HOR . 312 VEGETABLE PRODUCTION (2+1)

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THEORY

IMPORTANCE OF VEGETABLE GROWING

Introduction

Vegetables constitute an important component of a balanced diet for man. They supply important vitamins and minerals that the human body needs for a healthy and active life. Vegetables like carrot, pumpkin, peas, turnip, beetroot, tomato, sweet potato, cabbage, greens like spinach, methi, green onion etc., are important source of vitamin A. Ascorbic acid or vitamin C is present in appreciable quantities in chilli, palak, methi (fenugreek), cabbage, tomato, cauliflower, bitter gourd etc. Vitamin D is available in greens which are good source of Vitamin E also. Green leafy vegetables are good source of the other essential Vitamins *viz*., niacin and vitamin K.

Vegetables are also rich sources of minerals. Of the ten minerals needed, the most important are calcium, phosphorus and iron. Calcium is obtained from vegetables like beans, carrot, cabbage, cauliflower, onion, peas, tomatoes, amaranthus, fenugreek etc., Vegetables like potatoes, carrot, tomatoes, cucumber, cauliflower and spinach are good sources of phosphorus. Iron is supplied to the body by vegetables like cabbage, peas, beans, amaranthus, tomato, carrot, bittergourd, onion. Iodine which is essential for the human body is provided by onion, okra, summer squash etc.

Many of the vegetables are of the nature of roughage aiding in digestion. Most of the vegetables with the exception of tomato are alkaline in reaction which is very beneficial to neutralize the acid reaction of non-vegetarian foods.

Vegetables like potato, sweet potato, cassava, yams etc., are good sources of carbohydrates and therefore are important subsidiary foods while others like peas and

beans of different types are rich in protein. Besides the above merits, many of the vegetables add palatability to our food.

Spicy vegetables like onion, garlic, coriander, fenugreek, mint etc., add taste and flavour to our food. The added advantage of these spicy vegetables is their protective nature against diseases. A recent report in Spice India Journal goes an "An armament of onions, cloves, mustard and fenugreek with a splash of celery and coriander is what the body needs to ward off cancer and bacteria invading our body say nutrition scientists. The national institute of nutrition in Hyderabad reports that most spices prevent cancer and attach of harmful bacteria and fungi while some reduce blood sugar levels, help digestion and reduce cholesterol levels".

Besides their importance in human nutrition, vegetable crops are commercial crops supporting market gardening, truck gardening or commercial gardening. Raising of vegetable crops also supports many other industries like the processing industry, seed industry, fertilize and plant protection chemical industries, the weedicide industry, farm machinery and implements and packing and marketing industries.

Vegetable crops in comparison to field cops are high output crops. Being short term crops, their cultivation is intensive and in year, two or three crops with yields varying from 40 to 60 tonnes / ha per annum can be raised. The ease of cultivation, their versatility for growing in plains and hills of different altitudes and the high returns they fetch make them choice crops for commercial growing. They are also crops which can be fitted into many remunerative crop rotation and cropping patterns like inter cropping, multiple cropping and companion cropping. Vegetable growing enables maximum utilization of land since it can be taken up in small vacant spaces or strips around our homes to large scale commercial growing. By virtue of the foregoing characteristics, vegetable growing also provides employment for labour round the year unlike growing of cereal and other crops which are seasonal in nature.

Although India is mainly a vegetarian country, we are no self-sufficient in vegetables production. The current production of vegetables is adequate to provide hardly 120g. as against 300g. of vegetables required per day per adult. This situation of low production is mainly on account of the dearth of technical known-how on scientific methods of cultivation of these crops. With the tremendous rate of population growth in

India and at the global level in general, there is an urgent and imperative need to improve the vegetable crops productivity per unit area so that self sufficiently can be achieved in vegetable production.

State-wise area, production and productivity of vegetables

State/UT's	Area (in 000' HA)				Production (In 000' MT)				Productivity (in MT/HA)			
	1991-92	1998-99	1999-00	2000-01	1991-91	1998-99	1999-00	2000-01	1991-91	1998-99	1999-00	2000-01
Andhra pradesh	155.2	249.3	230.1	249.9	1452.6	3451.2	2839.1	3147.7	9.4	14.2	12.3	12.6
Arunachal pradesh	17.1	16.7	16.9	21.0	79.9	80.9	80.9	83.7	4.7	4.8	4.8	4.0
Assam	22.4	245.9	255.9	238.3	2132.3	2834.8	3089.4	2693.1	9.6	11.5	12.1	11.3
Bihar	843.3	616.6	626.0	707.8	8643.1	9418.4	9548.8	10219.7	10.2	15.3	15.3	14.4
Chhattisgarh	-	-	-	84.2	-	-	-	1146.3	-	-	-	13.6
Delhi	55.0	45.5	45.7	114.8	627.8	651.9	651.9	862.7	11.4	-	14.3	7.5
GOA	-	7.6	7.6	7.6	-	70.0	70.0	76.0	-	9.2	9.2	10.0
Gujarat	114.6	189.9	201.0	205.6	1667.9	3255.0	2647.0	3070.8	14.6	17.1	13.2	14.9
Haryana	60.8	120.0	135.0	141.7	877.0	1850.0	2094.5	2191.5	14.4	15.4	15.5	15.5
Himachal pradesh	38.7	45.8	40.6	44.8	476.0	606.4	660.9	734.2	12.3	13.2	16.3	16.4
Jammu & Kashmir	180.3	41.2	41.4	45.7	745.0	606.9	584.4	757.9	4.1	14.7	14.1	16.6
Jharkhand	-	-	-	149.8	-	-	-	2109.5	-	-	-	14.1
Karnataka	351.1	309.7	361.6	343.7	3673.2	4944.9	6796.9	5763.0	10.5	16.0	18.8	16.8
Kerala	202.1	159.7	159.7	114.8	3229.1	2857.2	2857.1	2530.9	1.0	17.9	17.9	22.0
Madhya Pradesh	176.4	234.0	258.7	238.5	2221.0	3276.2	3632.0	3501.9	12.6	14.0	14.0	14.7
Maharashtra	241.1	341.2	385.3	409.0	4171.3	4479.5	4828.6	5142.0	17.3	13.1	12.5	12.6
Manipur	11.8	8.5	7.4	9.7	50.3	45.0	53.1	67.4	4.3	5.3	7.2	6.9
Meghalaya	25.9	3.6	29.2	37.7	219.2	308.7	252.9	303.6	8.5	8.4	8.7	8.1
Mizoram	6.0	8.4	8.3	7.9	31.8	62.4	56.3	47.3	5.3	7.4	6.8	6.0
Nagaland	8.2	15.1	20.9	26.9	66.9	313.3	235.7	253.6	8.2	10.7	11.3	9.4
Orissa	710.3	883.9	788.1	702.5	7275.0	10087.1	9096.0	8089.1	10.2	11.4	11.5	11.5

Punjab	84.5	117.1	135.4	131.0	1450.0	1906.3	2285.0	2310.0	17.2	16.3	16.9	17.6
Rajasthan	62.9	99.3	98.7	95.1	307.0	396.1	472.6	386.4	4.9	4.0	4.8	4.1
Sikkim	7.6	9.4	9.6	13.5	46.1	42.2	43.0	59.7	6.1	4.5	4.5	4.4
Tamil Nadu	889.3	206.7	209.1	218.6	3796.9	5704.8	5660.3	6011.0	4.3	27.6	27.1	27.5
Tripura	30.3	18.4	18.4	31.8	306.8	232.8	232.8	328.1	10.1	12.7	12.7	10.3
Uttranchal	57.1	91.5	81.9	104.8	617.6	840.7	733.2	1138.1	10.8	9.2	9.0	10.9
Utter Pradesh	576.7	640.7	688.9	668.1	9627.3	12680.6	13842.4	13030.4	16.7	19.8	20.1	19.5
West Bengal	456.0	1100.0	1122.3	1075.0	4680.0	16367.4	17413.8	17779.4	10.3	14.9	15.5	16.5
Andaman and Nicobar	3.4	3.1	3.1	3.1	13.2	15.8	15.8	15.8	3.9	5.1	5.1	5.1
Chandigarh	0.3	0.4	0.1	0.1	11.1	11.5	1.2	1.7	17.0	18.8	12.0	17.0
Dadra and Nagar Haveli	1.5	1.5	1.5	1.5	13.6	13.5	13.5	13.5	9.1	9.0	9.0	9.0
Daman and Diu	0.1	0.1	0.1	0.1	0.3	1.0	1.1	1.1	3.0	10.0	11.0	11.0
Lakshadweep	0.4	-	0.3	0.2	0.4	-	0.2	0.2	1.0	-	0.7	1.0
Pondicherry	2.3	2.2	2.6	3.7	22.3	33.5	32.6	54.2	9.7	15.2	12.5	14.6
Total	5592.7	586.0	5991.4	6248.5	58532.0	87532.0	90823.0	93921.5	10.5	14.9	15.2	15.0

Source: Indian Horticulture Data Base, National Horticulture Board

Area, production and productivity of vegetable crops

S1.No.	Crop	2000-2001		
		Area	Production	Productivity
1.	Potato	5561	100688	18.11
2.	Tapioca	108005	4153046	38.45
3.	Sweet potato	1096	18683	17.05
4.	Yam	1369	41070	30.00
5.	Carrot	2133	53325	25.00
6.	Beet root	1024	25600	25.00
7.	Turnip	61	1220	20.00
8.	Onion	28644	279295	9.78
9.	Brinjal	9998	83495	8.35
10.	Lady's Finger	6209	52566	8.47
11.	Lab Lab	2093	27209	13.00
12.	Cabbage	1915	92301	48.20
13.	Tomato	27071	257950	9.53
14.	Pumpkin	954	21942	23.00
15.	Snake gourd	807	12105	15.00
16.	Ribbed gourd	359	4308	12.00
17.	Bottle gourd	124	1736	14.00
18.	Bitter gourd	1018	12216	12.00
19.	Ash gourd	654	11772	18.00
20.	Cucumber	664	4648	7.00
21.	Beans	3148	28332	9.00
22.	Karamani	408	1224	3.00
23.	Drum Stick	5097	254850	50.00
24.	Cauliflower	448	8960	20.00
25.	Radish	1026	20520	20.00
26.	Colacasia	1194	95552	8.00
27.	Greens	2222	35552	16.00
28.	Watermelon	2502	75060	30.00
29.	Muskmelon	179	4475	25.00
30.	Other vegetables	2213	59751	27.00
	Total	218196	5753451	26.37

District wise area, production and productivity of vegetable crops 2001-2002

S1.No.	District	Total vegetables		
		Area	Production	Productivity
1.	Coimbatore	14155	208522	14.73
2.	Cuddalore	6153	207884	33.79
3.	Dharmapuri	25858	632580	24.46
4.	Dindigul	16073	234331	14.58
5.	Erode	11185	334499	29.91
6.	Kancheepuram	1880	43511	23.41
7.	Kanniyakumari	8071	206953	25.64
8.	Karur	2238	76521	34.19
9.	Madurai	2373	36174	15.24
10.	Nagapattinam	352	8921	25.34
11.	Namakkal	29065	1209671	41.62
12.	Perambalur	7934	172436	21.73
13.	Pudukottai	213	3267	15.34
14.	Ramanathapuram	94	1681	17.88
15.	Salem	39053	1095744	28.06
16.	Sivagangai	108	1431	13.25
17.	Thanjavur	707	11027	15.60
18.	The Nilgiris	5805	175863	30.30
19.	Theni	5022	75584	15.05
20.	Thiruvanamalai	3390	47149	13.91
21.	Thoothukudi	5043	96004	19.04
22.	Tiruchirapalli	9381	335457	35.76
23.	Tirunelveli	4097	61418	14.99
24.	Tiruvallur	1307	23588	18.05
25.	Tiruvarur	153	3627	23.71
26.	Vellore	2614	34049	13.03
27.	Villupuram	13167	386034	29.32
28.	Virudhunagar	2705	29525	10.91
	State Total	218196	5753451	26.37

Nutritive value of vegetables (per 100g of edible portion)

S1. No.	Name of the Vegetable	Calories	Moisture content %	Carbo -hydrates %	Protein (g)	Fat (g)
1.	Amaranthus tender	45	85.7	6.1	4.0	0.5
2.	Ash gourd	10	96.7	1.9	0.4	0.1
3.	Beet root	43	87.7	8.8	1.7	0.1
4.	Bitter gourd	25	92.4	4.2	1.6	0.2
5.	Bottle gourd	12	96.1	2.5	0.2	0.1
6.	Brinjal	24	92.7	4.0	1.4	0.3
7.	Cabbage	27	91.9	4.6	1.8	0.1
8.	Cauliflower	30	90.8	4.0	2.6	0.4
9.	Cluster bean	16	81.0	10.8	3.2	0.4
10.	Carrot	48	86.0	10.6	0.9	0.2
11.	Cucumber	13	96.3	2.5	0.4	0.1
12.	Colocasia	97	73.1	21.1	3.1	0.1
13.	Colocasia leaves (green)	56	82.7	6.8	3.9	1.5
14.	Dolichos bean	48	86.1	.7	3.8	0.7
15.	Drumstick	26	86.9	3.7	2.5	0.1
16.	Drumstick leaves	92	75.9	12.5	6.7	1.7
17.	Fenugreek leaves	49	86.1	6.0	4.4	0.9
18.	French bean	26	91.4	4.5	1.7	0.1
19.	Knol Khol	21	92.7	3.8	1.1	0.2
20.	Kovai (*Coccinia sp*).	18	93.5	3.1	1.2	0.1
21.	Kena sag	22	92.2	2.5	2.1	0.4
22.	Lady’s finger	35	89.6	6.4	1.9	0.2
23.	Lettuce	21	93.4	2.5	2.1	0.3
24.	Muskmelon	17	95.2	3.5	0.3	0.2
25.	Onion	50	86.6	11.1	1.2	0.1
26.	Onion stalk	41	87.6	8.9	0.9	0.2
27.	Potato	97	74.7	22.6	1.6	0.1

28.	Paruppu keerai (Portulaea)	27	90.5	2.7	2.4	0.6
29.	Peas	93	72.1	15.9	7.2	0.1
30.	Pumpkin	25	92.6	4.6	1.4	0.1
31.	Radish white	17	94.4	3.4	0.7	0.1
32.	Sweet potato	120	68.5	28.2	1.2	0.3
33.	Snake gourd	18	94.6	3.3	0.5	0.3
34.	Tapioca	157	59.4	38.1	0.1	0.2
35.	Tomato (green)	23	93.1	3.6	1.9	0.1
36.	Tomato (red)	20	94.0	3.6	0.9	0.2
37.	Watermelon	16	95.8	3.3	0.2	0.2
38	Yam elephant	79	78.7	18.4	1.2	0.1

Source: Nutritive value of Indian Food (1980), National Institute of Nutrition, Indian Council of Medical Research, Hyderabad.

Classification of vegetables

There are more than fifty different kinds of vegetables. There are four general methods of classification namely (1) botanical classification (2) classification based on hardiness (3) classification based on parts used and (4) classification based on essential methods of culture.

Angiospermae are divided into Monocotyledoneae and Dicotyledoneae. These are further divided into family, genus, species, sub species and botanical varieties. The grouping of the vegetables are as follows. This botanical classification though brings out the relationship that exists between groups of different vegetables, in many cases, the purpose of the classification namely grouping of those vegetables requiring similar cultural requirements is not met. This does not give the final solution of avoiding repetition. The cultural operations of the vegetables belonging the same family are not always similar. Potato and tomato belong to the same family but their requirements are very different. The requirements of carrot are quite different from those of celery. Similarly most of the vegetables belonging to the family cucurbitaceae have similar requirements excepting chowchow which is perennial in habit demanding some special cultural requirements.

A Monocotyledoneae			
Family	**Genus**	**Species**	**Common name**
1. Graminae	*Zea*	*Mays var. rugosa*	Sweet corn
2. Liliaeae	*Asparagus*	*officinalis*	Asparagus
3. Araceae	*Colocasia*	*esculenta*	Taro
4. Alliaceae	*Allium; Allium*	*Cepa* *Cepavar, aggregtum*	Onion Multiplier onion
5. Diosoreaceae	*Dioscorea*	*alata*	Yam
B. Dicotyledoneae			
1. Polygonaceae	*Rheum*	*rhaponticum*	Rhubarb
2. Chenopodiaceae	*Beta*	*Vulgaris*	Beetroot
3. Cruciferae	*Brassica*	*oleracea var. capitata*	Cabbage
	Brassica	*oleracea var. Botrytis*	Cauliflower
	B. oleracea	*var.italica*	Sprouting broccoli
	B. oleracea	*var. gemmifera*	Brussels sprout
	B. compestris	*var. rapa*	turnip
4. Leguminosae	*Pisum*	*sativum*	Pea
	Vicia	*faba*	Broad bean
	Phaseolus	*vulgris*	French bean
	Vigna	*sinensis*	Cowpea
	Glycine	*Max*	Soybean
	Dolichos	*lablab*	Field bean
	Cyamopsis	*tetragonoloba*	Cluster bean
5. Euphorbiaceae	*Manihot*	*esculenta*	Tapioca
6. Malvaceae	*Abelmoschus*	*esculentus*	Bhendi
7. Umbelliferae	*Dauus*	*carota*	Carrot
8. Convolvulaceae	*Ipomoea*	*batatas*	Sweet potato
9. Solanaceae	*Solanum*	tuberosum	Potato

	Solanum	melongena	Brinjal
	Lycopersicon	esculentum	Tomato
	Capsicum	annuum	Chillies
10. Cucurbitaceae	*Cucurbita*	Moschata	Pumpkin
	Cucurbita	pepo	Summe squash
	Cucurbita	maxima	Winter squash
	Cucumis	melo	Musk melon
	Cucumis	sativus	Cucumber
	Momordicha	charantia	Bitter gourd
	Lagenaria	*vulgaris*	Bottle gourd
	Luffa	*acuangula*	Ribbed gourd
	Trichosanthes	*anguina*	Snake gourd
	Benincasa	*hispida*	Ash gourd
	Sechium	*edule*	Chayote or chow chow
11. Compositae	*Cynara*	*scolymus*	Artichoke
	Lactuca	*sativa*	Lettuce
	Helianthus	*tuberosus*	Jerusalem artichoke

2. Classificatin based on hardiness

Based on their ability to withstand the frost injury, vegetables are classified as hardy and tender. The hardy group of vegetables will endure ordinary frost without injury while tender group will be killed. Asparagus is a typical example for hardy vegetables. The vegetables are often grouped as 'cool season' and 'warm season' crops according to their temperature requirement. The cool season vegetables or winter season vegetables often comprise of edible parts such as root, stem, leaves and buds or immature flowers. There are two exceptions to this rule which are warm season crops viz. sweet potato and Newsland Spinach. Similarly warm season crops or summer season vegetables comprise of edible parts mainly of mature and immature fruits, exception being sweet potato and tapioca. Though this classification is simple, the purpose of classification is not fulfilled as all the cool season vegetables do not require similar type of cultivation. Peas and cabbage are cool season vegetables but their cultural requirements are entirely different. Besides with the improvement in the plant genetics, the distinction between cool season and summer season is slowly diminishing. This is

true because cauliflower once considered as a cool season vegetable is grown throughout the year in the plains of certain parts of Tamil Nadu.

Classification based on parts used as vegetable

a) Leaves or stems: Cabbage, asparagus, amaranthus, knolkhol

b) Fruits : Melon, tomato, egg-plant, beans and peas

c) Flower parts: Cauliflower and broccoli

d) Underground: Sweet potato, beet, radish, carrot, turnip, onion (roots, tubers, bulbs and corms) and garlic.

This method of classification is also not satisfactory because each group covers a number of cops differing widely in their cultural requirements.

Classification based on method of culture

This system of classification is based on essential methods of culture and those vegetable cops which require similar cultural requirements are grouped together. This enables it possible to give a general cultural practices for the group without the necessity of repetition in discussing individual crops. This is the most satisfactory method of classification and is being widely adopted. The grouping based on this method of classification is as follows:

Group 1	:	Perennial vegetables – Drumstick, ChowChow, Asparagus, Coccinea, Sesbania (Agathi) etc.
Group 2	:	Pot herbs or greens – Amaranthus, Spinach
Group 3	:	Salad crop – celery, lettuce, endive chicory
Group 4	:	Cole crop – cabbage, cauliflower, broccoli, brusseles sprout, knolkhol, chinese cabbage
Group 5	:	Root crops – Beet root, radish, carrot, turnip
Group 6	:	Bulb crops – onion, leek, garlic, shallot
Group 7	:	Potato
Group 8	:	Tuber crops – Tapioca, sweet potato, Dioscorea, elephant yam, colocasia, coleus
Group 9	:	Peas and beans-pea, French bean, broad bean. Field bean, cowpea, cluster bean

Group 10	:	Solanaceous vegetables – Tomato, brinjal and chillies
Group 11	:	Cucurbits – cucumber, musk melon, Ash gourd, pumpkin, bitter gourd, snake gourd, ribbed gourd, bottle gourd
Group 12	:	Okra

Types of vegetable growing

Vegetable growing can be classified into the following types according to the purpose for which they have been developed.

1. Kitchen garden

A home garden or kitchen garden refers to the raising of vegetable crops in the back yard of a house. But with the growing demand for the valuable land in urban areas the city dwellers may not have any land adjoining his apartment, yet the enthusiasts have interest in growing vegetables over the root or in the verandah. Special arrangements re made on the roof to grow vegetables on soils placed on floors after using water proof cementing. Other vegetables are grown in boxes, pots and such other structures. All these refer only to the kitchen gardening. Growing vegetables in one's own garden is not only an art but also a continuous training for the person and the family. It supplies fresh vegetables. It constitutes a healthy hobby and the spare time of the family is well utilized. The fresh vegetables not only ensure a better balanced diet but thee is also a delicate psychology behind the taste as every one will definitely appreciate the produce obtained by their own effort.

Selection of site

There will be a limited choice for the selection of a site for the kitchen garden. It is usually the backyard of the house. This is itself convenient as the members of the family can give a constant care to the vegetables during the leisure time and the waste water from the bath rooms, kitchen etc. can easily be diverted to the vegetable beds. The size of a kitchen garden depends upon the availability of land and number of persons for whom vegetables re to be provided. No choice in the shape of the kitchen garden wherever possible rectangular garden is preferred to a square one. By close attention to succession cropping and intercropping, five events of land may be adequate to supply vegetables for an average family of husband, wife and three children.

The main aim in kitchen garden is the maximum output and a continuous supply of vegetables for the table throughout the year. By following supply of vegetables for the table throughout the year. By following certain principles in the lay out of kitchen garden, the above objective can easily be fulfilled.

1. 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 culture of other vegetable crops.
2. Adjacent to the foot path all around the garden and the central foot path may be utilized for growing different short duration green vegetables like coriander, Ceylon spinach, fenugreek, alternanthera, mint and amaranthus. Each type of this green can be grown along each side of foot path and these crops can be rotated in different seasons.
3. The fence or trellises around the home garden may be utilized for growing light creepers like Basella, Coccinea, sponge gourd and bitter gourd. These may be also rotated in different seasons.
4. The compost pits are placed in two corners of the garden. They are meant for garden wastes and kitchen wastes. Pandals may be erected over the compost pits and trained with the creeper vegetables like lablab, ribbed gourd, snake gourd. This will hid off the compost pits from view.
5. Pandals may also be erected over the control foot bath, grapes varieties like Anab-e-Shahi or Black Prince may be trained over it.
6. Both the sides of the central foot path may be utilized to train tomato plants on single stemmed with the support of stakes.
7. The bunds separating the beds may be used for growing root crops or onion.

8. The conveniently divided small plots may be utilized to produce as much as possible by following a very intensive method of cultivation. This is possible by following continuous crop pattern in the form of succession and companion cropping.

Model kitchen garden and the cropping arrangements

Our dietician recommends under our condition to consume 300 gm of vegetables daily by an adult and based on this, a kitchen garden should supply 1.5 kg of fresh vegetables to an average family size of two adults and three children. This quantity of fresh vegetables can be assured from a kitchen garden, laid out in an extent of 5 cents (200 sq.m) following the above principles.

It is advisable to make a plan before undertaking the planting of a garden. The location of plots, crops to be grown, the probable date of planting, spacing between the plants, inter cropping and succession planting should be clearly indicated in the plan. This will guide the gardener to get constant supply of all kinds of vegetables avoiding a glut of any one crop.

A cropping pattern which may prove helpful for kitchen garden under Tamil Nadu condition (excepting the hill station) is suggested below: It may be observed from the above crop arrangements that throughout the year some crop is grown in each plot without a gap between any two crops (succession cropping) and wherever possible two crops (one long duration and the other a short duration one) are grown together in the same plot (companion cropping).

2. Market gardening

This type of vegetable garden is intended to supply vegetables for the local market. Therefore they are confined to the immediate vicinities of cities and towns. Such gardens are usually located within a radius of about 15 to 30 km from large tows and cities. Sine these type of gardens are close to urban, lands are generally costly. Hence intensive method of cultivation is followed. The gardener must be a versatile person as he is to grow a number of vegetables throughout the year to supply all kinds of vegetables to the market.

Plot	Name of the vegetables	Seasons
1.	Tomato and onion	June – September
	Radish	October – November
	French beans	December – February
	Bhendi	March – May
2.	Brinjal	June – September
	French beans	October – December
	Tomato	June – September

	Amaranthus	May
3.	Chilli and Radish	June – September
	Cowpea	December- February
	Bellary onion	March - May
4.	Bhendi and Radish	June – August
	Cabbage	September – December
	Cluste beans	January – March
5.	Bellary onion	June – August
	Beetroot	September – November
	Tomato	December – March
	Onion	April – May
6.	Bellary onion	July – September
	Carrot	September – December
	Pumpkin (small)	January – May
7.	Lab lab (bush type)	June – August
	Cauliflower and onion	September – December
	Bhendi	January – March
	Coriader	April - May

(Interspace with Amaranthhs)

Perennial plot	Drumstick	One row
	Banana (culinary cultivar)	Five rows
	Papaya	Five rows
	Tapioca	Two rows
	Curry leaf	One row
	Chekkurmanis	One row
	West Indian Cherry	Two rows
	Agathi	One row
	Indian stargooseberry	One row

3. Truck garden

This refers to producing some special crops in relatively larger quantities for distant market. The location of this type of gardens is determined by the sol and climatic factors suitable for raising those particular crops. Cultivation is more extensive. The commodities are usually marketed through middle – men. In Tamil Nadu, growing of cabbage and cauliflower in Nilgiris and tomatoes in Periakulam tract and sending them to distant places like Chennai are good examples of truck gardens.

4. Growing Of vegetables for processing

This is a type of garden which comes up around processing factories. They are intended to supply vegetables regularly to the factories. This type of garden is not yet developed in India due to lack of development of processing industries. Few factories which exist not are solely depending upon the local market for their raw materials. In foreign countries, it is a specialized type of vegetable garden and they grown only those varieties suitable for processing only. The vegetables may be processed by canning, freezing, dehydration and pickling and fermentation, Higher and continuous supply and also the quality of the produce are very important in this type of garden.

5. Vegetable forcing

It refers to the production of vegetables out of season in glass house. In England and other western countries where winter is severe, vegetables especially tomato and cucumber can not be grown outside during cooler months. As they are required throughout the year they are grown under protected conditions. Special varieties have been developed exclusively suitable for vegetable forcing in vegetable crops like tomato and cucumber. In India, this type of garden has little scope and there is also no need for it as all vegetables can be grown throughout the year in one part or other of our country. Yet certain big companies have recently ventured in this field in order to capitalize the off season marketing of important vegetable like tomato, capsicum etc.

6. Vegetable seed industry

Growing of vegetable to produce pure, true-to-type seed of good quality is another specialized activity. Soil, climate and disease free conditions are factors influencing location of seed producing areas. A thorough knowledge of the crop, its growth habit, mode of pollination, proper isolation

distances are all of prime importance in seed industry. The handling of the seed crop, curing, thrashing, cleaning, grading, packing and storage are the specialized techniques and a thorough knowledge on these aspects must be possessed by the grower. In India this is an expanding industry having vast scope. At present, certified seeds are produced for sale in Government forms and authorized private nurseries. Seed law is in force enforcing standards, compulsory seed testing and certification in India. In and around Coimbatore and Madurai some leading vegetable seed producing gardens have come into existence recently.

PRODUCTION TECHNOLOGY OF TOMATO

(*Lycopersicon esculentum* Mill) Family: Solanaceae

Tomato is essentially a tropical vegetable. The probable origin is the Peru in the South America. The ripe fruits are used as vegetable, soup, salad and in the preparation of products such as pickles, sauce, jam and ketchup. The fruit is a rich source of vitamin A (590 microgram / 100g) and C (27 mg/100g).

SOIL AND CLIMATIC REQUIREMENTS

A well drained loamy soil is ideal for its growth. It comes up well in a pH range of 6.0 to 7.0. It will not perform well if the temperature goes above 35°C. Similarly its performance will not be good when the temperature goes below 15°C. Between 20°C, this crop will exhibit its maximum potential.

VARIETIES

CO1

It is a reselection from Kalyanpur selection. The fruits are round without any grooves and crimson red in colour. It yields about 25 tonnes / ha. In a crop duration of 135 days. It is a semi determinate variety.

Co2

It is a selection from a Russain introduction. It is an indeterminate variety. The fruits are flat with 4-5 furrows. Each fruit weighs on an average 55-60 g. Ripe fruits are deep orange red in colour, its duration is 140 days and the yield is 28-30 tonnes/ha.

CO 3 (Marutham)

It is an induced mutant from Co 1; a determinate type suitable for close planting even as close as 30 cm x 30 cm. Fruits are round in shape with four light grooves and capsicum red in colour. It is a cluster bearing type capable of yielding as high as 40 tonnes/ha under a close spacing in a duration of 100-105 days. The above three varieties were evolved at Tamil Nadu Agricultural University, Coimbatore.

PKM 1

This is another induced mutant from a local variety called Annanji. The fruits are flat-round with prominent green shoulder and capsicum red colour. It is suitable for long distance transport. It yields about 30-35 tonnes/ha in a crop duration of 135 days. This variety was evolved at the then Horticultural Research Station, Periyakulam (Now Horticultural College and Research Institute).

Pusa Ruby

It is an indeterminate variety suitable for irrigated and also rainfed cultivation. The fruits are flat, medium in size with 7-8 furrows and capsicum red in colour. It was evolved at Indian Agricultural Research Institute, New Delhi. It yields about 25-30 tonnes / ha.

Paiyur-1

This variety was evolved by crossing Pusa. Ruby and CO 3. It is also suitable for rainfed cultivation. It yields about 30 tonnes/ha. It was evolved at the Regional Research Station, Paiyur of Tamil Nadu Agricultural University.

Arka Vikas

It is an improvement over an introduced variety 'Tip Top'. It was evolved at Indian Institute of Horticultural Research, Bangalore. It is an indeterminate variety with flat round fruits having 5-7 furrows, dark red in colour. It has an yield potential of 38 tonnes/ha in a crop duration of 110-115 days. Fruits are attractive with uniform ripening and suitable for fresh market.

Arka Saurab

It is an improvement over a tomato breeding line V-685 of Canada. It is a semi-determinate, firm fruited type having good taste and transport qualities. This variety is suitable for both fresh market and processing into juice, ketchup etc. It is resistant to fruit cracking and produces 35 tonnes / ha, in a crop duration of 105-115 days.

Arak Ahuti (Sel. 11)

It is a pureline selection from 'Ottawa-60' developed at IIHR, Bangalore. Plants are semi-determinate with a duration of 135 days; the fruits are oblong, thick fleshed, bilocular and uniform ripening. The fruits have a 'TSS of 5.25% with an acidity of 0.35%. It has an yield potential of 45 tonnes/ha.

Arka Ashish (IHR 674 SBSB)

Developed at IIHR, Bangalore. It is an improvement over UC83 B from California. The plants are determinate with concentrated fruit maturity. The fruits ar uniform ripening, very firm, bilocular, oval and the ripened fruits store well on the vine. It is tolerant to powdery mildew. The

colour is excellent (Lycopene 10 mg/ 100 g), TSS is 4.8% and with low acidity (0.35%), it makes excellent ketchup, juice and puree. It yields 35 tonnes/ha. In 130 days.

Arka Abha (BWR-1)

This is from line selection (IHR 638-12) from a SSD derived line got from AVRDC, Taiwan (VC8-1-2-1). The semi determinate vines bear oblate fruits with an average fruit weight of 75g with light green shoulder. It is resistant to bacterial wilt and is capable of yielding 25 tonnes/ha. in 135 days.

Arka Alok (BWR-5)

It is also a bacterial wilt resistant variety developed through pure line selection (IHR 719-1/6) out of an accession (CL114-5-1-0) from AVRDC, Taiwan developed at IIHR, Bangalore. The plant habit is determinate with a duration of 125 days. The fruit weighs on an average on 100g and is square round in shape, thick fleshed with light green shoulder. It has an yield potential of 35 tonnes/ha.

Pubjab Chhuhara

It is a firm fruited type suitable for processing. The fruits are oblong in shape and deep orange in colour. It was evolved at the Punjab Agricultural University, Ludhiana.

Shakthi

This was developed at College of Horticulture, Kerala Agricultural University, Vellanikkara. It is resistant to bacterial wilt disease. It has an yield potential of 30 tonnes/ha.

Pusa Early Dwarf

Developed at (AR) from a cross Improved Meeruti x Red Cloud. The plants are dwarf, determinate, early maturing, fruits flattish round, slightly furrowed, medium in size.

HS101

HS102

HS110

Hisar Arun (Sel-7)

Hisar Lalima (Sel-18)

Hisar Lalit (NRT 8)

Hisar Anmol (H24)

KS. 2

SL120

Pusa Gaurav

S12

Pant Bahar (AC 238)

Pant T3

Narendra Tomato 1 (NDT 5)

Narendra Tomato 2 (NDT 120)

Solan Gola

Arka Meghali

Arka Vishal (Fm Hybrid-1)

This indeterminate hybrid is the F1 hybrid between IHR837-6 and IHR 932. The average fruit weight is around 140g. The fruits are green shouldered, round, firm, deep red on ripening, tolerant to fruit cracking with good shelf life (13 days). It yields 75tonnes in 160 days.

Arka Vardan (FM Hybrid-2)

This indeterminate hybrid has its parents IHR 550-3 and IHR 932. It is resistant to nematodes and is suited for fresh market. It has an average fruit weight of 140g with oblate fruits, thick fleshed, green shouldered, deep red with a shelf life of 13 days at room temperature yielding 75 tonnes/ha in 160 days.

Pusa Hybrid 1

It was developed at IARI, New Delhi. The plants are determinate with medium sized (63g), smooth, round, firm, red fruits and with uniform ripening. The inner flesh colour is orange red. It has an added advantage of providing tomato fruits from June to mid July, the lean period in North India as it tolerates high temperature (upto 23°C night temperature). The yield during high temperature stress condition was 32 tonnes/ha against no fruit set in Pusa Ruby.

Pusa Hybrid 2

Another F1 hybrid developed at IARI, New Delhi with compact semi-determinate plants; highly suitable as spring-summer crop in the central Gangetic plains, as summer crop in Western Himalayas and autumn crop in the arid zones. Mid October-December is ideal time for sowing in north Indian plains. The fruits are medium in size round to flattish round in shape with red skin, orange red flesh and uniform ripening. It is also highly tolerant to nematodes. It has a potential yield of 60-70 tonnes/ha.

COTH 1 Hybrid Tomato

This was developed at the Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore by crossing IHR 709 and LE 812. It is a determinate F1 hybrid requiring minimum staking. The fruits are round to slightly oblong each weighing 50 g with deep red skin and thick flesh and borne in clusters of 4-5. The juice is acidic rendering the fruits for use in culinary preparation unlike the most of the hybrids developed by a number of private firms which lack acidity and hence used mostly for salad. The plants can be planted at a spacing of mostly for salad. The plants can be planted at a spacing of 60 x 45 cm. The estimated yield is 96 tonnes/ha in a crop duration of 110-115 days after transplanting.

Rashmi

Vaishali

Rupali

Naveen

Avinash 2

MTH 4

Sadabahar

Gulmohar

Sonali

NURSERY

Since the seeds are very small in size, they are normally sown in raised nursery beds and the seedlings are planted in the main field later on. About 300-350 g of seeds will be required to plant one hectare. Since the seeds of F1 hybrids are costly (Rs. 15,000/- to Rs. 20,000/- per Kg), seeds have to be sown individually in small plastic cups or ice cream cups in which 1-2 holes are made at the bottom to ensure drainage. By this method the quantity of seeds required to raise seedlings to plant one hectare can be reduced to 70-90 g. During last week of May or first week of December, raised beds of 60-70 cm width and of convenient length are prepared.

For management of root-knot nematode (Meloidogyne incognita) and reniform nematode (Rotylenchulus reniformis), at Indian Institute of Horticultural Research, Bangalore, an integrated plant protection strategy using botanicals and bio-agents has been developed and demonstrated to be very effective. While preparing the nursery beds, neem cake / castor cake / neem leaf / castor leaf / pongamia leaf / calotropis leaf has to be incorporated @ 400 g/m2 followed by application of spore suspension of a nematophagus fungus Paecilomyces lilacinus or *Verticillium arbuscular* mycorrhizae *Glomus fasciculatum* or G. mossae. This combined treatment reduced and reniform nematode

simultaneously increased the multiplication of endomycorrhizae and its colonization of tomato root which inturn could protect the crop from the nematodes in the main field also. Across the beds prepared, lines are drawn at a spacing of 2.5 cm.

Seed treatment with biofertilizer

The seeds required for one hectare can be mixed with required quantity of rice Kanji ust to have a thin coating. Then 100-200 g. of Azospirillum culture can be sprinkled over this and stirred thoroughly by a stick. The treated seeds are dried in shade for 30 minutes and then sown sparsely along the lines and then covered by the top soil. To protect the seeds from heavy rains, the seed beds are covered by a using rose can. About 4 cents of nursery area will be required to plant one hectare. Along the edges of the beds, BHC 10% dust is applied to prevent ants from taking away the seeds. For F1 hybrids, the seeds are sown in plastic cups or ice cream cups filled with pot mixture and watered by rosecan. At the time of transplanting the seedlings can be lifted from these cups along with ball of earth and placed in small pits formed on one side of the ridges without exposing the naked roots. This will help for cent per cent establishment of hybrid seedlings in the main field.

The seeds germinate in about seven to eight days. After germination, the straw cover is removed and the beds can be irrigated directly.

To avoid damping off disease, the seed beds have to be drenched with copper oxychloride solution 92.5 g/lit). Twenty days after sowing, 1.6 kg of Furadan granules are applied in lines between the rows of seedlings as a prophylactic measure to kill the thrips which transmit the virus, causing the dreaded disease 'Tomato Spotted Wilt' in this crop. This chemical protects the seedlings from other sucking pests also.

The seedlings are ready for transplanting in about 25-30 days after sowing. Root dip treatment of seedlings in 5% aqueous suspension of neem leaf mixed with spores of *Paecilomyces lilacinus* or

V. chlamydosporium for 20-30 minutes before transplanting was also demonstrated to be very effective in the management of these two nematodes in the field at IIHR, Bangalore.

PREPARATION OF MAIN FIELD

The field is ploughed three or four times. A the last ploughing 20-25 tonnes of farmyard manure has to applied. Ridges and furrows are formed at a spacing of 60 cm.

MANURES AND MANURING

The quantity of nutrient uptake varies from variety to variety as well as between variety and hybrids. The hybrids require more amount of nutrients to express their full yield potential. The nutrient requirement for varieties is 150:100:50 kg of NPK/ha and for hybrids is 250:250:250 kg of NPK /ha. Fifty per cent of the N is applied along with full dose of P and K as basal dressing.

WEED MANAGEMENT AND TRANSPLANTING

In the main field, a pre planting application of 1 lit of fluchloralin (as basalin 2lit/ha) dissolved in 500 lit. of water is done just before transplanting. The field is to be irrigated immediately and planting of the seedlings has to be taken up. Indeterminate varieties are planted at a spacing of 45 cm and determinate varieties are planted at a spacing of 30 cm along one side of the ridges and two seedlings are planted per hill. The seedlings have to be planted late in the evening for better establishment.

The seedlings of indeterminate F1 hybrids have to be plated at 100 cm along the row as they grow very vigorously.

For indeterminate varieties / hybrids, the seedlings have to be staked using bamboo sticks of two meter length. Instead or staking, planting of seedlings in broad ridge system can be adopted. Flat broad ridges of 90 cm width and 15 cm height are prepared. The seedlings are planted in the furrows at t spacing of 30 cm and the plant is allowed to spread on the broad ridge. Irrigation water is allowed only in the narrow furrows and the broad ridge is kept free of moisture . This will prevent the fruits

coming in contact with wet soil thereby rotting of fruit is prevented. In the normal system of planting, the seedlings are planted on the sides of the ridges and if left unstaked the fruits will not by coming in contact with the wet soil.

IRRIGATION

Life irrigation is given on the third day of planting and subsequently once in a week or 10 days depending upon the soil moisture conditions.

INTERCULTIVATION AND TOP-DRESSING

The plants are given a hoeing and then earthed up 30-35 days after transplanting. Just before earthing up, the remaining 50 per cent nitrogen is applied as top-dressing, mixed with the soil and the plants earthed up. Immediately after earthing up, the field is copiously irrigated. Foliar application of 0.1% CaCl2 during fruitset and maturity can help to prevent fruit cracking.

PRODUCTION TECHNOLOGY OF CHILLI AND CAPSICUMS

(*Capsicum annuum* L.) **Family : Solanaceae**

Chilli is yet another important vegetable cum condiment. It is called Red pepper or hot pepper whereas, the sweet pepper commonly known as 'Kudamilagai' is another botanical variety of capsicum annuum in which the fruits are very big in size with less biting taste and pungency. This is mainly used as a vegetable.

In the hot pepper or hot chilli, the pungent principle present is called 'Capsaicin' which is mainly present in the central placenta of the fruit as well as seed and to some extent in the ovary wall also. Generally the content of capsaicin varies from 0.2-0.4%.

The probable origin of this crop is South Central America and Chile while it was domesticated in Mexico from ancient times.

SOIL AND CLIMATE

It requires a deep, fertile, light loamy soil with a pH range of 6.5-7.5. it can be cultivated in black soil under rainfed cultivation. A temperature range of 20-30°C would be the most ideal for hot pepper while the sweet pepper can be successfully cultivated in a mild temperature of 17°C - 23°C. However, it can not tolerate frost.

VARIETIES

In the hot pepper there are two main groups. One is called the 'Samba' type in which the pods are long and another is called the 'Gundu' type in which the pods are round in shape and short. The gundu types are generally more pungent than samba types and they are adapted to rainfed culture than samba types.

HOT PEPPER

SAMBA VARIETIES

K 1 (Kovilpatti-1)

It is a selection from an Asam type B 72.A. it was released from Agricultural Experiment Station, Kovilpatti in Tamilnadu. The plants are tall and spreading. Unripe fruits are light green in colour while ripe fruits are red in colour, smooth with pointed tip. The crop duration is 210 days. It yields 1700 kg of dry pods per hectare.

K2 (Kovilpatti-2)

It was developed by crossing K1 and Sattur Samba. Plants are tall, and semispreading. Fruits are long, smooth with blunt tip. It yields 1800 kg of dry pods in a crop duration of 210 days.

CO1

It is a re-selection from Sattur Samba (CA(P)247 developed at Tamil Nadu Agricultural University, Coimbatore. It can be grown throughout the year. Duration is 210 days. Fruits are long and bright red in colour. It yields 2100 kg of dry pods per hectare.

G4 (Bagyalakshmi)

The plants are tall with medium long fruits attached to the pedicel firmly. Fruits have a blunt tip. Fruits are bright red in colour. It has got an yield potential of 2000 kg of dry pods per hectare in 210 days. It was developed at Agricultural Research Station Lam in Guntur of Andhra Pradesh.

Pusa Jwala

This is a hybrid derivative of NP 46A x Puri Red developed at Indian agricultural Research Institute, New Delhi. Fruits are long, thin, red in colour and usually curved at the tip. It is more suited for use as 'green chilli'.

Pant-C 1

A derivative from a cross of NP 46 A x local developed at Pant Nagar Agricultural University in Uttar Pradesh. Fruits are medium long. This variety can be identified by the erect fruits. The fruits have a blunt tip and a high level of pungency. It is suitable for both green and dry chilli. It yields 1600 kg of dry pods/ha.

Pant-C 2

It is another selection in the advanced generation of the same cross NP 46 x Local, but with pendant fruits. Yield is 1400 kg of dry pods/ha.

PKM 1

This is a hybrid derivative of the cross between AC No.1797 x CO 1 selected in F4 generation and fixed by selfing. It has very bold pods which are dark red in colour. It has got a very high yield potential of 3000-3200 kg of dry pods per hectare in a crop duration of 180 days. It was evolved at the then Horticultural Research Station (Presently Horticultural College), Periyakulam of Tamil Nadu Agricultural University.

CO 3 (CA 586)

This is a dwarf and less spreading type selected from an open pollinated type introduced from Sri Lanka. It is suitable for very close planting (30 cm x 15 cm). The fruits are long slender with attractive dark green colour before ripening and deep red colour after ripening. The fruits are borne underneath the canopy and less affected by heavy wind. The dried pods have a very low stalk / pod ratio (6.6%), high oleoresin (13%) and capsaicin content (0.402%) and hence suitable for export purpose. It is suitable for use as both green chilli and dried chilli. The crop duration is 165 days. It was developed at the department of Olericulture, College of Horticulture, Tamil Nadu Agricultural University, Coimbatore. The potential yield under a close spacing of 30 cm x 15 cm goes upto 15-18 tonnes of green chilli or 3500 kg of dry chilli/ha.

Arka Lohit (Sel 1)

It is a pure line selection from IHR 324 (a local collection) developed at IIHR, Bangalore. Fruits are dark green, smooth, straight, turning deep red on maturity (Capsanthin 0.205%), fruits are highly pungent (Capsaicin 0.708%). It has an yield potential of 3.5 t of dry chilli/ha in 180 days or 20 to 25 tonnes of green chilli/ha. It is also tolerant to moisture stress and does well under rainfed conditions.

Pusa Sadabahar

Jwala Mukhi

Jwala Sakthi

Ujwala

Jawahar Mirchi (Jawahar 2181)

Punjab Lal

Hisar Vijay (HC28)

Hisar Shakti (HC44)

RHRC pendent cluster

RHRC erect cluster

GUNDU TYPES

CO 2

This is a selection from Nambiyur local of Periyar district of Tamil Nadu (CA) (P) 63) suited for both green and dry chilli. Fruits are thick and red in colour with high seed content and pungency. It is capable of yielding 2100 kg of dry pods or 10740 kg green pods/ha in a crop duration of 200-210 days.

G 5 (Andhra Jyothi)

It is a derivative of a cross between G29 x 1331. It is tolerant to thrips. It has an yield potential of 1700 kg of dry pods/ha. It is also suitable for green chilli (8500 kg of green chilli/ha).

PMK 1 (Paramakudi 1)

It was developed at Agricultural Research Station, Paramakudi of TNAU. It is a hybrid derivative of the cross Co 2 x Ramanathapuram gundu (a local type of Ramanathapuram District). This variety is suitable for rainfed cultivation during North East monsoon season in South East parts of Tamil Nadu by direct sowing. It has an yield potential of 2300 kg of dry pods per hectare under rainfed conditions. The pods have a capsaicin content of 0.36 per cent.

PLR 1 (Palur 1)

It is a pureline selection (CA(P)8) from Kandangadu type developed at Vegetable Research Station, Palur of TNAU in Cuddalore district of Tamil Nadu. It is suitable for harvesting as green chilli and for cultivation under irrigated conditions of North Eastern Zone of Tamilnadu. It tolerates

salinity in the soil. The plant is dwarf statured and produces more number of fruits (190/plant). It has a high yielding potential of 18.4 tonnes of green chilli per hectare which is 13.3% increase over Co.2 and 23.5% over local type. It is suitable for picking also. Fruits are pendulous medium in size (8.66 cm length and 8.54 cm girth) with bulging base and blunt tip, glossy green appearance. The first picking starts 60 days after transplanting. The picking completes in 180 days after transplantation. The total crop duration is 210 days. The green pods are suitable for pickling using buttermilk.

SWEET PEPPER

The important varieties in sweet pepper are some of the introduction like California Wonder, Yolo Wonder etc. and some of the varieties released by IIHR such as Arka Basant, Arka Mohini, Arka Gaurav and some of the F_1 hybrids like Bharat developed by Indo American Hybrid Seeds Company, Bangalore. In tropical regions, the crop is grown in relatively cool season of the year *viz*., September, February.

Arka Basant

It was developed at IIHR, Bangalore. A pure line selection from a highly variable population of the Hungarian variety soroksari. Plants are semi-determinate in growth with upright bearing habit. Fruits are cream coloured, medium sized with 3-4 lobes, non pungent and excellent for stuffed cooking. It yields 15-20 tonnes/ha in 125-140 days after transplanting.

Arka Gaurav

It was also developed at IIHR, Bangalore as a pureline selection from the variety Golden Calwonder. Plants are indeterminate in growth with upright bearing habit. Fruits are dark green when mature, orange yellow on ripening, blocky with 3-4 lobes. Average fruit weight is 130-150 g. Flesh is thick, juicy, non-pungent and with pleasant aroma. Storage and transport qualities are good. It yields 15-20 tonnes/ha in 125-150 days after transplanting.

Arka Mohini

Developed at IIHR, Bangalore through pureline selection from a highly population of variety 'Titan' introduced from USA. Fruits are dark green when mature, red on ripening, blocky, 3-4 lobed, non pungent with pleasant aroma. Average fruit weight 180-200 g. It yields 15-20 tonnes/ha in 120 days after transplanting.

Green Gold

An F_1 hybrid developed by Maharashtra Hybrid Seeds Company, Jalna. It has early fruit bearing habit. Initial two pickings offer major yield. Fruits are dark green in colour, 11 cm in length and 9 cm in girth with 3-4 lobes. Skin is medium thick. The fruit weight ranged between 100 and 120 g. Except summer, it can be grown in any other season. August to February sowing gives the best yield. It is reported to be resistant to Tobacco mosaic virus. Its yield potential is 60-75 tonnes/ha.

Bharath

It is an F_1 hybrid developed by Indo-American Hybrid Seeds Company, Bangalore. Fruits are dark green with 3-4 lobes. Each fruit weighs 12-150 g. Yield ranges from 35-40 tonnes/ha.

PREPARATION OF NURSERY

During May-June and December-January, raised nursery beds are formed in an area of 3 cents after mixing 100 kg of farm yard manure. A quantity of 1250 g of seeds would be required to raise seedlings to plant one hectare area. The seeds are treated with 2.5 g. of Bavistin to prevent incidence of seed borne diseases. Lines are drawn across the beds at a spacing of 2.5 cm and seeds are sown sparsely along these lines and then covered with top soil. These beds are watered with the help of rose can after covering with paddy straw. Along the border of these beds, BHC 10% dust is applied to prevent ants from taking away the seeds. On 20th day of sowing, 300 g of Furadan 3G granules have to be applied in between the seedling lines across the bed, stirred with the soil and then the beds are irrigated.

TREATMENT OF SEEDLINGS WITH BIOFERTILIZER

The plants will be ready for transplanting in 40-45 days after sowing. At the time of transplanting, the seedlings may be treated with *Azospirillum* for better establishement and growth in the main field. Two kilograms of *Azospirillum* culture has to be mixed in 10 litres of water. The root portion of the seedlings are soaked in this mixture for 20-30 minutes and then planted in the main field.

PREPARATION OF MAIN FIELD, MANURING AND PLANTING

The filed is ploughed four or five times and 25 tonnes of Farm yard manure is applied at the last ploughing. Ridges and furrows are formed at a spacing of 60 cm or 45 cm depending upon the variety.

As a basal dressing, 60 kg of Phosphorus (375 kg of superphosphate) and 30 kg potash (50 kg of Muriate of potash) are applied along with 40 kg nitrogen (87 kg of urea) along one side of the ridges and mixed with the soil.

Just before transplanting, 2 litres of Basalin (Flucholoralin 1 lit. a.i./ha) has to be mixed with 500 lit. of water and sprayed on the soil surface as a pre-emergent herbicide. This should be followed by irrigation. Then the seedling are planted @ 2 seedlings per hill at a spacing of 30 cm along the side of the ridges in which the fertilizers have been placed. For dwarf and compact variety like CO3, a very close spacing of even 30 x 15 cm can be adopted to increase the yield per unit area.

IRRIGATION

The first irrigation is given at the time of transplanting. On third day, life irrigation is given and subsequent irrigations are given once in a week or 10 days depending on the soil moisture condition.

TOP-DRESSING

30th day of transplanting 40 kg of Nitrogen

60th day of transplanting 40 kg of Nitrogen

90th day of transplanting 40 kg of Nitrogen

The nitrogen is applied in the form of urea and plants are earthed up and irrigated. By this split application, the wastage of nitrogen leaching is avoided.

INTER-CULTURAL OPERATION

On 30th day, one hoeing and weeding are given and the plants are earthed up. On 20th, 40th, 60th and 80th day of transplanting, triacontanol 1.25 ppm (2.5 ml of Vipul dissolved in 10 lit. of water) may be sprayed on the foliage of the plants using a hand sprayer. Traiacontanol increases the photosynthetic efficiency and thereby the yield upto the tune of 500 kg of dry pods per hectare. To improve the fruitset, as well as to reduce flower and fruit drop, 50 ppm of Naphthalene Acetic Acid (equal to 1 ml of Planofix mixed with 4.5 lit. of water) has to be sprayed. For spraying these chemicals, only soft water should be used.

PRODUCTION TECHNOLOGY OF BRINJAL

(*Solanum melongena* L.) **Family : Solanaceae**

Brinjal is also called egg plant or aubergine. It is another tropical vegetable believed to be a native of India.

SOIL AND CLIMATE

A deep fertile silt loam or clay loam soil with a pH of 5.5 to 6.0 is the best for growth and development of brinjal. This crop grows very well in a temperature range of 25°-30°C. Very low temperature especially below 15°C will affect the growth of the plant as well as fruit quality. It cannot withstand heavy rains especially during flowering and fruit set.

VARIETIES

Selection of variety is an important consideration in the cultivation of brinjal as the local preference varies considerably from region to region and even district to district. A variety with a particular colour and size of the fruit fetching premium price in the market, may be totally rejected in another area. Since the ultimate aim of the farmer is to get maximum return for his produce, judicial selection of the type with reference to market demands is very important in this crop.

CO 1

It is a pureline selection. Fruits are oblong and medium sized with pale green shade under white background. The plants are compact and bushy. It has an yield potential of 20-25 tonnes/ha. The fruits are soft seeded even at full maturity. It was developed from the vegetable section of the then Agricultural College and Research Institute, Coimbatore. It is preferred in the markets of southern districts of Tamil Nadu such as Tirunelveli, Ramanathapuram etc., and also Karnataka State.

MDU 1

This was developed at the Department of Horticulture, Agricultural College and Research Institute, Madurai. The plants are vigorous and compact. Fruits are round with large size each weighing about 200-250 g., bright purple in colour and have less seed content. As the fruit matures, the purple colour fades to pale pink. It is a pure line selection from a local type called Kallampatti. It has got an yield potential of 30 tonnes/ha. in a crop duration of 135-140 days. Preferred in Madurai and Trichy districts of Tamil Nadu and also in Kerala State.

Annamalai

This is an aphid resistant variety developed at the Department of Horticulture, Faculty of Agriculture, Annamalai University. The fruits are oblong, deep purple in colour with a characteristic yellowish mark along the calyx border and a few thorns on the calyx surface. This is preferred in Cuddalore, Villupuram, Vellore, Thiruvannamalai and Chemgalpattu districts and Chennai market. It has an yield potential of 20-22 tonnes/ha.

PKM 1

It was evolved at the then Horticultural Research Station, Periyarkulam of Tamil Nadu Agricultural University from a local type called 'Puzhuthi Kathiri' through mutation breeding. It is adapted to rainfed cultivation in Madurai and Anna Districts. The fruits are small and slightly oblong ovate with green stripes.

PLR 1

This is a reselection from a Nagpur ecotype developed at the Vegetable Research Station, Palur of TNAU in Cuddalore district of Tamil Nadu. The fruits are small to medium in size, sometimes borne in clusters, egg shaped and with bright glossy purple colour. It fetches premium price in the markets of Cuddalore, Chengalpattu and Chennai. It has got a shelf life of 8-10 days under ambient temperature. It yields on an average 25 tonnes/ha.

Pusa Purple Long

It was developed at Indian Agricultural Research Institute, New Delhi through pureline selection. Fruits are glossy, light purple in colour, 25-30 cm long and smooth. It has an yield potential of 25-37 tonnes/ha.

Pusa Purple Round

It was also evolved at Indian Agricultural Research Institute, New Delhi. The plants are very tall with a thick stem of greenish purple colour. Leaves are highly serrated and deep green in colour. Fruits are round with purple colour. Each fruit weighs on an average 130-140 g.

Pusa Purple Cluster

It is a cluster bearing type developed at Indian Agricultural Research Institute, New Delhi.

Arka Sheel

It is a pureline selection from a Coorg type developed at Indian Institute of Horticultural Research, Bangalore. Fruits are medium long and deep purple in colour with less seeds. It yields about 39 tonnes/ha in 120 days.

Arka Shirish

An extra long brinjal cultivar improved from a local type called Irangeri brinjal of Karnataka State. Fruits are very long, light green in colour and the yield is around 45-47 tonnes/ha. in a crop duration of 115 days. It was evolved at IIHR, Bangalore.

Arka Kusumakar

This is another variety developed at IIHR, Bangalore through pure line selection from a local variety in Karnataka. The fruits are medium long, finger shaped and pale green in colour and borne in clusters of 5-7; yield is 45 tonnes/ha. in 120 days.

Arka Neelkanth

Developed at IIHR, Bangalore. Plants are tall (95.5 cm) and are compact. Fruits are short (12 cm length, girth 8.5 cm) with violet blue glossy skin, green purple calyx, tender flesh having slow maturing seeds and free from bitter principle. Each fruit weighs 40g on an average and are borne in clusters in two flushes. Young leaves are dark green with purple leaf base and veins. Stem is purple green. This variety is resistant to bacterial wilt and has very good cooking and keeping qualities. It yields 40 tonnes/ha in a crop duration of 150 days.

Arka Nidhi

It was also developed at IIHR, Bangalore. Plants are tall (90 cm) well branched and compact. Fruits are medium long (20 cm length and 9 cm girth) with blue black glossy skin, green purple calyx, tender flesh with slow maturing seeds, free from bitter principles. The fruits weight on average 43 g and borne in clusters in two flushes; cooking and keeping qualities are good. It is also resistant to bacterial wilt. It yields 48.5 t/ha in 150 days.

Pant Samrat

Pant Rituraj

Azad Kranti

Jamuni Gola

Kt 4

Pusa Kranti

Punjab Barsati

Punjab Neelum

APAU Gulabi

APAU Shyamala

APAU Bagyamathi

KKM 1

Aruna

Pusa Anmol

Arka Navneeth

MHB-1

MHB-9

MHB-20 (Kalpatharu)

Pusa Hybrid-5

Pusa Hybrid-6

Azad Hybrid

Hisar Shyamal (H8)

SEASON

May – June to October

December – January to May

NURSERY

Equal quantity of sand and well decomposed farm yard manure are mixed with soil and raised beds of 60-75 cm width and of convenient length are prepared. These beds are treated with a solution of 100g of blue copper dissolved in 40 litres of water. About 380-400 g of seds (treated with 2g. of Thiram) required to raise seedlings to plant one hectare will be sown in an area of 4 cents nursery. The seeds are sown in lines drawn at a spacing of 5 cm across the beds and covered with top soil. The beds are covered by a layer of paddy straw or dried grass and then watered by rose can. BHC 10% dust has to be applied around these beds to prevent the ants from taking away the seeds. Seeds germinate in 5-7 days. The seedlings are ready for transplanting in 40-50 days.

PREPARATION OF THE MAIN FIELD AND PLANTING

The field is prepared by ploughing four or five times. At the last ploughing, 25 tonnes of farm yard manure is applied. Ridges and furrows are formed at a spacing of 75 cm. Two kg in each of Azospirillum and Phosphobacteria can be mixed with 40 kg of sieved farm yard manure and applied evenly for one hectare.

Manures and Manuring

Basal Dressing

50 kg of Nitrogen (110 kg of urea) / ha

50 kg of phosphorus (300 kg of Super phosphate) / ha

50 kg of Potash (80 kg muriate of potash / ha.

The fertilizer are to be mixed and applied along one side of the ridges as band and mixed with the soil. Then the filed is sprayed with a pre-emergent weedicide such as fluchloralin 1 lit a.i. (Basalin 2 lit. dissolved in 500 lit. of water and used to spray one hectare). Immediately the field is irrigated and the seedlings are planted at a spacing of 50 cm on the side of the ridges where the fertilizers have been placed. Life irrigation is given on the third day of planting. Then the irrigation is done once in a week.

Top Dressing

Forty days after transplanting, 50 kg of nitrogen is applied in the form of urea (110 kg of urea) as a band application 5-10 cm away from the seedlings and mixed with the soil. The plants are earthed up and irrigated.

PRODUCTION TECHNOLOGY OF BHENDI (OR) ORKA

(*Abelmoschus esculentus* (L.) Moench) Family : *Malvaceae* This is commonly known as lady's finger. It is a tropical direct sown vegetable with a short duration of 90-100 days. South Africa or Asia is supposed to be the centre of origin of this crop.

Soil and Climatic Requirements

A well drained deep soil is ideal for its growth. It grows very well in a pH range of 6.0 to 6.8 and does very well in humid tropics with a temperature range of 25-30°C.

The best season for growing bhendi is from June to August. The seeds can also be sown during July and the harvest can be completed before October rains.

The seeds can be sown after the rains are over viz., last week of October or first week of November. The growth will be very slow when the minimum temperature goes to 15-17°C during January – February. Growing bhendi during summer is found to be very difficult becuase of dreaded disease called yellow vein mosaic which is caused by virus. This virus is transmitted by whitefly (Bemisia tabaci) whose activity is in its peak when the temperature is high. So to grow bhendi during summer season (March-May), varieties which are resistant to yellow vein mosaic disease such as Parbhani Kranti, Arka Abhay (IIHR Sel.4), Arka Anamika (IIHR Sel.10), Co3 Hybrid, Varsha Uphar have to be utilised.

Varieties

Pusa Sawani

This variety was developed at IARI, New Delhi. The fruits are bright green in colour, medium in length with five ridges. It has got an yield potential of 8-10 tonnes/ha. in a crop duration of 90-95 days. It is susceptible to yellow vein mosaic disease and hence can not be recommended for growing during summer. This variety can be sown during Kharif and Rabi season.

MDU 1

This variety was evolved at Agricultural College and Research Institute, Madurai, TNAU, by gamma irradiation of the seeds of Pusa Sawani. The fruits are light green in colour with long stylar end. The plants are compact with close arrangement of nodes. It is also susceptible to yellow vein mosaic disease. Yield is 10-11 tonnes/ha.

CO 1

This is a pure line selection from Hyderabad "Red Wonder". The fruits are pinkish red in colour. It has got an yield potential of 12 tonnes/ha. It is susceptible to yellow vein mosaic disease. It was developed at the Department of Horticulture, Tamil Nadu University, Coimbatore.

Punjab Padmini

This was developed at Punjab Agricultural University, Ludhiana fruits are dark green in colour and each fruit weighs 20 g. It tolerates yellow vein mosaic to certain extent under field conditions.

CO 2

It is a F_1 hybrid (AE 180 x Pusa Sawani) developed at the vegetable department of the College of Horticulture, TNAU, Coimbatore. The fruits are very long 22-25 cm, thick with 7-8 edges and light green in colour. It has an yield potential of 15-16 tonnes/ha. However it is highly susceptible to yellow vein mosaic disease and hence can not be recommended for growing during summer season. Because of its bigger fruit size it can be used for preparation of dehydrated products.

Parbhani Kranti

It was evolved at Marathwada Agricultural University Parbhani, Maharashtra State. This variety shows field resistance to yellow vein mosaic disease (less than 5% incidence) and is recommended for growing during summer season, when the disease incidence is at its peak. The fruits are dark green in colour. It yields on an average of 10-12 tonnes/ha during Kharif season and 7-8 tonnes/ha during summer season. It was evolved by back cross method of breeding using a wild relative of bhendi called *Abelmoschus manihot*.

Arka Abhay (IIHR Sel.4)

This variety was developed at Indian Institute of Horticultural Research, Bangalore through interspecific hybridization using *Abelmoschus manihot* ssp *tartraphyllus* Var *tetraphyllus* as a source of resistance and it exhibits a very high degree of resistance to yellow vein mosaic disease. It has an yield potential of 10-12 tonnes/ha. during summer and 16-18 tonnes/ha during kharif season. The fruits are short, dark green in colour and fetch a premium price in the market summer season. Duration is 120-135 days.

Arka Anamika (IIHR Sel.10)

This is yet another variety developed at Indian Institute of Horticultural Research, Bangalore through the same interspecific hybridization in which the previous variety was isolated. It shows very high degree of resistance to yellow vein mosaic disease and hence suitable for growing during summer season. It has an yield potential of 12-13 tonnes / ha during summer and 16-18 tonnes/ha in kharif. The fruits are dark green in colour and longer than Arka Abhay. Duration is 120-135 days.

CO 3 (Hy8)

It is an F_1 hybrid between Parbhani Kranti and MDU 1 and has an yield potential of 16-18 tonnes/ha. It is moderately resistant to yellow vein mosaic. Suitable for growing during Kharif as well as summer. It was developed at Dept. of Olericulture, Horticultural College and Research Institute, TNAU, Coimbatore.

Varsha Uphar (HRB 9-2)

It was developed at CCS Haryana Agricultural University, Hisar by inter varietal hybridization between Lam selection 1 and Parbhanik Kanti and following pedigree selection. It is an early, high yielding, YVM resistant variety recommended for cultivation in disease prone rainy season conditions in Haryana as well as zone IV and VI of the country by the All India co-ordinated vegetable Improvement Project. The plants are medium tall (90-120 cm) with short internodes, producing 2-3

branches each. Fruits smooth, dark green attractive with 5 ridges. The average yield during rainy season was 9.8 tonnes/ha.

Field Preparation

The field should be ploughed four to five times. At the last ploughing 25 tonnes of farm yard manure/ha is applied and incorporated. Ridges and furrows are formed at 45 cm interval. As basal dressing, 20 kg of Nitrogen (45 kg of urea) 50 kg of Phosphorus (300 kg of super phosphate) and 30 kg of Potash (50 kg of muriate of potash) are applied along one side of the ridges as band application and mixed with the soil.

Seeds and Sowing

Seed treatment with biofertilizer like Azospirillum can economise the use of inorganic form of nitrogen. To sow one hectare 7-8 kg of seeds will be required. This can be treated with 2 kg of Azospirillum culture. First the seeds are mixed with required quantity of supernatant fluid (Kanji) obtained in cooking the rice. The temperature of this fluod should be mild and should not be too high. By this a thin coating of the rice cooked fluid is formed on the surface of the seed. Then 2 kg of Azospirillum culture is sprinkled uniformly over this and stirred thoroughly so that a thin lining or layer of the Azospirillum culture is formed over the seed cover. The seeds are dried in shade for half an hour and then sown on one side of the ridges at the rate of 2 seeds/hill, spaced at 30 cm. Immediately the field is irrigated. The Azospirillum treatment of the seeds has been found to save 10 kg of nitrogen in the quantity of inorganic nitrogen recommended for the crop.

The Azospirillum can be applied through soil also by mixing 2 kg of culture with 10-15 kg of finely powdered well decomposed farm yard manure and placed as band before sowing the seeds. Along with this, 2 kg of phosphobacteria can be mixed so that the soil phosphorus will be made available early to the crop.

Irrigation

Immediately after sowing, the field is irrigated. Again on the third day, life irrigation is given and subsequent irrigations are given once in a week or 10 days depending upon the soil moisture.

Intercultivation and Top-Dressing

A pre-emergence application of 1 kg of Fluchloralin or 0.75 kg of metalachlor/ha on third day of sowing using 500 litres of water will help to control effectively the early emerging weeds. Manual weeding and hoeing is done on 25^{th} day. On 30^{th} day, 10 kg of nitrogen (22 kg of urea) is applied if biofertilizer has been applied basally. Otherwise, 20 kg of Nitrogen (44 kg of urea) has to be applied. The fertilizer is applied as a band 10 cm away from the plants, mixed with the soil, and the plants are earthed up and irrigated. The second earthing up is given 65 days after sowing. Foliar application of 10% solution of coconut milk (tender coconut) at fortnightly interval from 30 days after sowing can help to increase the yield as well as to delay the formation of fibre in the developing fruits.

PRODUCTION TECHNOLOGY OF ONION (*Allium sp*.)

There are two distinct species of cultivated onions. They produce under ground bulbs which are edible. The native home of onion and its related species is Central Asia and Mediterranean Region.

Allium cepa var. *cepa* which is called bellary onion or big onion is propagated by seeds. One big bulb is formed in each seedling.

Allium cepa var. *aggregatum* is country onion or multiplier onion or potato onion in which a number of bulbs are formed from a single bulblet which is used for propagation (Vegetatively propagated).

BIG ONION (OR) COMMON ONION

(*Allium cepa var. cepa*) Family : Alliaceae

Climate and Soil Requirements

Though it is a tropical crop, it can be cultivated under a wide range of climatic conditions. The best performance can be obtained in a mild weather without the extremes of cold and heat and excessive rainfall. The optimum temperature is 13°C to 24°C before bulbing and 16° - 21°C during bulbing. In the young stage it can even tolerate freezing temperature. Though it can be cultivated in a wide range of soils, a sandy loam or silt loam is the best. The optimum pH would be 5.8 – 6.5. Most of the cultivars are long day plants viz., at long days, the bulb formation is hastened. However, the short day cultivars are not really short day plants, but they can form bulbs relatively under short day conditions. Intermediate types are grouped in between these two groups.

Varieties

Pusa Red

It was developed at IARI through selection from a local cultivar. The bulbs are flattish in shape and purplish red in colour. Each bulb weighs on an average 80 g. It is a less pungent variety.

Pusa Ratnar

Released by IARI with large round red bulbs with good storage quality.

Early Grano

An introduction from USA with globular yellow bulbs having mild pungency and suitable for salad purpose. The bulbs come to maturity in 95 days after transplanting. It has an yield potential of 47 tonnes/ha. It does not have good keeping quality.

NP-53 (Niphad 53)

An improved strain with scarlet red bulbs. It has an yield potential of 19-20 tonnes/ha. It is commonly known as Nasik Red and suitable for Kharif season.

Arka Pragathi

It has globe shaped bulbs with thin neck and deep pink outer scales with high pungency suitable for both kharif and rabi seasons. It is an early variety with good keeping quality and can produce 45 tonnes of bulbes/ha in 130 days after transplanting. Developed at IIHR, Bangalore.

Arka Niketan

It possesses globe shaped attractive light pink coloured bulbs. It has high TSS (13 - 14 per cent) and pungency and it is suitable for growing both in kharif and rabi seasons. It has an yield potential of 41 tonnes/ha in 145 days after transplanting.

Punjab Red Round

Bulbs are red, globular in shape, 5-6 cm diameter and weighs 50-70 g each. They are firm with good keeping quality. It is tolerant to purple blotch. This variety was developed at Punjab Agricultural University, Ludhiana. The bulbs have a TSS of 12.7° brix. It has an yield potential of 40-45 tonnes/ha in 140-150 days after transplanting.

Arka Kalyan

It is suitable for growing during kharif season only. It has verydeep pink coloured bulbs with succulent concentric internal scales. It is moderately resistant to purple blotch disease. It has an yield potential of 47 tonnes/ha in a crop duration of 140 days after transplanting.

Agri Found Light Red

It was developed by National Horticultural Research and Development Foundation (formerly Associated Agrl. Development Foundations), Nasik. It is suitable for rabi sowing. The bulbs are light red in colour, conical in shape (with less equatorial diametere) with 30-40 g weight. the bulbs possess a TSS of 13° brix. It can give 30-32 tonnes of bulb/ha in a crop duration of 130 days after transplanting.

Agri Found Dark Red

This is another variety developed by NHRDF (AADF) suitable for rabi season. the bulbs are dark red in colour with a TSS of 12° brix. It has an yield potential of 25-30 tonnes/ha in 95-110 days after transplanting.

Pussa Madhvi (Pusa Line 102-1)

This was developed at IARI, New Delhi. It yields 25-30 tonnes/ha in 140 days. the bulbs are large round, light red in colour with a TSS of 12.5° brix.

Arka Bindu

This variety was developed for export market by mass selection from a local collection (IHR 402) at IIHR Bangalore. Bulbs are small in size (2.5 to 3.5 cm diameter) very deep red, highly pungent, flattish globe in shape and has high TSS (14-16%). It yields 25 tonnes/ha in 75-85 days after transplanting.

Arka Kirtimnan

It is a F1 hybrid of CMS 65 x Selection 13-1-1 developed at IIHR, Bangalore suitable for kharif and rabi season sowing. Bulbs are medium in size dark red in colour, scale leaves are compactly arranged. It can yield 45-60 tonnes/ha in 130 days. Bulbs have a shelf life of 3-4 months. Suitable for export to Gulf countries.

Arka Lalima

It is another F1 hybrid developed at IIHR, Bangalore (MS48 x Onion Se114-1). the bulbs are uniform, deep red, globe shaped, firm textured, each weighing 120-130 g. Tolerant to purple blotch. Bulbs have a good shelf life of 5 months. Suitable for export to Gulf countries.

Arka Pitamber (IIHR Yellow)

It is a short day onion variety having firm bulbs with attractive yellow skin and globe shape. The average bulb weight is 80 g it is moderately resistant to purple blotch. It has an yield potential of 35-38 tonnes/ha. Suitable for export to European countries.

VL Piaz 3

It has been evolved at Vivekananda Pravatiya krishi anusandhan Shala, Almora, Uttar Pradesh by hybridization using an exotic line BYG 2207 A and a line derived from the local collection, followed by three cycles of mass selection. It is mainly suited for hilly areas. It produces medium sezed, flat round, tight-skinned light red bulbs with closed neck. The bulbs are ready fo harvest in 160-170 days after transplanting. Its potential yield in hills was found to be 40 tonnes/ha. It can also be cultivated in plains where it registered on an average 33 tonnes of bulbs per hectare.

SEEDS AND SOWING

A quantity of 8 kg of seeds would be required to be sown in an area of 12.5 cents (500 square metres) to plant one hectare. Raised beds of convenient length and width ar formed and these beds are inoculated with Vesicular arbuscular Mycorrhizae @ 1 kg/sq. metre. The seeds ar then treated with Azospirillum @ 100 g/kg. of seeds, sown in lines at a depth of 1-2 cm and covered with top soil. These beds are then covered with straw or dried grass and watered by rose can. The seeds germinate in 7-8 days. Then the straw mulch is removed and the seedling are irrigated. They will be ready for transplanting in 45-50 days after sowing.

MAINFIELD PREPARATION, MANURING, PLANTIG AND TOP DRESSING

The field is ploughed 4-5 times and 25 tonnes of FYM is applied at the last ploughing. Along with this a quantity of 50 kg of Zinc sulphate or ferrous sulphate is applied and ploughed. Then beds and channels fof convenient sizes or ridges and furrows ar formed at a spacing of 30 cm. Just before

transplanting, the basal dose of N, P and K is applied on both the sides of the ridges. (30 kg N, 60 kg P and 30 kg K per hectare). On 30th day 30 kg of N/ha is applied as top dressing.

For rabi onion the response has been found up to 200 kg N/ha in a recent study conducted at APAU, Hyderabad. in this 50 kg of N has to be given as basal dose along with 30 t FYM + 80 kg of P and 50 kg K. On 20th and 40th day of transplanting 50 kg of N/ha has to be applied. On 60th day 50 kg N + 50 kg K/ha have to be applied.

INTERCULTIVATION AND IRRIGATION

Deep tillage is not recommended since it is a shallow rooted crop. Irrigation is necessary at the time of planting, again on 3rd day and then once i a week. the critical stage is bulb formation stage and there should not be any moisture stress during the period. Otherwise the yield will be drastically reduced. based on the findings of a recent research conducted at Andhra Pradesh it is recommended .

1. Vegetative stage (15-60 days after transplanting)-3-4 irrigations at 12 to 15 days interval.
2. Bulb initiation and development stage (61-105 DAT)-6 irrigations at 7 days interval.
3. Bulb maturity to harvest stage-2 irrigations at 7 days interval with 43 mm depth of water.

PRODUCTION TECHNOLOGY OF CAULIFLOWER

Brassica Oleracea var. *botrytis* Family : Cruciferae

Cauliflower was introduced from England in 1822 by Dr. Jenson took over the charge of Company Bhag, Saharanpur (U.P.) to carry out some horticultural experiment during the period of East India Company, Curd is used in making curries, soups, pickles as well as canning. The curd contains a good amount of vitamin B (10-15 mg/100 g). India command the largest area and production under cauliflower in world today and contributing nearly 35% (2.55 lacks hectare and 46.91 lakhs tonnes, respectively) of total area and production. However, the productivity is almost equal to the world average (18.4 tonnes) with 6th rank in the world. In India, cauliflower is grown both in hills and plain from 11°N to 35°N during July to March in northern plain and from March to November in hills.

Area, Production and Productivity of Cauliflower

Year	**Area (in 000' HA)**	**% of Total Area**	**Production (in 000' MT)**	**% of Total Production**	**Productivity (in MT/HA)**
1996-97	233.9	4.2	3419.0	4.6	14.6
1997-98	248.2	4.4	4471.0	6.2	18.0
1998-99	255.4	4.4	4690.6	5.3	18.4

Cultivars

Cauliflower grown in our country can be classified in two broad group, viz., Indian cauliflower or tropical or hot weather or heat tolerant cauliflower and early temperate type known as snow ball groups or late or European types. The different between Indian and European types of cauliflower are as follows.

Indian types	**European types**
Tolerant to heat	Not to learnt
Curd formation at and above 20°C	Curd formation at 5-20°C
Annual	Biennial
Yellow curds, loose with strong flavour	Snow-white curds with very mild or no flavour
Early	Late
More variable	Less variable
More self-incompatible	Less self-incompatible
Small Juvenile phase	Long Juvenile phase
No need of vernalisation but needs cold	Needs vernalization at 7°C for 8-10 weeks.

treatment at 10-13°C for 6 weeks	

Varieties

Early Kunwari

It is the earliest variety, ready for harvesting from September to mid October. Curds semi spherical with even surface.

Pusa Deepali

It is an early season variety, has erect tall plants with short, green waxy leaves. Curds are compact and self-branching type, medium size, white and almost free from riceyness.

Pusa Kataki

This is one of the early varieties maturing in October-November and having medium plants, bluish green and waxy leaves. Late planting beyond middle of August does not give good size curds.

Pusa Synthetic

It has erect plants synthesized from 7 inbred with 24-28 leaves, and narrow to medium frame. Curds are ready for harvesting from mid December to mid January suitable for planting for mid September in Northern plain.

Pusa Shubhra

It has been identified for all zones in 1985. Plants are erect with slightly long stalk and light bluish green leaves. Curds are compact and white. It is resistant to black rot. It takes 90-95 days to complete 50% harvest after transplanting.

Pant Gobhi-4

It has medium long stem, sparse, semi-erect leaves, hemispherical cremish-white, medium, compact, non-ricey cards. This is a November maturity group takes 115 days for marketable curds.

Pusa Snowball-1

It is a late variety, suitable for cool seasons. It has straight upright leaves covering the curd very tightly, compact good sized, white curds with good staying power after maturity. It takes 120 days from sowing to maturity. In northern plain, it can be sown grown mid September to end October.

Pusa Snowball-2

It has upright leaves covering head tightly and slightly puckered at the margins. The curds are solid, white with vary good staying power and slightly raised in the centre. It takes 110-135 days from sowing to curd harvesting. It yielded 150-200 q/ha in hills and 400-500 q/ha in plains.

Pusa Snowball K-1

The foliage is light green. The leaves are slightly puckered, serrated and waxy. This variety is becoming very popular due to its high yield, curd quality maintain even if harvesting delayed. It is resistant to black rot.

Pusa Hybrid-2

Pusa Hybrid-2 is the first F1 hybrid in cauliflower developed in India using self incompatible lines in November maturity group. Plants are semi erect with bluish greenish upright leaves. Curds are creamy white and compact. Average curd weight is 900 g. Curd to plant ratio is 10% higher in this hybrid due to its very compact curd and less leaf area.

Swarna

It can be grown from September to December in plain and around the year in the hills. Curds are white, compact and ready within 80-85 days after transplanting. It yielded to 2.5 kg on an average curd weight.

Pawas

It is most suitable for early crop, which can be grown from middle May to August. It produces 700-800 g average curd weight and ready with in 60 days after transplanting.

Summer King

It produce 400-500 g on an average curd weight. Whitish round shaped curd and ready for harvesting with 65 days after transplanting. It can be grown during summer season in northern plain.

Climate

Cauliflower now can be grown in wide range of climate but climatic factors like temperature play an important role, during vegetative, curding and seed production stages. The optimum

temperature for growth to young plant is first around 23oC but at later stage of growth 17-20oC are more favourable, the tropical cultivars can grow even at 35oC or still higher temperature. The curding precedes the floral initials in cauliflower and plant may transform of curding from 5oC to near 30oC depending on the cultivars.

Soil

Cauliflower can be grown on wide range of sandy loam to clay loam soils with efficient drainage facility and rich in nutrients. Early crop responses better in light soil due to easier drainage during rainy season. The optimum soil pH for cauliflower is needed between 6 to 7. The deficiency symptoms of magnesium may quickly appear in acid soil while the pH higher than 7 the availability of boron is reduced.

Nursery Raising

The optimum time of seed sowing in the nursery depending upon climate, varieties and their temperature requirement for curd formation. The nursery beds should be well prepared by addition of well rotten FYM or compact @ 10 kg/m2. Nursery beds needed to be 3 m long, one-meter width and 15 cm raised of about 20-25 beds for one hectare transplanting. In each beds 40 g DAP, 25 g urea, 30 g MOP and 3g. Furodan should be applied and thoroughly mixed. Beds should be pulverized, compact and slightly sloppy for good tilth before sowing. It should be properly drenched by Captaf of Thiran @ 2g/lit of water which prevent the attack of fungal diseases. Seeds should also be treated with Captaf or Thiran of 2.5 g/kg of seed before sowing as a more preventive measure. After the 3-4 days of drenching, slowing should be done in shallow furrow at 10 cm apart and 1.0-1.5 cm deep (15-20 seeds/30 cm). The seeds should be covered after sowing by sieving soil, FYM and sand mixture (1:1.1 ratio) up to 0.5 to 1.0 cm layer. The beds should be covered with a proper mulching material like grasses or polyethylene. If possible nursery beds should be covered by Agro Shed Net (75%) to protect direct sun light and rains in early and mid season crop.

Depending upon the curd maturity of the varieties, the following of sowing time is recommended.

Season group	**Sowing time**	**Seed rate**
Early group	January-mid July	600 g
Mid early group	July-August	500 g
Mid late group	September	400 g
Late group (Snowball type)	October	300 g

Nutritional requirements

The quantity of the nutrients to be added in the soil may be determined on the basis of nutrient present in the soil and nutrient uptake by that crop. The absorption of nutrients by cauliflower per hectare is 143-234 kg N, 22-37 kg P, 128-209 kg K, 55-91 kg Ca and 7-12 kg Mg. Nearly 20-25 tonne FYM should be added one month before transplanting in the soil. Generally, 150 kg nitrogen, 60 kg phosphorus, 50 kg potash and 10 kg boron should be given for one hectare. Full dose of phosphorus, potash and boron should be given at the time of final ploughing and remaining dose of nitrogen in two splits be given after 30 and 45 days after transplanting as top dressing.

Spacing

Normally, the seedlings of early cauliflower are planted at 40 cm row to row and 30 cm plant to plant distance. The mid season and late varieties are planted at 60 x 40 cm and 60 x 45 cm spacing respectively.

Irrigation

First light irrigation is given just after transplanting of the seedling. Further irrigation will depend upon weather and soil type. However, regular maintenance of optimum moisture supply is essential during growth and curd development. In areas having heavy rainfall, the planting is done on ridges or raised beds accordingly furrow irrigation is to be given.

Interactual Operation

The interactual operations would be done regularly to keep the crop free from weeds and aeration of the root system. Very shallow hoeing should be done in order to remove weeds and avoid injury to the roots. Generally in medium heavy and clay soils, there is crust formation soon after first irrigations. This crust must be broken otherwise water and air penetration in root systems is hindered which adversely affect plant growth.

Transplanting

Normally the 5 weeks old hardened seedlings give better results in establishment of the early crops during monsoon season while in mid season and late varieties 4-5 weeks old seedlings may be transplanted. Uniform and free from insect pest damaged seedling should be selected for

transplanting. It has been reported that hardening of seedling by with holding water for 4-6 days prior to transplanting proved useful in suppressing buttoning and increasing yield.

Blanching

Blanching is an important operation to protect the curds from yellowing due to direct exposure to sun. The curds may also loose some of their flavour because of this exposure.

Harvesting

The harvesting is to be done as soon as the curds attain right maturity and compactness. If the harvesting is delayed the curds become over mature, its quality deteriorated and turned into loose, leafy, ricy or fuzzy. The over matured curds should be sorted out while sending the produce to market. The curds should be cut off with stalk alongwith sufficient number of leaves. The trimming of leaves depends on the mode of packing and transport. If packing is done in crates, most of the leaves are removed leaving small portions of leaf stalks close to the curd surface. Where packing is done in gummy bags, the inner leaves covering the curd surface are left intact and rest outer leaves are removed but when transported, the sufficient numbers of leaves with stalk portion are retained. Severe trimming of leaves is to be done after unloading or before marketing.

Yield

The yield of the cauliflower varies greatly depending upon variety, maturity group and season. Early maturing cultivars have an average yield of 100-150 q/ha. The main season and snowball cauliflower produced up to 500 q/ha due to highly compact and larger curd size.

PRODUCTION TECHNOLOGY OF CABBAGE

Brassica Oleracea var. ***Capitata*** Family : Cruciferae

Cabbage is a typical cool season Cole crops, grown for thickened main bud called ‘head’. In our country, productivity is increasing day by day, presently, 23.4 t/ha productivity has been recorded,

which is very near to the World average (24.1 t/ha). However, still there is an ample scope to increase the productivity like Korea (50.8 t/ha), Japan (40.9 t/ha) and Poland (39.5 t/ha) by adopting the superior varieties and hybrids which grown fairly under high temperature/humidity conditions. It is however significant to record that cabbage may no longer be considered a typical temperate vegetable crop, requiring cool temperature for north India conditions. It is a rich source of Vitamin-A, B and C. It also contains phosphorus, potassium, calcium, sodium and iron in sufficient quantity.

Area, Production and Productivity of Cabbage

Year	Area (in 000' HA)	% of Total Area	Production (in 000' MT)	% of Total Production	Productivity (in MT/HA)
1996-97	210.2	3.8	3613.4	4.8	17.2
1997-98	228.2	4.1	5323.8	7.3	23.3
1998-99	239.9	4.1	5624.0	6.4	23.4

Cultivars

A large number of cabbage cultivars differing in maturity, head shape and size, colour of leaves and shape of the leaves are grown throughout the World.

Open Pollinated

Golden Acre

This is an early variety, takes 60-70 days after transplanting to head formation, 1-1.5 kg weight, solid head with sort core, prone to cracking under delayed harvesting. It has fewer outer leaves, which are cup shaped and arranged in two whorls.

Sel-8 (Pusa Mukta)

Heads are medium sized, slightly flattish round, compact with loose wrapper leaves, slightly later than Golden Acre, resistant to black rot. It has short stalk, medium frame, slightly bigger leaves than Golden Acre, waxy puckered at the margin.

Red Cabbage

All the Red Cabbage cultivars are tolerant to diamondback moth insect, which is serious pest of cabbage. It has distinct coat of wax and produces a head of 1-2 Kg taking about 90 days from transplanting to head formations.

MCV-1

Heads are ready after 80 days from transplanting. It has round shape, bigger head (1.5-2.5 kg) and compact. The foliage in dark green with waxy margins.

Hybrids

Sri Ganesh Gole

This is a vigorous growing hybrid after ready for harvesting at 80-85 days of transplanting with 2.5 kg weight, round and compact. It can stand up to 10-15 days in the field, after ready for harvesting. It produces 75-87.5 t/ha yields.

Hari Rani Gole

It is a good hybrid for medium late maturity. It produces medium sized, ball shaped dark blackish green, solid heads with good wrapper leaves. Each head weight 1.5-2.0 kg. It can be harvested after 95-100 days of transplanting.

Quisto

It is a high yielder and has ability to stand over severe hot conditions. Head can stand in the field conditions up to 70 days after maturity. Heads are compact round, and very solid with dark blackish colour. It is good for tropical climate.

Bajrang

Heads are dark green, smooth highly compact, average head weight is 1.0-1.5 kg, matures in 65-70 days after transplanting. It can be grown in summer conditions and stand on the field for 45 days after maturity.

Kranti

It ready for harvesting within 60 days after transplanting. It is good for close spacing. Heads are 0.8-1.2 kg weight, round and compact.

Mitra

An early hybrid with excellent head to plant ratio. Heads are fresh green uniform, compact, ball shaped with weight around 0.8 to 1.2 kg each. Good field retention ability.

Climate

It can withstand extreme cold and frost better than cauliflower. The optimum seed germination is obtained at 12.6 – 15.6oC soil temperature. The optimum temperature for growth is between 15-20oC whereas about 25oC growth is arrested in most of the cultivars. It looses flavour in dry and warm weather conditions. The minimum temperature for growth of cabbage is just above 0oC.

Soil

Cabbage can be grown the same soil as discussed in cauliflower. In saline soils, the plant shows die back margins and dark foliage and become more susceptible to the disease like black leg.

Nutritional Requirements

The fertilizer trials conducting from 1983-1989 under AICRP (Vegetable Crops) the highest yield was obtained at 150-180 Kg N, 50-80 Kg P2O5 and 50 to 75 Kg K2O/ha at different centers of

the country. It is heavy feeder of nutrients specially of nitrogen and potash. The amount of FYM and NPK should be applied as mentioned in cauliflower. A high correlation is found between head yield and nitrogen content during early plant development i.e. up to 8-10 leaf stage and it can be used as an index to forecast yield. The optimum nutrient level available in the aerial parts at 8-10 leaf stage for insuring high yield in early, mid and late maturing cultivars at the rate of 5.0, 4.5 and 4.2% N; 0.9, 0.9 and 1.1% P and 3.5, 3.7 and 3.2% K, respectively.

Raising Nursery

It is same as discussed in cauliflower. It thrice well when crop sown in plains usually in August, September and October for early, main and late season varieties, respectively. After good drainage facility and selection of tropical hybrids, it can be sown in June for rainy season crop. In some parts, farmers are growing during summer also putting nursery in January and transplanting in the end of February or March.

Spacing

Spacing is mainly depend on cultivars and season. The early and main varieties are transplanted at the distance of about 45 and 60cm from row to row and 30-45 cm and 45 plant to plant respectively.

Seed rate

Seed rate also depend on the cultivars and season. Early cultivars planted in closer spacing and chances of damage due to damping off as compared to main season cultivars. Therefore, early cultivars required 600-800 gm whereas main season crops required 300-500 g seeds for one ha of transplanting.

Inter-culture and Irrigations

Hoeing, weeding, earthing and irrigation should be done as per cauliflower.

Harvesting

Cabbage should be harvested when heads are firm and they attain the full size depending on the cultivars used. The early cultivars grown under slightly warmer conditions, develop loom heads at initial stage, but become harder at maturity. In such cases quality of heads is deteriorated and start cracking soon after the maturity if harvesting is delayed. The early cultivars took 60-80 days, medium 80-100 days and late 100-130 days for harvesting after transplanting.

Yield

The yield of early cabbage ranges between 300-400 q/ha whereas medium and late cabbage 600-800 q/ha in northern plain.

PRODUCTION TECHNOLOGY OF RADISH

The radish (*Raphanus sativus*), belongs to family cruciferae, is an easy to grow and widespread vegetable that can usually be found in most home gardens. Root is effective in curing liver, gall bladder and urinary disorder. The leafy tops are very rich in Vitamin A, B, C and minerals, particularly Ca and Fe. Young tender pods to rat tail radish are used as vegetable. There is no edible root formed in this radish. The pungent component of radish is 4 methylthio-3 butenyl iso-thiocyante.

Climate

Radish is best adopted to cool or moderate climate but Asiatic types can tolerate higher temperature. It attains best flavour, texture and size at 10°C to 15°C. At 20-25°C uptake of nutrients will be greater, accordingly dry matter content increased but at a still higher temperature (25-30°C) the water requirement of plant increases considerably and root deformations occur.

Improved varieties

There are two groups of radish varieties i.e. Asiatic (tropical and sub-tropical type) and European (temperate type). Asiatic types can produce seeds in plains and temperate type require chilling requirement for flowering, hence seeds production is limited to high hills only.

Improved varieties

Varieties	**Source**
Asiatic or Tropical type	
Pusa Desi	Local material (IARI, New Delhi)
Pusa Reshmi	-do-
Pusa Chetki	-do-
Punjab Safed	PAU, Ludhinan
Japanese white	IARI Regional Station, Katrain
Kalyanpur No.1	CSAUA&T, Kanpur
Kalyani White	BCKV, Kalyani
Co-1	TNAU, Coimbaotre
IIVR-1	IIVR, Varanasi
IIVR-2	IIVR, Varanasi
C-2	HAU, Hisar
Hybrid-11	MAHYCO
Sungro Chetaki	Sungro Seeds Company
Arka Nishant	IIHR, Bangalore
Chinese Pink	Dr. Y.S. Parmar University of Horticultural & Forestry, Solan
Hissar Mooli No.1	HAU, Hisar
Jaunpuri Mooli	Local
European or Temperature types	
Pusa Himani	IARI Regional Station, Katrain
White Icide	-do-
Rapid Red White tipped	Private Seed Company
Scarlet Globe	-do-
Scarlet Long	-do-
Silver queen	-do-
Burpee white	-do-
Burpee’s Red Giant	-do-

Pusa Deshi

Pusa Deshi is a selection from local material. It is a tropical cultivar, suitable for sowing from middle of August to October in the Northern plains. Roots are (30-35 cm) tapering, pure white with green tops and pungent taste. It matures in 40-45 days after sowing.

Pusa Reshmi

Pusa reshmi, a main season variety in Asiatic group was developed at IARI, New Delhi. Suitable for mid September to early October sowing. It has white tapering roots of medium to long size (30-45 cm).

Pusa Chetki

Developed by selection from a Denmark introduction, suitable to grow in warmer months. Sowing can be done from the middle of March to the middle of August. This cultivar sets seeds profusely in the plains because it bolts very early in the month of December. Roots medium long stumpy, pure white mildly pungent with soft texture and leaves entire upright, dark green and slightly lobed. It becomes ready for harvesting in 40-45 days after sowing and it yields about 200-250 q/ha (40 days).

Punjab Safed

A derivative of Cross Whites x Japanese White. Roots are white, smooth and tapered mild in taste, 30-40 cm long and 3-5 cm thick. It is a quick growing type with roots remains edible for 10 days after attaining full size. It takes 40-50 days for root formation. Developed at Ludhiana.

Japanese White

It was originally named as Shiroaguri-Kyo and released by IARI under the name Japanese White. It is an Asiatic variety, which matures in 45-50 days. The root is cylindrical and about 20 to

30 cm long, 5 cm in diameter, skin white, less pungent and with a blunt end. Suitable for October to December sowing.

Arka Nishant

It is an Asiatic variety. An improvement over a collection (IIHR-72) from Singapore, developed after 10 cycles of mass selection and released for commercial cultivation in1980 by IIHR. Roots are medium sized (25 cm x 3.4 cm), marble white, crisp texture, pleasant aroma, free from early bolting, pithiness, splitting and forking. Root and shoot length ratio is 1:1. Pungency is mild. It yields 200-300 q/ha. It matures within 45-55 days. Freely seeds under Indian plain conditions.

White Icicle

It is a medium-short European variety which matures in 30 days. A table variety, roots are 12-15 cm long, 2-3 cm in diameter, smooth icicle shaped white and less pungent, flesh crisp, icy white, sweet and flavoured. The main disadvantage of this cultivar is that the roots become pithy within a week after maturity. It is suitable for October and November sowing in the plains.

Pusa Himani

It is a European variety. It is an attractive cultivar for market and home, developed at IARI Vegetable Research Station, Katrain (Kullu Valley) by hybridization between a temperate type (black) and popular Asiatic type (Japanese White). It is suitable for December to February sowing in the plains when no other variety can form such good roots.

Rapid Red White Tipped

It is a very early European variety, which matures in 25 days. Bunching and table type.

IIVR-1

It is an important line developed through selection from Japanese materials, suitable for growing in spring, summer, autumn and winter season.

IIVR-2

It is suitable for planting from September to February and harvesting within 40-45 days after sowing.

Soil

Radish can be grown in all kind of soil but best results can be obtained on light, friable loam soil that contains high amount of humus. Usually the heavy soil produce rough ill shaped roots with number of small fibrous laterals. For early crop, sandy or Sandy loam soils are preferred however, for summer crop a cool, moist soil gives best result.

Land preparation

The field should be prepared by repeated 3-4 ploughings so as to make the soil very loose and smooth. The soil should not contain any undesirable organic matter, because that may result in forking of roots or mis-shape roots.

Sowing time

Being a cool season crop, its cultivation is preferred during winter season in Northern plains. In the areas of mild climate, it can be grown throughout the year. In the Northern hills, the seeds are usually sown in the first fortnight or March till late October or the beginning of November depending upon the temperature.

Seed rate and sowing

Radish seeds count about 80-125 seeds per gram, and about 9-12 kg of seeds are sufficient to sow one hectare depending upon the type and spacing. Sowing at a depth of 1.5 to 3 cm is recommended for semi long cultivars and surface sowing 1-1.25 m for round cultivars.

Nutrition

Radish is a short duration and quick growing crop, hence judicious and proper use of manures and fertilizer are essential to get good yield and excellent root quality. Different recommendations are being made by various workers at different agro climatic conditions. At Ludhiana conditions, application of NPK at the rate of 84 kg N and 50 kg use of phosphorus and potash are effective and economical. Application of 75 kg N + 80 kg P per hectare increased the root diameter and root yield at Udaipur condition. At recent study at Bangalore concluded that the total nitrogen uptake increased with fertilizer application up to 150 kg/ha.

Irrigation

Irrigation frequency and water quantities are depend on the planting season and available soil moisture. For rapid germination of seeds and production of tender and attractive roots, the soil should have sufficient moisture.

Interculture

Intercultural operations like weeding and hoeing are necessary at 20 to 35 days after sowing in mid maturity group of Asiatic type, while Temperate and Early Asiatic group require at 15-20 days after sowing.

Harvesting

The edible roots become ready for harvesting in 25 to 60 days after depending on the variety. European types reach harvest maturity in 25-30 days after sowing while Asiatic cultivars require longer period. Chetaki type of Asiatic cultivars get ready in 30-40 days after sowing whereas mid maturing group cultivars take 40-60 days after sowing. It is necessary that the roots are harvested at the right stage as they tend to become fluffy, bitter and un-marketable otherwise. A light irrigation may be given a day before harvesting to facilitate lifting of roots. The roots are washed and graded

according to size and tied into bunches along with tops for marketing purposes. Root can be stored at room temperature for 3-4 days without impairing its quality, and two months in the cold storage at 0°C and 90-95% relative humidity.

Yield

The average yield of Asiatic cultivars ranged between 200-500 q/ha in 40-60 days after sowing whereas European cultivars yield about 50-80 q/ha in 25-30 days.

Physiological Disorders

Pore extent or Pithiness

Pore development does much damage to the quality of radish, destroying its commercial value. Pores are formed by the collapse of parenchymatous cells in root tissue, caused by excessive root growth in comparison with the corresponding assimilation ability of leaf tissue.

Elongated root or Forking

Elongated root is brought about by secondary elongating growth in the root. Inter varietal variation are being considered to result from the degree of secondary elongating growth.

Bolting

Radish is a seed-vernalizing crop in response to low temperature. The degree of bolting ability has been studied because of its disadvantage in cultivation, and breeding research has been directed toward late bolting. The removal of early bolting plants from late spring and summer varieties has probably resulted in the decreased sensitivity to day length.

PRODUCTION TECHNOLOGY OF CARROT

Daucus carota Family : Apiaceae

Varieties

Pusa Yamdagni

Developed by hybridization between EC-9981 x Nantes. It combines the earliness of EC-9981 and self-coloured core character of Nantes. It takes 88-130 days to produce harvestable roots.

Nantes

It is grown in plains for root production, but not for seed production. It ranks first in quality, but has a weak, brittle top, which makes pulling difficult. It has delicious flavour, fine grain texture and self-coloured core with orange scarlet flesh colour.

Pusa Kesar

This is a selection from a cross of Local Red and Nantes Half Long. It can tolerate higher temperatures than Nantes and suitable for sowing from early September to mid November. It is also richer in carotene (3.8 mg/100 g edible portion) than Local Red (2.6 mg/100 g).

Pusa Meghali

This is also selection from a cross between Nantes and Pusa Kesar. It has long orange coloured tapering roots with self-coloured core. It is suitable for both, early cultivation (August-September) sowing and late sowing (October-November).

Sel-233

A derivative of a cross of Nantes x No.29 and released by PAU, Ludhiana in 1978. A desi type with all good qualities of Nantes. Harvesting can be delayed without bolting and impairing its edible qualities. It takes 90-100 days for root formation.

Soil

Soils for carrot production should be deep, loose, well-drained sandy loam or loams with a slightly acidic reaction. The edible roots may become mis-shaped as a result of poor soil structure or obstructions such as stones, clods or trash. For early crop a sandy loam soil is preferred, but for more yields silt or silt-loam soil is desirable. It does not grow well on highly acidic soil. The maximum yield is expected at pH 6.5. At high pH, Mn toxicity may result causing chlorosis of leaves.

Land preparation

For cultivation of carrots, the field should be worked deep to a good tilth and properly manured. If the soil is not thoroughly prepared and contain soil clods, or undecomposed organic

matter, good quality well shaped roots cannot be produced. Root deformity usually occurs in fields, which are under prepared.

Sowing periods

In the northern plains of India, carrot can be sown from the middle of August to the beginning of December. It is grown from March to August in hills. The tropical types are first sown while the temperature remains high. These can be sown till the end of September or the beginning of October.

Seed rate and sowing

The seed rate varies from 8 to 10 kg per hectare. Carrot seeds are sown either broadcasting or by drilling in lines. Seeds are mixed with fine sand before sowing to facilitate even distribution. The seeds in water for 12-24 hours before sowing to hasten germination. Carrot seed soaked for 12 h. in 50 ppm IBA solution and sown in row 20 cm apart gave the highest germination (98%), crop yield (200.64 g/ha), root carotene (8.8 mg/100g) and ascorbic acid (8.85 mg/100g) content.

Nutritional requirement

Carrot responds well to manures and fertilizers. Both organic and chemical fertilizers are applied. The carrot is a gross feeder, especially of potash. It is estimated that a yield of about 275 q/ha will remove 125 kg of potash, 40 kg of Nitrogen and 22.5 kg of Phosphate. Well-rotted FYM should be applied at the rate of about 30 tones/hectare should be incorporated into the soil to a depth of about 20-25 cm much before planting. When organic manure was applied, the need for fertilizers was reduced and an application of 50 kg N, 40 kg P and 90-110 kg K per hectare was considered sufficient to obtain optimum yield.

Irrigation

In the light soils the first irrigation may be given soon after sowing which may be followed by next at 4 to 6 days interval depending on the soil moisture available. The average irrigation application should very from 60 to 80 mm. It requires an abundant and well-distributed water supply.

Interculture

Carrot grows slowly at the seedlings stage. So removal of weeds is quite essential especially at earlier stage. Weeds are a serious problem in carrot fields and timely control of weeds is essential to avoid heavy loss in yields of top quality of roots due to weed competition.

Harvesting

In order to assure quality, carrots for fresh market are harvested before plants reach full maturity, while those for processing are allowed to grow longer in the season in order to maximize yields. The smaller sized roots used for fresh market are more tender, milder in flavour and more uniform in appearance than the large roots for processing. In India, harvesting is done manually, while mechanical harvesting is the rule in advanced countries. After harvesting, the roots are washed, cleaned, graded and tied in bunches of 6 or 12 roots. Carrots are sometimes marketed with their tops attached to indicate freshness.

Storage

Fresh carrots cannot be stored for more than 3-4 days under ordinary condition. At temperatures of 0°C-4.4°C with 93 to 98% RH they can be stored for 3 to 4 months. Cold storage at 32°F with high humidity (98-100%) gives best results. Mature topped carrots can be stored upto 7-9 months, while immature bunched carrots can usually be stored not more than 2-3 weeks. Controlled atmosphere storage in carrots has not been successful.

Yield

Generally, Asiatic types produce higher yields of 25 to 30 t/ha while European cultivars produce around 10-15 t/ha. The Asiatic varieties yield higher than the European varieties.

Physiological Disorders

Root splitting

Splitting or cracking of carrot roots is a major problem in many carrot-growing areas. Although the tendency towards splitting seems to be controlled by genetic factors, a number of other factors may be also involved.

Cavity spot

This disorder appears as a cavity in the cortex, in most cases the subtending epidermis collapses to from a pitted lesion. The cavity spot disorder is induced primarily be a deficiency of Ca. This was associated with an increased accumulation of K and a decreased accumulation of Ca.

Forking

It is most common disorders in radish and carrots formed by the enlargement of secondary root growth. The disorder is due to the excess moisture during the root development of radish and carrot. It is also occur in heavy soil due to the soil compactness. It can be corrected by reducing the moisture from the field, by balanced irrigation and also by sowing the radish and carrot in sandy loam or light soil having soils of loose and friable in nature.

PRODUCTION TECHNOLOGY OF BEETROOT

Beets (*Beta vulgaris*) belong to the goosefoot family (Chenopodiaceae). Based on the edible part, beets are generally classified into two major groups. The beets grown mainly for their fleshy roots belong to the Crassa, or garden, group and include yellow beets and the common table, or red beets.

Uses

Beet is a useful vegetable in a number of ways. Though, it is grown in almost every states of India, it is not as common as radish, carrot or turnips. The roots of table beets can be served boiled, pickled and in salads. The tops may be used much like spinach as leafy greens for salads or boiled. The tender leaves and the young beet plants are used as greens (Pot-herbs). The large sized beets are used for canning. The garden beet is rich in proteins, carbohydrates, calcium, phosphorus, iron and Vitamin C.

Climate

It is essentially a cool weather crop and hence it grows best in winter in plains of India. But it can also be grown in a bit worm climate. Beet plants are very sensitive to low temperature. If they are exposed to relatively low temperature of 4.5-10°C for 15 days or more, bolting is likely to occur before the roots reach marketable size. Temperature has a pronounced effect on the crop with regard to maturity and seedling. Good quality roots, rich in sugar and intense red colour are obtained always in cool (18.3-21.1°C) weather.

Variety

The varieties are being grouped according to their shape i.e. flat, short-top; deep oblate to round; globular or oval; half long and long.

Varieties	Source
Crimson Globe	IARI, New Delhi
Detroit Dark Red	IARI, New Delhi
Father Ball	USA
Egyptian Blood	USA
Edmond	USA
Eclipse	USA
Crosby Egyptian	USA
Early Wonder	USA

Crimson Globe

The roots are globular to flattened globe, medium red with little shoulders. The flesh is medium dark red with indistinct zones. The top is medium to tall with large, bright green leaves having maroon shade. It is heavy yielder.

Detroit Dark Red

Roots are perfectly round with smooth, uniform, deep red skin. Flesh dark blood red, with light red zoning, tender and fine grained, tops small, leaves dark green fined with maroon. It is a heavy yielding cultivar maturing in 80-100 days.

Crosby Egyptian

Roots are flat globe with a small top root and a smooth exterior. The top is medium tall, green with red veins. This cultivar reaches maturity in 55-60 days after sowing and shows pronounced white zoning when grown in warm weather.

Early Wonder

The roots are flattened globe with rounded shoulders with a smooth, dark red skin. The top is heavy, green with red veins. This cultivar also takes 55-60 days after sowing to reach harvest maturity.

Soil

Beets can be produced on a wide varied of soils, but deep, well-drained loams or sandy loams are considered best. Heavy soils are not satisfactory for beets since the roots are likely to be unsymetrical in shape when grown in such soils. The beet plant is sensitive to acidic soil. But thrives very well in alkaline soils with pH as high as 9-10.

Soil preparation

The soil for beet should he thoroughly prepared by ploughing 15-20 cm deep followed by sufficient disking and hoeing to pulverize the clods. The soil surface should be smooth, loose, and free from all clods and trashes. Well-rotted FYM on compost is also added at the time of land preparation.

Sowing period

In Northern Plains of India, usually seeds are sown in September-November, while in the Southern Plains its sowing is extended from July to November. In hills, seed is sown from first week of March to July end.

Seed rate and sowing

Beet seeds are usually planted directly in the field by sowing ‘seed balls’ that contain one or more seeds. The seed balls are planted at the rate of 7-9 kg/ha in row 45-60 cm apart and are thinned later to an in-row spacing of 8-10 cm. Cultivars with small tops like Flat Egyptian are given closer spacing than those with heavy tops like Detroit Dark Red.

Nutritional requirement

Beets have a fairly high nitrogen requirement. Nitrogen uptake by beet plants may be as high as 78% from the soil and 22% from the added fertilizer. Generally, 60-70 kg N, 100-120 kg P and 60-70 K kg per hectare are recommended in addition to 15-20 tonnes FYM.

Irrigations

The soil should be kept sufficiently moist until emergence of seedlings. A regular water supply is essential both for seed germination and high yield of good quality roots. Irrigation application at 0.2 bar soil moisture tension at 15-20 cm soil depth was found optimum for beetroot grown in sandy loam soils.

Intercultural operations

Clean, shallow cultivation is given to check weed growth, one or two earthing ups are also given to prevent the exposure of roots to sunlight which causes greening and lowers the quality of produce. Pre and post emergence sprays of Propacholor (2.5 kg/ha) gave weed control for 40 to 50 days and increased yield.

Harvesting

The harvesting operation is the same as that of radish or turnip. The marketable maturity is judged depending on the size ranging from 3 to 5 cm diameter. Usually the top is removed for marketing the roots. Within 60-75 days of sowing, the roots become ready for harvest.

Yield

The average yield of beet varies from 250 to 300 quintals per hectare. Beets store well at a temperature of 0°C and 90% R.H. It can be stored for at 2 to 3 days at room temperature.

Physiological Disorders

Internal black spot or brown heart

Boron deficiency may cause a physiological disorder in garden beets, which is known as internal black spot or brown heart or heart rot. Boron deficient plants usually remain dwarf or stunted. The leaves are smaller than normal. The roots do not grow to full size and under conditions of severe boron deficiency they remain very small and distorted, and have a rough, unhealthy, grayish appearance instead of being cleans and smooth. The quantity of borax needed for satisfactory control of boron deficiency varies with the nature of the soil, the soil reaction and soil moisture, an application of 10-15 kg of borax per hectare is recommended.

PRODUCTION TECHNOLOGY OF PEAS AND BEANS

GARDEN PEA

Pisum sativum Family : Leguminaceae

Garden pea, an important vegetable crop, has acquired a place of prominence not only in sumptuous banquets but in diets of the ordinary and poor class people also. It is being recognized as an important protein supplement. In India it is grown in about 2.25 lakh ha. Among states, Uttar Pradesh ranks first in area and production followed by Bihar and Madhya Pradesh. Gradually, Himachal Pradesh is also becoming an important vegetable pea producing state.

Varieties

In peas, the flowering begins at lower nodes and continues up the stem. Flowers may appear as early as sixth node in very early flowering cultivars and as late as 18^{th} node in late flowering cultivars. In general, plant types that flower in 9^{th} to 11^{th} nodes are considered early cultivars.

Early varieties

Variety	Source
Arkel	IARI, New Delhi
AP-3	CSAUA&T, Kanpur
JM-3 (early December)	JNKVV, Jabalpur
Mater Ageta (E6)	PAU, Ludhiana
Hisar Harit	HAU, Hisar
PM-2	GBPUA&T, Pantnagar
JM-4	JNKV, Jabalpur
Harbhajan (EC-33866)	IARI, New Delhi
PM-3	GBPUA&T, Pantnagar
VL-7	VPKAS, Almora
Early Badger	IARI, New Delhi

Mid (main season) varieties

Variety	Source
Bonneville	IARI, New Delhi
AP-1	CSAUA&T, Kanpur
JM-1	JNKV, Jabalpur
Pant Uphar	GBPUA&T, Pantnagar
P-88	PAU, Ludhiana
VL-3	VPKAS, Almora
Lincoln	IARI, Katrain
JM-2	JNKV, Jabalpur
JP-83	JNKV, Jabalpur (Resistant to P.M.)
JP-71	-do-
JP-4	-do-
PRS-4	GBPUA&T, Pantnagar

Arkel

Plants are dwarf. First flower appears in about 30 days after sowing. It takes 60-65 days to first picking. Pods are well filled and attractive. Three harvesting are done. The average green pod yield is about 50-60 q/ha.

Azad P-3

Plants are early, erect medium tall, dark green in colour. First flower appears in about 40 days after seed sowing. Pods are well filled, bold, green and attractive. First picking can be obtained in 70 days after sowing. 3-4 picking are done. Average green pod yield is about 65-70 q/ha.

Azad P-1

Plants are tall. First flower appears in about 45 days after sowing. Pods dark green in colour and borne in clusters. First harvesting can be done 75 days after seed sowing. 3-4 picking are done. Average green pod yield is about 85-90 q/ha.

Ageta

Plants are small, erect and green in colour. It is suitable for early sowing. First flower appears about 25 days after seed sowing and it takes about 6 weeks for first picking. Two picking are done. Average green pod yield is 50-55 q/ha.

Pant Matar –2 (PM-2)

PM-2 is an early maturing variety, developed at GBPUA&T, Pantnagar; derived through pedigree selection from the cross Early Badger x IP-3 (Pant Uphar). Pods are relatively smaller than Arkel; gives an average green pod yield of 100 q/ha.

Bonneville

This mid season variety is an introduction from America; introduced by IARI, New Delhi. Gives an average pod yield of 85 q/ha with 45% of shelling. Seeds are green and wrinkled. Recommended for release and cultivation in1975 for all over India.

VL Ageti Matar-7 (VL-7)

This is an early season variety, developed at VPKAS, Almora. Plants are determinate, dwarf with dark green foliage and white flowers. Pods are light green, slightly curved towards suture at distal end, gives 200-250 q/ha green pod yield with 42% of shelling.

Edible-podded pea

These varieties do not have a parchment layer in pods. They are large (10-15 cm), juicy fleshy, very sugary and are used wholly in their fresh form. Variety – Organ Sugar and JP-19.

Soil preparation

Pea can be grown all types of soil. Early crop can be obtained in light soils and higher yields in loose friable ad heavy soils. Soil compactness after sowing reduces the yield as a result of poor plant emergence and growth of individual plant.

Nutrient requirements

Pea crop approximately removed 50-70 kg of nitrogen, 20-30 kg of phosphorus and 40-60 kg of potash/ha. If available, 10-15 t well rotten FYM/ha should be applied 3-4 weeks before sowing. There are different recommendations from different parts of the country. However, for an average fertile soil, 40-50 kg N, 50-60 kg P_2O_5 and 40-50 kg/ha K_2O are recommended. Full does of phosphorus and potassium and half nitrogen are applied as basal dose and rest N is applied 30-40 days after sowing as top dressing. Foliar application of 0.1% ammonium molybdate has been reported to increase the number of root nodules, yield, TSS and number of seed per pod.

Temperature

Cool climate of about 4 months is ideal for pea growing as found in Punjab, Haryana, parts of Rajasthan, Delhi, hills of J&K, U.P., Himachal Pradesh, Bihar and West Bengal. The optimum temperature for seed germination is about 22°C however, it can germinate up to 5°C but at slow rate. At higher temperature the germination is rapid but plant stand is affected due to decay. Peas grow best at mean temperature of 13-18°C.

Sowing time

Peas are sown in rabi season from beginning of October to the end of November in plain and from middle of March to end of May on the hills. In Darjeeling this crop is sown from June to August. In Peninsular India, pea crop is also sown in June-July.

Seed rate and sowing

Seed requirement of dwarf varieties is 125-150 kg/ha and that of medium tall variety is 100-120 kg/ha. For early sowing seed rate is kept in higher order. Inoculation of seed with pea nodule

bacteria culture is recommended when it is sown for the first time in a field or grown in a poor soil. The culture material is emulsified in 10% Jaggery (Gur) or in sugar solution sufficient to moist the seed. This is mixed thoroughly with seed and dried in shade before sowing. The seeds may be treated with fungicides like thiram or captan (3 g/kg seed) or Bavistin (2 g/kg seed) to save the crop against wilt. If both the treatments are to be given, first the seeds are treated with fungicide followed by inoculation with rhizobium culture.

Water management

Water requirement of crop depends largely on agro-climate conditions of the locality. It can be grown under rain fed condition too, but at the time of sowing sufficient moisture is must in the field. Pea seeds can tolerate dehydration in initial stages of imbibitions but once the seed begins metabolic activity, dehydration causes damage to cotyledons and embryo.

Weed management

Herbicides have been found beneficial in controlling weeds. Pre-emergence application of any one of the herbicides i.e., 1 kg alachlor or 1 kg methabenzthiazuron or 1 kg pendimethalin may take care of weeds. In case of severe infestation, one or two weeding may be done to ensure weed free crop.

Harvesting

The high quality of pea is associated with tenderness and high sugar content. During maturity sugar content decreases rapidly and there is an increase in starch and other polysaccharides. Picking should be done as soon as green ovules are fully developed and pods still not over mature. Number of picking depends on varieties. In early variety, 2-3 pickings and in mid season varieties 3-4 pickings

are done at 7-10 days interval during the season. Picking should be done either early in the morning or late in the afternoon. Picking during mid-day deteriorates the quality of pea by heat.

Yield

The early varieties give an average green pod yield of about 40 q/ha while mid-season varieties give higher yields of about 80 q/ha.

Storage

Fresh pods can be kept for three weeks at 0°C and for two weeks at 5°C with 85-90% relative humidity. At about 2°C they can be stored for 4-5 days whereas at 21.5°C they become unfit for sale within 5 days. Keeping quality improves by storing in perforated polythene bags.

PRODUCTION TECHNOLOGY OF COWPEA

Cowpea belongs to the botanical species *Vigna unguiculata* (L.) Walp. Under the sub family Fabaceae of family Leguminoceae. Cowpea is a rich source of vegetable protein. It is consumed both as green pods and dry seed. Cowpea is grown both as summer and rainy season crop.

Varieties

Bush type

Variety	Source
Pusa Phalguni	IARI, New Delhi
Pusa Barsati	-do-
Pusa Do Fasali	-do-
Pusa Komal	-do-
Pusa Rituraj	-do-
Sel-2-1	NDUA&T, Faizabad
Sel-263	PAU, Ludhiana
Arka Suman	IIHR, Bangalore
IHR Sel-16	-do-

Pole type

Variety	Source
Arka Garima	IIHR, Bangalore
Yard Long Bean	Local

Some important varieties are described below:

Bush type

Sel-263

Sel-263 is an early maturing variety, developed through selection at PAU, Ludhiana. Plants are dwarf and can be grown in both spring and rainy seasons. Pods are green, thick, fleshy, tender and medium (20 cm long); resistant to mosaic and golden mosaic viruses; gives an average pod yield of 22 t/ha.

Sel 2-1

This variety has been developed at NDUA&T, Faizabad. Plants are 70-75 cm tall. Pods are green, 25-30 cm length, black seeded; susceptible to pseudocercospora and viruses.

IIHR-16

IIHR-16 is an early maturing variety developed at IIHR, Bangalore; derived through pedigree selection from the cross **Arka Garima X Pusa Komal**. Plants are erect bushy, 70-75 cm tall, photo-insensitive. Pods are green, medium thick, medium long (15-18 cm), tender, fleshy without parchment, good cooking quality; gives an average yield of 19 t/ha in 70-75 days of crop duration.

Pusa Komal (Sel-1552)

Pusa Komal has been developed at IARI, New Delhi. Plants are bushy and flowers in 45 days after sowing. Pods are light green, tender, 25-30 cm long; suitable for both spring summer and rainy season cultivation; resistant to bacterial blight; gives an average yield of 10 t/ha.

Pole type

Arka Garima (Sel-61-B)

This popular variety has been bred at IIHR, Bangalore; derived through backcross and pure line selection from the cross TUV-762 x *Vigna unguiculata* sub. *Sesquipedelis.* Plants are tall, vigorous, bushy, spreading with small vines with light green leaves and purple flowers. Pods are light green, long thick, round, fleshy and string less; tolerant to heat and drought; gives an average yield of 18 t/ha in 90 days of crop duration.

Temperature

It is a warm season crop and cannot sustain cold weather. It can be grown both in spring and rainy season in the plains. Cowpea can be grown at a temperature range of 20-35°C. If temperature increases above 35°C, fruit set is adversely affected. Like wise if temperature goes below 15°C the growth, flowering and fruiting are drastically reduced.

Soil preparation

Cowpea can be grown on all type of soils, but it does not thrive well in highly acidic or alkaline soil. The favorable range of soil pH is between 6.0-7.5. Early crop can be obtained in light soils and higher yields in loose friable and heavy soils.

Nutrient requirement

Cowpea crop removes approximately 40-50 kg of nitrogen, 20-30 kg of phosphorus and 40-60 kg of potash/ha. It available, 10-15 t well rotten FYM/ha should be applied 3-4 weeks before sowing. Being a leguminous crop it has low nitrogen requirement. Nitrogen is primarily required for stimulating early growth, however, higher does of nitrogen had adverse effect on nodulation and nitrogen fixation.

Seed rate and sowing

Twenty to twenty five kg seed/ha for bushy cultivars and 10-12 kg seeds/ha is sufficient for climbing cultivars. Sowing should be done on the ridges in both seasons. Seeds may be dibbled at 10-15 cm distance on the ridges at 50-60 cm apart for bushy cultivars. For climbing type cultivars line to line distance 80-90 cm and seed to seed 20-25 cm may be kept.

Water management

During rainy season no irrigation is required, but there should be sufficient moisture for seed germination at the time of sowing whereas during summer season irrigations at 7-10 days interval is must. Number of irrigation depends on crop stage and soil types.

Weed management

Weeding, hoeing and earthing up is necessary to keep weeds under control. It is done manually one month after sowing. For chemical control of weeds Alachlor at @ 1 kg ai/ha in 1000 liter water should be sprayed before sowing or Pendamethaline @ 1.0 kg ai/ha in 1000 liter of water may be sprayed within 2 days after sowing.

Training and support

For climbing type cultivars support of bamboos and G.I. wires should be provided for better growth and high yield of good quality green pods. It also helps in taking plant protection measures and harvesting.

Harvesting

Marketable pods are available in about 45 days. Harvesting should be done at 3-4 days interval for getting good quality tender green pots with high yield. Bushy cultivars gives 4-5 pickings while from climbing type cultivars 8-9 pickings can be harvested.

Yield

- Bush type cultivars yield 50-60 q/ha green pod.
- Climbing type yield 80-100 q/ha green pod.

Storage

Fresh pods can be stored satisfactorily for 6-8 days at 4-5°C with 95% relative humidity.

PRODUCTION TECHNOLOGY OF FRENCH BEAN

It is leguminous vegetable scientifically named *Phaseolous vulgaris* of family leguminoceae. French bean is commonly known as common bean, kidney bean, haricot bean, and snap bean. When dried seeds are used as pulse/vegetable, it is named as Rajmalh. Its green tender pods without strings are used as vegetable.

Composition and uses

It is a nutritious vegetable. French bean green pod (per 100 g of edible portion) contains 1.7 g protein, 0.1 g fat, 4.5 g carbohydrates, 1.8 g fiber, 221 IU vitamin A and 11.0 mg vitamin C besides minerals and other elements. In India, it is grown for tender vegetable while in USA it is grown for processing in large quantities.

Area and distribution

In India, in hilly region it grows during summer whereas, in plains it grows during winter season. Mainly cultivated in states like Himachal Pradesh, North Eastern states, Bihar, U.P., Karnataka, Tamil Nadu, Maharashtra and M.P.

Temperature

The favorable temperature for crop growth, flowering and fruiting is 18-23°C and if temperature drops below 15°C, growth and development are adversely affected. This crop requires plenty of sunshine especially in first phase of its development. It is heat loving but not resistant to high temperatures.

Varieties

Pole type

Kentucky Wonder, Pusa Himlata, Lakshmi, SVM-1, VL-Bean-12, VL-Bean-17.

Bush type

Giant String less, Contender, Pusa Parvati, V.L. Boni-l, Arka Komal, Jampa, Premier, Bountiful, Pant Anupama, Pant Bean-2, IIHR-909.

Some important cultivated varieties are described below:

Pole type

Kentucky Wonder

Pods ready for harvest in 60-65 days. Pods are 20 cm long, 5/cluster, flattish, appear to be seedy, meaty and string less. Average pod yield is 100-125 q/ha.

SVM-1

Pods green round, string less, 13-14 cm long. Ready for picking in 65-75 days. Average pod yield is 105-125 q/ha. Resistant to angular leaf spot both in leaves and pods.

Lakshmi

Pods are formed in clusters of three, 13-14 cm long, string less, green, round and attractive. Pods ready for picking in 65-70 days. Seeds are white in colour with light yellow scar. Average green pod yield is 120-140 q/ha. Tolerant to angular leaf spot diseases.

Bush type

Pant Anupama (UPF-191)

Pant Anupama has been developed at GBPUA&T, Pantnagar; derived through selection from line UPF-191. Plants are bushy, dwarf, upright green foliage; concentrated fruiting at mid height.

VL Boni-1

This variety has been developed at VPKAS, Almora. Plants are dwarf (30-40 cm) having white flower with purple tinge. Pods are round, light green, attractive, string less and fleshy;

Arka Komal (Sel-9)

Arka Komal has been developed at IIHR, Bangalore; derived through selection from an Australian introduction (IIHR-60). Plants are erect, bushy with bright green stem and foliage.

IIHR-909

This variety has been bred at IIHR, Bangalore; derived through pedigree selection from the cross Blue Crop X Contender. Plants are bushy and photosensitive.

Contender

It is an introduction from USA. Takes about 50-55 days for first picking. Pods are round, green, 13-14 cm long, string less, meaty and slightly curved. Pod yields 80-90 q/ha. Tolerant to mosaic and powdery mildew.

Pusa Parvati

Early bearing, pods ready in 45-50 days. Pods are 15-18 cm long, round, tender, string less, green in colour. Yields about 80-85 q/ha and resistant to mosaic and powdery mildew diseases.

Soil and soil preparation

French bean can be successfully grown in sandy loam-to-loam soil with pH ranging from 6 to 7.5. Acid damp soils with high standing sub soil waters are completely unsuitable for its cultivation. Plough the land once with mould board plough followed by 3-4 harrowing and planking.

Nutrient requirement

Beans, like other legumes, have a relatively high nitrogen demand during pod fill and, senescence and abscission may result from competition for N. Compost or FYM should be applied @ 25-30 t/ha 3-4 weeks before sowing. For raising good crop of French bean N:P:K @ 120:50:50 kg/ha is used. Full dose of P,K and half dose of N as basal and remaining half dose of N is applied at flowering stage as top dressing.

Seed rate and sowing

In North Indian Plains last week of October to first fortnight of November and in Tarai belt of U.P. during February month but in hills sowing can be done in summer and rainy seasons.

Temperature favorable for it cultivation ranges between 20-25°C. Bushy varieties require 60-75 kg seed/ha and for pole type 25-30 kg seed/ha is sufficient.

For bush type varieties a spacing of 40-50 cm between line and 10-12 cm from plant to plant with a depth of 2-3 cm is ideal. After sowing planking (Pata) is must for moisture retention. Pole type varieties may be spaced at 90 cm row to row and 25-30 cm seed to seed. After germination thinning should be done for maintaining proper spacing.

Water management

The French bean is always planted in sufficient moisture condition. Irrigation requirement mainly depends on soil type and climate. However, 1st irrigation may be done at pre flowering stage and second at pod setting. Light irrigation should be done at 10 to 15 days interval as per need of the crop.

Weed management

One hand weeding and one shallow hoeing should be done for weed control. For chemical weed control, use Alachlor or pendimethalin @ 1 kg ai/ha in 1000 liter of water within 48 hours of seed sowing.

Harvesting

To get maximum returns harvesting should be done for tender pods manually without damaging plants. First picking comes about 45-50 days from sowing in bushy cultivars and about 60 days after sowing in pole type. In bushy cultivars 3-4 pickings are done while 4-6 picking are done in pole type varieties.

Yield

Yield of bushy varieties range between 50-60 q/ha whereas, Pole types cultivars yield 80-100 q/ha.

Storage

Fresh pods can be stored in a good condition for 7-10 days at 4-7°C with 95% relative humidity.

PRODUCTION TECHNOLOGY OF POTATO

Solanum tuberosum Family : Solanaceae

Merits of TPS (True Potato seeds)

1) Amount 100g-2t/ha.
2) Wastage of tuber
3) Storage, Handling and Transport
4) Pest and Disease spread is reduced.

Potato in India 0.93 mha; 15.82 mt; 16.27t/ha. The productivity is very low in India due to non availability of good quantity planting merits of eyes/TPS. The breeder seeds in potato is able to generate certified seed supplement for 25-30% request. This gap is usually filled with degenerated seed stocks-reduce potential in production. Seed is produced in N. J, incidence of aphids (Vimi vectors) is low. The seeds are transferred to other potato growing areas follows increases in cost; Solequate cold storage also backing. Seeds in these are often don't reach the places at right time of planting reduce yield; The above problems during TPS-alternative technology in use of botanical seeds gains significances for the merits.

(1) Considerable amount of food in used as seed for next crop. By TPS the entire produce-table purpose.
(2) Cost of seed tuber-principle investment; TPS will be cheaper in very small quantity is needed (100 g/ha-2 t/ha).
(3) Bulky and Perishable transport difference; TPS transport from production site to the farmer even in inaccessible areas is however inexpensive and simple.

(4) TPS-lowcost pring material and can be produced in all post growing region. So reduce dependence of there areas for getting quantity seeds from North.

TPS-Xerox (Production)

Cabbage, Cauliflower, Knolkhol, Broccoli sprout, Sprouting broccoli, Kale, Chinese Cabbage, Potato, Radish, Carrot, Beet root, Turnip, Spinach, Lettuce, Celery, Globe Artichoke and J. Artich, Peas (Hill sown).

(5) TPS-introduce potato cultivations into new areas where good quality seed tubers are not produced and stoned economically.

(6) TPS-stored longer; Not request expensive and special storage it as that of seed tubers.

(7) Disease transmission lesser; While sending bacteria, fungi, are contaminates of S.T. These are filtered out during pollu & ferm, for production of seeds. Only a few viruses and viroids are known to be transmitted through TPS-Crops almost of free.

(8) Potato a sexual propagation. So fixed genotype. Each cell of a plant in field genetically identical. In contrast pathogens, commonly and genetically labile. As a consequence labile often readily overcomes the resistance of the clonally propagated crop. Incontrast heterogeneity of from TPS expected to offer gene diversity and resistance to pathogens.

Disadvantages:

(1) Heterogenity in pophn for various characters especially more farming operation, more, environment stresses than that of seed tubers.

These can be overcome by research efforts.

Productivity of Potato: India 6.6 t/ha → 16 t/ha which is reduce than temperate countries 30-40 t/ha. But productivity are area are time better. India in diverse ecological situations. On the basis of geography.

Potato growing areas 6 zones

1) W.N. Indian Plains – Pun, Hary, Raj and neighbouring – 10%.
2) C.N J.P. – P. U.P, M.P. – 25%
3) ENJP – E UP, Bengal P and Orissa – 30%
4) NJ Hills –15% N.W – Jammu Kashmir to N.E. – Kasi Hills.
5) Plateau – Mid country Plateau and S. Peunisular P., Gujarat, Maharashtra, Karnataka, 7%.
6) S.J. Hills – Nilgris, Palani hills, all round the year.

Generally 3 main Spring, Summer, Autum

Origin: SA, Peru, Clock, Boliria.

By Spanish – 16th century. Reached N. American Countries and Asia.

Tuber crops stolons underground lateral stems from buds aboveground on main stem, swollen by starch accumulation. The top portion called haulms, promote to erect habit bearing compiled leaves. Nutritive value : 725; 20-22% CH_2O on fresh weight basis 58% dry weight; Vitamin B,C, Niaccin, Thiamin, Ribo, Fe and Mg.

Climate:

Cool season crop, doesn't tolerate post. Days are sunny and nights cool. Overall optimum temperate 15-25ºC. For sprouting initial vegetable 20-24ºC. For hybridization 18-20ºC. If >30ºC. This severely affected. General warm temperate at planting will hartens emergence and development of foliage very low night temp T and Bulking. As crop enters are there should be short days. This will be very ideal for better tuber development and higher yield.

Soil:

Well drained deep alluvium of Indogenetic P. Loose fiable; Hand clay avoided; 5.5-7. Marketable yield is controlled by soil prone bac. Streptomyces cabbies. Characterised rough corley lesion on tuber. This is not active at pH < 5.4 & 7. When > 7 Potato cannot be cultivated. At 6-6.5 the total tuber yield very increases. But due to infection of scab the yield is decreased. So 5-5.2 pH is optimum.

(1) Tropical Tuber Crops – Mendel (2) Multiple Cropping system New arrivals.

Preparatory cultivation

For S.J. Hills; P are normally from tubers. Cut tubers with atleast one eye. They are curved by storing at 10-15ºC for 4-6 days for suborization and to wound or heal the periderm formation. Well sprouted 30-40 g tubers are recommended. In recent studies at Patna 96-98 with small.

K. Sindhuri showed most economical but tuber quality is deteriorated. The cut tuber are planted in flat beds of convenient size. Hills-across slop eating contour to control soil moisture. Since it is mainly grown as RF crop. Seed tuber min one eye. Even > 1 one sprout and suppress that of other. 1500-2500 kg/ha against 100 g of TPS. Due to hears cost of seed tubers, recently TPS was is many countries – America, China and India. Hybrid develop through TPS – CPRI HPS 1/13, 11/13, 24/111 are found to be high yield with tuber yield in Kashmir, Himachal Pradesh and Gujarat. In these cases seeds in nursery beds and transplanted 30 DAS.

Manures & Manuring: 25 FYM/ha. Before planting 60:100:120 NPK for S.J. Hills. In acidic acid laterists of hills, P not available P increases 100 – besides 2 kg of phosphobacteria.. In hills SSP application with Phosphorus is very effective in the availability of P for potato crop. Mixed with soil; Micronut define $ZnSO_4$ 20 kg, $MuSO_4$ (20), $FeSO_4$ (10), $CuSO_4$ (10), NH_4MOO_4(1 kg) Na Borate (1 kg) before last ploughing.

The seed tubers taken from cold storage and spread in shade.

This will encourage early sprouting. Seed tubers obtained from 1 pp, GA for 1 hours dried in shade expresses good germs. Filled in gunny bags. To increases sprouting besides GA, Thiourea, Thio SO_4, CS_2 can allowed. 0.2% solution of Bannslin for 3ºC avoid soil borne pathogen.

Planting: 60x15 R and F/Flat Beds.

N.J. Hills winter is very severe. 3rd with from February, to 2nd with of April N.J. Plains. Early crop in 3rd September to 1st with October.

Plains winter crop in November.

Irrigation: Heavy irrigation, crust formation, hinders sprout to come out, 10 d once, moisture, hills frost damage can be decrease by irrigation during night.

Intercultivation: Nitrogen ( ) 1 kg ai/Lasso (Alachlor) 2 kg ai Taphazin (Cimisin). 0.5 kg ai just after planting and imm. Irrigated.

20-28 DAP sholons arise from lower nodes. These penetrate and enter the soil. The 35 DAP. This is an stage when plants are to be earth up. Top dressing followed by irrigation before cup frost damage.

2nd E.U. 30 DA first E.U.

Harvest: Ready for multiply after haulms cut, tubers cleaned and packed in gunny bags. If stored or distant multiply haulms cut 10 days allowed to dry shin – hardened – increase shelf like. Drying of haulms built vector for virus disease. Safely 20 d after dug out heaped, facilitate further hardening and separation of soil. When tubers sorted out healthy tuber sorted according to size.

Oversized – Chips making

Med size – Maximum price

Small size - Production

Miniature - Naceturpodi

Mlif tubers – 25 to 30 t/ha.

Storage: 1-2.7ºC, 90-95% RH.

Plant Protection: Cutworms

Cut the sprouts at ground level soil application of borate 10 kg/ha around plants and rating done imm.

Leaf Eating Caterpillar: 1-5 ml/l. Endo.

Jasids and Aphids – Rogor 1ml/l.

***S. linera* – IPM**

(1) Deep ploughing – summer – pupae.

(2) Castor – trap crop around field – attract moth for laying eggs – egg maner and tiny caterpillar destroyed.

(3) Pheromone traps 9-10 / ha.

(4) Thoroughly sprayed 5% NSKE.

(5) EB: A. Solani LB: Physical infestans. Indofil Z78 2g/l.

(6) Bac. Scab checked by pH-5 to 5.2.

(7) Cyst Nema: DD-400 l/ha following crop rotation using nonsolanaceous crops. Planting material not from infested area.

Potato Virus X, PVY, Potato mosaic, PVA, MLO, Witches Broom. All these cases infested tuber avoided. Control aphids, hoppers, and systemic insecticide

TAMIL NADU AGRICULTURAL UNIVERSITY

HOR.312 VEGETABLE PRODUCTION 2+1

PRACTICAL MANUAL CUM RECORD

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2005

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Tamil Nadu Agricultural University

PRACTICAL MANUAL CUM

Name:_____ **I. D. No.:_____**

Year: III B.Sc (Agri) **Batch: _____**

Semester: VI **Course No. & Title: HOR.312 Vegetable Production (2+1)**

CERTIFICATE

Certified that, this is the bonafide record work done by the student Th._____, I.D.No: _____ in the Department of Vegetable Crops, Horticultural College and Research Institute, TNAU, Coimbatore-641 003 during 2004-05 for the above course.

……
Course Teacher

Submitted for the practical examination held on _____at Horticultural College & Research Institute, TNAU, Coimbatore-3.

Place: Coimbatore

Date:

External Examiner

EX. NO. 1

NURSERY MANAGEMENT, SEED TREATMENT SOWING SEEDS AND RAISING SEEDLINGS

Nursery : Nursery is a place where seedlings, cuttings and grafts are raised with care before transplanting.

Depending on the method of cultivation, vegetable crops can be grouped into thre types

1. **Direct sown vegetables** : Bhendi, radish, peas, amaranthus, cucurbits, beans, annual moringa etc.
2. **Transplanted vegetables** : Tomato, brinjal, chillies, Sweet potato, cabbage, cauliflower, bellary onion, seed propagated aggregatum onion.
3. **Vegetatively propagated vegetables** : Potato, Tapioca, sweetpotato, coccinea, chekurmanis etc.

For transplanted vegetables, raising of nursery is an important operation.

Advantages of raising seedlings in nursery

1. It is very convenient to look after the tender seedlings.
2. It is easy to protect the seedlings from pests and diseases
3. Economy of land usage (duration in the mainfield is reduced)
4. Valuable and very small seeds can be raised effectively without any wastage.
5. Uniform crop stand in the mainfield can be maintained by selecting healthy, uniform and vigorous seedlings in the nursery itself.

Preparation of nursery beds

Selection of site

1. The nursery area should be nearer to the water source.
2. Generally, the location should be partially shaded ie. Under the trees. If not, artificial shade to be provided.
3. It should be well protected from animals.
4. Proper drainage facilities should be provided.

Selection of soil

1. A medium textured, loam (or) sandy loam soil is preferred.
2. Soil should be rich in organic matter.
3. Soil depth should be preferably 15-25 cm.

Types of nursery bed

1. Flat bed
2. Raised nursery bed.

Preparation of raised nursery bed

Selected soil should be worked well to break the clods and weeds, stones and stubbles should be removed. Height of the raised bed should be 10-15 cm with a width of 1 m and length may be according to the requirement and convenience. Two parts of fine red earth, one part of sand and one part of FYM can be incorporated to each bed to improve aeration and fertility of the soil. Before preparing the bed, the soil should be drenched with 4% formaldehyde or 0.3% copper oxychloride to kill the pathogenic spores in the soil. Nowadays solarisation of nursery bed with white polythene sheet can check the nematode infection and weed growth.

Advantages of raised nursery bed

1. Water movement will be uniform and drainage of excess water is possible (In the case of flat bed, water moves from one end to the other and there is possibility of washing away of seeds).
2. Germination percentage of seeds is normally high.
3. Operations like weeding and plant protection measures are easy.

Seed treatment

The seeds should be treated with Captan or Thiram 2g or carbendazim one g or Trichoderma viride 4 g per kg of seed 24 hours before sowing to control the seed borne pathogens. Microorganism inoculants like *Azospirillum* and phosphobacteria can be mixed with rice gruel @ 250 ml per packet of *Azospirillum* or phosphobacteria and dried under shade before sowing. Normally two packets (400 g) are needed for treating the seeds required for one hectare. These inoculants are helpful in getting healthy vigorous seedlings in the nursery itself so that the correct population can be maintained in the main field.

Sowing of seeds

The surface of the bed should be prepared well mixed with well decomposed FYM or compost and leveled by using a wooden plank. Straight lines are drawn at a spacing of 10 cm to a depth of 1-2 cm. Seeds are sown in the lines and covered with sand or fine soil or powdered FYM. Line sowing of seeds facilitates easy weeding, and removal of disease infected seedlings. Depth of sowing determines the rate of emergence. If it is too shallow the seeds come up and dry out early. If it is two deep, the seedling

emergence is much delayed. So, a thumb rule is followed. Sow the seeds approximately at a depth of 3-4 times the diameter of the seed.

Season of sowing

In general, vegetable seeds are sown in there distinct seasons.

Brinjal	-	Dec.-Jan and May-June
Tomato	-	May-June, Nov-Dec, and Feb.-Mar.
Chillies	-	Jan. – Fed., June-July, Sept. – Oct.
Bellary onion	-	May-June and Jan.-Feb.
Cabbage and cauliflower	-	Jan.-Feb and July-Aug., Sept.-Oct. for hills Aug.-Nov. for plains.

After sowing the seeds, the bed is covered with paddy straw and watered by using a rose can so as to avoid packing of the soil and washing away of seeds. Watering should be done twice daily till the seeds germinate. The straw cover should be removed after germination and watering once a day will be sufficient. A week before transplanting, the seedlings should be exposed to full sunlight and the number of watering should be reduced so that the seedlings become hardy to bear the shock of transplanting in the main field.

Types of nursery

1. **Temporary nursery:** It consists of raised nursery beds. It can be changed from one place to another, depending on needs.
2. **Permanent nursery**: Sidewalls with drainage holes are constructed with concrete to a height of 75 cm. Seeds are sown in soil inside the concrete structure. After removal of each batch of seedlings, the soil is enriched with manures.

Seed rate: (Per hectare).

Cabbage	-	375-500 g	Tomato	-	400-500 g
Cauliflower	-	375-500 g	Chillies	-	1 kg
Bellary onion	-	8-12 kg	Brinjal	-	370-500 g

Pest and disease management

Pests

There are two types of pests, which normally attack the nursery plants.

1. Sucking pests – Aphids, white flies, thrips etc.
2. Biting (or) chewing pests – Beetles, grasshoppers, leaf eating caterpillars etc.

Apart from causing damage to the seedlings, the sucking pests also act as vectors for transmitting some of the viral diseases even in the nursery stage itself.

Eg. 1. Aphids spread mosaic disease in chillies

2. Thrips act as vector for leaf curl virus disease in chillies and spotted wilt virus disease in tomato.

Control

i. Application of systemic insecticides like Methyl demeton or Dimethoate @ one ml per litre of water by using a hand operated sprayer.

ii. Application of carbofuran @ 10g/sq.m 10 days before pulling of seedlings will also control the sucking pests in the nursery and at the early stages in the mainfield.

Diseases

Damping off (*Pythium* spp., *Phytophthora*, spp. *Rizoctonia* spp.)

Seedlings of tomato, chillies, brinjal, cabbage, and cauliflower are highly affected by this disease. Water logging with poor drainage leads to infection. The disease affects the seedlings in two ways.

(1) Affected seeds get decayed inside the soil resulting in failure of germination.

(2) After germination, the fungi attack the seedlings in the collar region. The tissues will become soft and succulent. In advanced stages, the seedlings become lodged and get decayed.

Control

1. Raising seedlings in raised beds with good drainage facility reduces the infection.
2. Addition of organic matter improve the soil texture and soil aeration.
3. Avoiding thick sowing of seeds in beds.
4. Periodical changing of nursery sites.
5. Treating the seeds with captan, thiram @ 2g or carbendazim @ one g/kg or *Trichoderma viride* @ 4g of seeds before sowing can reduce the infection.
6. Drenching the nursery bed once or twice with bordeaux mixture 1% or copper oxychloride 0.3% can also reduce the infection.

Nematodes

Root knot and lesion nematodes commonly infect the seedlings. Before sowing the seeds, carbofuran @ 10 g/sq.m should be incorporated in the soil and watered regularly.

Ants: Application of Lindane 1.3% dust at the rate of 100 g/bed on all sides to protect the seeds from ants.

Questions

1. What is a vegetable nursery? Give examples of direct sown and transplanted vegetables.
2. Write four advantages of raising a nursery for vegetables?
3. Write three criteria for selection of the site?
4. What are the two types of nursery beds? Indicate two advantages of raised nursery beds.
5. Give examples of bio-fertilizers and fungicides used for seed treatment.
6. Indicate the seed rate for tomato, chillies, onion and cauliflower.

EX.NO.2

PREPARATION OF MAIN FIELD AND PLANTING OF SEEDLINGS

Selection of site for vegetable cultivation

The points to be considered while selecting a particular site for vegetable cultivation are,

i) Marketing facility to sell the produce.

ii) Transport facilities and cost of transportation from production site to market place (more than one mode of transport is essential)

iii) Suitable climate for vegetable cultivation.

iv) Extent and suitability of land

v) Nature of available soil conditions

vi) Availability of labour force.

vii) Assurance of water supply.

A good soil for vegetable cultivation should have the following characters.

i) Soil should have ample plant nutrients for good yield.

ii) It should have a reasonable water storage capacity and ability to maintain sufficient moisture.

iii) Soil should have a good physical properties (which enables proper root development and anchorage of the plant)

iv) Soil should be free from adverse chemical reactions. Highly acidic or alkaline soil should be avoided.

Soil reaction influences the availability of plant nutrients. The N, P & K is highly available at a pH range of 6.5 to 7.0. The bacteria, which fix nitrogen and decompose organic matter, are very active in the pH of 7.0.

Each vegetable crop requires of optimum pH range for better performance. Cauliflower and spinach come up well in a pH range of 6.0 to 6.7, while peas and cabbage can tolerate a soil pH of 5.5.

Soil should be selected depending on the crop to be grown.

(1) Crops like celery, onion and lettuce have shallow root system. Plenty of organic matter and moisture should be available in the topsoil for these crops. So soils, which are high in fertility and moisture in top layer, should be selected.

(2) Cucurbits have tap root system, which grows to a depth of 45 to 75 cm. But the lateral roots spread as much as the spread of the top of the plant. Fertile, well-drained loamy soils should be selected.

(3) Some of the crops have adaptable root system and they can be practically grown in any type of soil provided it is well drained and supplied with fertilizers and reasonable amount of water (e.g.) tomato, brinjal.

For most of the vegetable crops, sandy loam soil rich in organic matter is the best because these soils can be easily worked, well drained, cultivation can be carried out immediately after rain and they respond readily to fertilizer application.

Preparation of field/land

The field should be ploughed three or four times with iron plough. The soil may be harrowed or rolled to break the clods. At the time of last ploughing, well-decomposed FYM 25 t/ha should be incorporated into the soil. Then the field may be made into ridges and furrows or beds depending upon the type of crops to be grown. In case of cucurbits, pits of recommended size should be dug.

Planting

Most vegetables are propagated by seeds and some by vegetative means, like stem cuttings (sweet potato, tapioca, chekurmanis, basella), tubers and corms (potato, yam, colocasia), bulbs (onion, garlic) etc.

Crops like sweet potato, tapioca, chekurmanis and basella etc, are propagated through stem cuttings. They are planted on the ridges in the mainfield. Tubers and corms like potato, yam, colocasia etc can be planted in beds or ridges. Bulbs like onion and garlic are planted in beds.

Sowing

Seeds are directly sown in the field in the case of cucurbits, bhendi, amaranthus, beans etc. In cucurbits, 30 cm^3 pits are taken at a spacing of 1.5m, filled with topsoil and FYM; irrigated and then 4-5 seeds are dibbled per pit. One week after germination, they are thinned to one or two seedlings per pit. In bhendi, field beans, cowpea etc, two seeds are dibbled per hill on one side of the ridge and later they are thinned to one. Since the amaranthus seeds are very small they are mixed with sand in the ratio of 1:8 and broad cost in the prepared beds.

Transplanting

The main field should be kept ready before lifting the seedlings from the nursery bed. The nursery bed should be watered well in advance before lifting the seedlings. Seedlings must be lifted carefully with as little injury to the roots as possible. Seedlings should not be allowed to dry after lifting. It is better to

cover them in a moist gunny and keep under shade till required for planting. The field should be irrigated well and left for sometime so that the soil absorbs enough moisture. While transplanting pressure should be exerted downwards and towards the plant so that the soil around the root system is properly pressed which prevents air pockets in the root zone. Pressing would give good contact with the soil.

While transplanting, roots are injured and the capacity of the plant to absorb water to compensate transpiration loss is reduced. Hence it is better to transplant in the late evenings or on a cloudy day. During summer, it is desirable to provide some artificial shade to newly planted seedlings by inserting twigs with leaves near the seedlings. Life irrigation should be given on the third day. Gap filing may be done during the life irrigation or during the subsequent irrigation.

Age of seedlings suitable for transplanting

	Crops	Age (days)
1.	Brinjal	30-35
2.	Tomato	25-30
3.	Chillies	40-45
4.	Bellary onion	40-45
5.	Cabbage	30-35
6.	Cauliflower	30-35

Seedlings in polybags

Cucurbits 30-35

Annual Moringa 30-40

Thinning is removal of seedlings (preferably weaker ones) from the nursery or from main field so as to maintain the optimum plant population. Thinning may also prevent overcrowding of seedling.

Reason for thinning

1. To prevent overcrowding – Overcrowding of seedlings results in weak thin seedlings which hastens poor establishment in the main field, if it is transplanted.
2. Competition for water, nutrients, space and sunlight can be minimized.
3. Overcrowding of seedlings may facilitate easy spread of disease infection in the nursery.

In nursery, damping off is the most commonly occurring disease. Affected seedlings show bending and lodging symptoms initially, leading to drying and death of seedlings, finally.

For direct sown vegetable crops like bhendi, cucurbits, thinning is practiced in the main field. Thinning is usually done when the seedlings are at 2-4 leaf stages at 10-15 days after sowing. In crops like bhendi, thinning can be followed at the time of first hand hoeing ie 15-20 days after sowing.

By practicing thinning,

(1) Healthy seedlings are obtained, which ensures to maintain a required population in the main field.
(2) Disease spread can be minimized to a certain extent.
(3) Maintenance is easy.

Earthing up

It is usually done at the time of first hand weeding/hoeing depending upon the duration of crop. For bhendi, earthing up can be done at 20 days after sowing. In tomato, brinjal and gourds, it is done 30 days after sowing. Earthing up encourages more aeration in the root zone thereby better root development. In crops like onion, earthing up facilitates, good bulking capacity of the developing bulbs.

Top dressing

Generally, top dressing coincides with earthing up. After weeding/hoeing, half the dose of recommended nitrogenous fertilizers is applied thoroughly mixed, earthed up and then irrigated. In amaranthus, hand weeding is followed by top dressing. In perennial vegetables and gourds, while doing earthing up, basins are also formed with gradual slope for better irrigation facilities.

Questions

1. How do you select the site and soil for vegetable cultivation?
2. How do you prepare the main field for planting vegetables?
3. Give examples of vegetative propagated vegetables?
4. How do you take up sowing in direct sown vegetables?
5. What are the precautions to be followed while transplanting vegetable seedlings?
6. Indicate the seedlings transplanting age for 5 vegetables.
7. Write a short note on thinning and earthing up of seedlings.

EX.NO.3

METHODS OF IRRIGATION IN VEGETABLE CROPS

Vegetables are composed largely of water. Adequate water supply ensures maximum yield, earliness in maturity, good market and table quality. Except a few crops, like tapioca and sweet potato, all other vegetables require regular irrigation. Uniform availability of water and plant nutrients in the root zone is essential for the growth, development and yield of vegetable crops.

Factors governing water supply to vegetable crops

i) Nature of crops

Some crops like tapioca, sweet potato are drought tolerant and require less irrigation. Crops like cauliflower and other root crops are drought sensitive, and require more frequent irrigation. A shallow rooted crop requires more frequent watering than a deep-rooted crop.

ii) Nature of soil

Fine textured soils hold moisture for longer time than soils of coarse texture. Deep soils hold large quantities of water than shallow soils. Incorporation of organic matter improves water-holding capacity. When water-holding capacity of soil is increased, the interval between irrigations can be extended.

Systems of irrigation

I. Surface irrigation: Water is directly applied to the soil surface. This system generally requires more quantity of water. The various types of surface irrigation systems are -

1. **Flooding**: This method of irrigation is followed widely in wetland banana cultivation. It is a wasteful method, which leads to the stagnation of water.
2. **Check**: This is a more economical method than flooding. Here, check bunds are formed enclosing the large area of trees, which are provided with channels between two rows.
3. **Basins**: This method of irrigation is widely practiced for perennial tree crops like coconut, mango and sapota. For vegetables, this can be followed for agathi and moringa.
4. **Ring**: Here a single irrigation channel connecting all the trees is formed and around each tree, the channel is widened to form a basin. This method is followed in cucurbitaceous vegetables.
5. **Beds:** Bed system of irrigation is followed for direct sown vegetables like amaranths, coriander, fenugreek etc. Hence, there is possibility of washing of seeds from one end of the bed to the other end.

6. Furrows: For crops like, tomato, brinjal, onion etc, this is the most common system of irrigation.

7. Drip irrigation

This type of surface irrigation ensures uniform supply of water to all plants. Here, water is supplied near to the root zone gradually. The water leaks from small holes in the hose and seeps into the soil at a slow and uniform rate. This method of irrigation can be followed for line planted vegetable crops like tomato, brinjal, chillies, beetroot etc. In general, the water consumption is about half to one fifth in the drip irrigation method as compared to other methods of surface irrigation.

II. Sub soil irrigation

This method supplies water through underground pipes or pitcher pots on one side. This is useful for green houses. Pipes are laid 45-60 cm deep and 6m apart. The pipes have holes at regular intervals. This method is too costly and deep cultivation is not possible. But, evaporation of moisture is prevented to a great extent.

Pitcher method

This method is highly useful, particularly for drought prone areas where fruit crops and widely spaced vegetables are grown. An earthen pot of 20 litres capacity having 4 small holes of about 1 mm at a height of 5 cm from the bottom is buried in pits of 50 cm diameter and 50 cm depth. The soil around each pitcher is pressed firmly. The pot has to be filled with water once in 4-5 days, which helps in the economy of water use, and at the same time, the root zone is supplied with enough moisture.

III. Overhead system of irrigation

Sprinkler irrigation

Sprinkler irrigation is a versatile means of applying adequate amount of water to any crop, in general.

Advantages

1. Saving in labour and water.
2. More uniform wetting of soil
3. Soil erosion can be minimized
4. Best suited for steep and terraced lands
5. Most suited for plantation crops and vegetables like cabbage, cauliflower etc.

Disadvantages

a) Due to the influence of wind, there may be non-uniformity in coverage.
b) In hot sunny days, water droplets on leaves and fruits may cause sunburn.
c) Certain disease may spread easily.

Based on water requirement and the rooting depth, vegetables are classified as,

I. Shallow rooted crops: (Root depth upto 60 cm)

1. Broccoli, 2. Brussels sprout, 3. Cabbage, 4. Cauliflower, 5. Celery, 6. Lettuce, 7. Onion, 8. Radish, 9. Potato, 10. Spinach.

II. Moderately deep rooted crops: (Root depth 61-120 cm)

1. Beans, 2. Beets, 3. Carrots, 4. Peas, 5. Sweet pepper, 6. Turnip , 7. Squash

III. Deep rooted crops: (Root depth 121-180 cm)

1. Artichoke, 2. Asparagus, 3. Lima beans, 4. Sweet potato, 5. Tomato, 6. Watermelon

Questions

1. Indicate the factors governing moisture availability in vegetable crops.
2. Name the systems of irrigation in vegetable crops.
3. List out the advantages & disadvantages of drip and sprinkler system of irrigation.

EX.NO.4

METHODS OF FERTILIZER APPLICATION IN VEGETABLE CROPS

Fertilization refers to the addition of nutrients in the soil for good plant growth. The primary objective of crop fertilization is to achieve an optimum plant response. Fertilization beyond this level must be considered a wasteful practice. Excessive fertilizers not only lead to loss by leaching and volatilization, but also it becomes toxic to crops.

Fertilizers may be classified as natural organics and chemicals. Natural organics (e.g. manure, blood, fish scraps and cotton seed meal) are compounds derived from living organisms. Chemical fertilizers, such as ammonium nitrate and super phosphate are synthesized from inorganic minerals.

In addition to soil application, nutrients may be applied directly through the foliage. N can be efficiently applied through the leaves by spraying with urea. The foliar application of trace elements like manganese, boron, Iron, Zn, etc. has also proved to be beneficial.

Important organic manures

1. **Cattle manure or farmyard manure:** The manures produced by horse, cattle or other animals are included in this category. It takes a long time for it to decompose, nearly an year before it becomes usable. It is more suited to light than heavy soils. This contains 0.6% N, 0.35% phosphorus and 0.6% potassium. However, the percentage of these nutrients may vary depending upon the substances in the animal feed, age of the animals, condition of animals and storage and handling including the kind of litter used. The manure is applied as a basal dressing by broadcast and immediately incorporated into the soil by ploughing.
2. **Bone meal**: This is rich in phosphoric acid and lime. Steamed bone meal contains not less than 3.5% N and 23% Phosphoric acid. Bone meal is especially beneficial to soil deficient in lime.
3. **Oil cakes**: They are residues left after the oil is extracted from the seeds of groundnut, castor, gingelly, pongamia, Neem, etc. Oil cakes contain 3 to 5% N and 1.5-2% P. They are best applied to potted plants in the form of liquid manure.
4. **Leaf mould**: Withered and dried leaves and garden sweepings are thrown into a pit in a shady corner in the garden and covered over with earth and watered copiously once or twice in summer to assist decomposition. Decomposition will be completed within a year. Leaf mould is rich in humus and is hence applied to both sandy and clayey soils. It is usually mixed with soil in the preparation of pot mixtures.
5. **Wood ash:** It is rich in potassium. Vegetables generally require liberal manuring with wood ash.

6. **Compost**: The soil organic matter can be increased by the addition of Compost. It may be defined as the material resulting from the decomposition of plant residues under the action of bacteria and fungi. Well-prepared compost contains 0.75-1% N, 0.60-0.75% P_2O_5 and 1-1.5% K_2O.

Sometimes, green manure or green leaf manures are ploughed into the soil for the purpose of incorporating organic matter, thus applying humus as well as nutrients contained in them. The following are the commonly grown green manure legumes in India.

1. Sunnhemp (*Crotolaria juncea*)
3. Pillipesara (*Phaseolus trilobus*)
3. Daincha (*Sesania aculeata*)
4. Sesbania (*Sesbania speciosa*)

Green leaf manuring refers to the incorporation of the green leaves and other tender parts of the plants collected from the shurbs and trees grown outside the field and also collected from the waste lands and nearby forests into the soil. The popular plants are

1. Gliricidia (*Gliricidia maculata*)
3. Pungam (*Pungamia pinnata*)
2. Daincha (*Sesbania aculeata*)
4. Sesbania (*Sesbania speciosa*)

Type of fertilizers			**Nutrient content**
	Nitrogenous fertilizers	-	**%**
a)	Ammonium sulphate	-	20.6
b)	Urea	-	46.0
c)	Sodium Nitrate	-	16.0
d)	Potassium Nitrate	-	12.5-13.5
	Phosphatic fertilizers		
a)	Superphosphate	-	16.0
b)	Rock phosphate	-	30.0-40.0
	Potassic fertilizers		
a)	Muriate of potash	-	60.0
b)	Potassium Sulphate	-	48.0

Mixed fertilizers: It is a mixture of straight fertilizers, which can supply more than one plant nutrient elements.

Advantages:

1. Saving in time and labour for application.

Disadvantages

1. Specific needs of crops for individual nutrient element cannot be met.
2. Unit cost of various nutrients contained in the mixed fertilizers will always be higher than the unit cost of nutrients in the straight fertilizers.

Biofertilizers

Fixation of atmospheric nitrogen is carried out by specific group of microroganisms either in free-living condition (Eg) *Azotobacter* or in symbiotic association with leguminous crops (eg.) *Rhizobium* and non-leguminous crops. (eg.) *Azospirillum*.

Application of phosphobacteria solubilizes the insoluble phosphorus thereby it increases the availability of phosphorus.

They are applied in the following methods.

a) Seed treatment or seed inoculation (400 g/ha)

b) Seedling dip or root bacterization (1 kg/ha for 10 minutes)

c) Soil application or broadcasting (2kg/ha)

Depending upon the nature of soil and the crop, there are different methods of fertilizer application.

Organic manures are mostly spread uniformly in the field and incorporated at the last ploughing.

Methods

1) Broadcast

The fertilizer is applied uniformly over the field before planting the crop. It is incorporated by using a tiller or cultivator. One of the main disadvantages in this method is that more amounts of fertilizers are leached out. It has the advantage that there is less chance of injury to roots.

2) Side band

Fertilizer is applied in bands to one or both sides of the seed or plant.

3) With seed

The fertilizers are applied along with the seed at the time of sowing. The emergence of seedlings is affected if seedlings get scorched.

Starter solution

Solution of fertilizers consisting of NPK is applied to young plants at the time of transplanting. Such type of solution is known as starter solution, which has the following advantages.

1. Nutrients reach the plant roots immediately.
2. Solution is sufficiently directed so that it does not inhibit growth (Eg) tomato.

Seed Treatment

Seed treatment with nutrient solution is also one of the ways to fulfill the nutrient needs of the crop at the early stages of growth. (E.g.) soaking of potato seed tubers in 0.5% solution of micronutrients *viz.*, Zinc sulphate, Ferrous sulphate, Manganese sulphate and copper sulphate for 4 hours has been found effective.

Foliar application

The water-soluble fertilizers may be applied directly to the aerial portion of the plants. The nutrients can penetrate the cuticle of the leaf and stomata and then enter the cells. This method provides, more rapid utilization of nutrients and permits the correction of observed deficiencies in shorter time than the soil treatments. Micronutrients are highly effective when given as foliar spray. Urea is highly suitable for foliar application because of its high solubility; easy and quick absorption by plant tissues and it contains more nitrogen. It can also be mixed with pesticides and fungicides while spraying. Urea injury could be corrected by sucrose or by the addition of Magnesium sulphate. Micronurients are highly effective if given as foliar spray because of their requirements in small amounts by the plants. Moreover, micronutrients like Zn, Cu and Fe are not highly soluble in soil. Foliar application of 2% urea at weekly intervals in bhendi for 6 times from 20 DAS is found to be highly beneficial.

Disadvantages

1. Skill is required in preparation of the solution for sprays as the foliage of the vegetable crops is damaged by high concentration of fertilizers.
2. Time of application is equally important. If the solution is sprayed in the hot sun, the foliage may get scorched due to rapid drying of sprayed solution over the foliage and thus increase in the concentration.

To avoid the scorching effect of foliar application of micronutrients, neutralization with 0.25% lime or 3.0% urea helps.

Nutrient requirement of Vegetable Crops

Vegetable crops are fertilized in order to supply the nutrient elements, which are not present in sufficient quantities in the soil.

Nitrogen

Nitrogen fertilizer is readily soluble in water and more loss is found to occur. This nutrient is required throughout the crop growth and all plants are found to absorb the nitrogen continuously

through out the entire growth phase. So it is advisable to supply nitrogenous fertilizers in split doses instead of applying the entire quantity at one time.

Phosphorus

This nutrient is required in large amounts in the early stages of plant growth. Phosphorus fertilizers are found to be slow acting and the available phosphorus become unavailable due to fixation.

Soil amendments like Lime, Dolomite or Magnesium sulphate are easily decomposable in acid soils. Iron pyrites may be incorporated in alkaline soils to change the pH before application of fertilizers to reduce the fixation.

Surface application or broadcasting is preferred for shallow rooted crops, whereas placement in the root zone is advantageous for deep-rooted crops.

Potassium

Potassium is required throughout the crop growth. But the release of this nutrient in the soil is very slow. Therefore, it is desirable to apply the entire quantity of K before sowing or planting of crop.

Time of application

Nitrogen:

It should be applied through more number of splits for long duration as well as perennial crops. A major part of nitrogen from urea broadcast on soil surface is lost easily.

Powdered neem cake and urea at 1:5 ratio (Neem coated urea) reduce quick mineralisation of ammoniacal nitrogen thus increasing the period of nitrogen availability for the crop and reduces losses by leaching and run-off from upland soils (slow release fertilizer).

Phosphorus

It is generally recommended that the entire quantity of phosphatic fertilizers should be applied before planting or sowing of crop.

Potassium

In acid soils, potassic fertilizers should be applied after Lime application; otherwise potassium may be lost by leaching.

Questions

1. List out the important organic manures with its nutrient content.
2. List out a few green manure and green leaf manure crops with botanical names.
3. Calculate the requirement of fertilizers for tomato and brinjal.
4. Highlight the use of bio-fertilizers indicating the methods of application.
5. Define starter solution. Write its advantages.

6. Indicate the micronutrients used as foliar spray in vegetables.
7. Write the method of application of NPK in vegetables?

EX.NO. 5

LAYOUT OF KITCHEN/NUTRITION GARDEN

A kitchen garden is a vegetable garden where the vegetable crops are grown in the backyard of a house or any available space in the home compound to meet the daily requirement of the family.

1. Growing vegetables by the family members serves as a good hobby and helps save money in purchase of fresh vegetables.

   For a balanced diet, 300 g of vegetables are to be included in our daily food. But on an average, Indians take only 160 g per day. Hence to fill up the gap, vegetable cultivation not only in farmers' holdings but also in home gardens is encouraged.
2. It helps to grow selected vegetables of our choice in fresh form.
3. Waste water and land available within our house compound are best utilized for growing vegetables.
4. It creates a healthy, beautiful atmosphere to the house.

Due to increased cost and non-availability of fresh vegetables, every home should lay out a small kitchen garden with available area. Arrangements may also be made to grow vegetables in containers, if little or no land is available.

Features of a Kitchen Garden

Perennial plot

This area should be located at the rear end of the garden so that the perennial plants can be grown effectively as its shade does not affect the growth of other crops. Crops like moringa, curry leaf, tapioca, yams, agathi and fruits like lime, banana, West Indian Cherry can be grown in this area.

Fence

It is very important to fence the garden to protect it from animals and trespass. If no compound wall is provided, live fence can be grown. Bamboo thatties, barbed wire or plain wire can be erected for fencing. On this fence line, coccinia, bitter gourd, lab lab and basella can be grown.

Manure Pits

Manure pits are dug at two corners of the garden at the rear end near the perennial plot. In this pit, garden and kitchen wastes including ash and household sweepings are dumped in and composted. This can be used for manuring kitchen garden.

Gourds like snake gourd, ribbed gourd can be grown near the manure pit and trained on pandal erected above the manure pit.

Paths and irrigation channels

A main path dividing the entire garden into two halves with side paths and walks are to be made. The area for main and side paths should be the minimum. The width of the path should be 45 to 60 cm. The number of irrigation channels should also be at the minimum. Along the main path, pandal may be provided and above that grapes can be trained. Along the side paths, greens like ponnanganni, palak, mint and small onions can be grown.

Beds

After allocating areas for the above features, the rest of the area can be divided into beds of equal size and rectangular shape. According to the area available, 6-8 beds may be formed. Ridges that are separating the beds may be grown with radish or small onion for effective utilization of the land area under cultivation.

The following vegetables can be grown in different beds depending upon the location, climate and choice of the family members.

				Duration
1)	Fruit vegetables	-	Tomato, Brinjal, Chillies	4-5 months
2)	Root vegetables	-	Radish, Carrot, Beet root, turnip	3 months
3)	Bulb crops	-	Small onions, bellary onion, garlic	3-4 months
4)	Legumes	-	Lab lab, Cowpea, French beans, peas, cluster beans	3-4 months
5)	Curcurbits	-	Pumpkin, bitter gourd, ribbed gourd, snake gourd, coccinia	4-5 months
6)	Tuber crops	-	Sweet potato, Tapioca, yams	8-9 months
7)	Cole crops	-	Cabbage, cauliflower, knol-khol	3-4 months
8)	Leafy vegetables	-	Amaranthus, coriander, fenugreek, palak, Alternenthra, mint etc.	2 months

In each bed, crop rotation has to be followed. Shallow rooted vegetable (onion) may be rotated with deep-rooted one (lab lab and Brinjal) or a leguminous vegetable (cow pea) may be rotated with a non-leguminous vegetable (brinjal and tomato) or tuber-forming vegetable (sweet potato) may be rotated with

non-tuber forming vegetable (Bhendi) etc. By crop rotation the soil characters are maintained without any crop loss.

For continuous supply of vegetables almost throughout the year, green leafy vegetables may be sown or planted at different dates, preferably short duration crops first and later the long duration crop, so as to ensure regular supply of vegetables. Growing more than one crop in a bed in a year enables judicious utilization of the soil nutrients and the air space above.

In general, vegetables could be grown throughout the year with a few exceptions. Cropping intensity should be the maximum in kitchen garden. A cropping programme for a kitchen garden is furnished below for guidance.

Bed No.	**Vegetables**	**Season of growing**
1.	Brinjal + radish	June-September
	Cabbage	October-January
	Bhendi	Feb-May
2.	Tomato + cluster beans	June-September
	Beet root	October-December
	Greens	Jan-Feb
	Cowpea	March-May
3.	Lab Lab	June-September
	Brinjal and Turnip	October-January
	Cluster beans	Feb-May
4.	Bhendi	June-Sep.
	Cauliflower	Oct-Jan
	Radish	Feb-March
	Greens	April-May
5.	Chillies + onion (small)	June- November
	Greens	Dec.-January
	Brinjal + Radish	Feb.-May
6.	Onion (Bellary)	June-September
	Chillies	Oct.-Feb.
	French beans	March-May

Crops and the duration

Sl. No.	Crop	Duration	Sl. No.	Crop	Duration (months)
1.	Tomato	3 ½ - 4 months	8.	Curry leaf	Perennial
2.	Brinjal	4 months	9.	Chekurmanis	Perennial
3.	Chillies	5 months	10.	Tapioca	Perennial
4.	Moringa	Perennial	11.	Amorphophallus	Perennial
5.	Banana	Perennial	12.	Dioscorea	Perennial
6.	W.I. Cherry	Perennial	13.	Colocasia	Perennial
7.	Lime	Perennial	14.	Spinach	Perennial

Questions

1. Highlight the importance of a kitchen garden.
2. Enumerate the important points of consideration while laying out a Nutrition garden.
3. Draw a layout for kitchen garden in 10 cents.
4. List out the features of a kitchen garden.

EX.NO.6

USE OF PLANT GROWTH REGULATORS AND PHYSIOLOGICAL DISORDERS IN IMPORTANT VEGETABLE CROPS

Vegetables occupy a vital place in our balanced diet. It is equally important that the area and production of vegetable crops should be increased. Use of high yielding varieties and improved technologies can increase the production to meet our growing demand for vegetables. Application of plant growth regulators has become essential for increasing the productivity of vegetable crops.

Plant growth hormones are chemical substances other than nutrients produced by plants in small quantities at one place and transported to the place of action. These growth hormones may promote or inhibit or otherwise modify the growth and development.

Plant growth regulators are also chemical substances which are applied exogenously to the plant system for various purposes (E.g.) Spraying of 2,4 D enhances fruit set in short styled flowers of brinjal.

I. Growth Promoters

(i). Auxins: The auxin like substances are produced in buds, tips of stem, root etc. Some of the synthetic substances having auxin activity are IAA, NAA etc.

Main action of these auxin like substances are (i) cell elongation (ii) cell enlargement (iii) cell differentiation.

(ii). Gibberellins: This kind of substances stimulates growth in tissues of young internodes (e.g.) GA_3.

It acts by (i) modifying RNA produced in nuclei i.e. it has control over cell elongation.

(ii) Cell elongation by hydrolysis of starch leads to increased concentration of sugar in cell sap, in turn make entry of water finally it stretches the cell size.

(iii). Cytokinins

This type of chemicals interacts with auxins. It acts on cell initiation/cell division. When cytokinin - auxin ratio is more, more shoots will develope. The prevalence of equal ratio leads to undifferentiated callus production.

II. Plant Inhibitors

Plant inhibitors have the actions like (i) induction of senescence, (ii) inhibition of growth, (iii) prolongation of rest period in seeds (Eg): ABA in seeds.

III. Plant growth retardants

Main action of these chemicals is retardation of stem growth / elongation by preventing cell division in sub-apical meristem. (E.g.) SADH, phosphon-D, CCC etc.

Some of the growth regulators widely used are (1) NAA (Naphthalene acetic acid) (2) GA (Gibberellic acid), (3) Ethrel (4) CCC (Cycocel), (5) MH (Maleic hydrazide), (6) 2-4-D (7) Triacontanol, (8) 2,4,5-T, etc.

1. Growth regulators are generally applied in the evening hours.
2. High volume hand operated sprayers are recommended for spraying.

List of growth regulators

	Name of growth regulator		**Make**
1)	P-Chlorophenoxy Acetic Acid (CPA)	-	SIGMA
2)	α-NAA	-	SIGMA
3)	2,4-Dichlorophenoxy Acetic Acid (2,4-D)	-	SIGMA
4)	6-Benzyl Amino Purine (BAP) (or) Benzyladenine (BA)	-	SIGMA
5)	Indole-3-Butyric Acid (IBA)	-	SIGMA
6)	Kinetin (6-Furfuryl aminopurine)	-	SIGMA
7)	1-Phenyl-3-urea (Thidiazron) / Thiourea	-	SIGMA
8)	Gibberellic Acid (GA)	-	SIGMA
9)	Paclobutrazol (cultar)	-	SIGMA

Role of growth regulators in vegetable crops

Tomato: Temperature requirement is a very essential factor for fruit set in tomato. Application of GA 50 ppm or 2-4-D 2 ppm or Triacontanol 1 ppm at 15DAP and at flowering will increase the fruit set and yield

when the night and day temperatures are below 15°C and above 35°C respectively. It has been found that spraying of cycocel 250 ppm can check the spread of leaf curl virus disease.

Brinjal : In brinjal, there are four types of flowers depending upon their style length *viz*. Long styled, medium styled, pseudo -short styled and true-short styled. Fruit set occurs mostly in long and medium styled flowers and to a certain extent in pseudo short styled flowers. By spraying 2-ppm 2,4-D or Triacontanol at the time of flowering, the fruit set increases considerably in true short-styled flowers also. A dose of 5-ppm 2,4-D can also be used for seed treatment for the above purpose. Brinjal responds well to application of micronutrients when combined with triacontanol 4 ppm at 15 DAP and at flowering for increasing production.

Chillies: In chillies, though the flowers are produced profusely, the fruit set percentage is very low. To increase the fruit set and check the flower and fruit drop, spraying of NAA 10 to 25 ppm (Planofix 1-2.5 ml per 4.5 litres of water) on 60 and 90 days after planting is recommended. This practice is widely followed by chilli growers. It has also been found that by spraying of 'Biozyme Crop' @ 180 ml in 180 litres of water on 35, 55 and 75 days after planting, the yield of chillies could be increased.

Gourds: In gourds, the number of male flowers is generally more than the female flowers (high sex ratio), which leads to drop in the yield. To increase the number of female flowers and fruit set, ethrel spray is recommended. For Ash gourd, pumpkin and ribbed gourd, ethrel can be sprayed at 250 ppm and for snake gourd and bitter gourd it can be sprayed at 100 ppm. The spray should be taken up four times at weekly intervals starting from 15 days after sowing. For bitter gourd, spraying of Triacontanol 5 ppm at four-leaf stage and at vining stage was found to improve the yield.

Onion: Long storage of onion bulbs is a difficult task. The bulbs would start sprouting during storage, if moisture content is increased. To arrest the sprouting of onion bulbs during storage onion crop can be sprayed with MH 2500 ppm as a pre harvest spray 15 days prior to harvest.

Tapioca: Spraying of ethrel 250 ppm five times at monthly intervals starting from 3rd month after planting can improve the tuber yield of tapioca.

Sweet Potato: Ethrel spray @ 250 ppm five times at 15 days interval starting from 15 days after planting can be practised to increase the tuber yield in sweet potato.

Method of application

Growth regulators are generally applied at very low concentrations i.e. in ppm (parts per million) i.e. one mg in 1 litre of water gives 1 ppm solution. The growth regulators may be applied in powder form or paste (lanolin paste) or spray solution. Good water should be used for dissolving chemicals. If the growth regulator is insoluble in cold water, hot water or alcohol can be used to dissolve the chemicals.

It is essential to prepare the solution of correct concentration for a particular crop to get the expected results. Higher or lower concentration of chemical may some times give negative effect. It is a general rule that spraying of growth regulators should be taken up in early morning and late evening hours for better utilization of the chemical.

Questions

1. What are growth regulators? Enlist the use of growth regulators in tomato, chilli and onion.
2. Define Auxins, Gibberellins and Cytokinins.
3. Differentiate between growth retardants and growth inhibitors.
4. Write a note on method of application of growth regulators.

EX.NO. 6. (Contd.)

PHYSIOLOGICAL DISORDERS IN IMPORTANT VEGETABLE CROPS

A. Tomato

(i) Blossom end rot: This is a very common and destructive disorder. Lesions appear at blossom end of the fruit while it is green. Water-soaked spots appear at the point of attachment of the senescent petals. The affected portion of the fruit becomes sunken, leathery and dark coloured. This occurs due to fluctuating rate of transpiration during moisture stress and reduced calcium content.

Remedy: Balanced irrigation and staking. A single foliar spray of 0.5% calcium chloride at the time of fruit development.

(ii) Catface: The fruit gets distorted at the blossom end. The fruits have ridges, furrows, indentations and blotches. Abnormal growing conditions during blossom formation are the main cause of cat-faced fruits. The cells at blossom end of the ovary die and turn black to form a leathery blotch. There is no progress in the size of the blotch unlike that of blossom end rot.

(iii) Puffiness: As the fruit reaches about two-third normal size, the outer wall continues to develop normally while the growth of internal tissues is retarded. Such fruits are light in weight, partially filled and lack firmness. This is due to non-fertilization of ovule, embryo abortion after fertilization and necrosis of vascular and placental tissue after fruit development.

Causes: High or low temp and low soil moisture.

Remedy: Maintaining high soil moisture.

(iv) Sunscald: Green or nearing green fruits when exposed to extreme heat and scald. The tissues have blistered, water-soaked appearance. Rapid desiccation leads to sunken area, which is white/grey in green fruits and yellow in ripe ones.

Remedy: Cultivars with heavy foliage provide protection to fruits.

(v) Cracking: It is of two types, radial (in ripe) and concentric (in semi ripe).

Causes: Rain after a long dry spell

Remedy: Irrigation regulation, resistant cultivars e.g. Sioux, crack proof etc should be grown.

B. Carrot

(i) Carrot splitting or cracking: It is a major problem in many carrot-growing areas. The splitting is reduced by low N and increases as the amount of N in the soil increases. High concentration of ammonium compounds in soil causes this problem. Wider the spacing, the greater is the amount of splitting and large roots are more likely to split than small ones.

(ii) Cavity spot: It is presence of cavity in the cortex.

Causes: It occurs due to decreased accumulation of calcium and increased accumulation of potassium.

Remedy: Increased calcium supplement.

C. Beet root

(i) Internal black / brown spot / heart rot: With in fleshy roots, hard or corky spots are found scattered through out the roots but more numerous on the light colour zone or cambium layers.

Causes: Boron deficiency

Remedy: Soil application of Borax 20% or 22 kg/acre.

D. Potato

(i) Poor / Uneven sprouting

Causes

- Planting soon after removal from cold storage.
- Crust formation on ridges due to excess irrigation.
- Decay of cut surface by fungal infection.

Remedy

- Tubers should be kept in cold storage till the end of dormancy period.
- Presprouting of seed tubers in diffused light at normal room temperature, 15 days before planting.
- Fungicide treatment (0.3% Agallol) before planting.

E. Brinjal

(i) Poor fruit set: Due to presence of large number of pseudo short styled and short styled flowers and dropping of long and medium styled flowers.

Remedy: 2,4-D (2 ppm) spray at flower initiating stage and NAA (60 ppm) spray at full bloom stage helps in fruit set.

F. Chilli and Sweet Pepper

(i) Blossom – end rot: Water-soaked spots appear on the blossom end of the fruit. The spots become light brown and papery as the lesions dry out.

Cause: Heavy irrigation after a dry spell and heavy application of nitrogenous fertilizer.

Remedy: Heavy dose of nitrogenous fertilizer should be avoided and irrigation should be properly done, soil should have good water-holding capacity.

(ii) Flower and fruit drop

Causes: Low humidity and high temperature resulting moisture stress which leads to abscission of buds, flowers and small fruits.

- High temperature during early flowering stages.

Remedy

Irrigation at flowering and fruit set.

- ♦ Foliar application of 50 ppm NAA at full bloom stage.
- ♦ Foliar application of 20 ppm NAA at first flower opening followed by two sprays an interval of 30 days increases fruit set.
- ♦ Application of Triacontanol (vipul 1 ml / 2 l water) also reduces flower and fruit drop.

G. Cole crops

(i) Boron deficiency

Browning: (Red rot or Brown rot) occurs in cauliflower. Water soaked lesions in the leaf, stem and curd surface appear, which turn rusty brown in colour. In knolkhol, splitting of tuber occurs. Potassium deficiency aggravates splitting. Leaves change in colour and thicken. Older leaves curl down ward. In cabbage, browning in stem appears due to this disorder along with thickening and brittleness of leaves.

Control: Soil application of borax @ 10-15 kg/ha. Four sprays of 0.25-0.50% solution of borax at the rate of 1-2 kg/ha along with 0.1% Teepol.

ii) Molybdenum deficiency (whiptail): Young cauliflower plants become chlorotic and turn white along leaf margins. They become cupped and wither. Sometimes only the mid rib develops thereby giving the name "whiptail" to this syndrome.

In cabbage and other cole crops, distortion of growing point along with reduction of leaf area are the symptoms.

Control: Molybdenum availability is low on very acidic soil, raising the pH to 6.5 by liming makes molybdenum available.

- ♦ Application of 1.5 kg sodium or ammonium molybdate per hectare mixed with fertilizers.
- ♦ Ammonium molybdate (0.1%) along with 0.1% Teepol.

(iii) Buttoning

Causes: Over aged seedlings, poor nitrogen supply, wrong cultivars etc. or any check in the vegetative growth of seedlings. The check may be insufficient nutrition or biotic stress.

Remedy: To avoid all kinds of biotic and abiotic stress.

(iv) Riceyness: Premature initiation of floral buds is called Riceyness.

Causes: Temperature fluctuation higher or lower than the optimum.

Control: Proper variety and good seed stock.

(v) Blindness: The cauliflowers lack terminal bud. The leaves are large dark green, thick a leathery. It does not produce curd.

Causes: Subzero temperature when plants are small, mechanical injury of terminal bud or injury caused by insects such as cutworms.

Control: Careful handling of plants, avoiding exposure of plants to very low temperature.

(vi) Multiple curds: A number of small button-like curds appear in a bunch.

Cause: Due to terminal bud injury and resultant branching before curd initiation.

Control: Same as blindness.

(vii) Leafyness or Bracting: Green leafy bracts in between segments of the curd.

Cause: High temperature during curd development.

Control: Selection of right variety.

H. Cucurbits:

(i) Preponderance of staminate flowers and low fruit set

Control: Too much vegetative growth should be avoided.

- Avoid excess nitrogen application and irrigation.
- Spray of growth regulators at 2-4 leaf stage helps in increasing the number of female flowers.
- Pumpkin, Cucumber and sponge gourd: Ethephon 250 ppm
- Summer squash – ethrel 600 ppm
- Ridge gourd – ethrel 300 ppm
- Muskmelon and water melon – Maleic hydrazide 200 ppm
- Bottle gourd – Maleic hydrazide 50 ppm, Boron 3 ppm, calcium 5 ppm.
- Snakegourd - Ethrel 100 ppm.

I. Okra

(i) Poor seed germination

Causes: Sowing during low temperature condition.

Control: Seed soaking for 24 hrs.

- Water soaked seeds tied in the cloth and put in fresh cowdung overnight, stimulates germination.

J. Onion

(i) Poor seed germination

Control: Use fresh seed

- Soaking of stored onion seeds in water or sodium phosphate solution for 2-6 hours followed by drying.

(ii) Bolting: Premature seed stock formation.

Causes: Low temperature at Bulbing and bulb development.

Control: Adjustment of transplanting time according to the temperature condition.

- Use of healthy 8-10 weeks old seedling.
- Cutting of seed stalks at early stage.

(iii) Poor bulb storage:

Control: Adjustment of planting time so that harvesting can be done in dry period. Spray bulbs with 0.2% Difolatan before storage.

- Irrigation should be stopped 15 days before harvesting.
- Spraying 2000 ppm MH 10-15 days before harvest.
- Harvesting at neck fall.
- Proper curing for 4-5 days.

Questions

1. Write the important physiological disorders and the remedies in tomato, chilli and cole crops?
2. Enlist the remedial measures taken for uneven sprouting in potato?
3. Write about whiptail disorder?
4. What is the remedy for preponderance of staminate flowers and low fruit set in cucurbits?
5. What are the symptoms and control measures of browning in cauliflower?

EX.NO. 7

FIXING MATURITY STANDARDS AND HARVESTING OF VEGETABLES

Identifying the correct stage of maturity and harvesting at proper time is one of the important pre harvest factors. Some visual character like (i) increase in size, (ii) colour development, (iii) softening of tissues (iv) seediness (v) development of net like structures (vi) drying of foliage or top (vii) flowering / bolting can be generally taken as maturity indices.

By analyzing the economic produce of vegetables, we can also fix the maturity standards like

(i) Increase in sugar content

(ii) Increase in fibre content

(iii) Increase in sugar: acid ratio

Tomato

The maturity standards of tomato are grouped as follows:

(i) Immature: Before seeds have fully developed and jelly like substance surrounding the seeds has formed. Fruits are not suitable for consumption.

(ii) Mature Green: Fully mature light green at bloom end and yellowish green in all other areas. Seeds are surrounded by jelly like substance, filling the seed cavity. This kind of fruit is artificially ripened and suitable for long distance market.

(iii) Turning: (Breaker Stage) ¼ th of the surface at blossom end shows pink colour.

(iv) Pink: ¾ th surface shows pink colour.

(v) Hard ripe: Nearly all the areas are red or pink but flesh is firm.

(vi) Over ripe: Fully coloured and soft. This is suitable for processing, as it possesses good quality and colour development.

Onion : Bulbs are considered mature when the neck tissues begin to soften and tops are about to abscise and decolourise.

French beans: Seed size, percent seed, dry matter content, distribution of seeds are some of the reliable maturity indices. Tender and fleshy pods can be harvested for vegetable purpose.

Peas: In peas, pod colour changes from dark green to light green with well-filled grains/seeds at full maturity.

Tapioca: In tapioca, maturity is indicated by the cracks formed in the soil, yellowing and falling of leaves.

Sweet potato: When the leaves turn yellow and begin to shed, tubers can be harvested. The tubers can also be cut and judged. In immature tuber, cut surface shows dark greenish colour while the colour will be milky white in fully mature tubers.

Dioscorea and Amorphophallus: In these crops, yellowing, drying and then dropping of leaves indicates maturity.

Cucumber: Tenderness is the main criteria for fixing maturity standard of brinjal and cucumber.

Muskmelon: Development of net like structure is the indication of maturity for harvesting.

Chilies: Development of uniform red colour is treated as maturity index.

Harvesting: Harvesting of vegetables at optimal maturity and careful handling constitute the successful storage life. Harvesting of vegetables is done in two ways *viz.* by hand, with or without mechanical aids or gadgets and mechanical harvesting. In India, most of the vegetables are harvested manually.

Root crops: Beet root, carrot, radish, turnip and tubers like potato, tapioca and sweet potato are easily harvested by digging into the soil below the roots or tubers. Then it is levered upwards so as to loosen the soil to reduce the possibility of mechanical damage. In Punjab, tractor drawn potato diggers are used for harvesting potato.

Leafy vegetables: In spinach and methi, the lateral buds and the stems are snapped off by hand.

Cabbage, cauliflower, knolkhol and lettuce: Here the main stem is cut off with a sharp knife.

Bulbous crops: Green onions and leaves can be easily pulled out by hand from the moist soil while for harvesting fully mature onions and garlic bulbs; soil is loosened first with a fork or hoe. Simple tractor drawn implements are also available for loosing in onions and garlic like crops. Onion could be harvested one week after 50% crop shows top fall to reduce losses in post harvest handling. Harvesting of immature bulbs cause and bolting.

Tomato: Harvesting the fruits at breaker stage is recommended for long shelf life and optimum quality. Harvesting during evening hours in summer keeps the fruit firm and uniform ripening.

Okra: Immature green, tender fruits should be picked 3rd to 5th day from the time of first pods are formed. Development of crude fiber is used to determine the optimum stage of maturity.

Brinjal: Brinjal is harvested at tender stage i.e. 15-20 days after set when the seeds are immature.

Questions

1. What are the parameters to fix the maturity standards in vegetable crops?
2. What are the indicators of maturity in okra, sweet potato and cabbage?
3. What are the maturity stages in Tomato?
4. Indicate the maturity standards and harvesting practices in amaranthus and tapioca.

EX.NO.8

SEED PRODUCTION TECHNIQUES IN VEGETABLE CROPS

Solanaceous Vegetables

Tomato, brinjal and Chillies

The method of cultivation of crops for seed production is more or less the same as for vegetable production. Individual plants with good fruiting quality should be marked and ripe fruits harvested for seed extraction.

Isolation distance: To maintain genetic purity of seeds, proper isolation distance should be given. This may vary according to the nature of pollination e.g; Tomato 50 m, Brinjal 200m and Chillies 400 m.

Extraction of seeds from ripe fruits:

1. Tomato

a. **Fermentation method**: The ripe fruits are crushed and allowed to ferment for 1-2 days. The pulp and skin floats and the seeds settle down at the bottom. The seeds should be washed thoroughly and dried.

b. **Acid method:** The fruits are cut into halves and the slimy mass is removed 100 ml of (10-15 ml per kg) commercial HCl is mixed with 10 kg of slimy mass. Seeds separate out from the mass within one hour. Then it is washed free of acid and dried. The flesh can be used after seed extraction. Average seed yield is 125 kg/ha. For bacterial canker – 0.8% acetic acid treatment for 24 hrs.

c. **Alkali method**: In this method, 300 g of washing soda is dissolved in 4 litres of boiling water. This solution is mixed with equal volume (4 kg) of slimy mass of seeds. Then it is allowed to cool down overnight. The next day morning it is washed with fresh water repeatedly until all the chemicals are washed away. In this method also, flesh can be used.

d. **Mechanical Extraction** - Tomato seed extractor is used. Moisture content of seed is 6-8% and viability is 2 years.

II. Brinjal

Fully ripe yellow coloured fruits are crushed and allowed to stand overnight. It is washed with water, dried and sieved. Average seed yield is 590-880 kg/ha.

III. Chillies

Red ripe dried pods are broken and the seeds are collected. Average seed yield is 105-225 kg/ha depending on varieties.

IV. Gourds and Melons

All melons and gourds are highly cross-pollinated. Except watermelon and roundmelon all the other melons are cross compatible with each other. No two melons should be grown in the same field for seed production. Isolation distance of 800 m is recommended. Proper roguing is essential. Seeds are collected from ripe fruits and dried under sun or using mechanical driers. Seeds are collected from fully matured fruits in bottle gourd, bitter gourd, ash gourd, pumpkin and cucumber.

V. Leguminous vegetables

Peas and beans

These are self-pollinated crops and hence no appreciable contamination is expected. Isolation distance of 50 m and 20 m is followed for beans and peas respectively. Agronomic practices for crop to be raised for seed production are more or less the same as f'or vegetable production. Dry pods are collected and threshed carefully without injuring the seed.

Average seed yield: French beans – 1000-1500 kg/ha

Peas – 2000-2500 kg/ha

VI. Root crops

Radish:

It is a cross pollinated crop and requires an isolation distance of 1600 m. Roots are harvested at marketable stage. Good quality roots are selected. One half or one fourth of the root is cut and planted in well-prepared field. Some growers leave the plants *in situ* and allow it to produce the seeds. This practice is not recommended as the removal of off types (which are not true to variety) is not possible.

Carrot:

European varieties do not set seed in plains; hence seed production is limited to the hills only, whereas the Asiatic varieties produce seeds in the plains. Isolation distance of 1000 m is recommended for foundation seed production. Roots are harvested at marketable stage, after removing the off types, the stecklings are given one third shoot cut and one fourth to one half root cut to obtain better quality and higher seed yield. The stecklings are again planted in the field at 75 x 20 cm spacing. Some times only root cut is given without any shoot cut.

VII. Cole crops

Cabbage

(i) Head to seed method

The time of planting of seedlings is adjusted so that full maturity of the heads occurs just prior to winter. When they mature earlier, they tend to split. At maturity, off types are rogued based on the shape and size of head and appearance of basel leaves. Heads which are less compact and with large number of non-wrapper leaves are also eliminated. The selected plants are uprooted and stored for over wintering.

Storing or over wintering

(a) Cellular method (or) Cold storage: 32°F (0°C) and 90-95%R.H.

(b) Trench method of storage:

A trench of 1m width, 3m length and 1m depth is dug. After maturity, the plants are removed from field during November. The non-wrapper leaves are removed. The plants are kept in a slanting manner inside the trench. The roots and stem are covered with soil. Trenches are covered with wooden plank. Soil is spread over it to a depth of 15 cm. On both the ends of trench, small holes are provided for ventilation, which keeps the head in good condition.

During first week of April, (melting of snow), the heads are taken out of the trench, again selection for true shape and size of head is done and replanted in a well prepared field at a spacing of 90-180 x 45-90 cm depending on varieties. Before planting, a crosscut of 2.5 cm deep is given to the head without causing injury to the growing point. This ensures better emergence of flowering stalk. This method of seed production is usually followed in Kulu valley of H.P. During spring, there will be mild temperature and bright weather, which facilitate cross-pollination. When pod colour changes from green to yellow, they are harvested, dried, threshed and seeds are sieved.

(ii) Seed to seed method

This is an easy method to adopt. The heads are left *in situ* in the mainfield. Off types are rogued and in late autumn, small furrows are dug in between two rows and the soil is used to cover the plant. The top is left exposed and partially buried plants withstand low temperature.

(iii) Stump method

After full maturity of the crop, heads are cut off just below the base by means of a sharp knife retaining the stem with outer leaves. Heads are marked and the deheaded portion of the plant, known as

stump is either left *in situ* or replanted during autumn. Through this method, the yield of seeds is increased and the crop matures 12-15 days earlier than the head intact method. But flowering shoots are spreading and may break down easily during inter cultural operation or spraying. Hence, staking and tying the flowering shoots is essential.

Stump with central core-intact method

Heads are not removed but chopped on all sides with a downward perpendicular cut. Pods are borne in racemes and harvested in two to three lots. Early plants are harvested first and the remaining crop is cut when about 75% of the pods turn yellowish brown. Harvested crop is piled, covered with tarpaulin and kept for 4-5 days. After curing, seed is thrashed and separated from dust. Seed is dried in sun and then graded. Average seed yield is 500-600 kg/ha.

Cauliflower

Seed to seed method

(i) Transplanting of seedlings and leaving *in situ*:

Scooping the curd at 2/3 rd maturity result in higher seed production. After curd formation, roguing is done for curd size, colour, compactness and free from riceyness/fuzziness etc. Under South Indian conditions for seed production, the time of sowing and transplanting is same as that of market crop. Seeds are sown during July-August, transplanted in Aug.-Sept. and curds are left *in situ* for seed production. Average seed yield is 500-600 kg/ha.

VIII. BULBS

Onion

Onion seed is usually produced in the temperate and subtropical conditions. Onion is a biennial crop for the purpose of seed production. In one season, bulbs are produced from seed and in the second season, bulbs are replanted to produce seeds.

It is a highly cross-pollinated crop. Isolation distance is 1000m. There are two methods of seed production (1) Bulb to seed method (2) Seed to seed.

Bulb to seed method

Seeds are sown and seedlings are transplanted to produce the bulbs

Roguing

Late maturing plants are discarded before harvesting the bulbs. After harvest, bulbs are rogued carefully for off types like thick necks, doubles, bottlenecks, under and over sized bulbs. Normally bulb

size is 50-60 g. Bulbs harvested during warm weather is carefully stored at a temperature of 4.5 to 12°C till October. The growing portion of the selected bulb is cut to the extent of ¼ to 1/3rd before planting for quick sprouting. The lower portion, which is disc like along with the roots, is used for planting. Planting is done normally during Oct-Nov at a spacing of 30 x 30 cm.

Advantages :

Since roguing of bulb is done, the seeds are pure which is favourable for production of nucleus and foundation seeds.

Disadvantages:

(1) It takes two years for seed production. (2) It is more expensive as large quantities of bulbs are to be stored for planting, (3) Loss during storage of bulbs is high.

Seed to seed method:

After bulb formation the plants are left *in situ* for bolting. In this method, the seed yield is more because of more number of plants and seed heads per unit area. Seeds from seed to seed method should not be used again, for seed production.

When fruits open and expose the black seed, the seeds are ready for harvest. All the umbels do not mature at the same time. When the 10% of the heads in the field have black seeds exposed, the umbels are harvested along with 10-15 cm stalk. Heaped for few days, threshed and seeds are cleaned. Seeds are dried to 8% moisture for packing in porous containers and 5-6% for packing in Aluminium foil. Viability decreases with paper packing; remain viable for 3-4 years in sealed containers.

Average seed yield is 800-1000 kg/ha.

Questions

1. What is an isolation distance? Give the isolation distance for Tomato, Onion, Bhendi and bittergourd.
2. What is rouging?
3. Define Breeder seed, foundation seed and certified seed.
4. Give examples of self and cross-pollinated vegetable crops.
5. List out the seed extraction methods in Tomato and explain at least one method.
6. Write a brief note on seed production in cabbage and carrot.

EX. NO. 9

DESCRIPTION OF VARIETIES / HYBRIDS IN MAJOR VEGETABLE CROPS

Crop	Varieties	Released by	Yield	Special characters
Tomato	Arka Saurabh	IIHR Bangalore by selection	30.8 t/ha	Plants are semi determinate; fruits are firm, round, thick fleshed, medium large, deep red with nippled tip.
	BT 12	OUAT, Bhubaneswar (1996)	20-25 t/ha	Interminate plants, 80 cm, fruits are thick skinned and round.
	Co 3	TNAU, Coimbatore (1987)	38.1 t/ha	Determinate and erect plant, fruits are thick skinned and round.
	Pusa Uphar	IARI, New Delhi (1996)	35-40 t/ha	Indeterminate, erect stemmed plant. Fruits are 2-3 in a cluster, medium sized, round and deep red.
	Roma	Introdution from America	25-31 t/ha	Small pear shaped deep red fruits. Plant is determinate, Good for distant market.
	Pant Bahar	GBPU, Pantnagar (1985)		Bushy plants, fruits are flattish-round, medium sized, slightly ridged and deep red.Resistant to *Verticillium* and *fusarium* wilt. Good storage and processing quality.
	VC 48-1	AAU, Jorhat		Plants are determinate very vigorous. Resistant to bacterial wilt.
Brinjal	Pusa purple Long	IARI, New Delhi	35 t/ha	Fruit long and purple, plant extra early in bearing
	Pusa purple cluster	IARI, New Delhi	30 t/ha	Tolerant to bacterial wilt. Fruits violet-purple, long and in clusters. Suitable for hill areas and mild climates.
	Arka shirish	IIHR, Bangalore	47 t/ha	Fruits are long and green. Suitable for climate of Southern India.
	Pant Samrat	GBPU, Pantnagar	35 t/ha	Tolerant to bacterial wilt. Fruits are long and purple. Plant is early in bearing.
	CO 2	TNAU, Coimbatore	35 t/ha	Oblong, dark-purple fruit.
	KKM 1	TNAU, Killi Kulam	37 t/ha	Fruit is milky white, and oblong in cluster.
	Pusa Anupam	IARI	30 t/ha	Purple long fruit in clusters. Resistant to Phomopsis blight.
	Arka navneet (hybrid)	IIHR	60 t/ha	Oval, dark purple fruit. Suitable for mild climate of Southern India.
	Arka Abir	IIHR, Bangalore (1995)		It is paprika variety, suitable for colour extraction

Crop	Varieties	Released by	Yield	Special characters
Chilli	Arka Lohit	IIHR,Bangalore (1990)		Tolerant to Powdery mildew
	Pusa Sadabahar	IARI, New Delhi (1989)		Virus resistant
	Jwala Sakshi	KAU Vellanikera (1987)		Virus resistant
	CO 2	TNAU, Coimbatore (1984)		Cherry type
	Punjab lal	PAU Ludhiana (1985)		Resistant to TMV, CMV, leaf curl virus, fruit rot and die back.
Cauliflower	Pant Gobhi-3	GBPU, Pantnagar	12 t/ha	Plants have long stem, semi-erect leaves and hemispherical creamy white, medium compact, non-ricey. Crop is ready by September.
	Pusa sharad	IARI, New Delhi	24 t/ha	Foliage bluish-green, leaf with narrow apex and prominent mid-rib. Semi-dome shaped white and very compact curd.
	Pusa synthetic	IARI, New Delhi	27 t/ha	A synthetic variety, plants erect, narrow to medium frame, curds creamy white and compact.
	Pant shubhra	GBPU, Pantnagar	25 t/ha	Curds creamish white compact, slightly conical and non-ricey.
	Ooty 1	TNAU, Coimbatore	46 t/ha	Suitable for hills of Tamil Nadu
Cabbage	Golden Acre	IARI, Kat rain	20-40 t/ha	Heads 1-1.5 kg, round and compact
	Pusa mukta	IARU, Kat rain	25-30 t/ha	Medium sized solid, flattish-round heads. Resistant to Black rot.
	Pusa Ageti	IARI	11-33 t/ha	Tropical variety. It can form marketable heads at 15-30ºC also but day temperature should not exceed 35ºC.Grey foliage and round compact head. Produces seeds in subtropical north-Indian plains.
	Bajrang	Beejo sheetal seeds Pvt Ltd.		Early maturing with dark green, smooth and compact heads. Resistant to *fusarium* wilt.
	Nath Lakshmi	Nath Seeds Ltd	50-70 t/ha	Uniform compact head. Good shelf life.
Brussels sprouts	Hilds Ideal	IARI Katrain		Average plant height is 60-65 cm having 45-55 sprouts/plant, measuring 7-8 cm across of 6-8 g each. Sprouts are light green, globular and solid.
Sprouting Broccoli	Pusa KTS – 1	IARI, Katrain		Compact light green heads, weighing 250-400 g, composing of small buds. Plant height 40-50 cm.
	Palam Samridhi	HPKVV Palampur	2-5 t/ha	Compact green head, free from yellow eyes and bracts. Average head weight 300-400 g.
	Punjab Broccoli 1	PAU Ludhiana	7 t/ha	Foliage dark green with smooth leaf surface and wavy margin with bluish tinge.
Knol Khol	White Vienna	Introduction		Plant dwarf with light green foliage and stem. Knobs are globular and light green. Flesh is tender, creamy with delicate flavour.
	Large green	Introduction		Vigrous plants with dark green foliage. Knobs flattish round and dark green in colour.

Carrot Asiatic Varieties	Pusa kesar	IARI New Delhi		The roots are red along with the core. Seeds can be acquired in plains also.
	Sel No 233	PAU Ludhiana		Roots are long, semi cylindrical, orange with light coloured core
Temperate Varieties	Early Nantes	IARI Katrain		Roots are cylindrical terminating in small thin tail, 12-15 cm long, orange coloured with self coloured core.
	Chantenay	Introduction		Good for canning and storage. Roots are 11-15 cm long. Cortex deep orange with self coloured core.
	Ooty	TNAU, Coimbatore		Roots are deep orange with self-coloured core.
	Pusa Yamadagni	IARI Katrain		Roots 15-16 cm long, orange with self-coloured core, slightly tapering with stumpy to semi-stumpy ending.
Radish Asiatic varieties	Pusa Desi	IARI New Delhi		Roots are 30-35 cm long, pure white pungent in taste.
	Pusa Reshmi	IARI New Delhi		Roots are 30-35 cm long, tapering, pure white pungent in taste. Tolerant to slightly high temperature.
	Punjab Safed PAU Ludiana			Roots 33 – 40 cm long smooth and white, foliage light green. Takes 50-60 days for root formation.
	CO 1	TNAU, Coimbatore	9-10 t/ha	Roots milky white less pungent, 23 cm long, cylindrical. Sets seeds in plains.
Temperate varieties	Pusa Himani	IARI Katrain		Can grow throughout the year in hills. Roots 30-35 cm long, semi stumpy, pure white with whitish green shoulders, mildly pungent, crisp with sweet flavour. Tops with green cut semi erect leaves.
Beet Root	Detroit dark red	Introduction		Perfect round roots with smooth, uniform deep red skin, flesh blood-red with light red zoning, tender and fine grained. Tops small, leaves dark green tinged with maroon.
	Ooty – 1	TNAU, Coimbatore	31-45 t/ha	Thin skin with blood red flesh colour. Crop duration is 120-130 days. Suitable for South Indian hills.
Turnip	Pusa chandrima	IARI, New Delhi		Roots are medium large, 8-9 cm in length and 9-10 cm in diameter. Tops are medium. Skin is smooth, pure, white, fine grained, sweet and tender. Matures in 55-60 days.
	Pusa Swati	IARI, New Delhi	20-30 t/ha	Attractive white roots, produces seeds in plains. Harvest in 45 DAS.
Onion Red varieties	Pusa Red Arka Niketan Agri found light red Udaipur 103	IARI IIHR NHRDF UdaipurUniv	25-30 t/ha 33 t/ha 30 t/ha 25-30 t/ha	Flattish round, very good in storage-wider adaptability Light red, good for storage. Suitable for Rabi season, good in storage Dark red.
White varieties	Pusa white flat Udaipur 102	IARI Udaipur Univ.	33-35 t/ha 30-35 t/ha	Suitable for dehydration, good in storage. Suitable for dehydration.
Yellow varieties	Early grano	IARI	50-60 t/ha	Large bulbs, good for salad, poor storage.

Multiplier Onion	CO. 4 Agrifound red	TNAU, Cbe NHRDF	18 t/ ha 18-20 t/ ha	8-10 lateral buds, 90 g wt of clump. Maturity 60-65 days. Light red, Weight of clump is 65 – 68 g
Garlic	Agrifound parvati	NHRDF	17.5-22.5 t/ha	Suitable for Northern India hills. Bulbs are big in size, tolerant to common disease, medium storage.
Peas	UN 53 (6) Ooty 1	IIHR Bangalore TNAU, CBE	8-9 t/ha 11.9 t/ha	Whole pod is edible. Crop duration is 90 days. Crop duration 90 days, Dwarf type.
French bean	Pusa parvati Ooty 1	IARI, New Delhi TNAU, Ooty	8-8.5 t/ha 34 t/ha green pots	Resistant to mosaic and powdery mildew Moderatly resistant to leaf spot, Anthrac nose and pod borer.
Cowpea	Pusa phalguni Pusa dofasali	IARI, New Delhi IARI, New Delhi	5-10 t/ha 7.5-8 t/ha	Dwarf, bushy, matures in 60 days. Suitable for summer and rainy season.
Okra	Arka Anamika Parbhani kranti	IIHR Bangalore MAU Parbhani	12.5 t/ha 8.5-9 t/ha	Pigmented stem petiole and lower leaves. Fruits are dark green with 5 prominent ridges and rough surface. Resistant to YVMV. Fruits are smooth dark green, slender 5 ridged with long beak.
Cucurbits Cucumber	**Japanese long green** Pusa sanyog	IARI, Kat rain IARI, Kat rain		Suited for hills, 45 days maturity, fruits 30-45 cm long fresh, light green and crisp. High yielding hybrid, 28-30 cm long, dark green cylindrical fruit with yellow stripes, crisp, suitable for subtropical and temperate regions.
Watermelon	Sugar baby Pusa bedana	IARI, New Delhi ARI, New Delhi		Fruits 3-5 kg round, bluish-black rind, deep pink flesh & small seeds. Harvest in 85 days. Seedless, medium green, 3-4 fruits/vine.
Bottle gourd	Pusa hybrid 3 Arka bahar	IARI, New Delhi IIHR, Bangalore	42.5 t/ha 40-47 t/ha	1 kg, green long fruits without neck. Suitable for distant market. Medium sized, straight fruits light green and shining without neck.
Bitter gourd	MDU.1 Pusadomausmi CO 1	TNAU, Madurai IARI, New Delhi TNAU, Cbe	30-35 t/ha 9-12 t/ha 15-18 t/ha	Induced mutant with greenish white fruits, spiny, 30-40 cm long. Fruit maturity 120-130 days. Short fruits, green with smooth angular ribs. Thin fleshed with moderate bitterness. Fruits dark green, spiny, 20-25 cm long each weighing 100-115 g.

Snake gourd	CO 1 CO 2 Konkan sweta	TNAU, CBE TNAU, CBE KKV, Dapoli, Maha	18 t/ha 35 t/ha 15-20 t/ha	Early maturing cultivar, comes to harvest in 70 days. Fruits are long (160-180 cm), dark green with white stripes, flesh light green. Bears short fruits (30 cm long), Fruits are light greenish white. Suitable for high density planting. Medium sized white colour fruits.
Pumpkin	CO 1 CO 2 Arka Suryamukhi	TNAU, CBE TNAU, CBE IIHR, Bangalore	30 t/ha 23-25 t/ha 36 t/ha	Late maturing large globular fruits. Immature fruits are dark green in colour and turns to brownish-Orange after full maturity. Crop duration 150-160 days. A local selection with small flat green colour fruits. Fruits are small, round with deep orange, streaks on rind. Flesh is firm and orange-yellow in colour. Keeping quality Crop duration 100 days.
Ash gourd	CO 1 CO 2	TNAU, CBE TNAU, CBE		Globular fruits about 5-6 kg, less seeded. Crop duration 140 days. Small, long spherical, less seeded fruits, with light green coloured flesh.
Sponge gourd	Pusa supriya	IARI, New Delhi	10-11 t/ha (kharif) 8-9 t/ha (Spring summer)	Fruits distinct, pale green, 15-20 cm long, straight and slightly curved at the stem end, pointed distal end, non-hairy, slim.
Ridge gourd	CO 1 PKM.1	TNAU, CBE TNAU, Periakulam	 28-30 t/ha	Early bearing variety having 10-12 fruits per vine. Fruits are 60-75 cm long and 30 cm in girth. Dark green fruits. Kharif and summer season crop.
Potato	Kufri Giriraj K. Chipsona 2	Kufri Res. Stn, Shimla Kufri Res. Stn, Shimla	20-25t/ha 25-30 t/ha	Tubers are medium to large, white, oval with fleet eyes. Resistant to late blight. Resistant to late blight and tolerant to frost.
	Spinachbeet / Palak Ooty 1	TNAU, Ooty	6 t/ha	Leaves are green 40-50 cm in length and 8-10 cm in breadth. First harvest 45 days after sowing, subsequent harvests after 45 days, 4 times.
Greens	Pusa Bharati	IARI, New Delhi	50 t/ha	Green tender leaves, high in Vit. C and B-Carotene.
	Amaranthus CO 3	TNAU, CBE	30.71 t/ha	Clipping type. 1st clipping is 20 days after sowing, totally 10

	Pusa lalchaulai CO 5	IARI, New Delhi TNAU, CBE	45 t/ha 40 t/ha	clipping can be taken. Suitable for summer and rains. Stem and leaves are deep red. Soft thick edible stem. Leaves with reddish tinger.
Perennial Vegetables				
Drumstick	PKM.1 PKM.2	TNAU, Periyakulam TNAU, Periyakulam	 98 / ha	Annual type, plants flower in 100-125 days. Each bears 200-250 pods/year. Pod length is 75 cm. Can be kept as ratoon for 3 years. Each pod is 125 cm long. Each tree yield 220 pods/year.
Cassava	CO 3	TNAU, CBE	42.6 t/ha (irri) 27.3 t/ha (rainfed)	Tubers have brown skin, creamy white and white flesh with 35.6% starch. Duration of the crop is 8 months.
Yam	Sree Priya	CTCRI, Trivandram	35-40 t/ha	Leaves dark green with wavy margin. Tuber surface is smooth. Crop duration is 9 months.
Curry leaf	DW 2	UAS Dharwad		Pale green leaves, less aromatic. Insensitive to low temperature, superior in number of bud burst, and internodal length. Shoot growth is very fast.

List of F_1 hybrid vegetables released by public and private sector

Crop	Hybrid	Source
Tomato	COTH.1	TNAU, Coimbatore
	Pusa Hybrid – 2	IARI, New Delhi
	NA – 501, NA – 701	Nath seeds
	Gotya, Summerset cross B	Namdhari
	Sonali, Samridhi	Mahyco
	Madhuri, Manisha	Bejo sheetal
	Ratna, Avinash-2	Novartis
	Arjuna, Karna	Sungro
	SG Prolific, SG wonder	Sungro
	Swarna, Rishi	Century seeds
Brinjal	Arka Navneet	IIHR
	Pusa Anmal	IARI
	Punjab Hybrid	PAU, Ludhiana
	Azad hybrid	CA, Kanpur
	Pant hybrid-2	GBPU, Pantnagar
	COBH.1	TNAU, Coimbatore
	Sungrow mukta, Sungrow pragati	Sungro
	Suphal	Indo American Hybrid seeds
	Shyamal	Ankur seeds
	Kalpataru	Mahyco
	Sumex-9, Sumex-19	Sumex seeds
	Nisha, Vardaan	Century seeds
Chilli	CH.1	PAU, Ludhiana
	Delhi Hot	Hung Nong seeds
	Tegaswini	Mahyco
	Agni	Novartis
	Gayatri	Bejo sheetal
	Champion	Seoul
Sweet pepper	Solan hybrid – 1	Solan
	Bharat	Indo American Hybrid seeds
	Indira, Lario	Novartis
	Early bounty	Suttons
	Hira	Nath seeds

Crop	Hybrid	Source
Okra	DVR - 3	IIVR, Varanasi
	Panchali	Century seeds
	Priya Hybrid	Sungro seeds
	Tara hybrid	Bejo sheetal
	Nath shobha	Nath seeds
	Hybrid bhendi No.10	Mahyco
	NS-503	Namdhari
	Varsha	Indo American Hybrid seeds
Cabbage	Deepa Hybrid	Royal slouis
	Snow pak hybrid	Indo-American hybrid seeds
	Green globe hybrid	Syngenta
	Summer queen hybrid	Seoul seeds
	Kranti, Hari Rin Gol	Mahyco seeds
	Uttam, Uttara	Hindustan lever
Cauliflower	Hybrid summer	Sungro seeds
	First Mari Hybrid	Bejo sheetal
	Swati, Himani	Indo American Hybrid seeds
	Early Himani	Century seeds
	Pawas	Syngenta
	Serrano	Novartis
	Nath Ujwala, Nath shweta	Nath seeds
Radish	Hybrid – 11	Mahyco
Bottle gourd	NDBGH-7	Faizabad
	Pusa hybrid – 2	IARI
	PBOG-2	Pantnagar
	Gutka, Harit	Century
	Varad	Mahyco
Pumpkin	Pusa hybrid – 1	IARI
Bitter gourd	Pusa hybrid – 1	IARI
	COBgOH-1	TNAU, Coimbatore
	MBTH – 101	Mahyco
Ribbed gourd	Surekha	Mahyco
Sponge gourd	Harita	Mahyco

EX. NO. 10

IDENTIFICATION AND DESCRIPTIVE BLANK FOR TOMATO, BRINJAL AND CHILLI

DESCRIPTIVE BLANK FOR TOMATO

1.	Accession Number	
2.	Origin	Semi determinate / Village / District / State / Country
3.	Habit	Semi determinate / Indeterminate / Spreading
4.	Leaf type	Normal / Potato leaf
5.	Leaf colour	Green / high green / dark green / yellowish green
6.	Stem type	Round / angular
7.	Stem thickness	Thin / medium / thick
8.	Stem Pubescence	1. Stem-Smooth/Pubescent 2. Petiole – Smooth/Pubescent 3. Leaf-Smooth/Pubescent
9.	Leaf cover	Poor/moderate/good / excellent
10.	Pigmentation	1. Stem – present / absent 2. Petiole – present / absent
11.	Flower size	Small / medium / large
12.	Flower colour	Deep yellow / light yellow / Reddish yellow / white / others
13.	Style position	Exerted / non-exerted
14.	Pistil type	Branched / highly branched
15.	Fruit shape	Round / oblong / flat / pear shaped / bottle shaped / others
16.	Fruit surface	Smooth / slightly corrugated / Highly corrugated / attractive
17.	Blossom end	Round / nipped
18.	Green stem end of fruit	Nil / slight / moderate / prominent
19.	Cracking 1. Concentric	Nil / low / moderate / high

	2. Radial	Nil / low / moderate / high
20.	Fruit abnormalities	Present / absent
21.	Type of placenta large	Uniform / green / small / medium
22.	Firmness of fruits	Soft / intermediate / firm
23.	Pulpiness	Pulpy / highly pulpy / juicy
24.	Skin thickness	Thin / medium / thick / very thick
25.	Suitability for transportation	Poor / medium / good / excellent
26.	Seediness	Low / medium / high

Quantitative characters (average of 5 plants)

1. Plant height (cm) :
2. Days to appearance of first flower in 50% plants :
3. Days to first fruit (in 50% plants) :
4. Days to first fruit harvest :
5. Number of primary branches :
6. Number of flower clusters per plant :
7. Number of flowers per plant :
8. Number of fruits per plant :
9. Number of fruits per plant :
10. Number of weight of marketable fruits (g) :

Incidence of diseases and pests

1. Wilt : Nil/low/moderate/high
2. Leaf curl : Nil/low/moderate/high
3. Blight : Nil/low/moderate/high
4. Stem end rot : Nil/low/moderate/high
5. Sun scalding : Nil/low/moderate/high
6. Pythium : Nil/low/moderate/high
7. Fruit borer : Nil/low/moderate/high
8. Others : Nil/low/moderate/high

DESCRIPTIVE BLANK FOR BRINJAL

1.	Accession number	:	
2.	Origin	:	Village/District/Station
3.	Habit	:	Erect/bushy/tall/spreading
4.	Stem pubescence	:	Pubescent/smooth
5.	Stem spiny ness	:	Spiny/non-spiny
6.	Leaf colour	:	Green/purple
7.	Leaf spiny ness	:	Spiny/non-spiny
8.	Midrib colour	:	Purple/green
9.	Leaf texture	:	Pubescent/smooth
10.	Stem colour	:	Green/purple/deep purple
11.	Spiny ness of mid rib	:	Spiny/non-spiny
12.	Petiole colour	:	Short/long
13.	Petiole spiny ness	:	Spiny/non-spiny
14.	Petiole size	:	Fleshy/non-fleshy
15.	Petiole spiny ness	:	Loose/persistent
16.	Calyx fleshiness (sepal)	:	Spiny/non-spiny
17.	Calyx type	:	Purple/white with purple/others
18.	Calyx spiny ness	:	Small/medium/large
19.	Flower colour	:	Purple/white with purple/others
20.	Fruit size	:	Small/medium/large
21.	Fruit shape	:	Long/oval/oblong/round
22.	Fruit base colour	:	Purple/green/white
23.	Fruit colour		
	1. Immature – white/green/purple/deep purple/splashes/others		
	2. Ripe – yellow/orange/others		
24.	Fruit apex	:	Blunt/pointed
25.	Fruit surface	:	Smooth/wrinkled
26.	Mesocarp (Flesh)	:	Compact/loose, hollow/full
27.	Seediness	:	Low/medium/high
28.	Fruits (bearing nature)	:	Solitary/cluster
29.	Seed colour	:	Yellow/brown/white

30.	Seed texture	:	Smooth/spongy
31.	Hilum	:	Prominent/non-prominent

Quantitative characters (average of 5 plants)

1.	Plant height (cm)	:	Nil/low/moderate/high
2.	Number of primary branches	:	Nil/low/moderate/high
3.	Days to flowering (first flower in 50% plants)	:	Nil/low/moderate/high
4.	Days to first fruit set	:	Nil/low/moderate/high
5.	Days to first harvest (Marketable fruits)	:	Nil/low/moderate/high
6.	Percentage of short and pseudo-styled flowers	:	Nil/low/moderate/high
7.	Number of flowers per cluster	:	Nil/low/moderate/high
8.	Number of fruits per cluster	:	Nil/low/moderate/high
9.	Number of fruits per plant	:	
10.	Number of clusters per plant	:	
11.	Fruit size (Average) (Length and diameters cm)	:	
12.	Average fruit weight (g)	:	
13.	Marketable fruit yield per plant (g)	:	
14.	Days to maturity (First fruit ripening in 50% plants)	:	
15.	Equatorial perimeter of fruit (cm)	:	
16.	Days to last harvest (Marketable fruits)	:	

Disease and pests incidence

1.	Phomopsis	:	Nil/low/moderate/high
2.	Little leaf virus	:	Nil/low/moderate/high
3.	Wilt	:	Nil/low/moderate/high
4.	Fruit borer	:	Nil/low/moderate/high

DESCRIPTIVE BLANK FOR CHILLIES

I. Name of a variety or strain

II. HISTORY

a) Origin – Name of the place
b) Type (Needle, bell pepper, gundu, samba, etc.,)

A. VEGETATIVE CHARACTERS

I. HABIT : annual / herbaceous annual / perennial

a) Plant type – Dwarf or bushy, medium spreading, medium compact
b) Vigour – Less vigorous / moderate / high
c) Height in cm.
d) Spread in cm.

II. BRANCHING

a) Erect
b) Crawling
c) Erect and branching
d) Lying low but not crawling
e) No. of branches (Main)
f) No. of laterals (Tertiary)

III. STEM

a) Round or cylindrical
b) Pubescent or non-pubescent, light medium, light
c) Pricky or armed

d) Colour (green, purple, white etc.)

IV. LEAVES

1) LAMINA:

a) Size: Length at the longest place – Normal, small big
b) Breadth at the broadcast place
c) Shape: Ovate or round, lanceolate, elliptical or date, narrow lanceleote
d) Margin: Serrate or entire
e) Pubescence: Light, medium or high
f) Colour – green, dark – green, light green

2. PETIOLE

a) Length in cm
b) Thickness in cm
c) Pubescence – Light, medium, high or non – pubescent
d) Pigmentation – Violet, purple, light

B. FLORAL CHARACTERS

1. INFLORESCENCE

a) Single or in clusters
b) Nature of pedicel – erect or pendulous
c) Colour – light green, green, dark green
d) Length of pedicel in cm.

2. BUD SIZE: Small, medium, large

3. CALYX:

a) Colour – green, light, green, dark green
b) Length of sepal in cm.
c) Breadth of sepal in cm.

4. COROLLA

a) Colour – white, pinkish, yellow
b) Length of petal in cm

c) Breadth of petal in cm

d) No. of lobes

5. STYLE

Position: Terminal, oblique, lateral

Length of style: Long, medium, short

6. STAMENS

Number position:

Anther colour – Yellow, pinkish, etc.

Length – long, medium, short

C. FRUIT CHARACTERS

I. FRUIT

a. Position	:	Pendent, erect
b. Shape	:	Conical, oval, needle – like, globular elongated
c. Colour	:	Pre-ripening, light green, green, Ivory white
Post – ripening	:	Red, Scarlet red, yellow, pinkish etc.
d. Attachment of calyx	:	Firm, loose, medium
e. Base of the fruit	:	Board, compressed, slightly compressed, puffy
f. Apex of the fruit	:	Pointed, blunt

g. Fruit length in cm

h. Fruit girth in cm

i. Pericarp thickness in cm.

j. Length of the pedical

II. SEED

a) Colour – Yellow, pinkish yellow, golden yellow

b) Shape – (Round, serrated)

c) Size – Small, big, medium

d) Weight of 1000 seeds in gms

e) Seed %

No. of seeds per fruit

III. Biology

a) Days taken for flowering
b) Days taken for fruit set
c) Blossom falling
d) Abscission layer
e) Drying percentage

D. ECONOMIC CHARACTERS

1. a) No. of days from sowing to first and final flowering
b) No. of days form sowing to first and final fruit set
c) No. of days for ripening
d) No. of days from sowing to change of colour from green
e) No. of green chillies
f) Weight of green chillies
g) Yield of dry chillies
h) Ascorbic acid content
i) Capsaicin content
j) Seasonal adaptability
k) Disease and pest resistance

EX.NO. 11

IDENTIFICATION AND DESCRIPTIVE BLANK FOR BHENDI, BEANS, LABLAB AND GOURDS

1.	Plant height	:	
2.	No. of branches	:	
3.	Stem pigmentation	:	Dark green/pale green/green with purple pale green with purple tinge/purple tinge
4.	Stem pubescence	:	Hairy/glabrous/smooth/thorny
5.	Leaf lobing	:	Deeply lobed/shallow/not lobed
6.	Leaf colour	:	Pale green with pink tinge/purple tinge
7.	Petiole colour	:	
8.	Petiole pubescence	:	Pubescence/not pubescence/Slightly pubescent
9.	1st flowering	:	
10.	Calyx pigmentation	:	
11.	Petal base pigmentation	:	Both other and inner surface
12.	Petal coloration	:	Purple/yellow
13.	Fruit colour	:	Green to yellow/pale green Green/dark green/purple Green with purple tinge/red (Co.1)
14.	No. of ridges/fruit	:	
15.	Fruit length at harvest	:	
16.	Fruit girth	:	
17.	Fruit weight	:	
18.	Fruit surface	:	Pubescence/smooth/spiny
19.	Fruit tip	:	Pointed/blunt/curved
20.	Fruit number/plant	:	
21.	Fruit yield/plant (g)	:	
22.	No. of Seeds/pod	:	
23.	Dry pod weight	:	
24.	Weight of seeds/pod	:	
25.	100 seed weight	:	

26.	Seed colour	:	Brown/cream/white

DESCRIPTIVE BLANK FOR FRENCH BEANS AND LABLAB

1.	Habit plant height (cm) Plant height (cm)	:	Climbing / bush
2.	Stem	:	Angular / circular
3.	Branching	:	Medium / High
4.	Leaf shape	:	Triangular / Oval / Oblong
5.	Flowering	:	Early / Late
6.	Flower colour	:	White / Purple
7.	Fruit bearing	:	Single / Cluster
8.	Nature of pod flesh	:	Fleshy / Thin
9.	Colour of the pod	:	
10.	Shape of the pod	:	
11.	Length of the pod (cm)	:	
12.	Breadth of the pod (cm)	:	
13.	No. of seeds/pod	:	
14.	Average weight of 10 pods (g)	:	
15.	Pest incidence, if any	:	
16.	Disease incidence, if any	:	

DESCRIPTIVE BLANK FOR GOURDS

1.	Spreading habit	:	Medium / heavy
2.	Nature of vine	:	Thick
3.	Branching habit	:	Medium / High
4.	Number of leaves	:	High / Moderate
5.	Flowering	:	Early / Medium / Late
6.	Fruit size	:	Long / Medium / Seeper long (Ribbed gourd)
7.	Thickness	:	Slender / Thick / Medium
8.	Colour of the fruit	:	Deep green / Green / Light green
9.	Number of female flowers / plant	:	
10.	Number of male flowers / plant	:	
11.	Sex ratio	:	
12.	No. of fruits / plant	:	
13.	Length of fruit	:	
14.	Average fruit weight	:	
15.	Earliness of male flowers	:	
16.	Earliness of female flowers	:	
17.	Weight for fruits/plants	:	

EX. NO. 12

DESCRIPTIVE BLANK FOR TAPIOCA AND SWEET POTATO

DESCRIPTIVE BLANK FOR TAPIOCA

1.	Plant type	:	To be recorded at the time of harvest at 10th month
2.	Nature of stem	:	Erect branching; erect non-branching, spreading and branching.
3.	Leaf	:	Broad, Narrow
4.	Rind	:	Cream/light pink/pink
5.	Colour of stem	:	Dark gray, gray, light gray, light brown, reddish brown
TUBER		:	Brownish yellow
6.	Taste	:	Non bitter/slightly bitter/bitter
7.	Flesh colour	:	White, very light yellow, light yellow, yellow
8.	Young stem	:	Green, lightly streaked, streaked, highly streaked
9.	Stipule	:	Green, light purple, purple
10.	Colour of leaf	:	Green, light green
11.	Petiole	:	Recorded during 5th month green, purple
12.	Dorsal vein	:	Green, very light tinged, Lightly tinged, tinged
13.	Ventral vein	:	Green, very light tinged, Lightly tinged, tinged
14.	Tuber shape	:	Fusiform, cylindrical
15.	Yield	:	Yield per plant (kg)
16.	Colour of skin	:	Light brown, brown, dark brown
17.	HCN (µg / g)	:	
18.	Male flower disc	:	Yellow, orange, purple

19.	Pollen fertility	:	High above: 71% Medium: 31-70% Low: upto 30% (Male sterile)
21.	CMV (Cassava mosaic virus disease)	:	Recorded at 2nd and 4th months Present / absent
22.	BLSD (Brown leaf spot disease)	:	Recorded at 5th month Tolerant / susceptible / highly susceptible
23.	Spider mite	:	During peak flowering time Low / Medium / High

DESCRIPTIVE BLANK FOR SWEET POTATO

1.	Accession Number	:	
2.	Plant type	:	Spreading vine length above 1.5 m Semi spreading vine length Between 0.5-1.5 m
3.	Leaf type	:	Entire/shallow lobed/deeply lobed
4.	Leaf size	:	Broad/medium/narrow
5.	Leaf colour	:	Dark green/light green/yellow
6.	Petiole length	:	Long – above 20 cm Medium – between 10-20 cm Short – below 10 cm
7.	Flowering	:	Early within one month of planting Late-After one month of planting
8.	Pubescence	:	High/medium/low absent
9.	Pigmentation of petiole	:	Green/light purple/purple/greenish brown/light brown
10.	Pigmentation of emerging leaf	:	Light brown / dark purple Greenish brown / green / light purple / purple / light green
11.	Pigmentation of vine	:	Green/light brown/purple/greenish brown

12.	Tuber shape	:	Fusiform/spherical/elongated
13.	Pigmentation of dorsal vein	:	Light purple/green
			Light brown/purple/dark purple
14.	Pigmentation of tuber skin	:	Purple/light purple/cream
15.	Pigmentation of tuber flesh	:	Green/brown/purple/cream/
			Orange/white/light green/light brown/dark
			Brown/light purple/dark purple/light orange/
			Dark orange/greenish brown
16.	Tuber number	:	Low less than 2 / plant
			Medium between 2-4 / plant
			Low above 4 / plant
17.	Tuber weight	:	Medium between 101-250 g/plant
			High above 250 g/plant

EX. NO. 13

DESCRIPTIVE BLANK FOR AMARANTHUS AND MORINGA

1.	Growth habit	:	Erect/spreading
2.	Stem pubescence	:	Slightly pubescent/smooth/pubescent
3.	Stem colour	:	Green/dark green/green with stripe/pale pink with green streaks/pink streaked/light green/pale green/yellowish green/green with pale pink streaks/pink pale green with pale pink streaks/pink pale green with pale pink tinge/green with red stripes/pale green with brown streaks/green with pink specks
4.	Leaf pigmentation	:	Green/pale green/dark green/light Green/pink/pale green with light pink/greenish pink
5.	Leaf shape	:	Lancolate/obovate/ovate/elliptical/ovoid
6.	Leaf margin	:	Entire/undulated/smooth
7.	Leaf veins	:	Prominent/smooth/slightly Prominent
8.	Leaf tip	:	Pointed/blunt/acute
9.	Leaf	:	Medium/small/large/very large
10.	Petiole colour	:	Cream/purple/light purple/pink/light green/pale green/ pale pink base and light green/pink tinged/pale green with pink tinge/pink tinge at the dorsal side.
11.	Petiole pubescence	:	Smooth/pubescent/slightly pubescent
12.	Inflorescence type	:	Panicle / spike / panicle-long branched/spike with long branched/panicle short branched/compact panicle.
13.	Inflorescence shape	:	Drooping / erect / semi erect
14.	Axillary inflorescence	:	Present / absent
15.	Density of inflorescence	:	Dense / Intermediate
16.	Colour of inflorescence	:	Green / pink / pale green / pale pink / cream /

yellowish green / purple / brownish green / yellowish brown

17. Seed shape : Round / ovoid / flat / ellipsoidal
18. Seed colour : Black / dark brown / brown / cream / pale yellow / cream tinge
19. Plant height :
20. Green yield : a) Stem and leaf
    b) Leaf weight
21. Seed yield / 10 plants (g) :
22. 100 seed weight :

Moringa :

1. Botanical name :
2. Family :
3. Growth habit :
4. Plant height :
5. No. of branches :
6. Height at 1st branching :
7. Leaf type :
8. Inflorescence type :
9. Flower shape :
10. Flower colour :
11. Fruit type :
12. Fruit length :
13. Fruit weight :
14. No. of fruits/plant :
15. Seed colour :
16. 100 seed weight :
17. Total fruit yield :
18. Disease and Incidence :
19. Pest Incidence :

EX. NO. 14

IDENTIFICATION AND DESCRIPTIVE BLANK FOR BULB AND ROOT CROPS

I. ONION

1.	Height of plants (cm)	:	
2.	No. of shoots/clump	:	
3.	No. of leaves/clump	:	
4.	No. of bulbs/clump	:	
5.	Plant weight (g)	:	
6.	Bulb weight/clump (g)	:	
7.	Bulb length (cm)	:	
8.	Bulb weight (g)	:	
9.	Bulb girth (g)	:	
10.	Colour of the bulbs	:	Shinning deep red / pink red
11.	Leaf shape	:	Cylindrical
12.	Leaf colour	:	Dark green/light green
13.	Duration (days)	:	

II. ROOT CROPS (CARROT, RADISH AND BEETROOT)

B. Name of the variety

1. Plant weight :
2. No. of branches :
3. Leaf length (cm) :
4. Leaf Breadth (cm) :
5. Leaf margin :
6. Petiole length (cm) :
7. Leaf-Mid rib colour :
8. Root length (cm) :
9. Root shape :
10. Root colour :
11. Root diameter (cm) :
12. Crop duration :
13. Any physiological disorder :

EX. NO. 15

DESCRIPTIVE BLANK FOR CABBAGE AND CAULIFLOWER

A. CABBAGE

1. Plant height (cm) :

2. Number of leaves :
3. Leaf length (cm) :
4. Leaf width (cm) :
5. Petiole length (cm) :
6. Size of the head : Small/medium/large
7. Shape of the head : Round/oval/oblate
8. Colour of the head : Green/pale green/others
9. Diameter of the head (cm) :
10. Weight of the head (g) :
11. Number of days for maturity :
12. Number of days for bolting :
13. Number of seeds/plant :
14. Weight of seeds/plant (g) :
15. 100 seed weight (g) :
16. Seed colour : Light brown/brown

B. CAULIFLOWER

1. Plant height (cm) :

2. Number of leaves :
3. Leaf length (cm) :
4. Leaf width (cm) :
5. Petiole length (cm) :
6. Size of curd : Small/medium/large
7. Compactness of the curd : Compact/loose/semi-compact
8. Colour of the curd : White/pale white
9. Earliness of the curd : Early/medium/late
10. Diameter of the curd (cm) :
11. Weight of the curd (g) :
12. Number of days for maturity :
13. Number of days to bolting :
14. Number of seeds/plant :
15. Weight of seeds/plant (g) :
16. 100 seed weight (g) :
17. Seed colour : Light brown/brown

EX. NO. 16

VEGETABLE PRODUCTION IN GREEN HOUSE/POLYHOUSE STRUCTURES

(a) Green house

The choice of the crops to be raised in greenhouse is made on the basis of the physical size of the structure and the economics of the crop production. The high value vegetable crops have been more popular for cultivation in greenhouse. The labour and other input requirement per unit of cultivated area in greenhouse is more than that of field conditions. There is always a large and sustained demand of fresh vegetables round the year in big cities. The demand for off-season and high value vegetables also exists in these big cities. Greenhouses can be commercially exploited for successful cultivation during off season and production of several high value thermo sensitive vegetables like cucumber, tomato, sweet peppers, during winter and summer months and crops like cauliflower, cabbage, tomato, lettuce, radish etc. during summer and rainy season.

Several single and multispan greenhouses have been developed in India. The following is the list of such greenhouses.

1. Single span 5m x 24m
2. Single span 6m x 24m
3. Single span 8m x 24m
4. Single span 9m x 24m
5. Four span 20m x 40m
6. Lean to greenhouse for colder regions
7. Saw tooth type greenhouse (24mx 36m)
8. Wooden framed greenhouse of IPCL design
9. Bamboo framed greenhouse of Jorhat design (Assam)

The selection for greenhouse design has been made with a view to maintain relative simplicity of the framework and to encompass various types of structures.

(b) Polyhouse

A poly house is framed on an inflated structure (light weight) covered with a transparent polythene which permits at least partial control of plant environment and which is large enough to permit a person to carry out cultural operations. Depending upon the environment control facilities and the cost involved in the construction, the polyhouses are categorized as low cost, medium cost and high cost. The low cost polyhouse does not have any control system. It has only the supporting structure, which may be made of GI pipe, iron angle or even bamboo. UV stabilized 200 micron thick plastic film is normally used for coverage. The medium cost polyhouse us made of iron structure may have double layer of UV stabilized plastic film with cooling pad/fan or heating arrangements. It may also have misting and shading facilities. The high cost polyhouse may have all the modern facilities including, UV stabilized cladding film/poly carbonate sheet, heating, cooling and humidification system, drip irrigation system, auto control mechanism etc. The main consideration in choosing the vegetables to be grown inside the limited and expensive space of polyhouse is the most efficient and economical utilization of space for the longest period possible. In this context low volume and high value crops may be most profitable to grow in the environmental controlled poly house.

Greenhouse structures designed to extend the cropping season of tender vegetables and ornamental crops and to protect them from adverse environment conditions, such as low or high temperatures, gusty winds and precipitation and from certain diseases and pests. Air exchange from warm soils tends to accumulate, creating a high humidity. Greenhouse production requires high levels of economic investment, and space is at premium. Although any vegetable could be grown under greenhouses economics are viable for high value crops only. Growing vegetables in the open field during off-season is not all that successful and greenhouse cultivation during such periods can produce the desired results.

In India, the structure of the greenhouse depends on the economic condition of the farmers. Thus there are three types of green houses made in India.

i. Low cost green house / poly house

The low cost poly house is a zero energy chamber made of polythenes sheet of 700 gauge supported on bamboos with “Sutli” and nails. Its size depends on the purpose of its utilization and availability of space. Like the green house, it has one opening for 1-2 hours during the day, especially in the mornings to reduce the level of humidity inside. The temperature within polyhouse increases by 6-10ºC more than out side. In UV-stabilized plastic film covered, pipe framed polyhouse, the day temperature is higher and night temperature is lower than outside. The solar radiations entering the poly house is 30-40% lower than that reacting the soil surface outside.

ii. Medium cost green house / poly house

With a slightly highest cost, a Quonset shaped poly house / green house can be framed with GI pipe of 15mm. This poly house has a single layer covering UV stabilized polythene 800 gauges. The exhaust fans are used for ventilation and these are thermo statically controlled. Cooling pad is used for humidifying the air entering the polyhouse. The polyhouse frame & glazing material have a life span of about 20 years and 2 years respectively.

iii. Hi-Tech green house / poly house

This type of green house consists of fully controlled automation facilities. The temp, RH & light are automatically controlled. These are indicated through sensor or signal receiver. Sensor measures the variables, compares the measurement to a standard value and finally recommends to run the corresponding pounding device. This model is highly expensive, requiring qualified operators, care and precautions.

Vegetable forcing for domestic consumption

During winters in N.I. and hills, solar radiation is suboptimal for growing off-season vegetables – like tomato, capsicum, brinjal, cucurbits, okra, off-season vegetables – like tomato, capsicum, brinjal, cucurbits, okra, amaranths and chilli. In tomato, low temperature and low radiation cause puffiness and blotchy ripening. Hence during extreme conditions of winter season (October-February) these vegetables can be well cultivated under poly house.

Application of greenhouse technology in vegetable growing

In the present scenario greenhouses in India can best be exploited to serve two broad aspects of vegetable growing viz., to produce transplants and to cultivate greenhouse vegetable crops.

1. Transplant production

Transplant production is a very specialized segment of the vegetable business, which demands facilities, and careful attention and any laxity on the part of a grower growing his own transplants at this stage can prove to be very expensive. Here the services of a quality conscious transplant producer can be utilized.

The system to be chosen for producing transplants depends on the crop, the degree of earliness desired, the season and the geographical location. The whole program has to be scheduled so that transplants are produced as per the requirements. The transplants can be produced in various containers (clay pot, soil block, peat pot, peat pellet, plastic pot, perforated plastic tray, fiber tray). High value hybrid vegetable seedlings are generally raised in the containers.

Under North Indian conditions when winter is severe transplants can be raised under greenhouses or polytunnels. Under South Indian conditions there is enough scope to raise disease free transplants under cover during rainy season. Generally seedlings grown in open field beds in conventional methods carry diseases caused by fungi like *Pythium, Phytophthora* and bacteria like *Pseudomonas* and *Erwinia.* Similarly during summer there is a severe incidence of viral diseases in tomato, capsicum and cucumbers, which are transmitted by vectors like aphids, thrips and whiteflies in the seedling stage. This infection can be minimized when seedlings are raised under cover.

Media for transplant production

One has to minimize the use of the filed soil in a seedling media as they may crust or drain poorly and may harbour pests and disease organisms. These days many commercial mixes of organic origin (e.g., coir and peat, coco peat) are available in the market any of those could be used at the recommended proportions to raise transplants. Sand and peat/cocoa peat mixtures or mixtures of peat and vermiculite or perlite form the best seeding media. A desirable seeding media should provide good drainage but retain moisture well enough to prevent rapid fluctuation, have good aeration, should be low in soluble salts and be free from insects, diseases and weed seeds. Irrespective of the type of media used, it should be pasteurized before seed sowing.

Questions

1. What is a green house? Indicate the various sizes of single and multispan green houses?
2. What is a polyhouse? Write a brief note on it.
3. Write a brief note on the three types of green houses based on cost?
4. What is a transplant? Write a brief note on transplant production.
5. What are the media used in transplant production.
6. Give examples of vegetable hybrids recommended for green house cultivation?
7. Explain vegetable forcing.