabaceae

Pea is highly nutritive containing high percentage of digestible protein (very valuable for the vegetarians) alongwith carbohydrates and vitamins A and C.
□□It is also very rich in minerals Ca and P.

□□It is an excellent food for human consumption taken either as a vegetable or in soup.
□□Large proportion is processed (canned, frozen or dehydrated) for consumption in the off-season.
□□Being N fixing legume, it is recognized as a soil building crop
□□Pea is being used in a growing snack market.

Brief about origin: Central Asia, the Near East, Abyssinia and the Mediterranean are the centres of origin for peas (Vavilov, 1926). *Pisum elatius*, a wild species is considered as the ancestor of *pisum sativum*.

Climate: It is a cool weather crop and grows best at the opdmum mean monthly tem¬ perature of 10°-18°C. The seed can germinate even at a minimum temperature of 5°C and the optimum temperature for germinadon is about 22°C. At higer tem¬ perature, the germination is rapid but plant stand is affected due to decay. The plants are able to withstand reladvely low temperatures especially during the early stage but may not withstand a severe continued frost. Hot dry weather interferes with pollination and seed setting, affects the number of pods per plant, pod weight and lowers the quality of pods produced due to the conversion of sugars into hemicellulose and starch.

Soil: Garden peas can be grown on a wide range of soils. However they thrive best on well drained, loose and friable loamy soils. Early crop can be obtained in light soils and higher yields are expected in heavy soils. The most favourable range of soil pH is from 5.5-6.0. Application of domestic lime stone is recommended in acid soils.

Improved varieties: Varieties

Pea cultivars are grouped on the basis of seed into smooth or wrinlke seeded types; bush, medium tall and tall types based on height and early, mid-season and late cultivars according to maturity. I|n early types, pods mature in 50 days, in mid¬ season types in 60-65 days and in late types 70-75 days. Usually, dwarf types are early, mid-season types are medium tall and late types are tall and require support.

Early group

Asauji: It is smooth seeded cultivar suitable for early sowing.

Arkel: It is a most popular exotic pea introduced from England and occupies a large area in India, it yeilds 5 tonnes/ha and plants are susceptible to collar rot.

Jawahdr matar 3 and 4: These varieties have bold wrinkled seeds and yield 4—6 tonnes/ha.

Mid-season group

Bonneville: It is a popular variety in India introduced from USA and yield 10 tonnes/ha. Plants are susceptable to powdery mildew.

Arka Ajit: It was developed by IIHR, Bangalore as a variety resistant to pow¬ dery meldew and rust and yield 10 tonnes/ha in 90 days.

Jawahar matar 1 and2: These varieties have bigger pods and yield 10-12 tonnes/ ha. The plants are susceptible to powdery mildew.

UN 53 (6): It is a snap pea (whole pod edible) line developed by IIHR, Bangalore, and yields 8-9 tonnes/ha in a crop duration of 90 days.

Ooty 1: It is a pure line selection from the accession PS 33 among the germplasm maintained at TNAU, horticultural Research Station, Ooty with a crop duration of 90 days. It is dwarf type with an yeild potential of 11.9 tonnes/ha. It is resistant to white fly.

Cultivation practices:

Time of sowing: Generally, pea is sown from beginning of October to mid-November in the plains of northern India. The crops sown earlier or later suffer from wilt and mildew attacks respecively. Peas can be grown as early as June-July in Peninsular India. In the hills, peas are sown in March for a summer crop and in May for an autumn crop.

Seed Rate (kg/ha): Early varieties: 120-130, Main season varieties: 75-100

Planting distance: Early varieties are sown at a closer spacing of 30cm between rows and 5-10cm between plants within a row. In main season crop the spacing of 45x10cm is recommended. In raised beds it can be sown on both sides of the bed which are 120-150cm wide with furrows between them. Seeds are sown about 2.5cm deep.

Seed inoculation: Inoculation of seed with Rhizobium culture can be used. The culture material is emulsified in 10% sugar or jaggery solution sufficient to moist the seed. Mix the emulsified culture thoroughly with seed and dry in shade before sowing. Seed inoculation helps in quick nodulation on the roots which in turn fix atmospheric nitrogen.

Seed treatment: The seeds may be treated with fungicides like thiram or captan (3g/kg of seed) or bavistin (2.5-3 g/kg of seed) to save the crop against wilt disease. If both seed inoculation and fungicide treatments are to be given, then at first the seeds are treated with fungicide followed by inoculation with Rhizobium culture.

Manures and fertilizers: Full dose of farmyard manure @ 20 tonnes, 20-50 kg nitrogen, 30-
60 kg phosphorus and 30-60 kg potassium per hectare should be applied at the time of sowing based on fertility status of the soil.

Irrigation: Irrigation: In general, pre-sown irrigation is essential for proper germination. It is important to apply irrigations before flowering, during flowering and at pod formation stage to obtain quality pods and good yield. It is possible to grow pea under rainfed conditions but sufficient moisture must be present in the field at the time of sowing.

Weed management: First hoeing and earthing up is to be done after 2-3 weeks of sowing and second at flower initiation to get higher yield. Hoeing helps in removing the weeds and pulverizes the soil for proper aeration. Herbicides have also been found beneficial in controlling weeds. Pre-emergence application of Alachlor @ 3litres/ha or Pendimethalin @ 3litres/ha or Fluchloralin @ 2.5 litres/ha may take care of weeds in the initial growth stages.

Harvesting: Garden peas must be harvested at the proper stage of pod maturity because they start losing their quality rapidly after reaching the edible stage. The green pods of the early varieties are ready for harvest in 50 days while mid- and late-vaneties, which are generally indeterminate, take 60-65 days and 70-75 days re¬

spectively. As the pod attains marketing stage it turns dark- to light-green and the grains are well filled in the pod. In the processing industry, the maturity of pea is tested with the help of tenderometer. If the harvesting is delayed, the pod surface becomes coarse which brings down the market value of the produce and due to the conversion of sugar into starch, the quality deteriorates especially when the temperature is very high. The quality also reduces fast if the harvested pods are left in the field. As such the produce needs to be removed and kept in a cool place. Usually, four pickings are done during the season which is spread over 4-5 weeks at 10 days interval.

Yield: In early varieties the yield is 2.5-4.0 tonnes/ha of green pods while in mid-season varieties yield is 6-7.5 tonnes/ha. Late varieties yield 80-10 tonnes/ha. The shelling per cent ranges from 35-50.

Physiological disorders

Lecture: 9

Cole Crops

This group of vegetables includes cauliflower, cabbage, broccoli, knolkhol, kale and Brussels‟ Sprout. The word “cole” seems to have derived from the abbreviation of the word “caulis” meaning stem. It is a group of highly differentiated plants originated from a Single wild ancestor *Brassica oleracea* var. *oleracea* (*sylvestris*), commonly

known as wild cabbage. Cole crops are the most popular vegetables grown during winter season and among these, cauliflower and cabbage are the important ones. Broccoli is also gaining popularity due to its high medicinal value

Crop name: Cabbage

Botanical name: *Brassica oleracea* var. *capitata*

Family: Brassicaceae

Origin: Mediterranean region

Varieties: White cabbage cultivars are divided into three groups on the basis of maturity of heads after transplanting. These are as under:

Early Group: It takes 55-70 days for maturity. The commonly grown varieties are Golden Acre, Pride of India, Copenhagen Market, Pusa Ageti, Pusa Mukta,
Pusa Cabbage Hybrid-1 (KGMR-1).

Mid season Group: The **c**ultivars fall between early and late maturity groups. September, and Pusa Drum Head are the common varieties from this group.

Late Group: It takes about 85-130 days for maturity *e.g.* Late Large Drum Head

Soils: The soil requirement for cabbage is almost same as that of cauliflower.
On heavy soils, plant grows slowly and the keeping quality is improved because of compactness. Most cabbages are somewhat tolerant to salt.

Climate: It can withstand extreme cold and frost better than cauliflower. It thrives best in a relatively cool and moist climate. The optimum seed germination is obtained at 12.6-15.6oC soil temperature. The optimum temperature for growth and head formation is 15- 20oC whereas, the growth is checked above 25oC.

Planting time: In the Northern Indian plains, transplanting of different varieties can be done from October –January.

Seed Rate: For raising nursery for one hectare area, **e**arly season varieties needs 600-800 g/ha whereas the seed requirement for main season varieties is 200-500 g/ha.

Soil preparation and transplanting: Prepare the field for transplanting in the same manner as described for cauliflower.

Spacing: The spacing depends upon the head size to be produced as per the demand in the market. For getting small sized heads, transplanting is done at closer spacing while plants are transplanted at larger spacing for producing big size heads. General spacing which is recommended is as under:

Early varieties:	45cm × 30cm or 30 cm × 30 cm (round & smaller heads)
Late varieties:	60cm × 45cm or 60 cm × 60 cm

Nutrient management: Manures and fertilizer requirements in cabbage depend upon fertility of soil. Mix 200-250q/ha farmyard manure thoroughly at the time of field preparation. Application of 120-180 kg nitrogen, 75-80 kg phosphorus and 60-75kg potassium per hectare is required to raise a healthy crop of cabbage. Half quantity of nitrogen and full quantity each of phosphorus and potash is applied at the time of transplanting. Remaining quantity of nitrogen is applied after 30-45 days of transplanting.

Intercultural operations: Similar to cauliflower, cabbage is a shallow rooted crop, so it is essential to perform shallow hoeing to remove weeds and to avoid any injury to the roots. Regular hoeing operations keep crop weed free and provide aeration to the root system. Crust formation in medium heavy and clay soils hinder water and air penetration in root system. The crust should be broken otherwise it adversely affects

plant growth. Earthing up is important in rainy season as roots get exposed after every shower and should be done 4-5 weeks after transplanting. Critical period for crop-weed competition is between 30-50 days after transplanting. Use herbicides in initial stages followed by hand weeding in later stages of plant growth along with fertilizer top dressings. Application of Alachlor (Lasso) @ 2kg a.i./ha or Trifluralin@ 0.5 kg/ha or Fluchloralin @ 0.5 kg/ha before transplanting is beneficial for controlling annual and broad leaved weeds. Pendimethalin (Stomp) @1.2 kg a.i. /ha or Oxyflurofen (Goal) @ 600 ml/ha) can also be used before transplanting if there is problem of annual weeds only.

Water management: Cabbage is very sensitive to soil moisture. Maximum growth and yield can only be obtained when sufficient quantity of water is available to the plants. First irrigation is given just after transplanting of seedlings. Irrigation may be applied at 10-15 days interval according to the season and soil but optimum soil moisture should be maintained regularly. Cabbage is usually irrigated by furrow method of irrigation. Heavy irrigation should be avoided when the heads have formed, as it results in cracking of heads.

Harvesting: In general, the heads are harvested when they are firm and solid. The heads are cut with a knife, frequently attached with some non-wrapper leaves. These non-wrapper leaves give protection to the heads from bruising injury.

Yield (q/ha): Early varieties: 250-300, Late season varieties: 400-500

Pre and post harvest handling: Harvesting should be done preferably in the late evening or early morning so that the product remains turgid and fresh. Trim diseased, damaged, rotten and discoloured leaves. Avoid direct contact of heads with the soil and exposure to direct sunlight. Proper packing is to be done to avoid bruising.

Cauliflower

Botanical Name: *Brassica oleracea* var. *botrytis* L.,

Family: Brassicaceae

Origin: Mediterranean region

Cultivars: Cauliflower cultivars grown in India can be classified in two broad groups:

1. Indian Cauliflower/tropical/hot weather/heat tolerant.
2. European types/ Early temperate type known as Snowball or late cauliflower

Indian Cauliflower	**European types**
Annual and tolerant to heat	Biennial and not tolerant to heat
Curd formation at and above 20oC.	Curd formation at 5-20oC
Yellow to creamish curds, loose with strong flavour.	Snow white curds with very mild or no flavour (better quality curds).
Plants are short having long stalk and loosely arranged leave	Steady plants and long leaves giving protective jacket to curd.
Early in maturity	Late in maturity
More variable (heterozygous)	Less variable (homozygous)
More self-incompatible.	Less self incompatible.
Small juvenile phase.	Long juvenile phase.

Soil: Cauliflower can be grown in all types of soil with good fertility and good water holding capacity. The mid season and late crop grow very well in medium, medium heavy and heavy soils. For early crop, a light to light medium soil should be preferred so that the drainage is easier in the rainy season. The water stagnation checks the growth, which leads to disappointment to the growers. It prefers a soil reaction ranging from pH 6 to 6.5.

Climate: Climatic factors play an important role during transformation from vegetative to curding and curd development stages. Temperature 10-21oC is good for germination. It is highly sensitive to temperature *i.e.* temperature influences growth from vegetative to reproductive stages. Transformation from vegetative to curding takes place when plants are exposed to 5oC to 28-30oC, depending upon the cultivar of a particular maturity group. Optimum temperature for growth of young plant is 23oC in initial stages while for growth in later stages, favorable temperature range is 17-20oC. Plants continue to grow vegetatively without any curd formation if temperature remains higher than optimum for curding. Late group cultivars require 15-20oC for optimum growth but the same temperature would cause curd formation in the early cultivars. Temperature should not fluctuate too much during curd initiation phase, otherwise curd quality deteriorates.

Conclusion: Temperature higher or lower than optimum for curding results in physiological disorders like riceyness, leafyness, blindness, loose and yellow curd. Accordingly, varieties of cauliflower have been divided into four different maturity groups (I-IV) on the basis of their temperature requirement for curd formation under the northern Indian plains

Maturity group	**Nursery sowing**	**Transplan-ting time**	**Opt. temp. range for curding**	**Varieties**
Early I (A) Sept. maturity (mid Sept-mid Nov.)	Mid May	July beginning	20-25 oC	Early Kunwari, Pant Gobhi-3, Pusa Meghna, Pusa Kartik Sankar
Early I (B) Oct. maturity (Mid Oct-mid Nov)	May end to Mid June	Mid July	20-25oC	Pusa Katki, Pusa Deepali, Pant Gobhi-2
Mid Early (II) Nov. maturity (Mid Nov-mid Dec)	July end	Sept beginning	16-20oC	Improved Japanese, Pusa Hybrid-2, Pusa Sharad, Pant Gobhi-4
Mid late (III) Dec maturity (mid Dec-mid Jan)	Aug end	Sept end	12-16 oC	Pusa Synthetic, Pusa Subhra, Palam Uphar, Pant Subhra, Pusa HimJyoti, Pb Giant 35, Pusa Paushja, Pusa Shukti

Late (IV) Snowball (Jan-March)	Sept end to mid Oct	Oct end-mid Nov	10-16 oC	Snowball 16, Pusa Snowball-I, Pusa Snowball K-1, Pusa Snowball KT-25,Dania, Ooty-1,

Seedlings become ready for transplanting in 4-6 weeks time. Seedlings 5mm in diameter and about 10-12cm in length are appropriate for transplanting in the field as they have better crop stand with low mortality.

Seed Rate: The seed requirement for raising nursery for one hectare area is as under:

Early varieties	600-750g
Mid-Early season varieties	500g
Mid-late varieties	400 g
Late varieties	300g

Soil preparation and transplanting: The soil should be well prepared by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. Ploughing should be followed by leveling and bringing the soil to a fine tilth. The manure should be applied at the time of field preparation. Drainage is a problem for early and some times for mid season crop when rains coincide with cropping period. Therefore, early crop should be transplanted on ridges or raised beds while the mid and late cultivars can be planted on flat beds.

Transplanting should be done during late afternoon to avoid losses due to sun heat.

Spacing: Early varieties	45cm × 30cm
Mid and Late season varieties	60cm × 45cm

Manures and fertilizers: Manures and fertilizer requirements in cauliflower depend upon fertility of soil. Mix 200-250 q/ha farmyard manure thoroughly at the time of field preparation. Application of nitrogen, phosphorus and potash @ 120-180: 75-80: 60-75 kg per hectare, respectively is required to raise a healthy crop of cauliflower. Full dose of phosphorus and one-third of N and half of potassium should be applied at the time of transplanting. Remaining part of N should be top dressed at an interval of one month each while half of potassium is to be applied alongwith N during second top dressing.

Interculture and weed control: Cauliflower is a shallow rooted crop, so it is essential to do shallow hoeing to remove weeds and to avoid any injury to the roots. Regular hoeing operations keep crop weed free and provide aeration to the root system. Earthing up is important in rainy season as roots get exposed after every shower and should be done after 4-5 weeks of transplanting. Critical period for crop-weed competition is between 30-50 days after transplanting. Use herbicides in initial stages followed by hand weeding in later stages of plant growth along with fertilizer top dressings. Application of Alachlor (Lasso) @ 2kg a.i./ha before transplanting is beneficial for controlling annual and broad leaved weeds. Pendimethalin (Stomp) @1.2 kg a.i./ha or Oxyflurofen (Gol) @ 600 ml/ha) can also be used before transplanting if there is problem of annual weeds only.

Irrigation: Cauliflower needs very careful irrigation that should be applied at right time and in sufficient quantity as both overwatering and insufficient irrigation are harmful to the standing crop. First light irrigation is given immediately after transplanting of the seedlings. Regular maintenance of optimum moisture is essential during growth and curd development.

Use of growth hormones: NAA 10ppm treatment to cauliflower seedlings as starter solution has been found effective in respect of plant stand in the field and vegetative growth. Application of GA4 + GA7 @ 80 mg/l of water shortened the period from transplanting to the harvest.

Harvesting: The harvesting of curds is to be done as soon as the curds attain prime maturity and compactness. It is better to harvest little early than late if there is any doubt about the maturity. Delayed harvesting leads to the elongation of flowering stalk, loose, ricey, fuzzy and over matured curds which deteriorates the quality of the curd. Such curds should be eliminated from the consignment to be sent to the markets as they wilt rapidly and spoil the appearance of the consignment. The curd should be cut-off with stalk along with sufficient number of jacket leaves to protect the curd. Severe trimming of leaves is to be done after unloading or before marketing.

Yield (q/ha):

o Early varieties: 100-150

o Mid and late season varieties: 150-225.

o Snowball group may produce yield upto 500 q/ha.

Physiological disorders:

1. Buttoning: It means development of small curds or buttons. The general basis is that any check in the vegetative growth of the seedlings may induce buttoning. Buttoning is the result of planting of over-aged seedlings which do not get sufficient time to initiate vegetative growth before transformation to curding or selection of wrong cultivars means planting early variety late or root injury by insects or diseases. Planting suitable variety at appropriate seedling growth stage and at optimum time helps in managing this disorder.

2. Riceyness: A premature initiation of floral buds or elongation of peduncle stalk of inflorescence is characterized by riceyness. The curds are considered to be of poor quality for marketing. Temperature higher or lower than the optimum required for curding or high application of nitrogen result in riceyness. Manage proper soil moisture and fertility during curd development stage.

3. Fuzzyness: It is the elongation of pedicels of the individual flower. Almost all the prefloral bud which develops precociously on the curd surface give the fuzzy appearance. The possible reasons for the occurrence of this disorder are same as that of receyness in cauliflower.

3. Blindness: Blind plants are those, which are without terminal bud. They do not form curd. It is due to poor fertility of the soil or damage to the terminal portion during handling at the time of planting or by insects, diseases *etc*. Healthy and vigorous seedlings with terminal portion intact should be planted.

4. Bracting: The bracts are underneath the prefloral meristem which corresponds to axillary buds. These bracts or leaves come out of the curd resulted in poor quality of curds for marketing as they turn green or purple in colour on receiving the direct

sunlight at the surface of the curd. Temperature higher than the optimum during curding leads to this disorder.

5. Purple colouring: Some time various pigmentations develop on the curd which deteriorates the quality of the final produce. Fluctuations in the temperature are the main reason for this disorder.

6. Whip tail: It is caused by the deficiency of Molybdenum (Mo). Young plants become chlorotic and turn white particularly along the leaf margins. In older plants, the lamina of the newly formed leaves is irregular in shape and leaves have only a large bare midrib. This is because of this condition, the disorder is called as "Whip tail". Apply molybdenum @ 1kg/ha to manage the deficiency.

7. Browning (Red or Brown rot): It is caused by boron deficiency. The stem become hollow with water soaked tissues surrounding the walls of the cavity. In more advance stages, a pinkish or rusty brown area develops on the surface of the curd and hence is known as red or brown rot. Application of borax @20kg/ha can manage this disorder.

Knol Khol

Botanical name: (***Brassica oleraceae var. gongylodes***)

Family: Brassicaceae

Origin: Mediterranean region

Knolkhol is characterized by the formation of tuber, which arises as thickening of the stem tissue above the cotyledons. This tuber or knob develops entirely above the ground. It is this portion that is used for vegetable, though young leaves are also used. In India, mainly two cultivars are commonly cultivated.

Origin

The place of origin of cole crops is coastal areas of Mediterranean sea from where these crops spread to Europe and other parts of the world. Introgression among different types, mutation and selection have played major role in the evolution of present day forms. Knol khol was in cultivation much before it was known to the Romans and perhaps was in cultivation as early as 600 BC. Cultivation of broccoli and Brussels sprouts started only in the beginning of 19^{th} century.

Cultivars of knolkhol: are White Vienna, Purple Vienna and Palam Tender Knob.

Soil: It can be grown on all types of soil. However, good soil condition and fertility favour growth in a uniform manner.

Climate: It is mainly grown as a winter vegetable crop and thrives well in relatively cool moist climatic conditions. Seeds germinate well at 15-30oC. Optimum temperature requirement for its growth is between 15-25oC depending upon cultivars.

Raising of nursery and sowing time

Knoll khol is generally sown in raised nursery beds. The nursery beds are well prepared and 5kg sieved farmyard manure is added in the soil. Excessive nitrogen should be avoided. However, sowing is done in August-September in the plains of north India. After the final preparation of nursery beds 2 days before sowing, the nursery beds are drenched with 0.3% Captan or Thiram solution @5 litre/m2 to control the pathogens like Pythium, Rhizoctoma, Phytophthora and Fusanum which

are mainly responsible for damping off disease in the nursery. When the soil is sterilized with formalin (1 : 48), it must be done 3—4 weeks before sowing. Treated beds should be covered with alkathene sheet for about 6-7 days. It must be aerated by turning the soil upside down and kept open for a week before sowing. The seeds are treated with Thiram of Captan or Agrosan @3g per kg or Bavistin lg/kg before sowing. About 300-400g seed is required for one hectare. Sowing is done in rows spaced at 8—10cm apart and 1.5—2.5cm deep. For planting crop in one hectare, about 60-80m" nursery area is required for raising the seedlings. After sowing, the seeds are covered with fine soil and surface of the bed is made uniform. The beds are covered with fine layer of dry grass. This helps in retaining moisture for longer time and avoids crust formation. Watering with wateringcan will help in maintaining uniform moisture. When the emerging seedlings have come to the soil level, dry grass cover is removed, otherwise seedlings will become pale- and- lanky. Seedlings are thinned properly and drenched with 0.2% Captan or Thiram solution to save them from post- emergence damping-off disease. Proper mois¬ ture is maintained to get healthy seedlings.

Transplanting

Seedlings are ready for transplanting after 4—5 weeks. Older seedlings generally give poor yield. Under north Indian plains, planting is done in September-October to get better yield. The planting time should be adjusted in such a way that at the time of sprout formation temperature is mild.

Planting time: under North eastern plains is September-October.

Seed rate: of 800-1000 g/ha is required to raise a crop of broccoli in one hectare area.

Spacing: The seedlings are transplanted at 30-40 cm between the rows and at 20-25 cm between plant-to-plants in a row. Proper moisture should be maintained during its growth.

Weed control: Pre-planting application of herbicides followed by hoeing and weeding in the later stages keep the crop free of weeds. Any check in the growth results in the development of fibrous knobs.

Manure and fertilizer: Mix 200-250q/ha farmyard manure thoroughly at the time of field preparation. Application of nitrogen, phosphorus and potash @ 75-100: 60-80: 60-80 kg per hectare respectively is required to raise a healthy crop of knol-khol. Half quantity of nitrogen and full quantity each of phosphorus and potash is applied at the time of transplanting. Remaining quantity of nitrogen is applied after 30 days of transplanting.

Irrigation

The crop is irrigated immediately after transplanting of seedlings and subsequent irrigation depends upon the climate and soil conditions. Sufficient moisture is maintained during growing period to get better yield. In general, the crop requires irrigation at 8-10 days interval.

Harvesting: Tubers are harvested before they are fully developed as delayed harvesting make tubers fibrous. Generally bright colour tubers of 5-8 cm diameter along with the foliage are favoured in the market. For its marketing, the main root is cut off and the enlarged stem along with the leaves are tied up. Individual tuber may weigh 200-250 g while the yield may vary from 12-25 t/ha under Indian conditions.

Lecture: 10

Onion

Botanical Name: *Allium cepa* L.

Family: Amaryllidaceae

Origin: Central and South Western Asia

Uses: The green leaves, and immature and mature bulbs are eaten raw. It is used in preparation of sauces, soups and seasoning of food on accounts of its special characteristic **Pungency in onion** is due to allyl-propyl-disulphide. Also used in processed form e.g. flakes, powder and pickles. Onions are diuretic, applied on bruises, boils and wounds. It relieves heat sensation. Bulb juice is used as smelling on hysterical fits in faintness. It is used to relive insect bites and sour throat. Onions play a part in preventing heart diseases and other ailments. Onions are given in jaundice, spleen enlargement and dyspeptic after cooping in vinegar. Roasted onions mixed with cumin, sugar candy and butter oil are a demulcent of great benefit in piles. The essential oil contains a heart stimulant, increases pulse volume and frequency of systolic pressure and coronary flow and stimulates the intestinal smooth musculature and the uterus. It reduces blood sugar & has lipid lowering effect.

Climate: The onion is a cool season crop. Onion can be grown under wide range of climatic conditions. It grows well under mild climate without, extreme heat or cold or excessive rainfall. The plant is hardy and in the young stage can withstand freezing temperature. It does not thrive well in places where the average rainfall ^exceeds 75-100cm in monsoon period. It requires about 70% relative humidity for-good growth. For good vegetative growth 12.8°-23°C temperature before bulbing and for bulb development 20°-25°C are required. Very low temperatures in the beginning results in bolting while sudden rise in temperature favours early maturity of the crop in rabi and results in small sized bulbs.

The requirement of day length may differ with different varieties. Almost all cultivars grown in plains in India are short-day cultivars. Brown Spanish is long- day variety. This requires day length of more than 14 hours and lower temperature for proper development of bulbs. Kharif onion varieties require day length of 10- 11 hours where as rabi varieties require relatively higher temperature and 12-13 hours day length. Long-day varieties do not bulb under short-day conditions, whereas, short-day varieties if planted under long-day condition will develop early bulbs.

Other factors being equal onion bulbs more quickly at warm temperature than at cool temperature. As temperature conditions are never exactly alike year after year in the same district, onion varieties can not be expected to perform consistently even though cultural practices are similar. Temperature is more important than the day length in seed production, while photoperiod is more important than temperature for bulb formation.

Soil:

Soils for onion should be rich in humus with good drainage. Sandy soil needs more and frequent irrigation and favour early maturity, whereas heavy soils leads to mishappened bulbs and there is problem in digging of bulbs. The most desirable soil is the one that retains enough moisture and at the same time be favourable enough to be easily cultivated and to allow proper development of bulbs. The optimum pH range is between 5.8-6.5. Highly alkaline and saline soils are not suitable.

Improved varieties: The onion varieties have been classified on the basis of size and skin colour. Further, onion has been classified as common and multiplier onion.
There are 4 classes on the basis of colour of bulb**:** – White, Yellow, Red and Brown.
Red colour is due to anthocyanin pigment and yellow is due to **quercetin** pigment

1. **Red Coloured:** Agrifound Dark Red, Agrifound Light Red, Arka Niketan, Arka Kalyan , Pusa Madhavi, Pusa Ratnar, Pusa Red, Pusa Riddhi ,Udaipur 101, Udaipur 103, Bhima Raj, Bhima Red
2. ***Kharif* Onion**: Arka Kalyan, Arka Pragati, N-53, Arka Niketan
3. **White skinned varieties**: Pusa White Flat, Pusa White Round, Punjab-48, Udaipur-102
4. **Yellow skinned varieties:** Brown Spanish (Long day variety, suitable for growing in hills), Early Grano (Good for salad, suitable for green onions).
5. **Multiplier Onion:** Agrifound Red, CO-1, C-2 (resistant to purple blotch), CO-3 (resistant to thrips), CO-4 (moderately resistant to thrips), MDU-1.
6. **Small Onion:** Agrifound Rose (pickling type, suitable for export), Arka Bindu

Time of sowing:

Season	Time of sowing	Time of transplanting	Harvesting time
Northern India			
Rainy (*Kharif*)	May-June(July)	July-Aug(Mid Aug)	Nov-Dec
Winter (Rabi)	Oct-Nov (Nov)	Dec-Jan(Jan-Early Feb)	May-June

Seedlings become ready for transplanting in 8-10 weeks time. Seedlings must be about 15-20cm in length at the time of transplanting.

Nursery practices

Onion seed is generally sown in raised nursery beds of 15-22.5cm height. The width of nursery bed should be 0.45 metre and length can be kept 3-4 metres. About 45-60cm distance is kept between two beds to carry out the operations of watering, weeding etc.The surface of beds should be smooth and well levelled. The soil of nursery should be treated with Thiram or Captaf @ 0.2% or 4-5g/m2 area. Before sowing, seed should be treated with Thiram @ 2-3g/kg of seed to avoid damage from damping off disease. In case there is still problem of damping off disease the drenching with thiram or captaf @ 2—3g/litre of water should be taken twice once at 15 days after sowing and again after 30 days of sowing. Weeding and hoeing are carried out to manage problem of weeds. Stomp (pendimethalin) @3.35 litres/ha is applied before sowing to manage the weeds economically during rainy season.

Sowing should be done in lines spaced at 5-7cm distance. The seeds after sowing should be covered with fine powdered farmyard manure or compost followed by light-watering by rose can. The beds should be covered with dry grass or straw or sugarcane leaves to maintain required temperature and moisture. The watering should be done by water can as per the need till germination is complete. The grass cover is removed immediately after germination. Any delay in removal of the cover results in lanky seedlings. Time to time hoeing, weeding and irrigation are required for raising healthy seedlings. If the seedlings are poor a spray of 0.5% urea can used. The nursery will be ready for transplanting when plants are of 6-7 weeks-old and 0.6—0.9cm. in diameter for kharif and 8—9 weeks-old for rabi. If younger aged seedlings are transplanted the establishment will be poor. If overaged seedlings are transplanted there will be a problem of pre-mature bolting. In the nursery about 8-10kg of seed is sown for one hectare. About 5% of area will be required to produce seedlings for one hectare.

The best time for sowing of seed for early kharif crop is April-May in South; for kharif season May-June in South, Maharashtra and part of Gujarat as well as north and north-east India. The sowing of early rabi or late kharif is done in August-September in Maharashtra. For rabi crop sowing is done in September- October in South; Novermber-December in Maharasthra and part of Gujarat; October-Novermber in North and North eastern part. The rabi sowing in hills is done September-October and for summer (long-day type) October end and early November.

For direct sowing of the variety Agnfound Rose, 22.5kg/ha seed is required. In case of multiplier onion a sets, 1—1.2 tonnes or bulblets are required for planting one hectare

Seed Rate: 8-10 kg/ha

Transplanting techniques: Onion should be planted in well-pulverized field by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. Leveling should follow ploughing. Onion is normally planted in flat beds however kharif onion is planted on ridges. Transplanting should be done during late afternoon

Planting distance: The onion seedlings are planted at a spacing of 15-20 cm between rows and 5-10 cm between plant-to-plant. Transplanting on ridges is ideal for kharif onion crop.

Fertilizer requirements: Apply well rotten farmyard manure@200-300 q/ha, nitrogen @ 60-150 kg, phosphorus @ 35-150 kg and potassium@ 25-120kg per hectare depending upon the soil test, cultivar and growing season. FYM is applied at the time of field preparation. Apply 50% nitrogen and entire quantity of phosphorus and potash at the time of transplanting or bulb sowing. Remaining half of the nitrogen is top dressed 5-6 weeks after transplanting

Irrigation: Onion needs very careful and frequent irrigation as it is a shallow rooted crop. Water requirement of the crop at the initial growth period is less and increases during later growth stages. Irrigation should be applied at an interval of 10-15 days in cool weather and at a weekly interval during hot weather. Bulb formation and bulb enlargement stages (70-100 days after transplanting) are critical for water requirement. Insufficient moisture tends to slow down bulb growth while over supply causes rotting. Generally, 10-12 irrigations are given in *rabi* season. Stop irrigation when the tops mature and start falling down.

Weed management: Onion is a closely planted and a shallow rooted crop and thus, hand weeding is difficult to be performed which may damage the crop. Therefore, use of chemical weedicides at initial growth stage followed by 1-2 hand weeding is beneficial. The critical period of crop-weed competition is between 4-8 weeks. Application of Alachlor (Lasso) @ 2 litres/ha or Pendimetalin (Stomp) @ 3 litres/ha in 750 liters of water before transplanting is beneficial for controlling weeds.

Harvesting

Maturity of vegetables is usually determined by visual and physical methods, such as size, shape, color, firmness, and texture. the maturity index for potatoes and onions is the drying up of the plant body.Best time to harvest rabi onion is one week after 50-70% neck fall. In khanf season, since tops do not fall, soon after the colour of leaves changes to slightly yellow and tops starts drying, the bulbs are harvested.

Curing: Onion bulbs should be adequately cured because curing or drying of bulbs is an important process to remove the excess moisture from the outer skin and neck of onion bulb. Curing helps to reduce the chances of disease infection, minimizes shrinkage due to loss of moisture from the interiors and helps to develop good skin colour.

Bulbs are either cured in field or in open shades before storage. Onions are considered cured when neck is tight and the outer scales are dried until they rustle. Bulbs are cured in field for 3-5 days in wind row method. Then bulbs are placed in shade and cured for 7-10 days to remove field heat. This shade curing improves bulb colour and reduces losses during storage

Yield

The average yield of big sized common onion (big size) is 25-30 tonnes/ha, small sized common onion is 16-20 tonnes/ha and multiplier onion is 15-18 tonnes/ha.

Physiological disorders

Lecture: 11

Garlic

Botanical Name: *Allium sativum* L
Family: Amaryllidaceae
Origin: Central and South Western Asia
Pungency in garlic is due to the compound diallyl-disulphide**.**

Brief about origin: From its original home in central Asia, i.e. where it extends from mountainous (southern), Turkmenia north eastward in Pamir-Alai and Tien Shan regions, it spread in perhistoric times to the Mediterranean region, where its virtues are still cherished perhaps more than in any other region of the world. *A. longicuspis* Rgl.is believed to be its wild ancestor.

Soil: The soil requirements are the same as those for onion except that garlic needs a richer soil than onion. It thrives better on fertile, well drained loamy soils. The pH of soil between 6-7 is suitable for good crop. Highly alkaline and saline soils are not suitable for garlic cultivation.

Climate: Garlic is a frost-hardy plant, requiring cool and moist period and relatively dry period during bulb maturity. There are two types of varieties. One suitable for long-day conditions (around 30°N) and the other for short-day conditions. In India mosdy short-day types are grown. In general cool growing period gives more yield than warm. Garlic should be planted early to promote vegetative growth under short-day conditions and cool temperature. The critical day length for bulbing is 12 hours. Exposure of dormant cloves or young plants around 20°C or lower depending upon the varieties for 1-2 months hastens subsequent bulbing.

Improved varieties:

The varieties developed are Godavari and Sweta at MPKV Rahuri; HG 1 and HG 6 at CCSHAU, Hissar, Pusa Sel. 10 at IARI, New Delhi, LCC 1 at PAU, Ludhiana, ARU 52 at VPKAS, Almora and Agrifound White (G 41), Yamuna Safed (G 1). Yamuna Safed 2 (G 50), G 282 and Agrifound Parvati at NHRDF. These varieties are mosdy small bulbed and have more number (20-30) of smaller cloves. G 282 and Agrifound Parvati have bigger bulbs with bigger cloves and cloves are fewer in number. The characters of some of these varieties are give below.

Agrifound White (G 41): The bulbs are compact, silvery-white skinned with creamy-flesh. Diameter of bulb is 3.5-4.5cm and number of cloves/bulb is 20-25. The variety is susceptible to purple blotch and stemphylium- blight which are common in northern India. It is recommended for culdvation in the areas, where there is no much problem of purple blotch or stemphylium blight in rabi season. TSS 41%, dry-matter 43% and good storer. Average yield is 13 tonnes/ha.

Yamuna Safed (G 1): The bulbs are compact, silvery-white skinned with 25-30 sickle shaped cloves and creamy flesh. Diameter of bulb is 4.0-4.5cm. It is tolerant to insect pests and diseases like thrips, purple blotch and stemphylium blight. Total soluble solids (TSS) 38%, dry-matter 39.5%. The average yield is 15.0-17.5 tonnes/ ha. It is recommended for cultivation all over India.

Yamuna Safed (G 50): The bulbs are compact, attractive with 35-40 cloves/ bulb and white-creamy flesh. Bulb diameter is 3.5-4.0cm; TSS 38-40%; dry-matter 40-41%. The average yield is 15-20 tonnes/ha. The variety is recommended for northern parts of India.

G 282: The leaves are wider than other varieties. Bulbs are creamy-white and big size (5-6cm diameter), having 15-16 cloves/bulb. Total soluble solid 38-42% dry matter 39-43%, medium storer yield 17.5-20 tonnes/ha, suitable for export purposes. It performed very well in northern and central India.

Agrifound Parvati (G 313): A selection from the material collected from Hong Kong market. It is a long-day-type and as such is suitable for cultivation in hill of northern states. Bulbs are of bigger size (5-6cm diameter), creamy-white with pinkish-tinge, 10-16 cloves/bulb, tolerant to common diseases. Average yield 17.5-22.5 tonnes/ha. It is medium storer and suitable for export.

Some local cultivars are grown in different parts of the country. Two distinct types, viz. Fawari and Rajalle Gaddi, are grown in Bellary district. Some other local strains are Madrasi, Tahiti, T 56-4 and Jamnagar.

Time of sowing:

Region	Sowing time
North India	September- November
Mah.Karnataka,AP	August-November
WB,Orrisa,Gujarat	October-November

Transplanting techniques:

1. Dibbling: Cloves are dibbled 5-7.5 cm deep keeping their growing ends upwards.

2. Furrow planting: Cloves are dropped in the furrows by hand and covered lightly by loose soil.

Planting distance: 15-20cm between rows and 10 cm between plants to plant. Sowing depth is 2-4 cm.

Manures and fertilizers

The manure and fertilizers requirement are 60-125kg N, 35—65kg P and 0- 100kg/ha K for different parts of the country. Besides, organic manure (farmyard manure) 10-50 tonnes/ha is recommended. Farmyard manure may be mixed thoroughly in soil at the time of land preparation, whereas, complete dose of phosphorus, potash and half of nitrogen may be applied before planting. Another half dose of nitrogen may be applied after a month of planting. Excessive nitrogen results in thick neck and sprouting before harvest. Micro-nutrients are effective in increasing the yield. MnSOij, 0.1%, boric acid 0.2%, CuSCL 0.02/o or ZnSCL, 0.02%, stimulate dry-matter accumulation in the cloves. Borax up to lOkg/ha increases bulb size and yield.

Irrigation:

In general garlic needs irrigation at an interval of eight days during vegetative growth and of 10-15 days during maturation. As the crop reaches maturity (when crops first begin to break over or become dry) irrigation should be stopped.

Weed management: First weeding is done after onemonth of planting and second after two months of planting. Pendimethalin @ 3.35 litre/ha after planting and before first irrigation plus one hand weeding at 45 days after planting has been recommended for effective weed control.

Harvesting: The crop is ready for harvesting when tops turn yellowish or brownish and show signs of drying up and bend over. The bulbs begin to mature 4-5 months after planting depending on season and soil. Garlic is produced only in one season, i.e. winter (rabi). In India harvesting is done manually by hand. Bulbs are taken out along with tops and windrowed gathering several rows in each row. Harvesting in Madhya Pradesh is in February and continues up to March-Apnl. In most pockets garlic is harvested during March-Apnl

Yield: 100-150q/ha.

Physiological disorders

Lecture: 12

Carrot

Botanical name: *Daucus carota*

Family: Umbeliferae

Chromosome number: 2n=18

Origin: Afghanistan

- Acid present: Mallic acid
- Fruit type: Schizocarpic
- The edible part of carrot is modified root (conical form)
- Highest inbreeding depression is present in carrot
- Kanji: Beverage is prepared from black carrot, an appetizer
- Protandary found in carrot
- The orange colour carrots are rich in carotene, thiamine and riboflavin
- The taste of carrot is mainly due to the glutamic acid. Caffeic acid is predominantly phenolic acid in carrot
- Pink and black colour contains anthocyanins

Climate: Carrot is essentially a cool season crop. The Optimum temperature for seed germination is 7.5-23.5 degree centigrade and 18-22 degree centigrade for best root growth and development whereas 15-21 degree centigrade for colour development.
Soil: It thrives best under well drained, sandy loam soil. The optimum soil pH range is 6-7.

Field preparation: Land is ploughed to a fine tilth by thorough ploughing making it loose and friable. Clods are to be removed completely. Apply well decomposed

farmyard manure at the time of final ploughing. Flat beds or ridges and furrows are prepared.

Improved varieties: There are two distinct group of carrot

1. **European or Temperate type:** Require chilling temperature for bolting and seed production and are biennial in nature. They are low yielding and they do not produce seed under north Indian condition.

Nantes Half Long: Self coloured core
Early Nantes: Self coloured core
Chantenay: Excellent cultivar for canning and storage
Imperator: (Nantes X Chantaney), mid to late variety
Zeno: Introduced rom Germany, suitable for Nillgiri Hills, Self coloured core, exposed portion is pinkish green.
Ooty: Self coloured core
Pusa Yamdagini:EC-9981 X Nantes
Danvers: Suitable for fresh market and processing
Early Horn
Early Gem Imperator

2. **Asiatic or Tropical type:** Can produce seed under north Indian conditions, yield is comparatively high and are annual in nature.

Pusa kesar: Selection local red X nantes half long, scarlet incolour.
Pusa Meghali: Selection pusa keasr X nantes, self coloured core. Highest vitamin A contenet.
Sel No. 233: free from splitting.
Sel 21: Retains edible quality for a longer period in field without bolting.

Cultivation practices:

Time of sowing: In north India carrot can be grown throughout the year but the main season is from August- November. The European varieties can be grown for October-November.

Seed rate: About 8-10 kg seeds is sufficient to grow in one hectare.

Planting distance: 25-30 X 8-10cm and sowing depth 2-2.5 cm.

Fertilizer requirements:250-300q well rotten FYM, 120 Kg Nitrogen,60 Kg Phosphorus and 60 Kg Potash per hectare.

Irrigation: Irrigate the crop once in 6-7 days after sowing depending upon the rain and weather condition.

Weed management: Generally, two weeding at 15-20 and 30-35 days after sowing are sufficient to control the weeds.The pre emergence application of Fluchloralin or trifluralin 0.5-1.0Kg/ha and pendimethalin 1.0 Kg/ha as post emergence effectively control the weeds in carrot field.

Intercultural operations: Thinning is the most important operation during carrot cultivation as thick sowing is done because of small sized seed. The thinning operation is done 20-30 days after sowing to maintain 10 cm plant to plant distance.

Harvesting: Roots become ready for harvesting in 65-85 days. The crop should be irrigated before the pulling out of roots as it facilitates easy uprooting of the roots.

Yield: Asiatic type: 200-300 q/ha and European type:100-150q/ha

Physiological disorders

Carrot splitting; It is a major physiological disorder where roots crack and seems to be controlled by genetic factors but a number of other factors like heavy side dressing with nitrogenous fertilizers in the early stages, low chloride content in the soil, sowing at wide spacing, large size of roots and fluctuation in soil moisture are also found to be responsible for splitting.

Control: Grow resistant variety, sow the seeds at closer spacing, supply recommended dose of nitrogen, maintain optimum moisture in the field, harvest the crop at right maturity stage

Cavity Spot: Appearance of cavity in the cortex and in most cases the subtending epidermis collapse to form a pitted lesion. This is caused due to calcium deficiency, increased level of potassium and delay in harvesting.

Control: Incorporate calcium containing fertilizers in the soil and harvest the roots at optimum time.

Lecture: 13

Raddish

Botanical name: *Raphanussativus*

Family: Brassicaceae

Chromosome number: 2n=18

Origin: Europe (China and middle Asia)

- Sourness (pungency) is due to Isothiocynate
- Major sugar present in radish is Glucose
- The fleshy root of radish is modified form of root which is known as fusiform
- The edible portion of radish root develops from primary root and hypocotyl
- Radish is a suitable intercrop for companion planting
- It is a cross pollinated crop
- Sporophytic self-incompatibility found
- Pink colour of radish is due to anthocyanin
- Sinki is a kind of fermented product prepared from radish tap root
- Radish leaves are rich in minerals and vitamins (A & C)
- Radish has cooling effect and prevent constipation
- The tops (leaves) and roots are used as salad or cooked as vegetable in various ways.

Climate: Radish is essentially a cool season crop. Long days coupled with high temperature results in bolting after attaining marketable roots. The Optimum

temperature for best flavor, texture, root growth and development is 10-20 degree centigrade.

Soil: It thrives best under well drained, sandy loam soil. The optimum soil pH range is 5.5-7.

Field preparation: Land is ploughed to a fine tilth by thorough ploughing making it loose and friable. Clods are to be removed completely. Apply well decomposed farmyard manure at the time of final ploughing. Flat beds or ridges and furrows are prepared.

Improved varieties: There are two distinct group of radish

1. **European or Temperate type:** Quick growing, short duration (25-30) days, produce roots of good quality, less pungent and smaller in size. The yield is low (75-100q/ha). These require chilling temperature for bolting. Hence, the seed of these varieties may not be produced under the north Indian plain.
   White Icicle: Development of pithy roots if not harvested timely. Suitable for late Kharif and rabi season.
   PusaHimani: Developed by crossing tropical variety Black X Japanese White. It can be grown throughout the year except November- January in hills and mid-December to February in plains of India.
   Rapid Red White Tipped: Produce short foliage, roots are small and reed in colour with white top. It can also be grown in plains in November- December.
   Scarlet Globe, Scarlet Long etc.
2. **Asiatic or Tropical type:** More pungent, slow growing, long duration (45-55) and produced large size roots. The yield is high 250-300 q/ha. They do not require chilling temperature for bolting and set seeds freely under tropical conditions**.**
   PusaChetki: Suitable for growing in hotter months.
   PusaVrishti: Ist heat tolerant tropical variety.
   PusaDesi: Developed through selection from a local collection, more pungent and tapering with green stem end.
   Japanese White: Suitable for late Kharif and rabi season.it is less bolting variety and produce seeds in only hills.
   ArkaNishant: Roots are mild, crisp and mild pungent. It is free from early bolting, pithiness, splitting and forking.
   Punjab Safed: Roots are long, thick, pure white, tapering, smooth, mild in taste, medium pungent with good flavor and free from forking.
   Kashi Hans: Moderately resistant to alternaria blight.
   JaunpuriMooli: It is local variety of Jaunpur district of Uttar Pradesh. Roots are much longer (40-45 cm), thick (7-10 cm) and white. Flesh is soft, crisp, less pungent and sweet. On an average each root weights 2.5-3.0 Kg.

Time of sowing: In north India radish can be grown throughout the year but the main season is from August- January. The European varieties can be grown for September-March.

Seed rate: About 10 kg seeds for Asiatic or Tropical type and 12-14 kg for European or Temperate type is sufficient to grow in one hectare

Planting distance: 45 X 6-8 cm and sowing depth 1.5-3.0 cm.

Fertilizer requirements: 250-300 q well rotten FYM, 50 Kg Nitrogen,100 Kg Phosphorus and 50 Kg Potash per hectare.

Irrigation: Irrigate the crop once in 6-7 days after sowing

Weed management: First weeding should be done 15-20 Days after sowing. The pre emergence application of Fluchloralin 0.5Kg/ha effectively control the weeds in radish field.

Intercultural operations: Thinning of plants must be carried out 15-20 days after sowing keeping a distance of 5-10 cm between plants in a row. Earthing up is also necessary to get well developed, quality and elongated roots as generally the growing roots tend to push out of the soil.

Harvesting: European varieties are harvested 25-30 days after sowing whereas the Asiatic type varieties are uprooted 40-45 days after sowing. The crop should be irrigated before the pulling out of roots as it facilitates easy uprooting of the roots.

Yield: Asiatic type: 250-300 q/ha and European type:75-100q/h

Physiological disorders

Akashin: It is a disorder of radish caused due to boron deficiency. Also caused due to high day and night temperature (30/20^{o}C) as well as by low soil moisture.

Control: Spray 1-2 ppm of boron to rectify this disorder.

Pithiness: It is characterized by death of xylem and collapse of paranchymatous tissue in roots. It may lead to production of hollow roots. Pithiness is sign of senescence and its degree varies from varieties. Pithiness may occur due to excess N, P and K, High temperature prevailing before harvesting and delay in harvesting.

Control: Select resistant variety, plant at proper spacing, maintain optimum soil moisture, harvest at appropriate maturity stage and avoid excess fertilization and injury to the roots during intercultural operations and harvesting.

Forking: A common disorder in radish and carrot formed by the enlargement of secondary root growth.Excess moisture during the root development. It occurs on heavy soils due to soil compactness.

Control: Avoid excessive moisture and avoid heavy soil for root production.

Lecture: 14

Beetroot

Botanical name: *Beta vulgaris*

Family: Chenopodiaceae

Chromosome number: 2n=18

Origin: Mediterranean region

- Beet root are rich in protein, carbohydrate, mineral particularly calcium, phosphorous and vitamin C
- After sugarcane it is the second most important crop for the preparation of sugar
- Mallic acid is found
- Sporophyticself incompatibilityand protandry is present
- Colour of root due to:
  Red violet pigment: beta cyanins
  Yellow pigment: beta xanthins
- A gram of seed ball counts about 50 seeds
- Inflorescence is spike

Climate: Beet is a cool season crop but can be grown in slightly warm weather. Cool weather facilitates the accumulation of more sugar content. The optimum temperature for root and colour development is 18-21 degree centigrade. At 30 degree centigrade and above, the accumulation of sugar in the roots is checked.

Soil: It thrives best under deep loam to clay loam soil. The soil should be deep, friable, rich in organic matter and well drained. Neutral to slightly alkaline soils are best suited.

Field preparation: Land is ploughed to a fine tilth by thoroughly ploughing making it loose and friable. Clods are to be removed completely. Apply well decomposed farmyard manure at the time of final ploughing. Flat beds or ridges and furrows are prepared.

Improved varieties

Detroit Dark Red: Roots perfectly round with smooth uniform deep red skin; flesh dark blood red with light red zoning; heavy yielder with a duration of 80-100 days.
Crimson Globe: It produces round to flat round roots. Outer skin is medium red and flesh is crimson red without zonations; duration 55-60 days.
Early Wonder: Roots flat globular with dark red skin and dark red flesh and light red zoning.
Ooty-1: This TNAU variety has round roots with blood red flesh colour; yields 28 t/ha in 120 days; it sets seeds under Nilgiris conditions.
Crosby Egyptian: Roots flat globe with dark purplish red flesh; duration 55-60 days; produces white zoning under warm weather.
Madhur, Ruby Queen and Ruby Red are a few of the varieties marketed by private seed industry.
Time of sowing: In northern plains beet is sown from September- November.

Seed rate: About 8-10 kg seeds is sufficient to grow in one hectare

Planting distance: 30-45 X 8-10 cm and sowing depth: 2-3 cm

Fertilizer requirements: 200-250 q well rotten FYM, 80 Kg Nitrogen, 100-120 Kg Phosphorus and 60-70 Kg Potash per hectare.

Irrigation: Irrigate the field immediately after sowing. Light and regular irrigations should be applied for proper seed germination, growth and yield. Total 4-6 irrigations are required by beet. Stagnation of water is harmful.

Weed management: Generally first weeding should be done 15-20 Days after sowing. The pre emergence application of Fluchloralin or trifluralin 0.5-1.0Kg/ha and pendimethalin 1.0 Kg/ha as post emergence effectively control the weeds in field.

Intercultural operations: The seed of beetroot is multigerm which produce 3-4 seedlings per seed ball hence, thinning is an essential operation to maintain optimum plant population. About two shallow weeding and hoeings are sufficient to raise a healthy crop.Oneearthing at 20-25 days after sowing should be done to provide good environment for proper root development.

Harvesting: Turnip is harvested when the roots are tender and attain marketable size of 3-5 diameter. The crop is ready for harvest from 55-70 days after sowing. The crop should be irrigated before the pulling out of roots as it facilitates easy uprooting of the roots.

Yield: 250-500 q/ha depending on the variety, climate, type of soil and management practices.

Physiological disorders

Heart rot or crown rot: This is caused by boron deficiency. The leaves die in the crown which is covered with small deformed leaves. The older leaves wilt and become necrotic. The entire crown becomes necrotic and starts to decay. The inner portion of affected roots turn black and become unfit for consumption.

Control: Soil application of Borax 10-15 Kg/ha or spray of boric acid 0.2% at 2-3 times at vegetative stage, avoid the sowing of beet in acidic soil and avoid drought conditions by supplying regular irrigation.

Zoning: Alternate dark and light coloured rings are formed on the beet zone.it is occur due to high temperature above 30 degree centigrade, wide range fluctuation in day and night temperature and irregular supply of moisture during root growth and development

Control: Avoid drought conditions by supplying regular irrigation.

Speckled yellows: It is caused by manganese deficiency of boron. The leaves of affected plants show yellowish green chlorotic mottled areas. The chlorotic areas become necrotic resulting into breaking of lamina. The leaf margins roll upward and turn into an arrow shaped outline which remain upright. Generally the deficiency of Mn is observed in very sandy and very alkaline soils.

Control: Soil application of manganese sulphate @ 5-10 Kg/ha or foliar spray of manganese sulphate 0.25% at 2-3 times.

Lecture: 15

Potato

Botanical Name: *Solanum tuberosum* L.

Family: Solanaceae

O**rigin:** Peru and Bolivia in South America

Importance and Uses: Potato is the staple food of many European countries of the world and has proved its worth in feeding the nation in emergency. It is an important source of starch. It is a rich source of body building substances such as carbohydrates, vitamins (B1, B2, B6 and C), minerals (Ca, P and Fe) and protein. It contains all the dietary substances except fat.

Soil: It can grow in almost all types of soil. The well drained clay loam soil is considered as ideal for its cultivation. On sandy loam soil, crop can be successfully grown provided manuring is done heavily and the crop is irrigated properly and timely. It produces best when soil reaction is 6.0-6.5

Climate: It is a cool season crop and can tolerate moderate frost. It requires 20$_o$C soil temperature for better germination. Young plant growth is good at 24$_o$C but later growth is favoured by a temperature of 18$_o$C. No tuberization takes place when the night temperature exceeds 23$_o$C. Maximum tuberization occurs at 20$_o$C. Tuber formation stops completely at about 29-30$_o$C.

Varieties: The varieties of potato are categorized into three groups on the basis of their maturity. The important cultivars recommended for cultivation in different parts of India are as under:

Early varieties: These varieties are ready for harvest in 70-80 days such as Kufri Ashoka, Kufri Chandermukhi, Kufri Jawahar, and Kufri Lauvkar.

Main season varieties: They are ready for harvest in 90-95 days. Among the white coloured varieties, Kufri Jyoti, Kufri Sutlej, Kufri Pukhraj, Kufri Megha, Kufri Badshah, Kufri Anand, Kufri Bahar, Kufri Sadabahar, Kufri Deva, Kufri Sherpa, Kufri Swarna, Kufri Shailza, Kufri Surya, Kufri Himalini, Kufri Girdhari and Kufri Khyati are important.

Late varieties: Kufri Jeevan, Kufri Neelamani, Kufri Khasigaro, Kufri Naveen

Varieties for processing: Kufri Chipsona 1, Kufri Chipsona 2, Kufri Chipsona 3, and Kufri Himsona

AGRONOMIC PRACTICES:

Soil preparation and planting: A well prepared soil provides sufficient room for the development of tubers and also helps to retain moisture. The fields are ploughed to a depth of20-35 cm first with soil turning plough and afterwards by 4 to 5 ploughings with country plough/disc harrow. Clods must be broken to make the field well pulverized and leveled

Planting time

Region	Season	Planting time	Harvesting time
North western plains (Jammu, Punjab, Western U.P., Haryana, Rajasthan, Plains of M.P	Early Autumn Spring	Mid-Sept Mid Oct Jan	Mid Nov-Dec Feb-March April
North Central Plains	Winter	Mid-Oct	Feb-March

Seed Rate: 25-35 q/ha

Potato is traditionally propagated through tubers. The eyes on the tuber surface contain

axillary buds. The tubers have a dormancy of nearly 8-10 weeks after harvesting. The axillary buds on the tubers start germinating by producing sprouts only when this dormancy is over. The sprouted tubers put up fast and vigorous growth when planted in the soil.

Seed size and Spacing: Proper combination of seed size and spacing is essential to get

the required number of stems per unit area. It can be obtained by planting 40-50 g tuber with 40-50 mm diameter at a spacing of 45-60 cm between rows and 20-25 cm between the tubers with in the rows. Large tubers are cut into pieces and each should contain atleast 1-2 eyes. Tuber cutting is not recommended especially for the production of a seed crop as it transmits viruses and bacteria

Methods of Planting: Ridge and furrow method is the most popular method carried out manually or mechanically. Care should be taken that seed tubers should not come in direct contact with fertilizers. In mechanical method, furrows are made with the help of tractor drawn 2-4 row marker cum fertilizer drills so as to apply fertilizer in one sequence. This is followed by planting of tubers with the help of 2-4 row planter-cum-ridger.

Manures and fertilizers: Apply farmyard manure **@**100q/ha at the time of field preparation. Fertilizer dose varies depending upon the fertility of the soil. However, fertilizers are applied @ 120:80:60 kg N: P2O5: K2O /ha, respectively. Full dose of farmyard manure, phosphorus and potassium and half of N should be applied at the time of planting. Remaining part of N should be top dressed at the time of earthing up for effective utilization by the crop.

Interculture and weed control: Mulching helps in conserving soil moisture, reducing soil temperature and inducing quick germination. Local available materials such as pine needles or leaf litters are quite effective in controlling run off losses and conserving moisture. Weeds are effectively managed by cultural or chemical methods or combination of both methods. Weeds can be managed by hoeing and weeding

when the crop is about a month old followed by earthing up. Pre-emergence application of fluchloralin@ 1 kg *a.i.* per ha or alachlor @ 1 kg *a.i.* per ha or pendimethalin @ 1.8 kg *a.i.* per ha or atrazine @ 1.0 kg *a.i.* per ha can effectively control the weeds. Post emergence application (only 5-10% plant emergence) of paraquat @ 0.36 kg *a.i.* per ha is also effective. Application of Tok-e-25 @ 2.5kg *a.i.* per ha as post emergence application at about 2-3 leaf stage is also helpful in managing the weeds.

Irrigation: Pre-planting irrigation is advantageous for uniform germination. Second irrigation is given after about a week and subsequent as and when required. Light and frequent irrigations are better than heavy and less frequent irrigations. Water is applied effectively and economically at critical stages in crop development *i.e.* stolon formation, tuber initiation and tuber development stages of the crop. Irrigation is stopped about 10 days before harvesting of crop to allow firming of tuber skin.

Harvesting: The crop is harvested when it is fully matured which can be characterized byYellowing of haulms and no pulling out of skin on rubbing of tubers. At the time of harvesting, field should not be too wet nor too dry. Tractor operated potato diggers are available for digging the tubers from the fields.

Yield:

Early varieties	200 q/ha
Late varieties	300 q/ha

PHYSIOLOGICAL DISORDERS

Potato

1. Hollow heart: It is caused by rapid growth of tubers. Tubers become oversized and remain empty inside leading to the formation of cavity in the centre with the death of the small area of pith cells. This results in adjacent cracks and hollowness as the centre expands during the growth of the potato. Maintain soil moisture conditions to the optimum level. Avoid over fertilization particularly nitrogen. Grow those varieties which are less prone to this defect.

2. Black heart: It is caused by sub-oxidation conditions under potato tuber storage as there is no aeration in the centre of the piles. Due to high temperature and excessive moisture, blackening of tissues in the centre occur. The appearance of the tuber affect the consumers otherwise there is no decay. Provide proper ventilation. Keep potato tubers in layers. Do not store tubers in the heap.

3. Greening: The various factors which increase the glycoalkaloid contents are mechanical injury, premature harvest, and excessive application of fertilizers or exposure of tubers to sunlight. High glycoalkaloid contents lead to solanin production which is slightly poisonous. Proper earthing up of tubers as the tuber formation takes place. Store tubers in darkness after digging up.

4. Knobbiness: It occurs due to uneven growth of tuber cells/tissues. Uneven watering conditions lead to an obstruction in tuber growth. Heavy irrigation after a long dry spell leads to fast growth of some cells and as a result knobs are formed. Ensure frequent and optimum irrigation.

5. Cracking: It is due to boron deficiency or uneven water supply. Application of Borax @ 20kg/ha. Ensure frequent and optimum irrigation.

6. Sun scalding: It occurs, generally, in the autumn crop when both the temperature and sunshine are high. Emergence of sprouts and leaflets is drastically affected at that time leading to tip burn. It appears when temperature is more than 30oC. Water should be passed through the furrows to lower the soil temperature.

7. Black spot: It means the internal browning of potato tubers. It occurs in vascular tissues with in 3 days of mechanical injury. Phenols are related to black spot in potato tubers. Genetic make up of the varieties. Provide proper storage and growing conditions.

8. Freezing injury: It occurs due to the exposure of tubers to freezing temperature during or after harvest. It takes place at -1.5oC or below temperature. There is discolouration of the tissues and affect the vascular tissues at the ring and this is called as called ring necrosis and when fine elements or cells of vascular ring are affected, then it is called as net necrosis. Freezing injury render tubers unmarketable. Tubers show more damage towards proximal end. Avoid exposure of tubers to freezing temperature during storage or harvest.

9. Sprouting: It is often a serious problem in storage. It can be inhibited by spraying borax or iron sulphate @ 1000-1500 ppm about 2-3 weeks before harvesting. Chemicals like Chloro IPC (N-tetra chloro isopropyl carbonate) @ 0.5% and/or nomyl/amyl alcohol @ 0.05-0.12mg/ha also help in inhibiting sprouting.

Lecture: 16

AMARANTH

Botanical Name: *Amaranthus Sp.*
Family: Amaranthaceae
Origin: India

Chromosome No.

Cultivated species of amaranth include *Amaranthus dubius, A. tricolour, A. tristis* and *A. blitum*. *A dubius* is a tetraploid species having chromosome number $2n = 4x = 64$. All other species are diploid. *A tristis* and *A. blitum* have chromosome number $2n = 2x = 32$ where as *A. tricolour* has chromosome number $2n = 2x = 34$.

Introduction

Amaranth also known as pigweed and used primarily as potherb, is the most common leafy vegetable grown during summer and rainy seasons in tropical Asia and Africa. The leaves are usually green but they are sometimes blotched with brownish purple. Amaranth is unique in many respects. It fits well in multiple cropping systems because of its short duration and large yield per unit area. Whole young plants can be uprooted and harvested within a month after sowing or young tender leaves and shoots can be harvested continuously from established plants over several months. It is easy to cultivate in kitchen garden and on large scale, it responds favourably to fertilizers and organic matter and more than one crop can be grown in one year.

There are two types of amaranth, the leafy type and the grain type. However, there is no distinct separation between the two types as the young leaves of grain types are also eaten as greens. Among the leafy types, *A. tricolour* L. is the main cultivated species in India. Other cultivated species are *A. blitum*, *A tristis* and *A. dubius.*

Amaranth is a rich source of protein, vitamins A and C; minerals, especially calcium and iron; and dietary fiber. Amaranth protein is rich in lysine (5 per cent of total protein) and sulfur containing amino acids (4.4

per cent of total protein), both deficient in many vegetables and cereals. It can play an important role in meeting nutrient requirement of under-nourished population of tropical regions. Their moderately high level of oxalic acid inhibits the absorptoion of calcium and also means that they should be eaten in moderation by the people suffering from kidney disorders. However, oxalate levels are significantly reduced by steaming or boiling for about 10 minutes, which does not significantly reduce nutrient levels. Per 100 g amaranth contains 85.7 per cent moisture, 4.0 g protein, 0.5 g fat, 6.1 g carbohydrates, 9108 IU vitamin A, 0.03 mg thiamin, 0.30 mg riboflavin, 1.2 mg niacin, 99 mg ascorbic acid, 397 mg calcium, 83 mg phosphorus and 25.5 mg iron.

Uses

Amaranth is a leafy vegetable and cooked as a potherb. It is an excellent hot weather substitute for spinach beet and spinach. It is also grown as a high protein grain crop. The grain amaranths are popped or parched and milled to make flour or gruel. *A. tricolour* is an ornamental and is often grown in flower gardens. Yellow and green dyes are extracted from *A. tricolour*

Improved Varieties

A. tricolour

Co. 2 (TNAU, Coimbatore)

It has been developed through selection from a local material. This cultivar is particularly suited for early harvest. Its leaves are glossy green, lanceolate, slightly elongated and stem is green and succulent. Its average yield is 100 quintals per hectare.

Co. 5 (TNAU, Coimbatore)

It has been developed through selection from an introduced material. The leaves are double shaded (green and pink) and have rosette appearance in early stages. The stem is tender and consumable. First harvesting is possible 25 day after sowing. Average yield is 400 quintals per hectare.

Pusa Badi Chulai (IARI, New Delhi)

It has been developed through selection from a local material. Its stem is thick and green; leaves are large and green; responds to cutting and has longer growing period. First cutting is possible 35 days after sowing. It is best suited for summer season.

Pusa Kiran (IARI, New Delhi)

It has been developed from the naturally occurring inter-specific cross between *A. tricolour* □ *A. tristis*. Pusa Kiran has predominantly the characteristics of *A. tricolour*. The

leaves and stem are glossy green. First harvesting is possible 20-25 days after sowing. It is a heavy yielder and is suitable for cultivation in rainy season. Average yield is 350 quintals per hectare.

Arka Suguma (IIHR, Bangalore)

It has been developed by pure line selection from an exotic material introduced from Taiwan. Leaves are light green, succulent and broad. First harvesting is possible 20-30 days after sowing and total of 5-6 cuttings are possible. Average yield is 250-300 quintals per hectare. It is moderately resistant to white rust.

A. dubius

Co.1 (TNAU, Coimbatore)

This cultivar has been developed by selection from a local type. The leaves are dark green and broad with ridged appearance; stem is dark green, round and succulent. It lacks initial vigour but make rapid growth after about one month of sowing. It is especially suitable for late harvesting. Its average yield is 70 quintals per hectare.

A. tristis

Co.3 (TNAU, Coimbatore)

The cultivar has also been developed by selection from a local type. This is suitable for clipping of tender greens. This is also locally named as Araikeerai in Tamil. First clipping is possible 20 days after sowing and total of about ten clippings spread over three months are obtained. The leaf: stem ratio is high and this enhances the palatability of cooked vegetable. Its average yield is 307 quintals per hectare.

A. blitum

Pusa Chhoti Chulai (IARI, New Delhi)

It was developed through selection from a local material. Its plants are erect, dwarf with thin stem; leaves are small, green in colour; responds well to cutting. It is best suited for early summer and can be grown in rainy season also.

Pusa Kirti (IARI, New Delhi)

It was developed through selection from the material introduced from Tamil Nadu and is suitable for summer season cultivation. The leaves are green, broad with ovate lamina. First harvesting is possible 30-35 days after sowing. It is heavy yielder and average yield is 500 quintals per hectare.

Climate

Amaranthus is a widely adapted genus. Though, a warm season crop adapted to the conditions of hot, humid tropics, but is also suitable for temperate climate during summer. Amaranth prefers temperature between 25-30□C and is susceptible to frost. Seed germination

is quicker and better when soil temperature is 20□C or above. *Amaranthus* species, which grow under varying climatic conditions, differ in their day length requirements and respond differently to changes in photo and thermo-periodism. However, most species will flower when day lengths are shorter than 12 hours.

Soil

Amaranth is susceptible to water logging, so well drained fertile loamy soils are ideal for its cultivation. The ideal soil pH range is between 5.5 to 7.5, but some strains of Amaranth can be grown in soils with pH as high as 10.0. Since the crop is directly sown and the seed size is small, the seedbed should be thoroughly prepared and free from weeds and clods.

Sowing Time, Seed Rate and Spacing

Amaranth is planted either by direct seeding or transplanting. In North India, summer crop is sown in February to March and the rainy season crop in June-July. In South India, amaranth is sown almost throughout the year. The seed is sown by broadcast method or by drilling in lines 20-30 cm apart, depending upon the variety. In the South, there is a practice of transplanting amaranth especially the variety 'Badi Chulai' either as a pure crop or along the border of beds of other vegetables. When sowing direct, seed should be mixed either with fine soil or sand for its even distribution. Because of its small seed size, shallow sowing, about 1-1.5 cm deep, is recommended. Plant spacing within the rows is maintained at about 10 cm at the time of thinning. Seed rate is about 2 kg per hectare for direct sowing and 1 kg per hectare for transplanted crop.

Manures and Fertilizers

Although amaranth is usually grown on marginal lands, application of fertilizers considerably improves the yields. For optimum yields, apply twenty-five tonnes of FYM, 50 kg nitrogen, 50 kg phosphorus and 20 kg potash per hectare at the time of field preparation. For clipping type of amaranth (Co. 3), a higher fertilizer dose of 75 kg nitrogen and 25 kg per hectare each of phosphorus and potash is recommended. Excessive nitrogen application is not desirable as it leads to nitrate accumulation in leaves.

Irrigation

Amaranth is fairly tolerant to soil moisture stress and does not require as much irrigation water as other leafy vegetables. For transplanted crop, first irrigation is given as early as possible. For direct sown crop, there should be sufficient moisture in the soil. Otherwise, apply first irrigation immediately after sowing. Under assured irrigation conditions, subsequent irrigations are applied at 5-7 day intervals during summer. During rainy season, irrigation is given only if rains fail. As a rule, the fields should be irrigated if wilting occurs atnoon time.

Weed Control

Weeding is important especially in early stages of crop growth due to its small seed size and slow early growth. It is therefore important to sow the crop in finely prepared seedbed. Weed control in amaranth is achieved by cultivation, hand weeding and by management of plant populations using narrow row spacings. Narrow spacing helps to control the weeds by shading effect. Manually, one or two weedings are adequate to keep weeds under check.

Harvesting

The general practice of harvesting amaranth is that the plants are pulled as a whole, washed and sent to the market as tender greens. However, it is advantageous to make periodical cuttings of this crop. The first cutting is done 3-4 weeks after sowing and subsequent cuttings are made at weekly intervals in 'Chhoti Chulai' and 10-day intervals in 'Badi Chulai'. To reduce water loss from leaf surface, harvest during cooler part of the day such as early morning or late afternoon.

Yield

Depending upon the variety and the growing conditions, yield in amaranth varies from 100-400 quintals per hectare.

Lecture: 17

PALAK

Botanical name: Beta vulgaris var. bengalensis
Chromosome N0. : 18
Origin: Indo-China
Family : Chenopodiaceae

Introduction

Spinach beet is also known by other names like leaf beet, beet *palak, palak* etc. It is one of the most important leafy vegetables of tropical and sub-tropical regions. The leaves are long with entire margins and long petioles. It is closely related to beetroot (*Beta vulgaris*) and Swiss chard (*Beta vulgaris* var. *cicla*) and is a good substitute for spinach. It is rich source of vitamins A and C and also contains appreciable amounts of protein, calcium and iron. Per 100 g leaves constitute 86.6 per cent moisture, 3.4 g protein, 0.8 g fat,

6.6 g carbohydrates, 5862 IU vitamin A, 0.26 mg thiamin, 0.56 mg riboflavin, 3.3 mg niacin, 70 mg ascorbic acid, 380 mg calcium, 30 mg phosphorus and 16 mg iron. However, because of its high oxalates content, people suffering from kidney stones are advised to restrict its consumption.

Uses

Spinach beet is primarily used as potherb. 'Palak-paneer', beet leaves stir-fried with *paneer* (a fresh, pressed whole milk cheese) is a favourite Indian dish. It is also reported to be mildly laxative. The leaves mixed with gram flour batter (*besan*) are fried to make *pakoras*, a north Indian delicacy.

Improved Varieties

Punjab Green (PAU, Ludhiana)

It has been developed by selection from a local material. Plants are semi-erect; leaves are succulent, shining dark green, thick, long and broad and free from sourness. There is mild purple pigment on the stem. First cutting is possible 30 days after sowing. It is slow bolter and has low oxalic acid. Average yield is 300 quintals per hectare.

All Green (IARI, New Delhi)

It has been developed by selection from a local material. The leaves are

green and tender. A total of 6-7 cuttings at 15-20 day intervals are possible. Average yield is 120 quintals per hectare.

Pusa Harit (IARI, Katrain)

The variety was developed from an inter-specific cross involving sugar beet and Local Palak. Leaves are upright, green, thick, large and crinkled. It is a heavy yielder and has very late bolting habit. First cutting is possible 40-50 days after sowing. Average yield is 150-200 quintals per hectare.

Pusa Jyoti (IARI, New Delhi)

It has been developed by polyploidy breeding using colchicine for doubling chromosome number of the cultivar 'All Green'. Its leaves are large sized, thick, tender, dark green, succulent and crisp. Plants are very vigorous, quick growing and regenerate quickly after each cutting. It gives 6-8 cuttings and yields about 490 quintals per hectare.

Pusa Bharati (IARI, New Delhi)

It has been developed by selection from the variety Pusa Jyoti. The leaves are green, tender, cordate-shaped, about 25 cm long and 15 cm broad. First harvesting is possible 30-40 days after sowing. It is rich in vitamin C and □-carotene content. Average yield is 500 quintals per hectare.

Jobner Green (University of Udaipur, Jobner)

It has been developed by selection from a spontaneous mutation identified from a local material, 'Selection No. 5'. Leaves are green, thick, large and tender with entire margin and strong flavour. Average yield is 300 quintals per hectare.

HS 23 (HAU, Hisar)

It has been developed by mass selection from a local material. Leaves are dark green, large, thick, tender and juicy. It is a quick growing variety and is ready for first cutting 30 days after sowing. A total of 6-8 cuttings at two-week intervals can be obtained.

Arka Anupama (IIHR, Bangalore)

It has been developed by selection from the cross IIHR 10 □ IIHR 8. Leaves are medium large, dark green, succulent, crinkled and attractive. It has vigorous initial growth, regenerates faster and is a slow bolter. First cutting is possible 35 days after sowing and subsequent at 10- 12 day intervals. Average yield is 410 quintals per hectare. It is resistant to Cercospora leaf spot disease.

Ooty 1 (TNAU, Ooty)

It has been developed by selection from the material introduced from Himachal Pradesh. Leaves are green, 50-60 cm long, 8-10 cm broad. First harvesting is possible 45 days after sowing and subsequent four cuttings at 15-day intervals. Average yield is 150 quintals per hectare.

Climate

Although spinach beet is a winter season crop, but can be grown throughout the year under mild temperature conditions. It can tolerate frost better than other vegetables. It can also tolerate warm weather but high temperature leads to premature bolting without giving economic

yields.

Soil

Spinach beet can be grown on any soil having good fertility and proper drainage but sandy-loam soil is most suitable. Although, it can tolerate slightly alkaline soil but superior yields of better quality leaves are produced in neutral soils having soil pH around 7.0.

Sowing Time, Seed Rate and Spacing

The main sowing season in plains is from last week of August to second week of November. In places with mild climate, it can be grown throughout the year. In hilly regions, spinach beet is sown from March to May. To improve germination, soak seed in water overnight before sowing.

Sowing is done either by broadcast method or by line sowing. Line sowing is more desirable as it facilitates weeding, hoeing and harvesting. Line spacing is maintained at 20 cm and thinning is done to maintain plant spacing within lines at about 5 cm. Seed rate varies from 10-15 kg for winter crop and 25-30 kg for summer crop.

Manures and Fertilizers

Being a leafy vegetable, it requires more nitrogen for crown growth. It is better to apply fertilizer based on the soil analysis. In the absence of soil test, PAU recommends 25 tonnes of farmyard manure, along with 90 kg nitrogen and 30 kg phosphorus per hectare. Whole of FYM and phosphorus and half of nitrogen is applied at the time of seedbed preparation. The remaining half nitrogen is applied in two split doses, one after each cutting followed by a light irrigation.

Irrigation

In case of insufficient soil moisture, apply first irrigation immediately after sowing. Subsequent irrigations are given at an interval of 4-6 days during summer and 10-12 days during winter. The rainy season crop does not require much irrigation.

Harvesting

The crop is ready for harvesting about four weeks after sowing. Subsequent cuttings are taken at an interval of 20-25 days depending upon variety and season. In summer only one cutting is taken. Early morning harvesting is avoided if there is dew on the crop.

Yield

Depending upon growing season, variety and other environmental factors, yield in spinach beet varies from 250 to 450 quintals per hectare. Yield and quality of leaves are affected adversely if harvesting is delayed. Winter crop gives more cuttings and therefore higher yield than the summer crop.

Lecture: 18

Perennial Vegetables

- Perennial vegetables—crops that you plant just once and harvest year after year
- Perennial vegetables are those vegetables that are perennial meaning the plants can live more than 2 years.
- Perennial vegetables are an integral part of many cultural diets around the words, particularly in tropical agriculture.

Bread fruit (*Artocarpus altilis*)

- Native: Malaysia
- Chromosome no. : 2n=56
- Family: Moraceae
- Edible portion: Fruit
- It is a rich source of carbohydrates, calcium and fair source of vitamin A and B.
- Climate: Warm humid tropical climate with plenty of rainfall
- Optimum temperature: 15.5-37 degree centigrade
- Yellow Heart is the popular variety
- Sport is the seeded variety of
- Propagation: By seed, root cutting, air layering of root and suckers.
- Tree starts bearing from the 5 or 6 year after planting.
- Fruits are ready for harvest 60-90 days after emergence.
- *Yield:* One tree bears 50-100 fruits weighing 25-50 Kg annually.

Drumstick(*Moringa oleifera*)

- It is also known as multipurpose tree or miracle tree.

- Chromosome no.: 28
- Family: Moringaceae
- Native: Africa
- Edible portion: Pods and sometimes leaves
- Flower colour: White or creamy white

- Drumstick seeds contain an oil called ben oil or behen oil

- Optimum temperature: 25-35 degree centigrade
- Varieties: Jaffna, Moolanoor, Murangai, Kodikal Murangai, KM-1. PKM-1, PKM-2
- Propagation: Limb cutting, seeds
- Harvesting: Pods are ready to harvest after 60 days
- Yield: 200-500 fruits/tree/year

Cassava(*Manihot esculenta*)

- Chromosome no. :36,72
- Family: Euphorbiaceae
- Native: Brazil
- Cassava byproduct: Sago
- Toxic substance present: Cyanide or Hydrocyanic acid
- Yellow colour of flesh due to the presence of carotene
- Propagation: seeds, stem cutting called as stakes or setts
- Varieties: H-97, H-165, H-226, Sree Vishakam, Sree Sahya, Sree Prakash
- Optimum temperature: 25-30 degree centigrade

Yam(*Dioscorea species*)

- Family: Dioscoreacea
- Dioesgenin is present
- Edible portion: Tubers
- Optimum temperature: 25-30 degree centigrade
- Varieties: Sree Keertbi, Sree Roopa, Sree Shilpa, Sree Latba
- Propagation: Tuber pieces
- Double harvesting is practiced in yam
- Yield: 200-400q/ha

Asparagus(*Asparagus officinalis*)

- Chromosome number: 20
- Family: Liliaceae
- Edible part: Tender shoots called Spears are used as vegetable
- Origin: Europe, Asia
- It is dioecious in nature
- White crystalline substances : Asparagine
- Propagation: Through seeds or crown
- Green coloured spears are more popular and produce for fresh market
- Light green or white spears are used mainly for processing
- Optimum temperature: 16-24 degree centigrade
- Varieties: Perfection, Selection-841, Palmetto, Aggent evil
- Seed rate: 2-3 Kg/ha
- Yield: 25-40q/ha

- Blanching: To obtain the whitish spears particularly for canning purpose, cover the plants with soil up to a height of 25-30 cm

Globe artichoke(*Cynara scolymus)*

- Chromosome number: 34
- Family: Compositae
- Edible portion: Flower bud
- Origin: Mediterranean region
- It is a self pollinated crop
- The main active components of this plants are mono and dicaffeoyguinic acid.
- It has high content of poly unsaturated fatty acids.
- The thick receptacles of flower bud is known as 'heart' which is used for canning
- Varieties: Green Globe, Purple Globe. Buli, Spinora Sarda. Imperial Star.
- Propagation: Seeds and by suckers
- Optimum temperature: 12-18 degree centigrade
- It is useful for the person suffering from diabetes as flower buds contain insulin
- Sowing time: August-October –in plains
- March-May-in hills
- Average yield: 10-12 t/ha

Rhubarb(*Rheum rhaponticum*)

- Chromosome Number: 44
- Family: Polygonaceae
- Origin: Asia(Siberia)
- Edible portion: large thick leaf stalks and petiole
- It's a cold resistant plant
- It is a acid tolerant vegetable
- Propagation: Division of crown
- Varieties: Strawberry, Mcdonald, Valentine, Victoria, Cherry Red
- Flowers are protandrous

Chow Chow(*Sechium Edule*)

- Family: Cucurbitaceae
- Monoecious in nature

- Single seeded fruit
- The fruit is vivipary in nature
- Unripe fruits are used as vegetable
- Optimum temp:18-22 degree centigrade
- Yield: 25-35 tonnes/ha

Curry leaf(*Murraya koenigii*)

- Family: Rutaceae
- Edible portion : leaves
- Chromosome Number: 18
- Richest source of Calcium
- It is a self pollinated crop
- Ksenigin and muragin are crystalline glucosides present in leaves and flowers, respectively
- Varieties: DWD-1,DWD-2, Suwasini
- Propagation: Through seeds and root suckers
- Planting time: May-June
- Yield: 20-25 t of leaves/ha

Jerusalem Artichoke (*Helianthus tuberoses*)

- Chromosome number: 102
- Family: Compositae
- Edible part: Tuber

- It is a commercial source of levulose used as sweetning agent by diabetic patients

Seakale(*Crambe maritime*)

- Family: Cruciferae
- Edible portion: Young leaves and shoots

Sorrel (*Rumex acetosa*)

- Family: Polygonaceae
- Chromosome number: 14,28,42
- Sorrel is a perennial herb with tart, lemon-flavored leaves used for soups, salads, and sauces.
- Leaves contain small amounts of oxalic acid

Horse radish(*Armoracia rusticana*)

- Chromrosome number: 32
- Family: Cruciferae
- Fleshy cylindrical roots are used
- Pungency is due to the presence of allyl isothiocynates and butyl thiocynate.
- Propagation: Root cutting and by suckers

Chekurmanis (*Sauropus androgynus*)

- It is known as 21st century vegetable and multivitamin green.

- Family: Euphorbiaceae
- Native: Indo-Burma
- Edible portion: Leaves and tender shoots
- Propagation: Seeds and stem cutting
- Seed rate: 1 lakh cuttings/ha
- It is a highly cross pollinated crop
- Yield: 30-50tonnes/ha

Ceylon Spinach *(Talinum triangulare*)

- Native: Brazil
- Family: Portulacaceae

- It is also known as water leaf.

- Edible part: Leaves and tender shoots

- It is a short day and shade loving plant

- It is a soft mucilaginous leafy vegetable

- It is highly self pollinated crop
- Propagation: Seeds or herbaceous stem cuttings.

Basella (*Basella Sp.*)

- It is also known as Indian spinach, Malabar spinach,
- Malabar night shade
- Chromosome number: 24
- Origin: South Africa
- Family: Basellaceae
- Gintjoo: A bright red juice made from Basella
- Edible Portion: Succulent leaves with petiole
- Two species generally grown:
- *Basella alba:* Dark green and round to oval leaves
- *Basella rubra:* Red colourleaves and stem
- Propagation: Through seeds but stem and root cuttings are also used
- Seed rate: 12-15 Kg/ha
- Yield: 15-20 t/ha

Ivy gourd (*Coccinia grandis*)

- It is also known as little gourd, kundru, tondali, scarlet gourd
- Family: Cucurbitaceae
- Chromosome number: 24
- It is rich in carbohydrates, proteins, vitamin A and C
- Origin: India
- It is grown for its young and tender green fruits which are used as salad or cooked.
- It is a perennial dioecious plant.
- Vegetative parthenocarpy is found
- Climate: Warm and humid climate with an ideal temperature of 20-30 degree centigrade.
- Improved varieties: Indira Kundru 5 and Indira Kundru 35
- Propagation: It is propagated by stem cutting and tuberous root.
- Yield: 100-125q/ha

B.Sc. Ag III Sem

Production Technology for Vegetables and Spices

Credit - 2(1+1)

As per ICAR 5TH Dean Syllabus