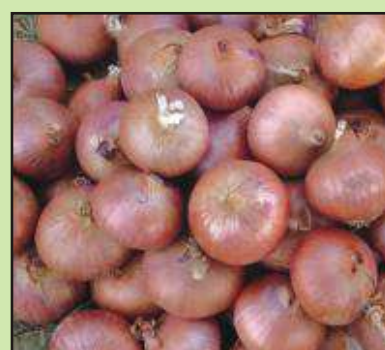
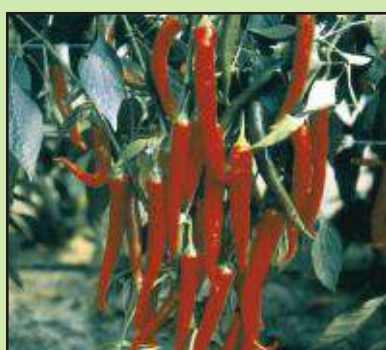
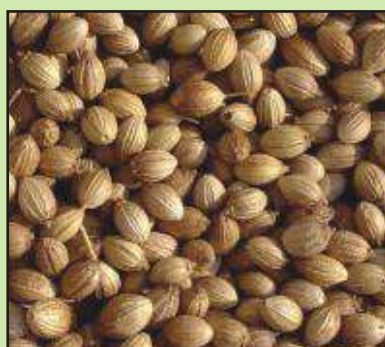
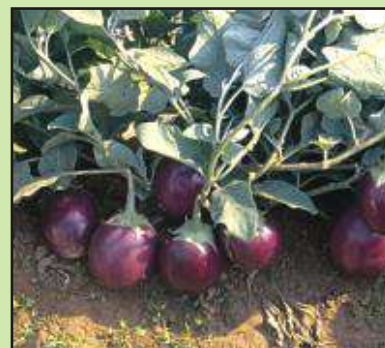
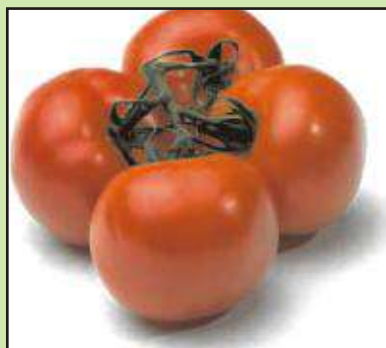




VEGETABLE SEED PRODUCTION



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FOREWORD

Vegetables are an integral part of human diet and known as protective foods, which contribute required minerals, vitamins and other nutrients of medicinal and therapeutic values. The production and productivity of different vegetable crops have increased significantly in the past 20 years as a result of research and development pursuits undertaken by various agricultural institutions and private sector. Modern strategic approaches are however, necessary for sustainable development of these crops so as to meet the increasing requirement both in domestic as well as export markets.

The most important and feasible approach to enhance the productivity of vegetable crops would be the production of quality seed and making it availability. The importance of good quality seed can hardly be over emphasized as it is crucial for high productivity. Several high yielding varieties of vegetables with improved technologies have been developed by CCS Haryana Agricultural University and other public and private organizations but availability of quality seed in sufficient quantities is a major constraint. In order to meet this challenge, there is need to popularize the improved seed production packages in vegetable crops which, would in turn, provide comprehensive knowledge to the seed growers regarding the recent advances in technologies for quality seed production of vegetable crops.

I wish to compliment the Scientists, Department of Vegetable crops and Business Planning and Development Unit, Directorate of HRM involved in the preparation and publication of this technical manual entitled "Vegetable seed production" elaborating the concepts and techniques in a very comprehensive and illustrative manner. I am sure this bulletin will be of great use for the farming community, entrepreneurs and other fraternity.

(K.S. Khokhar)

PREFACE

Vegetable constitute a major part in Indian agriculture in terms of providing food and nutritional security. In recent past, Indian agriculture has witness tremendous progress in vegetable production, due to the development of high yielding varieties, new technologies and marginal increase in area of certain vegetables. The introduction of new varieties of vegetable crops resistant to different diseases and nematodes also boosted the vegetable production in the country.

One of the major factors which influence the quantity and quality of vegetable crops is the seeds. To ensure better production, generally farmers purchased the seeds from the market which is very costly. With the knowledge of seed production technology of vegetable crops, the farmers can produce the seed at their own and save the money. However, they need proper experience/guidance to become well conversant with different aspects of quality seed production.

This manual deals with the seed production technology of different vegetable crops. Considering the non-scientific background of certain target users, the very idea was to define such terminology in simple language. It is hoped that this technology bulletin would meet the demand and fulfill the requirement for practical guide to the students and farmers engaged in the vegetable seed production.

Authors

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INTRODUCTION

Seed, the basic and primary requisite is most critical input for successful crop production. In most of the vegetable crops, the seed is an insignificant item in the total cost of production. But the efficiency of other costlier inputs like fertilizer, irrigation, weedicides, insecticides, fungicides, harvesting and processing revolves around the use of good quality seed.

A good quality vegetable seed must conform the following:

- i) Genetically pure.
- ii) Physically pure.
- iii) Physiologically viable.
- iv) Free from weed and other crop seeds.
- v) Free from designated diseases.

In India, large quantity of vegetable seeds are normally sold loose and without labelling. The most difficult problem faced by the vegetable grower today is the genetic purity of the seed. What is true to type and how to get it, is generally asked by the farmers. To understand the meaning of true to type properly, it will be pertinent to know the following terms, as used in seed industry.

Kind : A kind includes all the plants which in general use, are accepted as a single vegetable, e.g. pea, brinjal, okra etc.

Variety : The term 'variety' equivalent to 'cultivar' is defined as 'An assemblage of cultivated plants which is distinguished by any character (morphological, physiological, cytological, chemical or others) and which when reproduced sexually or asexually retains its distinguishable characters' e.g. Hisar Arun is a variety of tomato and Arkel is a variety of pea.

Strain : A group of individuals similar in phenotype and often in genotype. A strain is known as variety when released for commercial cultivation by a Variety Release Committee.

Stock seed : The seed of a strain produced by a breeder which has been identified but has yet not been released. It will be known as nucleus seed, once the strain is notified and released.

Vegetable seed growing is a highly specialized job. It needs specific knowledge and skill to be conversant with various aspects of seed production. Most of the vegetable crops produce seed satisfactorily in dry climate. But some crops like cabbage, late varieties of cauliflower and European varieties of root crops require cool climate for their seed production. Earlier age-old Indian tradition of preserving the best plant, the best fruit of the plant for seed was followed. Lately spectacular breakthrough has been achieved with breeding and release of new high yielding varieties which has been recognized by every vegetable grower. Technology of seed production, extraction, processing and storage has also advanced. Therefore, for the development of vegetable seed industry in the country, we have to train seed growers for production of quality seed for their own need and personnel of public sector undertakings like State Seed Corporations and National Seeds Corporation.

As per Seed Act, a seed grower has to get his seed crops inspected by the Seed Certification Agencies in order to get the label. There are different classes of seed and there are different standards of inspection for each class. The four recognized classes of seed are :

1. Nucleus seed : Seed produced by the breeder through mass selection (with progeny test) in a pure line variety or clone. This is the source of breeder seed.

2. Breeder seed : Seed or vegetatively propagating material is the progeny of nucleus seed produced by the breeder who has developed a particular variety. It is produced by the institution where the variety was developed in case the breeder who developed the variety is not available. Breeder seed is subjected to monitoring which is conducted (at seed maturity stage/ before harvesting) by breeder concerned and personnel of seed certification agencies.

3. Foundation seed : Foundation seed is the progeny of breeder seed and is produced and supervised by agricultural experts at University, NSC, HSDC and Government farms. Its production is subjected to certification so as to conform to the prescribed standards for the class. Foundation seed is intended for the production of certified seed.

4. Certified seed : Certified seed is the progeny of foundation or certified seed. To be certified, the seed must meet the prescribed requirements regarding genetic identity, purity and quality. It is generally produced by State Seed Corporations and National Seeds Corporation through contact growers for general distribution.

The above stages are based on the generation system, number of multiplication in each generation is limited and each generation must conform to official standards.

After harvesting, threshing and drying, seed is subjected to processing. The objective of processing is to maintain and improve various quality factors such as physical purity, germination, vigour and storability. This is done by removing various impurities and undesirable material such as inert matter, broken, immature, rotten, diseased and insect damaged seeds, weed seeds and seeds of other crops. Processing includes cleaning, grading, treating and packing.

The length of time for which a seed remains viable (longevity) depends upon a number of factors like the kind of seed, proper maturity, drying to a desired low moisture content and storage conditions. The important vegetable crops can be grouped in four according to the time for which they remain viable under ambient storage conditions.

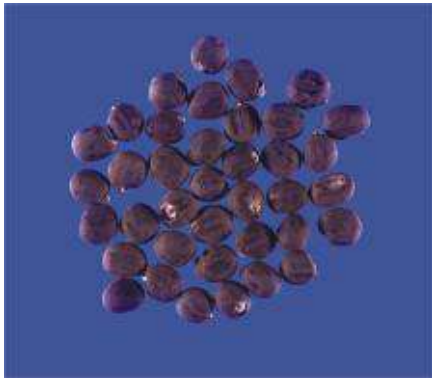
Table 1. The longevity of seeds of important vegetable crops

Group	Name of crop	Longevity (years)
I	Onion	One
II	Carrot, okra, chilli and beans	Two
III	Peas, gourds, luffa, summer squash, radish and turnip	Three
IV	Tomato, brinjal, muskmelon, watermelon, cauliflower, cabbage and spinach	Four-Five

Although this grouping according to longevity can form a good basis to judge the suitability of seed for its use, yet the best method for vegetable grower is to know the germination percentage.

Since the sale of seed is governed by the Seed Act, the information on various aspects of seed production is presented in this bulletin with the hope that it will be a useful guide to the vegetable seed-growers.

OKRA



Okra or Bhindi or ladyfinger (*Abelmoschus esculentus* L. Moench) belongs to the family Malvaceae. Okra is said to be the native of South Africa or Asia and has been predominantly a vegetable of tropics and hence it has been grown in India for more than one and a half century.

Climatic requirement :

Okra is a warm season crop and thrive best during warm moist season although it grows fairly in hottest summer. However, it requires cooler night. It is susceptible to frost. The seeds of okra will not germinate below 16°C temperature, Optimum temperature for germination is 26-30°C. Under Haryana conditions seed yield of summer crop is much lower as compared to rainy season crop. Seed size of summer crop remains small. Moreover, early rains (May-June) at the time of pod maturity and drying impair the seed quality. Hence, under Haryana conditions, seed should be produced from rainy season crop.

Varieties

i) Pusa Sawani : Developed at IARI, New Delhi. The stem and leaves are moderately hairy. The top leaves are deeply lobed (3 to 5 lobes) and the first fruit appears at 8th node. The cultivar is characterized by the presence of purple patch at the base of yellow petals on both sides and slight pigmentation on the stem petiole

and base of the leaf. The fruits are dark green, smooth with five ridges and about 10-12 cm long at marketable stage. It is suitable for both spring-summer and rainy season crop. Its tolerance to yellow vein mosaic virus has broken down.

ii) Varsha Uphar : Developed at CCS HAU, Hisar. Plants are of medium height with lesser distance between nodes. Leaves deeply lobed with dark green colour. Fruits long, five ridged, attractive and appear on 4th node. Tolerant to yellow vein mosaic disease and suitable for rainy season.

iii) Hisar Unnat : Developed at CCSHAU, Hisar. Plants are medium in height with 2-3 branches. Fruits appear on 4th node. Fruits are green, attractive and five ridged. Length of fully developed fruit is 15-18 cm. Tolerant to yellow vein mosaic.

iv) Punjab Padmini : Developed at PAU, Ludhiana. Plants are tall with mild purple tinge on the stem and petiole. Leaves dark green, deeply lobed and hairy. Fruits quick growing, dark green, hairy, 5 ridged and remain tender for longer period. It shows field tolerance to yellow vein mosaic. Suitable for both spring-summer and rainy season.

v) Prabhani Kranti : Developed at Marathwada Krishi Vidyapeeth, Prabhani, Maharashtra. Fruits long, tender and of green colour. Tolerant to yellow vein mosaic. Suitable for both seasons.

Flower characters and pollination :

Flower bud appears in the axil of each leaf from 4th to 8th leaf depending upon the cultivar. Flower bud takes about 22-26 days from initiation to full bloom. The time of anthesis varies with the cultivar, temperature and humidity and it ranges from 8 to 10 A.M. The dehiscence of anthers is transverse and occurs 15-20 minutes after anthesis. The pollen fertility is maximum during the period an hour before and an hour after opening of flower. The flowers remain open for a short time and they wither late in the afternoon. The stigma is receptive as flowers open. Under Indian conditions cross-pollination by insects has been reported to the extent of 4.0 to 19%. The extent of pollination at a particular place will depend upon the cultivar, competitive flora, insect population and season etc.

Isolation :

Okra is categorized as often-cross pollinated crop. To prevent cross-pollination an isolation distance of 500 meters for foundation and 250 meters for certified seed is necessary.

Soil :

It can be cultivated in soil ranging from sandy to clay provided they are well drained, fertile and rich in organic matter. Best results with regard to seed are however, obtained from a friable well manured soil. It is slightly tolerant to acidity. The optimum pH range is 6 to 7.

Sowing time :

In north Indian plains, okra crop is grown two times i.e. February-March for summer crop and in June-July for rainy season crop. However, to produce quality seed, crop should be sown around mid-June.

Seed rate :

8-10 kg/ha.

Method of sowing and spacing :

Seed is sown either in flat beds or on the ridges depending upon the type of soil and irrigation facilities available. Spacing between lines or ridges should be 60 cm. At the time of sowing there should be enough moisture in the soil. Seed should be soaked overnight and two seeds are sown per hill at a spacing of 30 cm. Later, one healthy plant is retained per hill and the weaker one is thinned. Where sowing is done by seed drill, thinning should be done when plants are about 12-15 cm high to maintain 30 cm spacing between plants.

Manure and fertilizers :

At the time of field preparation about 30 tons of well rotten farmyard manure per hectare is incorporated in the soil. In addition, the crop needs about 100 kg nitrogen, 50 kg phosphorus and 50 kg potash per hectare. Half of the nitrogen and full dose of phosphorus and potash is drilled or incorporated in the soil before sowing. The remaining half nitrogen is top dressed 30-35 days after sowing.

Care of the crop :

During summer and rainy season, depending upon the soil moisture the crop is irrigated as and when required. During rainy season, excess water should be drained off from the field. At pod formation and seed development stage crop should be irrigated at required interval to maintain moisture in soil.

To keep the crop weed free, hoeing and weeding should be done at regular interval. For chemical weed control spray fluchloralin one kg (Basalin 45 EC @ 1.5 lt in 625 litres of water per ha) two days before sowing of seed. Immediately after application rake the field upto 3-4 cm to incorporate the chemical. Never apply the chemical in bright sun shine.

Roguing :

To check the spread of yellow vein mosaic disease, it is essential to rogue out the affected plants as soon as they are noticed. As per the standard, plants bearing pods after 6-7 nodes are off type and should be removed. On the basis of growth habit and flower colour off type plants, plants bearing pods having more than 5-6 ribs and wild bhindi should be rogued out.

Specific requirements (Field standards)

Items	Max. permitted (%age)	
	F. seed	C. seed
Off type	0.10	0.20
Objectionable weed plants (wild bhindi)	None	None
Plants affected by YVMV	0.10	1.00

Inspections :

Minimum three inspections are made :

1. Before flowering
2. At flowering and immature fruit stage
3. Mature fruit stage

Harvesting and threshing :

When the pods are completely dry they are harvested. The picking of pods may be affected by climatic conditions. If there is no danger of rain at pod maturity stage, the pods may be harvested in one lot. However, if there is danger of rains, the picking may be done twice or thrice. The pods are piled for curing for few days. Then they are threshed and seed is winnowed.

Drying and processing :

After threshing the seed is further dried to a moisture content of 8-9%. The seed is then cleaned and graded on air screen machine by using 11/64 inches grading screen. To remove insect damaged, black coloured and light seeds, gravity separator may be used.

Seed yield :

10-15 qtls/ha

Seed Standards

Items Factors	Class of seed (%)	
	F. seed	C. seed
Off type	0.10	0.20
Pure seed (minimum)	99.00	99.00
Inert matter (maximum)	1.00	1.00
Other crop seeds (maximum)	None	0.05
Weed seeds (maximum)	None	None
Objectionable weed seed (max.)	None	None
Germination (minimum)	65.00	65.00
Moisture content (maximum)	10.0	10.0
Vapour proof container (max.)	8.00	8.00

Plant Protection Measures

Pests

1. Jassid (*Amrasca biguttula biguttula*) :

Both nymphs and adults of this wedge shaped pale green leaf hopper cause damage to the crop by sucking sap and injecting some toxic material, with the result that the leaves turn pale and curl upward. In case of severe infection, the leaves have a burnt look and fall down.

2. Whitefly (*Benisia tabaci*)

Young and adult suck the sap from lower side of leaves and leaves turn yellow. Whitefly serves as vector and spreads yellow vein mosaic disease in okra.

3. Spotted boll worm (*Earias sp.*)

At the larval stage, they bore into the growing shoots, flower buds, flowers and fruits of okra, either killing the plant or distorting or shedding of fruit.

4. Spider mite (*Tetranychus sp.*)

The nymphs and the adults attack leaves, suck cell sap and ultimately cause defoliation.

Control :

For the control of these pests spray alternately malathion 50 EC @ 800 to 1250 ml/ha and carbaryl @750 g to 1.00 kg/ha in 500 to 625 litre of water (as the vegetative growth of

crop increases enhance the dose of insecticides.

Diseases

1. Damping off and root rot (*Pythium sp.*, *Rhizoctonia sp.* and *Fusarium sp.*)

Attack of these fungus results in pre- and post-emergence death of seedlings.

Control : Treat the seed with Thiram or Emisan or Captan @ 2.5 g/kg seed before sowing.

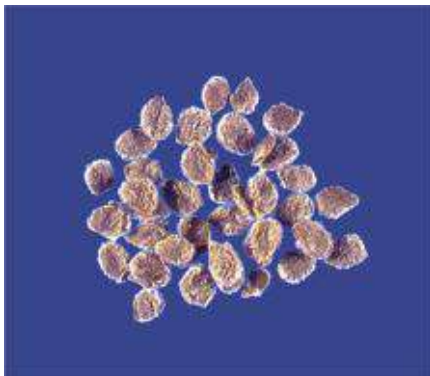
2. Yellow Vein Mosaic virus

This is most destructive viral disease of okra. Infects at all stages of the crop. Veins of leaf become yellow and at later stages whole leaf becomes yellow. Severely reduces the growth and yield of crop.

SOLANACEOUS VEGETABLES

Solanaceous group includes three importance fruit vegetables i.e. tomato (*Lycopersicon esculentum* Mill), brinjal or egg plant (*Solanum melongena* L.) and chillies and capsicum (*Capsicum annum*). Although, they relate to different genus and species but belong to same family Solanaceae.

TOMATO



Tomato is a very popular vegetable grown successfully throughout India. Ripe fruits are eaten raw as salad or cooked with other vegetables. Large quantity of tomato fruits are used to prepare soup, juice, ketchup, puree, paste and powder. Tomato is fleshy fruited vegetable that present a special problem, because at harvest the seed is wet rather than

Control :

(i) Grow resistant varieties.

(ii) Whitefly is the main vector of this disease. Hence, spray insecticides regularly to control whitefly.

3. Root knot nematode (*Melodogyne incognita*)

It causes yellowing of leaves, patchy and unthrifty growth of plants. Knot like galls are found on roots.

Control :

Application of DD into the infected soil @ 200 litres/ha before sowing or Nemagon @ 30 litres/ha with irrigation is recommended.

dry. Hence, raising of crop and seed extraction is a specialized job. Special features of tomato seed production are given below:

Climate : Tomato is a warm season crop and requires a frost free period of about four months for seed production. Optimum temperature for seed germination is 16° to 29°C and for growth

and fruit set between 20° to 25°C. Below 15°C and at/above 32°C, the pollen germination is very poor. Hence, very high or very low temperature and draught adversely affect fruit setting. High temperature combined with dry winds causes blossom drop. A warm and sunny weather is most suited for proper fruit set, fruit and seed development which results in higher seed yield.

Varieties

Hisar Arun : Developed at CCS HAU, Hisar. Determinate, prolific bearer, fruit medium size, uniform ripening, heavy yielder (300q/ha) and suitable for both spring-summer and autumn-winter season.

Hisar Lalit : Developed at CCS HAU, Hisar. Determinate, nematode resistant, fruits medium size, attractive, uniform ripening, heavy yielder (250-300 q/ha). Produce good yield even in nematode infected soils.

Pusa Ruby : Developed at IARI, New Delhi. Early cultivar, fruits with yellow stem end, slightly furrowed, uniform ripening, heavy yielder (250 q/ha). Suitable for both spring-summer and autumn-winter season.

Pusa Gaurav : Developed at IARI, New Delhi. Leaves serrated and light green, fruits red with yellowish tinge, smooth and egg shaped with yellow stem end, uniform ripening. Suitable for canning and long distance transportation.

Pusa Shital : Developed at IARI, New Delhi. Determinate, good growth, leaves serrated and green, fruits flattish round, smooth, uniform in maturity, heavy yielder (300-325 q/ha). Sets fruit at low temperature, hence suitable for early sowing in Indo-Gangatic plains.

Punjab Kesari : Developed at PAU, Ludhiana. Early variety suitable for plains and hilly areas of North India. Resistant to late blight. Plants bushy, susceptible to nematodes and average yield 300-350 q/ha.

Pantnagar Tomato-1 : Developed at Pantnagar. Suitable for both spring-summer and

autumn-winter season. Plants medium sized, fruits large, smooth and fleshy. Average yield 300-350 q/ha.

Pantnagar Tomato-2 : Plants spread less, fruits small to medium, pear shaped, fleshy with thick pericarp, cluster bearing habit. Suitable for hilly areas. Average yield 300-350 q/ha.

Flower characters and pollination

The number of flowers vary from 4 to 12 in each cluster, average number is 4-5 per cluster. The flowers are small pendent, calyx are 5-6, sepals parted green in colour with many hairs. This persist until fruit mature. Corolla sulphur yellow in colour and form a short tube. Stamens-five in number and are borne on the throat of the corolla, long anthers partly united. Pistil – two or multicarpellary, elongated style, simple bulbous stigma, stigma extend through and somewhat beyond encircling androecious.

Daily temperature influences time of opening of flower, anther dehiscence and stigma receptivity. Anthesis is correlated with temperature and soil moisture. The petals open between 8-10.30 a.m. The dehiscence takes place between 9-10.30 a.m. The receptivity of stigma is between 8.30 to 11.30 a.m. The dehiscence is 24 to 48 hours earlier than opening of corolla, hence tomato is a self pollinated crop. Bumble bees sometimes visit tomato flowers and cause cross pollination. About 1.7 to 3.8% cross pollination has been reported under Delhi conditions.

Isolation : To maintain the purity of variety, a minimum distance of 50 m for foundation seed and 25 m for certified seed should be provided all around the field to separate it from other varieties of tomato.

Soil : A well drained loam, clay loam or silt loam soil with fair moisture holding capacity and pH range of 6-7 is most suitable for tomato seed production.

Manures and fertilizers : The exact requirement of manures and fertilizers would depend on the fertility status of the soil. However, general recommendation for Haryana state is 25 tons FYM, 100 kg nitrogen, 50 kg phosphorus and 50 kg potash (potash only in deficient soils) per ha. FYM should be incorporated in soil 3-4 weeks before transplanting. Full dose of phosphorus and potash and one third of nitrogen should be applied before preparation of ridges. The rest of nitrogen is applied as top dressing in two equal doses i.e. 30 and 50 days after transplanting. After top dressing earthed up the plants and it should be followed by light irrigation.

Seed rate : 500-600 g/ha.

Sowing time : Time of sowing is very important factor and in northern plains only spring-summer crop is recommended for seed production. The sowing is done in middle of December.

Nursery raising : The seed is sown in well prepared raised beds. Nursery beds are irrigated daily with watering cane and beds are given shelter with the help of Sarkanda thatch or white polythene. When the plants are 4-5 cm tall, thinning is done to avoid over crowding.

Transplanting : Four to five weeks old 12-15 cm tall seedlings are transplanted in the field. The ideal time for transplanting of spring-summer crop is from 20th January to 10th February. It is always better to transplant the seedlings after the danger of frost is over. Transplanting is done on raised beds of 60-75 cm width on one side at a plant distance of 45-60 cm. Transplanting should be followed by light irrigation.

After care of crop : Keep the field weed free. Normally two hoeings /weedings i.e. 20-25 and 40-45 days after transplanting are carried out. Soil should be earthed up around the plants. Weeds can also be controlled by the use of weedicide. Apply one kg pendimethalin (Stomp

3.3 litre) in 650 litre of water per ha, 4-5 days after transplanting.

Tomato needs very careful irrigation. Over watering and insufficient irrigation is always harmful. The interval of irrigation depends on soil texture, temperature, stage of crop and method of irrigation and may vary from 7-15 days. Water stress conditions leads to restricted development and dropping of flowers and arrests the fruit growth. After stress, frequent and heavy irrigation at the time of fruit development and maturity may cause severe fruit splitting/cracking. Therefore, the crop should not be irrigated frequently during fruit ripening stage.

Roguing : To maintain purity, all the plants which are not true to type on the basis foliage characters, fruit characters (shape, size and colour) and affected with seed borne diseases are removed. First roguing is carried out before the start of flowering on the basis of foliage, second roguing when the fruits are green and the third and final roguing at fruit maturity stage.

Specific requirement (Field standards)

Factors	Maximum permitted %age	
	F. seed	C. seed
Off type	0.10	0.50
*Seed borne diseases	0.10	0.50

*Early blight, Leaf spot and Mosaic (TMV)

Field inspections : Number and stages of field inspection for certification are:

1. Before flowering
2. Full flowering/immature fruit stage
3. Mature fruit stage

Harvesting and seed extraction

For seed extraction fully red ripe fruits are harvested. To improve the seed quality, avoid the fruits of lat picking.

i) Fermentation method : Red ripe fruits are crushed well in a non-metallic container to make slurry. This material is allowed to ferment. The fermentation period depends upon the ambient temperature and may require 24 to 48 hours during summer and 48 to 72 hours during winter. When fermentation is complete, it shows profuse foam on upper surface of material and tomato flesh separates from seeds completely. The material is then put in water in a tub, where pulp and skin float up and seeds settle down in bottom. The seed is then washed repeatedly and cleaned. Longer fermentation may spoil the seed quality.

ii) Acid treatment method : Commercial hydrochloric acid @ 100 ml/11 kg of tomato pulp is thoroughly mixed and stirred and is left for about 30 minutes. The pulp is then again stirred and washed repeatedly with clean water.

iii) Cold extraction method (use of pulper) : For large scale seed extraction, specially designed electrically operated tomato pulpers can be used effectively. In this operation the juice is separated from the relatively dry residual mixture of seeds, pulp and

skin. The mixture is then left over night and next day the seed is easily separated by repeated washings with clean water.

Seed drying : The washed seed is spread thinly in a airy place under shade for few hours before it is allowed to dry in sun.

Seed Standards (%)

Factors	Class of seed	
	F. seed	C. seed
Pure seed (minimum)	98.00	97.00
Inert matter (maximum)	2.00	2.00
Other crop seeds (maximum)	0.05	0.10
Weed seeds	None	None
Germination (minimum)	70.00	70.00
Moisture content (maximum)		
i) Ordinary container	8.00	8.00
ii) Vapour proof container	6.00	6.00

Seed yield : Seed yield varies with the variety due to variation in seed content of a particular variety. Temperature at fruit set, development and maturity stage also plays an important role on seed yield. However, on an average seed yield of tomato is 100-150 kg/ha.

BRINJAL



Brinjal is one of the most popular and principal vegetable crop grown for its fruits. It is thought to have originated from tropical regions of India. It can be grown in almost all parts of India all the year round except high altitudes.

Climatic requirements

Brinjal is a warm season crop and is susceptible to severe frost. A long and warm growing season is desirable for successful brinjal production. Cool nights and short summers are

unfavourable. However, late round varieties are tolerant to mild frost to some extent than early long varieties. A daily mean temperature of 13 to 21°C is most suitable for better growth and yield. Its seed germinate well at 25°C temperature.

Varieties

According to colour, there are white, yellow, brown, green, pink, black, purple and striped, while according to shape they may be round, oblong, long and pear shaped. In north India pinkish purple or violet and black varieties are preferred.

Pusa Purple Long : Developed at IARI, New Delhi. The plants are semi-erect. It is early and fruits ready for picking in 100-110 days. Fruits are glossy, light purple in colour, 25-30 cm long, smooth and tender. Suitable for spring and autumn plantings and average yield is about 275 q/ha.

Hisar Pragati : Developed at CCS HAU, Hisar. Early variety, leaves green, flowers white purple, fruits 15-20 cm long, attractive, dark purple in colour. Yield 325 q/ha.

Pusa Purple Cluster : Developed at IARI, New Delhi. Very early, ready for picking in 75 days. Plants erect and tall, leaves and stem are purplish in colour. Fruits small, dark purple in colour, and born in cluster. On an average, each fruit weights about 21 g with bearing of 50 fruits per plant.

Pusa Kranti : Evolved at IARI, New Delhi. Plants dwarf and spreading. Stems are medium thick and half green, half purple in colour. Leaves long, narrow, highly serrated and light green in colour. Fruits oblong and stocky and dark purple in colour. This cultivar is good for both spring-summer and autumn-winter planting in north India. On an average, each fruit weights 68 g with a bearing of 22 fruits per plant.

Hisar Jamuni : Developed at CCS HAU, Hisar. Plants are medium in height and less

spreading, leaves spineless and purple in colour, flowers light purple. Fruits oblong, 10-15 cm long, fleshy and blackish purple which can be retained much beyond the commercial stage. Suitable for both spring-summer and autumn-winter plantings. Average yield about 300 q/ha.

BR-112 : Early cultivar, plants bushy, fruits round, fleshy and light purple in colour. Average yield about 250 q/ha.

Hisar Shyamal : Developed at CCS HAU, Hisar. This is prolific bearer, fruits round and dark purple in colour, stems and leaves purple in colour. Fruits ready for picking in 75 days. Average yield 325 q/ha.

Pant Rituraj : Stem erect, 60-70 cm in height, Fruits roundish, attractive, soft with less seeds and having good storage capacity. It is ready for picking in 60 days and has long fruiting period (rainy season to summer season). Average yield 400 q/ha.

Jamuni Gol : Developed at PAU, Ludhiana. Plants medium in height, spreading type and spineless. Fruits round and purple in colour, ready for picking in 65 days after transplanting.

Flower characters : In most Indian varieties flowers are born in clusters. Some varieties particularly Japanese and some American bear flower singly. In both single flower bearing and cluster bearing type, the flowers are perfect. In Pusa Purple Long and Pusa Kranti, the inflorescence may contain 4-5 flowers but only first flower is perfect and rest of the flowers being incomplete drop out. Four types of flower appear in brinjal :

1. Long styled with normal ovary.
2. Medium styled with normal ovary.
3. Short styled with rudimentary ovary.
4. Pseudo-short styled with rudimentary ovary.

It is first type which sets fruit. In case of cluster bearing type e.g. Pusa Purple Cluster, all flowers in the cluster are of first type i.e. long

styled with normal ovary. That is why all flowers set fruits.

Pollination : In brinjal cone like formation of anthers favour self pollination, in the same way as it occurs in tomatoes. The anthers discharge the pollens through terminal pores. Since stigma ultimately projects beyond the anthers, therefore, there is ample opportunity for cross pollination because in such position, it comes more easily into contact with insects (bumble bees) visiting the flowers. Cross pollination in India under Delhi conditions is 1.1 to 1.99%, whereas in Bulgaria 30-40% and in Japan 0.2 to 46.8%.

Opening of flowers in brinjal starts by 7.00 or 8.00 a.m. depending upon the temperature. Lower temperature delays the opening. The opening of flowers continue till 2.00 p.m., after which flowers start closing back which continue till late evening. The same flower reopen next day and similar cycle continues for three-four days. The receptivity of stigma is maximum on the day of anthesis and decreases in following days.

Isolation : Minimum isolation recommended for the production of foundation seed is 300 metres and for certified seed is 150 metres.

Soil : Generally, silt loam and clay loam soils are preferred for brinjal. The soil should be deep, fertile and well drained and should have pH around 6.5 for higher seed yield.

Manures and fertilizers : Being a long duration crop, requires good amount of manures and fertilizers. The general recommendations for improved varieties are 25 tons of FYM or compost, 100 kg nitrogen, 50 kg phosphorus and 25 kg potash per ha. FYM should be applied at the time of land preparation. Full dose of phosphorus and potash and one third of nitrogen should be applied as basal dose. The remaining nitrogen should be applied in two equal instalments as side dressing at 30 and 60 days after transplanting.

Seed rate : 400-500 g/ha.

Sowing time : For seed production in northern plains, only rainy season crop is recommended. Seed is sown in well prepared nursery beds in the month of June-July.

Nursery raising : Seed is sown in raised beds in lines about 8-10 cm apart. Cover the seed with well rotten FYM. Irrigate the nursery beds in the morning and evening daily. When the plants are about 4-5 cm tall, thinning is done to avoid over crowding.

Transplanting : During the month of July-August, when the seedlings are about 4-5 weeks old and 12-15 cm in height are transplanted in well prepared field. In general, seedlings of long fruited varieties are transplanted at a spacing of 60x60 cm whereas, round fruited varieties are transplanted at a spacing of 75x75 cm. Transplanting should preferably be done in the evening and should be followed by light irrigation.

After care of crop : Gap filling if required, is done 4-5 days after transplanting at the time of second irrigation. Later irrigation is applied as and when required to maintain proper moisture level in the field. Brinjal is shallow rooted crop, hence require frequent irrigations.

Initially brinjal is slow growing crop, hence incapable to offer any competition to the aggressive weeds. Infestation of weeds also increases insects-pests and diseases. Therefore, the weeds should be controlled as soon as they appear, either by the traditional methods of hand weeding and hoeing or by application of herbicide. For chemical weed control spray one kg pendimethalin (3.3 litre Stomp 30 EC in 650 litre of water) per hectare 3-4 days after transplanting.

Rouging : The elimination of off-types on plant basis is most essential. Plant characters, fruiting habit, fruit characters and infection of diseases is taken into consideration while rouging. Plants affected with seed borne

diseases like phomopsis fruit rot should also be rogued out. Plants affected with little leaf disease should also be eliminated since they become unproductive. First roguing is done on the basis of foliage characters before flowering. Second roguing is done at the time of early fruiting stage and third roguing when fruiting is complete.

Specific requirement (Field standards)

Factors	Maximum permitted %age	
	F. seed	C. seed
Off type	0.10	0.20
Seed borne diseases (Phomopsis blight)	0.10	0.50
Not seed borne disease (little leaf)	0.50	2.00

Field Inspections : Number and plant growth stages for field inspection for certification are :

1. Before flowering
2. Full flowering/immature fruit stage
3. Mature fruit stage

Harvesting and seed extraction

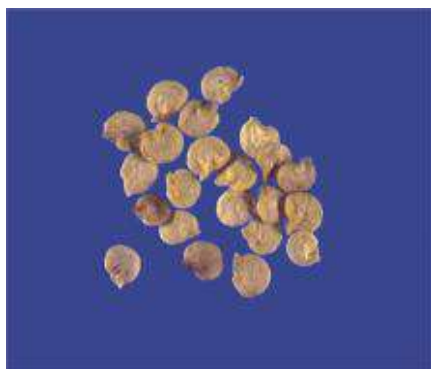
The mature yellow fruits are harvested, cut into pieces and crushed after adding required quantity of water. The material is then fermented for 48-96 hours (depending upon temperature). After fermentation the material is washed repeatedly with water to separate seeds from pulp. Clean seed is then dried under shade.

Seed yield : Depending upon the variety and condition of crop, seed yield varies from 4.0 to 6.0 q/ha.

Seed Standards (%)

Factors	Class of seed	
	F. seed	C. seed
Pure seed (minimum)	98.00	97.00
Inert matter (maximum)	2.00	2.00
Other crop seeds (maximum)	None	None
Weed seeds	None	None
Germination (minimum)	70.00	70.00
Moisture content (maximum)		
i) Ordinary container	8.00	8.00
ii) Vapour proof container	6.00	6.00

CHILLI AND SWEET PEPPER



The native home of chilli is considered to be tropical America, particularly Brazil. Portuguese introduced it to India in seventeenth century and is grown practically all over the country. The varieties of chilli are broadly divided into two groups, long pungent types and bell-shaped non-pungent mild, thick fleshed type. The non-pungent types are used as vegetables and commonly known as 'Sweet pepper' or 'Shimla mirch'. The seed production of Shimla mirch is either done in the hills during summer or in areas with mild climate like that of Bangalore. Pungent type chillies are grown for their green and dried ripe fruits. Its ripe fruits are bright red, slender and thin walled which are specially liked for pungency and spicy taste. The seed of pungent types can be produced successfully in northern plains of India. The special features of seed production of pungent type are as under:

Climate :

Chilli can be grown in both tropical and sub tropical areas at altitudes ranging from sea level to 2000 metres above MSL. Temperature ranging from 20 to 25°C is ideal for chilli production. It is susceptible to frost. A warm and humid climate with moderate rainfall (60-120 cm) favours growth while dry weather enhances fruit-maturity. Good germination occurs at soil temperature of 17-30°C. High light intensity increases the yield but reduces the capsaicin content (pungency) and fruit colouring is delayed considerably. Low soil moisture during

blossom development and fruit formation results in abscission of buds, flowers and small fruits.

In capsicum, fruit development is adversely affected at temperature of 37.8°C or more. High temperature and low humidity at flowering results in abscission of buds, flowers and small fruits. Higher night temperature increases the capsaicin content.

Varieties

CHILLI

NP-46,A : Plants are dwarf and spreading type. The pods are red measuring about 10.5 cm long. The cultivar is less seeded and contains 0.53 mg capsaicin per gram of fruit.

Pusa Jwala: This is an early cultivar. The plants are long, thin and usually curved. The pods are red. The dried fruits have shrunken skin. The fruits contain 0.48 mg capsaicin/gram of fruit.

Hisar Shakti : Plant erect and medium in height, leaves light green in colour. Fruits 8-9 cm long, dark red at ripening and high in capsaicin content. Resistant to tomato mosaic, cucumber mosaic and leaf curl disease.

Hisar Vijay : Plants alike Hisar Shakti, leaves large and green in colour. Fruits 8-9 cm long, smooth and bear in clusters. Fruits highly

pungent and good for making powder. Resistant to tomato and cucumber mosaic and leaf curl.

Pant C-1 : Plants are erect and 50-60 cm tall. Fruits are green when immature and red when ripe. Fruit surface smooth with a blunt apex. Fruits 6-7 cm long and highly pungent. Leaf curl and mosaic incidence very low.

SWEET PEPPER

California Wonder : Plants are vigorous, upright and prolific. Fruits are 3-4 lobbed, upright, smooth with medium thick sweet flesh.

Yellow Wonder : Plants dwarf and prolific bearer. Fruits large, 3-4 lobbed, medium thick flesh, mild and sweet in taste.

Chinese Giant : Plants are vigorous and prolific bearer. Fruits are 3-4 lobbed, smooth, thick sweet flesh and the skin is dark green.

Flower character and pollination :

The flowers are complete, usually borne singly and open in the morning between 2.00 to 10.00 a.m. The anthers normally dehisce an hour after the flower opening and maximum dehiscence is between 8.00 to 10.00 a.m. Pollen viability and stigma receptivity is maximum on the day of anthesis. Flower opening and anther dehiscence to a large extent depend on the weather condition. During cold and cloudy days, the opening is delayed.

In sweet pepper, anthesis takes place between 7.15 to 11.15 a.m. and anther dehisce 30 minutes after anthesis. The stigma remains receptive upto two days from the day of anthesis. These are self as well as cross pollinated crops. Cross pollination by wind and insects occurs from 10 to 20 per cent, therefore, these crops have been put in often- cross pollinated group.

Isolation :

Since these are often-cross pollinated crops and chilli can also cross pollinate with Shimla mirch, therefore, they should be isolated from each other in addition to their own varieties. A

minimum isolation distance of 500 meters for foundation seed and 250 meters for certified seed is necessary.

Soil :

A well drained sandy loam or loamy or clay loam soils rich in organic matter and lime are best suited for chilli production. Acidic and alkaline soils are not suitable. Although sweet pepper can grow almost in all types of soil, well drained clay loam soil is considered ideal. It can withstand acidity to a certain extent. The ideal soil pH for sweet pepper is 6.0-6.5.

Manures and fertilizers :

Incorporate 20 to 25 tonnes per hectare well rotten FYM or compost at the time of field preparation. The requirement of fertilizers varies with fertility status of the field, however, generally 65 kg nitrogen, 30 kg each of phosphorus and potash is recommended. One third dose of nitrogen and full dose of phosphorus and potash be applied at the time of last ploughing. Remaining nitrogen should be applied about 6 weeks after transplanting.

Seed rate :

One kg seed per hectare is sufficient.

Time of sowing :

In northern plains, for chilli seed production the seed is sown in nursery during May-June. The sweet pepper is generally sown for autumn-winter and in November for spring-summer crop. In hilly areas of north-India seed is sown in nursery in March-April (under cover).

Transplanting :

Five-six weeks old seedlings of chilli and four-five leaved seedlings of sweet pepper are transplanted in well prepared field at a spacing of 60x45 cm. The nursery beds should be irrigated before seedlings are lifted. Transplanting should preferably be done in evening and should be followed by irrigation.

Care of the crop :

Gap filling should be done 4-5 days after transplanting i.e. at the time of second irrigation. These are shallow rooted crops, hence require irrigation at frequent interval. Depending on the rainfall, irrigate the field at an interval of 4-7 days during summer and 12-15 days during winter. When there is danger of frost irrigate the field to keep the soil moist.

Chilli a slow growing crop is incapable of offering any competition to aggressive weeds. The weeds should be kept under check either by traditional method of hand weeding and hoeing or by using herbicide i.e. spray 1.0 kg pendimethalin/hectare (3.3 litres of stomp, 30 EC in 625 litres of water) 3-4 days after transplanting.

Flower and fruit drop :

There is a problem of flower and fruit drop in chilli, particularly in the early stage i.e. in the month of August-September. To overcome this problem, the crop may be sprayed with 10 ppm NAA (one ml planofix in 4.5 litres of water) at the time of flowering. Second spray should be done three weeks after the first spray.

Specific requirement (Field standards)

Items	Max. permitted (%age)	
	F. seed	C. seed
Off type	0.10	0.20
Seed borne diseases (leaf blight, anthracnose)	0.10	0.50
No seed borne diseases (viruses)	0.50	2.00

Roguing :

Roguing is done on the basis of plant as a whole rather than individual fruits. The off-types on the basis of growth (particularly leaf size), flowers and fruits (shape and colour) should be removed as soon as they are observed. Minimum three roguings are carried out at early growth stage, flowering stage and full fruiting

stage. Plants affected with virus and seed-borne diseases (leaf blight and anthracnose) should also be removed.

Field inspections :

Number and stages of field inspection for the purpose of certification are as under :

1. Before flowering
2. At flowering and immature fruit stage
3. Mature fruit stage

Harvesting and seed extraction :

Red ripe fruits of chilli are harvested and dried in the sun. Completely dried fruits are threshed and winnowed or the seed is extracted with the help of machine (seed extractor). Thereafter, the seed is dried to 8 per cent moisture content.

The fruits of sweet pepper should be picked when red ripe, cut and crushed. Seed is repeatedly washed to make it free from pulp and skin. After washing it should be dried in sun.

Seed yield :

Depending on the variety, seed yield of chilli varies from 3 to 5 qtl/ha, whereas that of sweet pepper 1-2 qtl/ha.

Seed Standards (%)

Items	Class of seed	
	F. seed	C. seed
Pure seed (minimum)	98.00	97.00
Inert matter (maximum)	2.00	2.00
Other crop seeds (maximum)	0.05	0.10
Objectionable weed seed (max.)	0.05	0.10
Germination (minimum)	60.00	60.00
Moisture content		
(i) Ordinary container	8.00	8.00
(ii) Vapour proof container	6.00	6.00

Plant Protection Measures

Tomato

Pests

1. Whitefly (*Bemesia tabaci*)

These are minute white insects which suck sap from lower side of leaves and leaves turn yellow. It acts as nectar to transmit leaf and disease.

2. Jassids (*Empoasca devastans*)

They suck the sap from lower side of leaves causing curling of leaves.

Control : Whitefly and jassid can be controlled by spraying 1.0 litre of Malathion 50 EC in 625 litre of water per ha at an interval of 15 days.

3. Fruit borer (*Helicoverpa armigera*)

The moths are brown to yellowish brown with slight strips. The caterpillars are greenish which after hatching crawl over the leaves and feed on tender leaves, buds, flowers and cuts holes and furrow in flowers.

Control : This insect can be controlled by spraying any of the following insecticides in 625 litres of water per ha.

- (i) 190 ml Fenvalerate 20 EC or 500 ml Deltamethrin 2.8 EC or 150 ml Cipermethrin 25 EC or 375 ml Cipermethrin 10 EC.
- (ii) 1.250 litre Endosulfan 35 EC or 1.250 kg carbaryl 50 W.P.

Note : For effective control spray any of the insecticide given in i) and ii) alternately.

4. Root knot nematodes (*Melodogyne sp.*)

Plants infected with root-knot nematodes remain dwarf, foliage discoloured (yellowish) and growth remain stunted. Roots contain swelling which vary from spheroid gall to elongated spindles.

Control :

- (i) To raise root-knot nematode free seedlings, treat the nursery with carbofuron (Furadon 3G) @ 7 g per square meter.
- (ii) Practice deep ploughing during May and June.
- (iii) Grow resistant variety like Hisar Lalit.

Diseases

1. Damping off and root rot

This disease is caused by *Pythium* spp., *Rhizoctonia solani*, *Phytophthora parasitica* etc. This is very serious disease of nursery which kills the seedlings pre- and post-emergence. Symptoms of post-emergence damping off consists of rapid shrinking and darkening of cortical tissue of the hypocotyls.

Control : Treat the seed with 2.5 g Emisan or Captan or Thiram per kg of seed before sowing. After germination, nursery beds should be drenched with 0.2 per cent Captan (2 g Captan in one litre of water).

2. Early blight

Round or triangular brown spots are scattered over the leaf. These spots later show concentric narrow dark lines. Older spots become dark brown. In severe cases plants dry up and dies. On fruits these spots first appear on the stem-end.

Control :

- (i) Do not over irrigate the nursery.
- (ii) Treat the seed as suggested in damping off.
- (iii) Spray the crop with Difolatan or Mancozen or Indofil M-45 @ 1.0 kg in 500 litre of water per ha. Repeat the spray after 10-15 days.

3. Leaf curl and mosaic (viruses)

These diseases result in stunted plant growth, leaves characterized by curling and reduction in size or thick with uneven surface.

Fruits remain smaller in size and in severe cases plants remain unfruitful.

Control : Use healthy and disease free seed. Control whitefly (nectar) in nursery as well as in fields by spraying insecticides suggested for the control of whitefly. Virus infected plants should be rogued out from the very beginning.

Plant Protection Measures

Brinjal

Pests

1. Shoot and fruit borer (*Leucinodes orbonalis*)

This insect alone may cause of loss upto seventy per cent in yield. The short pinkish larvae attacks the terminal shoots and bores inside as a result of which the shoots wither and dry. It also bores into young fruits by making holes and feeds inside. In severe cases, it may cause totting of fruits.

2. Epilachna beetle (*Epilachna dodecastigma*, *Henosepilachna vigintioctopunctata*)

It is a polyphagous insect that feeds on the leaves of potato, brinjal, tomato etc. The grubs are yellowish in colour and stout-bodies with stiff hairs on their bodies. Beetle is bronze to red, small, spherical and mottled with black spots. The grub and adults feed on leaves and tender parts of the plant. As a result of the feeding of green chlorophyll, skeletonized patches (lace-like) appears on the leaves and ultimately leaves dry away.

3. Red spider mite (*Tetranychus neocaledonicus*, *Tetranychus cinnabarinus*, *Paratetranychus indicus*)

These are small, polyphagous insects found in large colonies on underside of the leaves covered with fine silky webs. As a result of their feeding, white specks appear on the leaves

which develop into white patches. The entire affected leaf becomes discoloured and withers.

4. Aphid (*Aphis grossypii*, *Myzus persicae*)

The aphid is small, soft, yellowish green or greenish brown insect found in colonies on tender shoot and undersurface of tender leaves. Both nymphs and adult suck the sap of leaves. Affected leaves curl, fade gradually and finally dry up.

5. Whitefly (*Bemisia tabaci*)

White minute insects which suck the sap from the lower side of leaves. The affected leaves turn yellow.

Control : To control all above mentioned pests spray one litre malathion in 625 litres of water at an interval of 15 days. As the fruiting starts spray synthetic-parathyroid (20 ml Fenvelrate – 20 EC, 175 ml Cypermethrine 25 EC and 500 ml Deltamethrine 2.8 EC) and other insecticides (1.250 kg Carbaryl 50 WP, 1.250 litre Endosulfan 35 EC) in 625 litres of water per hectare about 40 days after transplanting. Spray of synthetic parathyroid should be repeated at an interval of 21 days while other insecticides at 15 days interval.

Note : Remove all branches infested with borer and burn them.

6. Root knot nematodes : As in tomato crop.

Diseases

1. **Damping off :** As in tomato.

2. Phomopsis blight (*Phomopsis vexana*)

This is serious disease of brinjal. Infestation of this fungus may cause seedling blight, leaf spot and fruit rot. In seedling infection, it causes damping-off symptoms. On leaves circular spots appear which become grey to brown with irregular blackish margins. The affected leaves may turn yellow and die. Infected area on fruits turn brown and fruits begin to rot.

Control :

1. Use clean and disease free seed.
2. Treat the seed with Thiram or Captan @ 2.5 g/kg of seed before sowing.
3. Spray Zineb or Dithane M-45 @ 1 kg/ha in 625 litres of water at weekly interval after fruit formation.

3. Little leaf (*Mycoplasma*)

Little leaf affected plants generally remain shorter in stature, but possess a large number of branches, roots and leaves than a healthy one. The petioles get shorter considerably. The leaves are malformed into tiny chlorotic structures and plants give a bushy appearance. Flower parts are deformed leading the plant to be sterile.

4. Mosaic

Plants infected with viral disease are stunted in growth and show mosaic symptoms on leaves.

Control :

- (i) Rogue out little leaf and mosaic affected plants from the field as and when noticed.
- (ii) Treat the roots of seedlings with tetracycline solution (500 mg/litre of water) for half an hour before transplanting.
- (iii) Control insect vectors (aphid and whitefly) in nursery bed and also after transplanting in the field.

Chilli

Pests

1. Termite (*Odontotermes obesus*) or white ants

It is found in abundance in sandy soils. Its infestation starts soon after germination/transplanting and may continue till harvest. The pest being sub-terranean, lives at the roots and stem below the ground level and tunnels upwards.

The affected plants turn pale, wither and dry away.

Control

- (i) Remove all stubbles of the previous crop.
- (ii) Sandy and termite infested soil should be avoided.
- (iii) Soil application 3.75 litre chloropyrifos 20 EC or 3.75 litre endosulphan per hectare is effective in minimizing the attack of termite.

2. Thrips (*Scirtothrips dorsalis*)

The larvae and adults infest tender leaves and feed on the sap causing curling of leaves. Severe infestation causes heavy curling and stunting of the crop. Buds and flowers are also damaged.

3. Aphids (*Aphis gossypii*)

The insects suck the cell sap from leaves and petioles and cause considerable loss in yield.

4. Whitefly (*Bemisia tabaci*)

These are minute white insects and suck the sap of the plants. It acts as vector for transmitting leaf curl disease.

5. Mites (*Polyphagotarsonemus latus*)

The tiny spider like creature may be found in large number on the underside of leaves, covered with fine webs. Both nymphs and adults suck the cell sap and devitalize the plants.

Control

To control thrips, aphids, whitefly and mites spray one litre malathion 50 EC in 625 litre of water per hectare at 15-20 days interval.

Diseases

1. Damping off : As in tomato crop.

2. Anthracnose and fruit rot (*Colletrotrichum capsici*)

The symptoms of this fungus appear mostly on ripened fruits. The spots are usually circular and sunken with black margins. As the diseases advances, the spots start spreading. The fruits with many spots drop off prematurely resulting in heavy loss in yield. The fungus may also attack the fruit stalk and spread along the stem causing dieback symptoms.

Control

- (i) Treat the seed with thiram or captan or emisan @ 2.5 g/kg of seed before sowing.
- (ii) Spray the crop with 1.0 kg copper oxychloride (Blitox-50, Phytolan) or Mancozeb (Dithane M-45) or Zineb in 625 litre of water per hectare at 10-15 days interval.

3. Leaf curl and Mosaic (viruses) :

As in tomato crop.

CUCURBITACEOUS VEGETABLES



Being warm season crops, cucurbits are of tropical origin, mostly in Africa, tropical America and South-East Asia. This group consists of a wide range of vegetable crops cultivated in India. Cucurbits are used either for cooking (all the

Crops

English name	Hindi name	Botanical name
1. Muskmelon	Kharbuja	<i>Cucumis melo</i> L.
2. Cucumber	Khira	<i>Cucumis sativus</i> L.
3. Longmelon	Kakri	<i>Cucumis melo</i> var. <i>Utilissiemus</i> Duth & Full
4. Watermelon	Tarbuz	<i>Citrullus lantus</i> (Thumb) Masurs and Naki
5. Round melon (Indian squash)	Tinda	<i>Citrullus fistulosus</i> Duthie and Fuller Syn.
6. Bottlegourd	Lauki, Ghiya	<i>Lagenaria siceraria</i> (mor) Stand 1
7. Bittergourd	Karela	<i>Momordica charantia</i> L.
8. Ridgegourd	Kali Tori	<i>Luffa acutangula</i> (Roxb) L.
9. Spongegourd	Ghia tori	<i>Luffa cylindrica</i>
10. Pumpkin	Sitaphal	<i>Cucurbita moscheta</i> Duch ex poir
11. Summer squash	Chappan kaddu	<i>Cucurbita pepo</i> L.
12. Wax gourd or Ash gourd	Petha	<i>Benincasa hispida</i> (Thunb) Gogn.

gourds) or as salad (cucumber and longmelon) or as desert fruits (muskmelon and watermelon) or candied or preserved (ash gourd). In general, the cucurbits are annual except few perennials like chow-chow and Ivy gourd. Most of the cucurbits are propagated by seed, besides few vegetatively propagated ones like pointed gourd (parwal). This group commonly called vine crops belong to the family 'cucurbitaceae'. This family include about 117 genera and 825 species distributed in the warmer regions of the world. In India alone 36 genera and about 100 species of cucurbits have been reported, however, in this chapter seed production method for crops commonly grown in North-India is discussed below.

Climate :

Cucurbits are warm season crops hence, mainly cultivated in tropical and sub-tropical regions. For proper growth and development cucurbits require long warm dry weather and abundant sunshine except few which do not stand extreme dry weather but require moderate humid conditions (pointed gourd). These crops are sensitive to even slightest frost, hence require partial protection if grown during winter months (river bed cultivation). Excessive humid conditions promote diseases and pests.

Most of the cucurbits germinate best when day temperature is above 25°C. For normal growth average monthly temperature should be around 30°C with minimum and maximum range between 20°C to 40°C. As compared to other cucurbits, cucumber and summer squash prefer slightly lower temperature hence are grown extensively in subtropical regions and lower hills. In hills, summer squash and cucumber are grown in summer (April-August). Melons grow best in tropical climate with fairly high temperature of 35 to 40°C particularly during fruit development stage. Other such as gourds are grown mostly in summer as well as rainy season.

Varieties

MUSKMELON

i) Hara Madhu : Released by P.A.U., Ludhiana. A shy bearer late variety. Fruits globose with dark green strips, flesh colour light green, juicy and very sweet (12 to 15% TSS). Average weight of fruit one kg, keeping quality poor.

ii) Punjab Sunehri : Released by P.A.U., Ludhiana. Vine length about two meters, leaves dark green. Early maturing, fruits flattish, round, pale green, thick skin, flesh salmon-orange thick with moderate sweetness (11 to 12% TSS). Good for distant markets.

iii) Pusa Sarbati : Released by IARI, New Delhi. An early variety, maturing in 85 days, with round fruits having netted skin. Flesh thick and firm with salmon-orange colour. Seed cavity small. Moderately sweet (11-12% TSS).

iv) Pusa Madhuras : Released by IARI, New Delhi. Vine length good with green leaves having long petiole. Fruits flatish-round and smooth, yellow colour having green strips. Flesh orange, juicy and very sweet (12-14% TSS). Average fruit weight is 1.1 kg.

v) Durgapura Madhu : Developed by Agricultural Research Centre, Durgapura. Fruits oblong, medium size, skin smooth and light green. Flesh green, juicy and very sweet (13-14% TSS). Average fruit weight 600 g.

CUCUMBER

i) Poinsette : An American introduction multiplied by National Seeds corporation. Originally developed at Charleston (South Carolina) USA. Fruits dark green, 20 to 25 cm long and cylindrical. Resistant to downy mildew, powdery mildew, anthracnose and angular leaf spot diseases.

ii) Japanese Long Green : A temperate cultivar released by IARI Regional Station, Katrain (Kullu valley) H.P. suited to hills and

lower hills. Very early, matures in 45 days, fruits 30-40 cm long, flesh light green.

iii) Straight eight : Released by IARI, Katrain. Early cultivar suited to hills, white spined, fruits medium long, thick straight with round end, colour medium green.

iv) Kalyanpur Green : Vines of this variety are about 2.5 meters long with light green hairy leaves. Fruits green and ready for picking in 60 days.

v) Khira-60 : Developed at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. Fruits cylindrical, long having good girth, crisp with tight flesh. Fruits green with white stripes, apical end yellowish.

LONGMELON

i) Lucknow Early : An early variety, prolific bearer, fruits long and light green in colour.

ii) Karnal Selection : Developed by CCS HAU, Hisar. Early and prolific bearer, fruits long, light green, tender and flesh crispy.

iii) Punjab Longmelon-1 : Released by PAU, Ludhiana. Fruits long, smooth and fleshy.

WATERMELON

i) Charleston Grey : Old variety of USA characterized by large sized oblong to cylindrical fruits. Flesh red, thick with less seeds. Suitable for long distance transportation. Resistant to fusarium wilt and anthracnose.

ii) Sugar Baby : An early American introduction released by IARI, New Delhi. Fruits smaller weighing 3-5 kg, round having bluish black rind, deep pink flesh (11 to 13% TSS) and small seeds. Fruits ripen in 85 days.

iii) Asahi Yamato : A mid-season Japanese introduction released by IARI, New Delhi. Fruits medium weighing 6 to 8 kg. Rind colour light green with deep pink flesh (11 to 13% TSS). Fruits ripen in 95 days.

iv) Special No. 1 : Released by PAU, Ludhiana. Early in maturity, fruits round and small with red flesh and red seeds.

v) Improved Shipper : An American introduction released by PAU, Ludhiana. Fruits large sized weighing 7 to 9 kg, dark green with moderate sweetness (8-9% TSS).

vi) Durgapura Meetha : Released by Agricultural Research Station, Durgapura, Rajasthan. A late variety maturing in 125 days. Fruits round and light green, rind thick with good keeping quality. Flesh sweet (11% TSS) with dark red colour. Average fruit weight 6-8 kg. Seeds with black tip and margin.

INDIAN SQUASH OR ROUNDMELON

i) Hisar Selection-1 : The variety is quite heavy yielder, fruits are green and tender. Suitable for both spring-summer and rainy season.

ii) Bikaneri Green : A high yielding variety. Fruits are of green colour.

iii) Arka Tinda : An early summer season variety, fruits round, light green skin with soft hairs. Fruits reach edible stage in 5-6 days after pollination. Gives 8-10 pickings.

BOTTLEGOURD

i) Pusa Summer Prolific Long : Released by IARI, New Delhi. A prolific bearer (10-15 fruits per vine), fruits 40-50 cm long, pale green in colour. Suitable for both summer and rainy season.

ii) Pusa Navin : Released by IARI, New Delhi. Fruits green, straight, smooth, 20-25 cm long weighing about 250 g. Suitable for both summer and rainy season.

iii) Punjab Komal : Released by PAU, Ludhiana. This variety is prolific bearer (10-12 fruits per vine), fruits medium sized, light green. Bear fruits on fifth node and tolerant to cucumber mosaic virus.

iv) Pusa Summer Prolific Round : Released by IARI, New Delhi. Prolific bearer, fruits round (15-18 cm in girth when young) and green in colour.

BITTERGOURD

i) Pusa Do Mausmi : Released by IARI, New Delhi. Fruits reach edible stage in about 55 days, fruits dark green, long, medium thick, club shaped with 7-8 continuous ridges, 18 cm long at edible stage, 8-10 fruits weigh one kg. Suitable for both spring-summer and rainy season.

ii) Coimbatore Long : A selection by National Seeds Corporation, prolific bearer, fruits long and white in colour. Suitable for rainy season.

iii) Arka Harit : Released by IIHR, Bangalore. Fruits are attractive, spindle shaped with green colour, small in size with smooth regular ribs. Suitable for both summer and rainy season.

iv) Punjab-14 : Released by PAU, Ludhiana. Fruits light green weighing about 30 g, ready for picking in 65 days. Suitable for both summer and rainy season.

v) Pusa Vishesh : Developed by IARI, New Delhi. Vine growth less, hence planted at closer spacing. Fruits tender, green with medium length. Suitable for pickles and canning.

vi) Kalyanpur Baramasi : Developed at Vegetable Research Centre, Kalyanpur, Kanpur. Vines dark green, fruits 20-25 cm long, dark green with flat and pointed ends having 8-10 seeds. Picking starts in 65 days. Tolerant to fruit fly and mosaic.

RIDGE GOURD

i) Pusa Nasdar : Released by IARI, New Delhi. An early variety, starts fruiting in 60 days, fruits ridged club shaped, 15-20 per vine, light green in colour.

ii) Punjab Sadabahar : Developed by PAU, Ludhiana. Vine growth medium having dark green leaves. Fruits 3-5 cm thick, green, ridged and tender. Suitable for rainy season.

iii) Hisar Kali Tori : Developed at CCS HAU, Hisar. Vine growth vigorous with several branches. Fruits long, tender and grow very fast. Suitable for summer season.

SPONGE GOURD

i) Pusa Chikni : Released by IARI, New Delhi. An early variety, starts flowering in 45 days. Fruits 15 to 20 per vine, smooth, more or less cylindrical and dark green. Suitable for both summer and rainy season.

ii) Kalyanpur Chikini : Early variety, vine growth medium. Fruits green characterized by light strips, cylindrical, fleshy end remain tender for longer period.

PUMPKIN

i) Pusa Vishwas : Developed by IARI, New Delhi. Vine growth vigorous, leaves dark green with white spots. Fruits round and light brown. Flesh thickness good with yellow colour. Average fruit weight 5 kg and mature in about 120 days.

ii) CO-I : Released by Tamil Nadu Agricultural University, Coimbatore. Late maturing, globular fruits weighing 7 to 8 kg. Each vine produce 7-9 fruits.

SUMMER SQUASH

i) Hisar Selection-1 : An early prolific bearer variety. Fruiting starts in 25 to 30 days, fruits yellowish green and disc shaped.

ii) Punjab Chappan Kaddu : Plants bushy, fruits green and disc shaped, flesh colour white, becomes yellowish to orange at ripening. Fruiting starts in 50 days. Tolerant to powdery mildew and cucumber mosaic virus.

iii) Australian Green : An introduction released by IARI Regional Station, Katrain. Very early, plants bushy, fruits dark green and very tender at edible stage.

ASH GOURD OR WAX GOURD

i) **CO-1** : Released by Tamil Nadu Agricultural University, Coimbatore. Crop duration medium (140 days), fruits globular weighing 5-6 kg with less seeds. Six to eight fruits per vine.

ii) **CO-2** : Released by Tamil Nadu Agricultural University, Coimbatore. Early maturing (120 days), fruits small weighing 3 kg, spherical, flesh light green with less seeds. High yielder than CO-1.

Flower Characters and Pollination

Flowers are borne in singles and clusters in leaf axils. They are classified mostly as monoecious, andromonoecious (in muskmelon) and dioecious (which are usually propagated vegetatively). Staminate flowers born on long pedicels have complete corolla, free filaments and three stamens of which two stamens have two locules and one unilocular. Pistillate flowers are epigynous, usually with three carpels terminated by three bilobed or divided papillate stigma and these are usually borne singly or short peduncles.

The very fact that staminate and pistillate flowers are separate on the same plant, imposes a situation conducive to cross-pollination. This group of crops is classified, but in nature, self pollination does take place. The extent of cross pollination ranges from 60 to 80 per cent under different environmental conditions. Flowering in cucurbits, normally starts in about 40 to 45 days after sowing. The sequence of flowering follows a set pattern, namely the first 4 to 5 flowering nodes would bear staminate flowers and later pistillate or perfect flower appear on few nodes on the main axis and secondary branches. The ratio of staminate flowers to pistillate flowers within a plant is termed as sex ratio. The staminate flowers are produced in abundance than the pistillate flower (usually sex ratio ranges from 15:1 to 30:1).

Anthesis, pollen dehiscence and fruit-set in cucurbits are influenced by environmental factors. Usually, fruit set takes place in the early morning between 6 a.m. to 8 a.m. in the month of March and April in cucumber, muskmelon, watermelon and pumpkin. Optimum temperature favouring anthesis and dehiscence is from 13°C to 18°C. Cucurbits like bottlegourd and bittergourd, which flower later in the day and set fruits at higher temperature in the afternoon.

The pollination is entomophilous and bees (mostly *Apis florum*, *Apis dorsata*, *Nomioides* sp., *Halictine* sp.) are the main pollinating agents. For maximum fruit set and seed yield, availability of pollinators is a pre-requisite. Two bee-colony per hectare are recommended for obtaining higher seed yield of cucurbits.

Isolation : Minimum distance of 1000 meters for foundation seed and 500 meters for certified seed between two varieties of the same spp. has been recommended for maintaining the purity of a variety.

Method of seed production

Soil : For cultivation of cucurbits, a well drained loamy, deep, fertile soil rich in organic matter is preferred. Soil pH should be between 6 to 7. All cucurbits are sensitive to acidic and alkaline soils. For quick germination and early maturity the soil temperature should not go below 10°C and maximum beyond 25°C, the optimum range is around 18-22°C. Cucurbits require good moisture but not excessive during vegetative growth, hence it should be at least 10-15 per cent above the permanent wilting point.

Manures and fertilizers

All cucurbits respond well to organic manure and fertilizers. The dose of manures and fertilizers depend upon the soil type, fertility level, climate and method of cultivation. The general recommendations are 15 tons well rotten FYM, 50-55 kg nitrogen, 25-30 kg phosphorus and 25-30 kg potash per hectare. FYM or compost is applied about 3 weeks before

sowing at the time of field preparation. Full dose of phosphorus and potash and one third dose of nitrogen is applied before last ploughing or *in-situ* where seeds are to be sown. *In-situ* the fertilizer mixture should be mixed well into soil before seed sowing. Remaining two third nitrogen is applied in two equal splits i.e. first at the time of vining and second 15 days later. While top-dressing field should have adequate moisture, as top-dressing is followed by weeding and earthing up. It is always better to complete nitrogen application before fruit set. In general, high nitrogen, high temperature and long day conditions promote maleness and number of female/perfect flowers per vine get reduced resulting in low fruit set and low yield.

Sowing time : In north-India seed crop of muskmelon, longmelon and summer squash is sown from mid-February to 1st week of March, while other cucurbits are sown during rainy seasons i.e. June-July. In northern hills cucurbits are sown in the month of April-May.

Method of sowing : Depending on the season and crop different methods of sowing are adopted. In north-India during summer furrow method of sowing is common. In this method, furrows are made (distance as per crop requirement) and sowing is done on the top of the sides of furrow and vines are allowed to trail on the ground. During rainy season cucurbits are grown on raised beds. The width of the bed is kept as per requirement of crop. The seed is sown on both sides of furrow or channel between the beds. The essential feature of this method is that irrigation water should not spoil the fruits while the vines spread on beds.

Care of crop : Soil moisture is an important factor for good germination particularly in crops like bottlegourd, bittergourd and luffa whose seed coat is thick, therefore, adequate moisture has to be maintained at the time of emergence. Usually the furrows or channels are irrigated a day or two prior to sowing. After sowing light irrigations are given at four-five days interval to

maintain soil moisture and prevent crust formation. After germination, irrigate the crop as per requirement. The interval of irrigation will depend upon the soil, season and temperature. In general, summer crop is irrigated at an interval of 6-7 days, while in rainy season if the rainfall is well distributed, irrigation may not be required at all. Do not over irrigate the crop ever. Irrigation water should be restricted to the base of plant or root zone and it should not wet the vines or vegetative parts, particularly during flowering, fruit set and fruit development stage. Usually, irrigation frequency is reduced, when the fruits reach near maturity and completely stopped in the last stage of harvest. In early stages of crop growth, field should be kept free from weeds.

Seed rate and planting distance

Crops	Seed rate (kg/ha)	Planting distance	
		Row to row (meters)	Hill to hill (cm)
Muskmelon	2.5-3.0	2.0-2.5	45-60
Cucumber	2.5-3.0	1.5-2.0	45-60
Longmelon	2.5-3.0	1.5-2.0	45-60
Roundmelon	5.0-6.0	1.5-2.0	45-60
Watermelon	3.5-5.0	3.0-4.0	60-90
Bottlegourd	4.0-5.0	3.0-4.0	60-90
Bittergourd	4.0-5.0	1.5-2.0	30-45
Ridge gourd	4.0-5.0	3.0-4.0	60-75
Sponge gourd	4.0-5.0	3.0-4.0	60-90
Pumpkin	5.0-6.0	2.5-3.5	60-90
Summer squash	4.0-5.0	0.75-0.90	45-50
Wax gourd	5.0-6.0	2.5-3.5	60-90

Roguing : The cross pollinating nature of cucurbits promote variation even within a pure cultivar. Therefore, removal of off type variants (on the basis of growth, flowering and fruiting habit and fruit characters) is absolutely necessary to maintain purity of a cultivar. In most of the cucurbits selection of desirable plants is possible at the time of fruit maturity, where fruit quality and other fruit characters can be verified (in other words pollination precedes selection unlike in onion, root crops and cole crops). As

in case of melons where fruit quality is judged by flesh colour, flesh thickness and TSS. At the time of fruit maturity characters like spine colour in cucumber, netting and strips in rind of muskmelon, strips and rind pattern in watermelon can help in early detection of variants, but not before pollination. Therefore, to maintain purity, all wild species and off type plants should be rogued out before flowering. All plants infected by mosaic and viruses should be rogued out as and when observed. In fact there is need to constantly watch the crop and continuous rouging during vegetative, flowering and fruit development stage should be carried out.

Specific requirement (Field standards)

Items (for all cucurbits)	Max. permitted %age	
	F. seed	C. seed
Off type	0.10	0.20
Seed borne diseases (mosaic in muskmelon)	0.10	0.20
Not seed borne diseases (viruses)	0.10	1.00
Wild spp/objectionable weeds	None	None

Field inspections : Number and plant growth stages for field inspection for certification purposes for all cucurbits are as under :

1. Before flowering
2. At flowering and immature fruit stage
3. Mature fruit stage

Harvesting and seed extraction

For seed purpose harvest only the earlier set, full size ripe fruits because such fruits produce plump seeds and higher yield.

In case of bottlegourd, sponge gourd, ridge gourd and summer squash seed is extracted when fruits are dry and seeds rattle inside the shell. The shells have to be broken to extract the seed and clean them.

In case of muskmelon and watermelon select fully mature and ripe fruits on the basis of quality characters (TSS and flesh colour). Besides

muskmelon and watermelon, the seed of cucumber, longmelon, roundmelon, bittergourd, pumpkin and wax gourd is mixed with pulp and placenta. There are three methods of seed extraction :

- i) The seed of these crops is scooped out with pulp. This scooped material is rubbed with sand or ash (to remove the pulp), washed and dried.
- ii) The pulp with seed is fermented for 48 hours (add some water, if required). This fermented material is washed to separate the seeds from pulp and then seed is dried.
- iii) The seed can also be separated by acid treatment. Add 25 to 30 ml HCl or 10 ml commercial sulphuric acid per 25 kg of pulp containing seed and stir well and left for 25-30 minutes. Then wash the seed thoroughly to remove the acid, pulp and floating seeds. After washing seed is dried in sun.

Seed yield : Seed yield varies with location and availability of pollinators, however, the average seed yield is given below :

Crops	Seed yield (q/ha)
Longmelon, muskmelon, watermelon, roundmelon	2-3
Cucumber	1-2
Bottlegourd, spongegourd, summer squash	5-6
Bittergourd, ridgegourd	4-5

Seed Standards (%)

Items	Class of seed	
	F. seed	C. seed
Pure seed (minimum)	99.00	99.00
Inert matter (maximum)	1.00	1.00
Other crop seeds (maximum)	0.05	0.10
Total weed seed (maximum)	0.10	0.10
Objectionable weed seed (max.)	None	None
Germination (minimum)	60.00	60.00
Moisture content (maximum)		
i) Ordinary container	7.00	7.00
ii) Vapour proof container	6.00	6.00

Plant Protection Measures

Pest

1. Red pumpkin beetle (*Raphipolpa foveicollis*)

These are orange-red coloured elongated small beetles. The beetles attack most of the cucurbits at seedling stage and make holes in cotyledonary leaves. In case of severe attack the crop is totally destroyed. They attack the vines in grown up stage also. Grubs feed on the roots at a depth of 5-10 cm resulting in wilting of plants.

Control

Dusting with 12.5 kg carbaryl 55 dust + 12.5 kg ash per hectare or spray 500 ml endosulphan 35 EC or 60 ml. Cypermethrin 25 EC or 150 ml cypermethrin 10 EC or 75 ml fenvalerate 20 EC or 250 g carbaryl WP in 250 litre of water per hectare. For the control of grubs apply 4.0 litre chloropyrifos 20 EC or 2.5 litre endosulphan 35 EC with irrigation water on moth after sowing.

Note:

- (i) Use only recommended quantity of pesticides as cucurbits are sensitive to pesticides.
- (ii) Do not dust when leaves are wet.

2. Aphids (*Aphis* sp.), Jassids (*Amrasca biguttula*) and Mites (*Tetranychus* sp.)

These pests cause damage by sucking the plant sap.

Control

To control these pests spray 625 ml malathion 50 EC in 625 litre of water hectare at 10 days interval.

3. Fruitfly (*Bactrocera cucurbitae*)

The adult fly lays eggs below the skin of the young ovaries. The eggs hatch into maggots

which feed inside young fruits and cause rotting. The fly attack is severe after summer rains when the humidity is high. The damage is more serious in long melon, muskmelon, ridge gourd, bitter gourd, Indian summer melon and watermelon.

Control

Control of maggots is difficult because they are inside the developing fruits. The adult flies can be controlled by spraying 625 ml fevithion (Eccothion/folithion/sumithion) 50 EC or 1.0 litre malathion 50 EC or 1.250 kg carbaryl-50 WP in 625 litre of water. Add 3.0 kg Gur molasses in this solution. Repeat the spray at 10 days interval.

Note : Collect and destroy the rotten fruits.

Diseases

1. Powdery mildew (*Sphaerotheca fuliginea*)

The fungus forms white floury patches or coating on the leaves, stem and other succulent parts of the plant, particularly in dry weather. In severe cases disease covers both the surfaces of leaves which shrivel and defoliation may occur. Fruits of affected plants do not develop fully and are poor in quality and flavour.

Control

A single dusting of fine sulphur dust @ 20-25 kg/hectare on the affected plant check the disease entirely. Apply dust in the morning or in the evening. Avoid dusting when the temperature is high during the day.

Do not dust sulphur on muskmelon spray the crop with 0.25% wettable sulphur (sulfex or wetsulf) i.e. 1.250 kg wettable sulphur in 500 litre of water per hectare to control the disease.

2. Downy mildew **(*Pseudoperonospora cubensis*)**

This disease is prevalent in areas of high humidity, especially when summer rains occur regularly. The disease is characterized by formation of yellow or purplish, angular spots on upper surface of leaves. This disease spreads rapidly. In severe cases leaves dry up and death of plant may occur.

Control

Spray the crop with Dithane M-45 or Blitox-50 (one kg in 500 litre of water/ha) and repeat the spray at 10-15 day interval. Never use blitox in muskmelon crop.

3. Anthracnose (*Colletotrichum* sp.)

This disease is promoted by high humidity and moist weather. In case of muskmelon and cucumber reddish brown dry leaf spots are formed which cause shriveling and death of leaf. Lesions on petioles and stems are water soaked and yellowish. The leaf spots on watermelon are black and presents a scorched appearance. It spreads to fruit in bottle gourd and watermelon in severe case of incidence.

Control

Spray 500 g of Dithane M-45 in 250 litre of water per hectare. Repeat the spray at 7-10 days interval.

4. Gummy collar rot **(*Mycosphaerella citrullina*)**

Muskmelon is affected by this disease mostly in April-May. Symptoms consist of yellowing at collar region followed by stem splitting and oozing of gum like substance.

Control

To control this disease spray the affected stem at soil level with 0.1% Carbendazine or Bavistin.

5. Mosaic

Leaves of affected plant shows yellowish and greenish spots. Fruit yield is reduced considerably.

Control

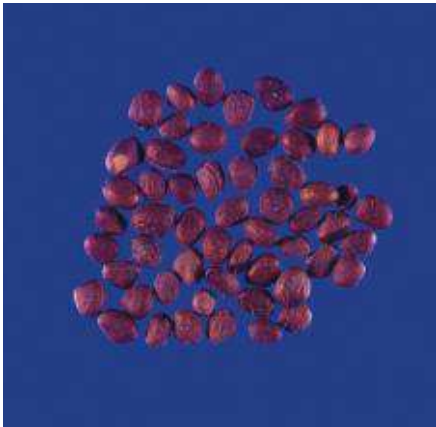
- (i) Rogue out all infected plants.
- (ii) To control insect vectors spray insecticide as suggested for jassids and aphids.

ROOT CROPS

Commercially cultivated root crops in north India are radish and carrot. These root crops have two distinct types i.e. temperate or European and tropical or Asiatic types. Owing to the special climatic requirements, the seed of temperate types can only be produced in the hills. The Asiatic type can produce seed both under plains and hill conditions.

All these crops are considered biennial from seed production point of view, because in the first season when the seed is sown, the plants form root and rosette of leaves (vegetative stage). In the second season, when the roots are planted, they produce flowering shoots, flowers and form seed.

RADISH



Radish (*Raphanus sativus* L.) belongs to family cruciferae. It is one of the most ancient vegetable and popularly grown in both tropical and temperate regions. Radish is a good source of vitamin C and variety of minerals. Leaves of radish are good source of protein and young leaves are cooked as vegetable. Roots are eaten raw as salad. Radish preparations are useful in liver and gall-bladder troubles.

Climatic requirement

For proper vegetative growth and root development of radish, cooler or moderate climate is best suited. The Asian cultivars with higher temperature adaptation can resist heat more than the European cultivars. So far as the seed production of radish is concerned, the cultivars cultivated in India can be classified into three groups: (i) Japanese or winter radish (biennial) which produces seeds only in temperate hills of India. These cultivars require

low temperature for flowering. (2) The second group includes summer radishes of temperate regions (e.g. white Icicle, Rapid red white). These cultivars are very quick in root development and behave like winter radishes for seed production. (3) The third group includes cultivars which produce seeds freely in the plains and can produce good seeds in the hills. Generally, the seed of first two groups is produced in the hills.

Flowering of radish, especially of biennial types, is influenced by temperature. Low temperature is a critical factor for flowering which is accelerated by long photoperiod. In Japanese type, low temperature treatment for longer period (about 25 to 30 days) hasten flower bud differentiation; flower stalk development, earlier and more uniform flowering, higher percentage of fruit set, larger fruits and heavier seed. Bolting and flowering of Asiatic types are more sensitive to

temperature than day length, whereas, European types respond equally to both factors. A temperature of 32°C or higher causes the stigma to become dry and pollens fail to germinate. For good quality seed production radish requires low humid climatic but long dry periods are not suitable.

Varieties

Pusa Chetki : Developed at IARI, New Delhi. Roots are medium large and stumpy, pure white, tender and smooth and mildly pungent. It can be grown as summer and monsoon crop from March to September. Roots become ready for harvesting in 40-45 days. The cultivar sets seeds profusely in the plains.

Pusa Himani : Developed at IARI Vegetable Research Station, Katrain by crossing Temperate type (Black) and Asiatic type (Japanese white). Roots are 30-35 cm in length and 10-12 cm girth with green stem end. They are semi-stump to tapering with short tops. The skin is pure white, flesh is crisp and sweet-flavoured with mild pungency. Matures in 55 days. This cultivar is suitable for growing all the year round in the hilly region of north India. It can be grown successfully in spring in plains of north India with mild climate.

Pusa Rashmi : The roots are 30-45 cm long, white with green tinge on top. It is suitable for early sowing in cooler months, but can tolerate slightly higher temperature. Roots are ready for harvest in 55-60 days.

Japanese White : Released by IARI, New Delhi. Roots are cylindrical, 22-25 cm in length and 5 cm in diameter. The skin is snow white, flesh crisp, solid and mildly flavoured. Suitable for growing between October-December in plains and July-September in hills.

Punjab Safed : Developed by PAU, Ludhiana. Roots are white, tapering, smooth, mild in taste, 30-40 cm long and 3-5 cm thick. Roots remain edible for 10 days after attaining full size.

Hisar Sweti-1 : Developed at CCS HAU, Hisar. Roots white with white shoulder, foliage less, early and high yielding. Roots remain tender, non-pithy and remain edible for longer period.

Flower characters

The inflorescence of radish is a typical terminal raceme of cruciferae. Flowers are small, white, rose of lilac in colour with purple veins in bractless racemes; sepals erect and petals clawed.

Pollination

The radish is cross-pollinated by insects chiefly honeybees. Flowering in temperate varieties usually starts by second fortnight of March depending on the temperature. The pod formation begins by second fortnight of April. In Asiatic varieties flowering starts by the end of February or early March and pod formation a month later.

Isolation

As per Indian seed certification standards radish cultivars for foundation and certified seed production be isolated at a distance of about 1600 m and 1000 m, respectively.

Methods of seed production

As in case of carrot, both seed to seed and root to seed methods are employed for seed production in radish. The later method is preferred for nucleus and stock seed production. Commercial seed can be produced by seed to seed method provided the stock seed is of high quality. Root to seed method can not be employed in case of European cultivars (group two) because they do not stand transplantation well. Detail of these methods has been described under carrot seed production.

Soil

Fertile loamy soils are best suited for radish crop. Even light sandy soils with liberal use of organic manures give good results. Very heavy

clays and sandy soils are, however, not suitable for radish root as well as seed crops.

Root production

Apply 20-25 tonnes of well rotten FYM per hectare and prepare the field well. Forty kg nitrogen and 40 kg each of phosphorus and potash per hectare is applied before last ploughing. The remaining nitrogen (40 kg/ha) is applied three weeks after sowing as top dressing.

Seed rate

About 10 kg of seed is required to plant one hectare. This provides sufficient stecklings to plant 4-5 hectares.

Sowing

The spacing depends on the variety. The temperate types which become ready in 25-30 days are sown closely whereas, tropical types need larger spacing and sown on ridges 45 cm apart.

Hills :

Mid-September to first week of October.

Plains :

Asiatic varieties – first fortnight of October.

After care of crop

After germination plants are thinned to a distance of 7-8 cm. One or two hoeings are done to keep the crop weed free. Irrigate the field as and when required.

In seed to seed method, the crop is further thinned when roots are mature to maintain proper spacing between plants. The crop should be earthed up during spring after bolting to support the plant.

Lifting and selection of roots

Plants with off-type foliage and early bolters should be removed prior to lifting of roots. Fully developed roots are pulled out and true to type

roots are selected. The roots are observed for shape, size and colour etc. All the under developed, deformed, forked, diseased and off-type roots are discarded.

Preparation of stecklings

For stecklings medium size roots are preferred to large roots. Half of the lower portion of root and two-third upper portion of leaves is removed.

Planting of steckling

Depending upon the variety stecklings are planted at a spacing of 60 x 45 or 60 x 60 cm in well prepared field. The crown of the steckling should be kept leveled with soil surface or slightly below it. If the crown protrudes above the soil, shriveling and ultimately death of steckling may take place.

Manures and fertilizers

For seed crop apply 20-25 tonnes of well rotten FYM per hectare and prepare the field well. Forty kg each of nitrogen, phosphorus and potash per hectare is added before last ploughing. A second dose of 40 kg nitrogen is top dressed at the time of bolting and should be followed by earthing up and light irrigation.

Care of crop

Irrigate the crop as and when required. Weeding is done regularly to keep the weeds under check. Care should be exercised to avoid water stress at flowering and seed set stage as it may reduce the seed yield and its quality considerably. Honeybees are the chief pollinating agents and hence, radish seed yield is greatly influenced by the number of honeybees visiting the flowers.

Roguing

Minimum three roguing are recommended. First roguing is carried out at vegetative stage i.e. about a month after sowing off-type plants on the basis of foliage characters are removed. The second when roots are lifted and replanted

(as discussed earlier) and the third at flowering on the basis of flower colour. All early and late flowering plants and plants having different colour flowers are removed. All weeds especially wild radish, wild turnip, wild mustard and plants of other crops/variety should also be removed to avoid possible cross pollination.

Field standards (specific requirements)

Items	Maximum percentage permitted	
	Foundation seed	Certified seed
Off-type	0.10	0.20
Seed borne diseases	0.10	0.50
Not seed borne diseases	0.50	1.00
Objectionable weeds	-	-

Seed borne diseases : Black rot, Black lag, Leaf spot

Not seed borne diseases : Phyllody

Stages of field inspection

1. 20-30 days after seed sowing
2. Steckling preparation and replanting
3. At flowering

Harvesting and threshing

Unlike other cruciferous crops, radish pods do not dehisce. Since there is no danger of shattering, the pods are allowed to mature and ripe fully before harvesting. In case of temperate varieties, the crop is harvested from June end to mid-July (Kullu valley). The harvesting of Asiatic varieties is normally done from April end to mid-May.

Threshing of radish seed crop is difficult. It is always better to dry the pods thoroughly before threshing. After thorough drying the pods, the pods break open easily during threshing processing. Threshing can be manually by beathing the material with sticks or by thresher or by moving a tractor on dried plants on a concrete floor. Immediately after threshing, the seed is thoroughly dried in the sun otherwise its viability may be affected adversely. After drying, the seed is cleaned and graded through air-screen cleaners.

Yield

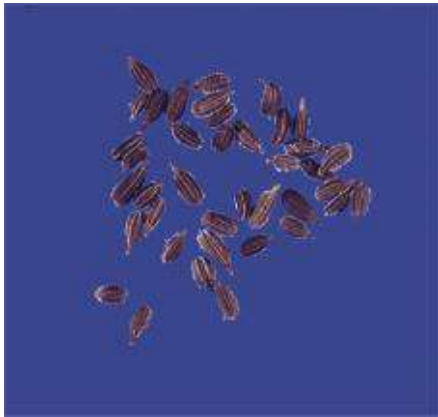
Seed yield varies from variety to variety, however, the average yield is as follows :

Temperate varieties	-	175 to 250 kg/ha
Asiatic varieties	-	400 to 600 kg/ha

Seed Standards (%)

Items	Class of seed	
	F. seed	C. seed
Pure seed (minimum)	98.00	97.00
Inert matter (maximum)	2.00	3.00
Other crop seeds (maximum)	0.05	0.10
Germination (minimum)	70.00	60.00
Moisture content (maximum)		
i) Ordinary container	6.00	6.00
ii) Vapour proof container	5.00	5.00

CARROT



Carrot (*Daucus carota* L.) belongs to the family Umbelliferae. It is a cool season crop. It is grown all over the world in spring, summer and autumn in temperate countries and during winter in tropical and sub-tropical climate. Carrot is valued as food mainly because it is rich source of a and b-carotene. Carrots are used to prepare vegetable, soups, curries, salad, pickles and delicious dish (Gajar Halwa). In some countries (France) carrot is cultivated for its seed, which is the source of an essential oil having odour of orries and is used for flavouring liqueures and all kind of food substitutes.

Climatic requirement : Carrot is a cool season crop though some of the tropical types can tolerate high temperature. Seed germination and root growth are greatly influenced by soil temperature. A temperature range of 7.2 to 23.9°C is considered optimum for seed germination. Climate is considered much more often as a limiting factor than the soil. Asiatic or tropical types of carrot are well adapted to the climatic conditions of plains in India and seeds freely under tropical conditions. The area of seed production is restricted to regions where rainfall is negligible during summer. A dry warm atmosphere is desirable for proper maturity and drying of plants as well as umbels.

The temperate or European types require low temperature of 4.8 to 10°C (vernalization) for 4-6 weeks any time during root development or after they mature, either in storage or under field condition. Seed stalk formation results only when these plants are subjected to a subsequent temperature of 12 to 21°C. Plants grown continuously at a temperature of 21 to 27°C fail to develop flower primordia and that is why seed of European types is produced only in hills in India, where the winters are severe or chilling requirement of plants is fulfilled.

Varieties

A) Tropical or Asiatic or oriental or annual types :

These varieties do not require low temperature for flowering and seed freely in the plains of India.

i) Pusa Kesar : The leaf top is markedly shorter, tapering roots with semi blunt tip, narrow central core which is sufficiently red coloured. Roots contain high amount of carotene (38 mg/100 g edible portion). Roots can stay for a month in field without showing any sign of bolting. Forking is significantly lower than other local varieties. The seed crop matures about 15 days later but seed development is normal. Tolerates higher temperature than Nantes and is suitable

for sowing from early September to mid-November. Average yield 250 q/ha.

ii) Hisar Gairic : Developed by CCS HAU, Hisar. It is a tropical type. Roots long and orange coloured. Average yield 255 q/ha.

iii) Pusa Meghali : Developed by IARI, New Delhi. Vegetative growth less, roots smooth and tapering. Roots contain very high amount of carotene. Suitable for early (August-September) and late (October-November) sowing. Average yield 270 q/ha.

B) Temperate or European or biennial types

These varieties are biennial in character and require low temperature (4.8 to 10°C) treatment for flowering. They do not produce seed in the plains of India.

i) Nantes : The roots are half long, slim, well shaped, cylindrical with stumped end forming small thin tail, deep orange-red cortex and core. It ranks first in quality and can be grown for roots in the plains during cooler months.

ii) Chantenay : It is an excellent cultivar for canning and storage. Roots are 11.5-15 cm long having 3-5 cm diameter with tapering to blunt end, deep orange cortex and core.

iii) Imerator : A cross between Nantes and Chantenay. It is a mid-season to late maturing variety grown for fresh market. It has large and strong foliage, roots are 15-17.5 cm long having 2.5 to 4.5 cm diameter with short tapered end, deep orange cortex and slightly less pigmented core.

Flower characters : The inflorescence is a compound umbel. There is a single king umbel or umbel of the first order or primary umbel that flower first. The umbels terminating the branches arising from the main stem are called second order umbels. Similarly, there are third and fourth order umbels in succession. The number of umbels in different orders may vary according

to the varieties (2nd-12 to 15; 3rd – 13 to 42 and 4th – 46 to 53).

Usually the flowers of the king umbel open first. The peripheral umbellets flower first followed by inner umbellets. After about eight days the process starts in one or more second order umbels to be followed by about 12 days by the third order umbels. The time required for the entire umbel to pass through the flowering is about 8-10 days depending on the size of umbel and climate.

The flowers are perfect with small petals, usually white or greenish white or yellowish. The calyx is entire and there are five stamens. Both the tips of the petals and stamens when young tend to turn inward like short rays. The ovary is inferior and consist of two locules, each with single ovule. On the upper surface of the ovary there is a swollen nectar secreting disc, which supports the style and stigma.

Pollination

In carrot, the stamens mature first and are thus protandrous in nature. Due to this cross-pollination is a rule. Many type of insects including honey bees and house fly visit carrot flowers and account for the cross-pollination.

Isolation

Carrot is a cross-pollinated crop, therefore, isolation distance of 1000 meters for foundation seed and 800 meters for certified seed production is required. Isolation from wild types is also necessary particularly for temperate types.

Methods of seed production

There are two methods of seed production:

1. Seed to seed method : In this method the seed production is taken up *in situ* where the seed was sown. This method is employed only when the genetic purity of the stock seed is beyond doubt.

Advantages

- i) Cost of cultivation is low because there is no expenditure on field preparation and lot of saving in labour which is required for lifting of roots, preparation of stecklings and replanting of roots.
- ii) Seed yields obtained in this method is higher over root to seed method.
- iii) Maturity of the crop is early.

Disadvantages

Since roots are not lifted in this method, therefore, selection of roots is not possible.

Root to seed method : This method is being mostly followed for seed production in India, since highest purity of stock seed has not been attained so far. In this method, seed is sown for root production and rouging is done on the basis of vegetative growth characters. Roots are lifted, inspected and true to type roots are selected before preparation of stecklings. Prepared stecklings are replanted at proper spacing for seed production.

Advantage : This method is preferred for high quality seed production.

Disadvantage : In this method, the production cost is high and yield is low as compared to seed to seed method.

Soil

For proper development of roots well drained sandy loam or loamy soil is preferred. Soil pH should be between 6.5 to 7.1 and similar type of soils are ideal to seed production. Carrots do not grow well in highly acidic or saline or alkaline soils.

Production of roots

The method of root production for seed crop is as under:

For cultivation of carrot, the field should be worked deep to a good tilth. Well rotten FYM

@ 50 tonnes per hectare should be incorporated in soil at the time of land preparation. Thirty kg nitrogen (half dose), 30 kg phosphorus and 30 kg potash per hectare should be applied at last ploughing.

The Asiatic types are sown in the plains in the month of September for seed production. Temperate cultivars are sown from mid-July to mid-August in the hills. About 3 kg seed of Temperate types and 5 kg seed of Asiatic type is sufficient for one hectare of land, which in turn will produce roots for planting of 4-5 hectares. Row and plant spacing depend on the cultivar, however, seed should be sown in lines or ridges at a spacing of 30 to 45 cm at a depth of 1.0 to 1.5 cm. After germination 6-8 cm spacing between plants is maintained by thinning. Thirty kg nitrogen per hectare should be applied 4-5 weeks after sowing. Keep the crop weed free and irrigate the crop as and when required.

Lifting and selection of roots

Roots are lifted when they are fully developed. All small, cracked, injured, diseased, forked or hairy roots are discarded. Thorough examination to select true to type roots is made on the basis of tops (small or heavy), colour of skin, shape and size of root, colour of flesh and colour and size of core etc. Roots with thick neck and bolting should also be rejected.

Preparation of stecklings

To prepare steckling lower half portion of root is pruned and the leaves are clipped 7-8 cm above the crown.

Storage of steckling

The ideal storage condition, if required for carrot stecklings (Temperate type) is a temperature of 0°C and RH 90-95 per cent.

Planting of stecklings

The soil of the field where stecklings are to be planted should be deep, fertile and

thoroughly prepared. Normally 20-25 tonnes of FYM per hectare are applied while preparing the field. Forty kg each of nitrogen, phosphorus and potash is applied at last ploughing. At bolting stage 40 kg nitrogen is top dressed which is followed by light irrigation.

Stecklings of Temperate types are planted in November in hills whereas, Asiatic types are planted from mid-December to mi-January in plains. Depending upon the growth habit of variety row to row spacing varies from 45 to 60 cm and plant to plant 30 to 45 cm. While planting the crown should just be kept at soil level. The field is irrigated immediately afterwards otherwise stecklings may shrivel and fail to grow. The stecklings when planted immediately after lifting survive much better and give higher yields.

After care of crop

Keep the crop weed free. Irrigate the crop at 8-10 days interval until the crop is noticeably mature. A light earthing up may be necessary in places where the soil is loose. This help in preventing lodging.

Roguing

Roguing should be done thrice. The first at vegetative stage in root crop, the second when the roots are lifted and the third at flowering. Remove all early bolter and off type on the basis of flower characters.

Specific requirement (Field standards)

Factor	Max. permitted %age	
	F. seed	C. seed
Off type	0.10	0.10
Seed borne diseases	-	-
Not seed borne diseases	-	-
Objectionable weeds	-	-

Stages of field inspection

1. 30 days after sowing
2. At lifting of roots and steckling preparation
3. At flowering

Harvesting and threshing

The crop is harvested when the secondary umbels are fully ripe and the tertiary umbels begin to turn brown. Shattering is negligible. Carrot seed contain a germination inhibitor, which is known as carrotal. Immature seeds contain maximum level of carrotal which usually does not change during storage. Therefore, to obtain best quality seed fully ripened and dried umbels of first and second order should be hand picked. The umbels may ripen unevenly, hence 2-3 pickings may be required. These umbels are kept for curing in small heaps. Curing may require 5 to 12 days or even more depending on weather conditions. After the umbels are dried completely threshing and cleaning is done mechanically or manually. Then the seed is graded.

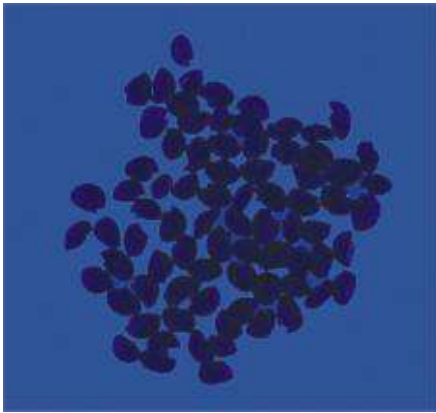
Seed yield

The seed yield of Temperate type varies from 3.5 to 5.5 quintals and Asiatic type varies from 8 to 10 quintals per hectare. The size and viability of seed of first and second order umbels is same but in the third and fourth order umbels the size and viability of seed is reduced.

Seed Standards (%)

Factors	Class of seed	
	F. seed	C. seed
Pure seed (minimum)	95.00	94.00
Inert matter (maximum)	5.00	6.00
Other crop seeds (maximum)	0.05	0.10
Germination (minimum)	60.00	55.00
Moisture content (maximum)		
i) Ordinary container	8.00	8.00
ii) Vapour proof container	7.00	7.00

ONION



Onion (*Allium cepa* L.) is a major bulbous crop among the cultivated vegetable crops and it is of global importance. It was probably originated in Afghanistan, Iran and Pakistan but is cultivated in many areas of the world including tropics and temperate regions. The productivity of onion in India is 12.5 t/ha, which is much lower than the productivity of USA (41.12 t/ha). The higher productivity of onion in USA is due to the growing of the long day hybrids and open pollinated varieties. The reasons for lower productivity of onion in India could be attributed to the limited availability of quality seed and lack of development of hybrids in onion is the major limiting factors among the others. Onion is a major vegetable grown in Kharif and Rabi season by the small and marginal farmers. The farmers in absence of cheap seed availability prefer to produce the local onion seed in traditional manner. The resultant seed is often inferior giving bolted onion, split onions and uneven sized onions affecting the marketable quality severely. The local onion cultivars are disease and pest tolerant but the yield is poor. In 1925, male sterility in onions was discovered and this finding quickly led to the development of a hybrid onion seed industry.

Potential areas for seed production:

In India, the short day types of onion is cultivated on large scale in the northern plains, central and southern part of the country expect

higher hills where the long day types onion varieties like Brown Spanish and Yellow Spanish etc. are grown over a limited area. Therefore, the seed production of the short day types of onion is done in central part of the country particularly in Mandore and Khandawa region of MP, Nasik and Pune of Maharashtra and Rajkot district of Gujarat. However, northern state like Punjab, Haryana and Rajasthan are not preferred by the seed industry due to sever attack of stemphylium and purple blotch and lower seed yield but there is a potential for seed production in north under delayed planting.

Floral biology and pollination :

Anthesis occurs in early morning (6-7 hrs). Anther dehiscence is between 7.0 and 17.00 hr and on next day also with peak between 9.30 and 17.00 hr. Pollen fertility is highest on the days of anthesis. Stigma receptivity is also high on the day of anthesis. The duration of anthesis is approximately 4 weeks on individual umbel. The anthesis begins from outer flowers and goes centrally in succession. The flower is protandrous in nature and stigma becomes receptive when shedding of pollen is over. Onion is cross-pollinated in nature and bees, flies and other insects to achieve the full potential of onion seed. The onion inflorescence is an umbel that produces 50 to 2,000 flowers. Flowering can be as long as two weeks and is not uniform since the umbel actually consists of aggregations of

smaller 5 to 10 flowered inflorescences called cymes. Onion does not produce quality seed if insects do not visit the flowers. In commercial seed production, the crop depends on *Apis mellifera* for pollination. In mountainous regions of India, the availability of natural pollinators is a major drawback in seed production. The utilization of honey bees on onion seed production would effectively increase seed quality and quantity.

Improved varieties of onion and their source :

Variety	Source
Pusa Red, Pusa Ratnar, Pusa Madhvi, Pusa White Flat, Pusa White Round, Early Grano, Brown Spanish	IARI, New Delhi
Arka Niketan, Arka Kalyan, Arka Bindu	IIHR, Bangalore
Agrifound Light Red, Agrifound Dark Red, Agrifound Rose, Agrifound Red	NHRDF, Nasik
Punjab Red Round	PAU, Ludhiana
Hisar-2	HAU, Hisar
Kalyanpur Red Round	CSAUA&T, Kanpur
Co-1, Co-2, Co-3, Co-4	TNAU, Coimbatore

Isolation

Onion seed field shall be isolated from contaminants viz., fields of other varieties and the fields of the same variety not conforming to varietal purity requirement for certification at least 4 m for foundation seed and certified seed during mother bulb production and 1000 m and 500 m for foundation and certified seed production respectively during seed production.

Method of seed production :

There are two methods of seed production. The seed to seed and bulbs to seed methods and both the methods are in use in onion seed production. But bulb to seed method is most commonly used method of seed production.

a) Bulb to seed method :

In this method, the seed is sown in raised bed at 4-5 cm spacing for raising the seedling. The seedlings of 12-15 cm length are

transplanted and this height attained 7-8 weeks after the seed sowing. Thus, 6-8 kg seed/ha is sown. The seedlings are transplanted in previously developed beds in 15x10 cm spacing. The bulbs are lifted when the 75% plant show neck fall/top die down. The bulbs are dried/curing under naturally ventilated place then neck is trimmed leaving 2-3 cm attached with bulb. The bulbs are roughed at this stage based upon the colour, shape and size. The damaged, twin bulbs and long necked bulbs if any are discarded. The medium size bulbs weighing (50-80 g) bulbs are selected and stored. The bulbs are examined again before replanting in the following season. This method helps to maintain purity of the variety and also gives higher seed yield, but disadvantage is it requires more labour.

b) Seed to seed method :

In this method seedlings are transplanted in first week of October and allow over-wintering at the same place and allowing bolting (flowering). The seed are threshed from the mature umbel. This method does not allow to examine the mature bulb characters and field is rogued for off-types. Seed to seed method is not popular, since all the varieties are not suitable for annual seed production due to poor bolting habit and lower seed yield. The seed produced in this method is not suitable for further multiplication.

Production practices

Land requirement : Land to be used for seed production of onion should be free from volunteer plants. Although onion can be grown nearly in all types of soil from sandy loam to heavy clay soil, but clays are not satisfactory unless well supplied with humus to lighten them. The soil pH should preferably be 6.0-6.8.

Weed Control : Weed should be kept under check manually or by using Pendimethalin 1.5 kg or Fluchloralin 1.5 kg/ha which is followed by one hand weeding at 90 days after planting.

Mode of Pollination : Onion is cross-pollinated.

Bulb Production		Manures and Fertilizers (ha)	
Seed rate	: 10 kg/ha	FYM	: 50 tons
Time of sowing	: Last October	Nitrogen	: 100 kg
Transplanting	: End December – Mid January	P ₂ O ₅	: 50 kg
Spacing	: 15 x 10 cm	K ₂ O	: 50 kg
		Harvesting	: Mid-June
		:Curing	: Harvested bulbs are cured by spreading in shade for a week
<ul style="list-style-type: none"> - Select bulbs of uniform size, shape and colour. - Very small and large size bulbs are discarded. - Stored at 70% RH and 32°F temperature. 			
Seed Crop		Manures and Fertilizers (ha)	
Time of bulb planting	: Mid-Oct. to 1 st week of Nov.	FYM	: 50 tons
Seed rate	: 12-15 q/ha (40-60 g bulbs) (whole bulbs better than cut bulbs)	Nitrogen	: 100 kg
Spacing	: 45x30 cm or 60x20 cm	P ₂ O ₅	: 50 kg
		K ₂ O	: 50 kg

Half nitrogen and full dose of P and K is applied at planting as hill placement. Rest half of nitrogen is applied in two instalments. Half at 35-40 days after planting and half at bolt emergence.

Time of Inspection and Roguing

Four field inspections are done and undesirable plants if any are rogued out. The time of inspection is as follows:

1. 30-40 days after transplanting.
2. When bulbs are lifted.
3. At the time of bulb replanting.
4. At the time of flowering.

Specific Requirement

Field Standards : Max. %age permitted.

Class of seed	Off-type	Plants affected by diseases	Objectionable weeds
FS	0.20	-	-
CS	0.50	-	-

Seed Standard (%)

1. Pure Seed	(F&C)	98%
2. Inert matter	(F&C)	2%
3. Other crop Seeds	F	0.05%
	C	0.1%
4. Weed seeds	F	0.1%
	C	0.2%
5. Objectionable weed seeds	(F&C)	Nil
6. Germination	(F&C)	70%
	TFL	65%
7. Moisture content		
	a) Ordinary container	9%
b) Vapour proof container		6.5%

Harvesting

Although all seed heads on an onion plant do not mature simultaneously, there still is usually one harvest in the seed field. This is accomplished by harvesting the seed heads at about 30% moisture (the heads have some opened capsules with black, ripened seeds exposed) by hand cutting 10 to 15 cm (4 to 6 inches) of the flowering stem below the umbel. A study revealed that harvesting umbels with seed stalk had no effect on the seed yield and on seed physiological potential. The best harvesting period was at the beginning of capsule opening or when 10% of capsules were opened resulting in higher seed yield. Harvesting at beginning of capsule opening was helpful in avoiding loss of seeds by thresh or diseases. Harvesting of cool climate onion seed crop before capsule dehiscence will result in a loss of potential seed yield and quality. Harvesting at 20-30% dehisced capsules resulted in seed with better quality. When cutting, the umbel is supported in the palm of the hand and held between the fingers to avoid seed shattering.

The seeds are dried enough for threshing when the capsules and small seed stems are brittle and readily break when rolled in the palm of the hand. Yields range from 560 to 784 kg per hectare.

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