

PACKAGE OF PRACTICES FOR CULTIVATION OF VEGETABLES

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The Package of Practices for Cultivation of Vegetables-2021 contains the latest recommendations and readily-usable information provided by the specialists of vegetable crops of PAU through the coordination of the Director of Research. These improved farming techniques for stepping up productivity of vegetables have been discussed and finalised in the ‘Research and Extension Specialists’ **‘Virtual Research & Extension Specialist’s Workshops on Horticultural Crops’ held on 7 January, 2021 (Winter) and 6 July, 2021 (Summer)**. It is purposely written in a simple and easy-to-understand language because these recommendations are intended for the use of field level extension workers and the farmers of Punjab.

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IMPORTANT NOTICE

The information on the performance of recommendations given in this book holds good only when used under optimum conditions. Their performance may either change in due course of time due to several factors or can vary under different systems of management. Mishandling/negligence of the user can also result in damage/loss/non-reproducibility of results. The Punjab Agricultural University accepts no legal responsibilities.

CAUTION

Chemicals used to control insects, diseases and weeds are poisons for human beings. Farmers are cautioned to use these poisons carefully to avoid any effect on human health. For safe use of these chemicals see Appendix III given at the end of this book.

Note :

1. For proper presentation of information on pesticides, fungicides, etc., it is sometimes necessary to use the trade name of the product or equipment. No endorsement of the named product or equipment is intended nor criticism implied of a similar product or equipment not mentioned in this book.
2. Volume of spray material to be used for controlling different insects and diseases of various crops is based on the usage of shoulder-mounted knapsack sprayer having “fixed type hollow cone nozzle.” Spray volume may vary when other types of sprayers/nozzles are used for this purpose.
3. It should, however, be ensured that the actual amount of insecticides recommended in the “Package of Practices” should not be reduced. For proper control of weeds, it is always necessary to use flood jet or flat fan spray nozzles.
4. The use of endosulfan 35 EC is not recommended till the decision of Hon’ble Apex Court.

NEW RECOMMENDATIONS

VEGETABLES VARIETY

Chilli

CH-52 (2021): It is a hybrid between MS-13A x IS-261 and suitable under low tunnel cultivation. The plants are dark green, spreading and tall. First picking is possible 112 days after transplanting. The fruits are long, thin skinned, pendent, borne singly, deep green in colour when immature and deep red on maturity. The fruits are pungent (0.9% capsaicin) and high in dry matter (25%). The hybrid is moderately resistant to leaf curl virus, fruit rot and root knot nematodes. It gives average yield of 255q/ha.

PRODUCTION TECHNOLOGY

Cultivation of tomato in soil less medium under protected condition: Tomato hybrids; NS 4266, Himshekhar and Punjab Sartaj can be grow in soilless medium under protected condition.

Cultivation of cucumber in soilless media under naturally ventilated polyhouse: Parthenocarpic cucumber cultivars (hybrid Multistar or Kafka and PAU variety Punjab Kheera 1) are recommended for growing in soilless media under naturally ventilated polyhouse.

PLANT PROTECTION

Control of whitefly in cucurbits: Spray 1200 ml of PAU Neem extract using 100 -125 litre water per acre.

Management of cucumber root knot nematode in poly/net house : For the integrated management of nematode, apply 1 ton mustard cake + 1 ton *Neem* cake before 10 days of sowing of cucumber.

Control of whitefly in brinjal: Spray 1200 ml of PAU Neem extract or 1500 ml Maize or Sorghum or Bajra juice or 200 gm Pegasus 50 WP (diafenthiuron) using 100-125 litre water per acre. After Pegasus spray, harvest the fruit by keeping one day waiting period.

Control of fruit borer in chilli: Spray 50 ml Coragen 18.5 SC (chlorantraniliprole) or Tracer 45 SC (spinosad) in 100 litres of water per acre.

Control of jassid and whitefly in okra: Apply 1-2 sprays of 80 ml commercial *Neem* based insecticide Ecotin (azadirachtin 5%) or 2000 ml PAU *Neem* extract in 100-125 litres of water per acre.

Control of Spotted bollworms in okra: Spray 50 ml Coragen 18.5 SC (chlorantraniliprole) or 200 Sumipleo 10 EC (pyridalyl) in 100-125 litres of water per acre.

Control of mite in okra: Spray 1600 ml PAU Dharek extract in 100 litres of water per acre.

Control of Thrips in onion: Spray 30g Jump 80 WG (fipronil) or 250 ml Rogor 30 EC (dimethoate) in 100 litres of water per acre.

POST HARVEST TECHNOLOGY

Preparation of Lacto-fermented turmeric beverage: The bioprocess was optimized by fermenting the blend of turmeric juice (turmeric juice 100 ml, ginger extract 1.5 ml, lemon juice 5.0 ml) water 1:3 and salt (condiment) @ 1.0% followed by pasteurization at 55°C for 15 seconds with functional starter culture (Consortia of ten allochthonous lactic acid bacteria @ 5.0% (w/v) by incubating at 37°C for 24 hrs.

Preparation of Lacto-fermented beverage from turmeric powder: Use mixture of 4% of turmeric powder with ginger (1.5%) and lemon juice (5%), and initiating the fermentation with functional starter culture after pasteurization.

Preparation of turmeric pickle: The bioprocess for the fermentation of turmeric pickle; dip the 1 inch aseptically chopped turmeric pieces in 5% brine solution followed by the addition of actively grown functional starter culture (Consortia of ten LAB strains @ 5% w/v) and fermenting till 48 hrs at 37°C in tightly stoppered sterilized glass jar.

1. VEGETABLES

Introduction

In Punjab state the vegetables are grown in an area of 3.06 lac hectares producing 61.09 lac tonnes with average productivity of 20.0 tonne per hectare. The area, production and yield of different vegetables during 2020-21 ie as under:

Table : Area, yield and production of vegetable during 2020-21

Vegetable	Area (000 ha)	Av. Yield (q/ha)	Production (000 t)
Potato	107.09	275.34	2948.55
Pea	43.89	106.41	467.01
Root crops	28.07	249.27	699.61
Cucurbits	18.01	195.09	351.27
Cauliflower	22.98	196.12	450.60
Onion	10.35	238.27	246.52
Tomato	10.28	259.74	266.91
Chilli	8.78	20.09	17.63
Garlic	8.87	109.10	96.77
Cabbage	7.98	161.68	129.01
Muskmelon	7.01	194.87	136.62
Brinjal	5.47	225.72	139.79
Okra	5.31	103.44	54.88
Watermelon	2.19	180.84	38.30
Other vegetables	19.22	34.39	66.09
Total	305.5		6109.56

In the state, among vegetable crops, about half of the total area is covered under potato which is raised for fresh market and seed potato. The state has established itself as a seed producing state of potato.

At present, production of vegetables is about 61.09 lac tonnes which does not include post harvest losses (20-40%), quantity procured and crop raised for seed production. It is estimated that per capita per day availability of vegetables in the state is less than 200 g. To feed the present population of the state, there is a need to double the total production of vegetables. Besides this, the state has to produce additionally to meet the requirement of the processing industry, exports and seed industry. Therefore, there is an immense scope of increasing area in the state. The vegetables are grown mostly in the vicinity of cities for commercial purpose. The supply of vegetables in the cities is uneven and uncertain which results into fluctuations in their prices. However, in the villages, the availability of vegetables is more disappointing than in the cities. On the contrary, the inclusion of vegetables in the daily diet is indispensable for the maintenance of good health. For the supply of fresh vegetables, the available area near and around the houses or near the tubewells at the farms can be utilized for growing vegetables.

2. MUSKMELON

Climate and Soil

Muskmelon plants flourish well under warm climate and cannot tolerate frost. The optimum temperature for germination of the seed is 27-30°C. With the increase in temperature, the plants complete their vegetative growth earlier. Stormy weather particularly dust storm during flowering reduces fruit setting. Dry weather with clear sunshine during ripening ensures a high sugar content, better flavour and a high percentage of marketable fruits. High humidity increases the incidence of diseases, particularly those affecting foliage. Cool nights and warm days are ideal for accumulation of sugars in the fruits.

A well drained loamy soil is preferred. Lighter soils which warm up quickly in spring are usually utilized for early yields and in heavier soils, the vine growth more and fruit maturity is delayed. Sandy river beds with alluvial substrata and subterranean moisture of river streams support its growth. In fact, the long tap root system is adapted to growth of this crop in river beds. The soil should not crack in summer and water should not stagnate. It is necessary that soil should be fertile well provided with organic matter. Muskmelon is sensitive to acidic soils. It prefers a soil pH between 6.0 and 7.0. Alkaline soils with high salt concentration are also not suitable.

Muskmelon is a warm season crop, but in the important muskmelon growing areas, it is sown during winter under proper protection against cold. It is also sown in February and March.

Improved Hybrids/Varieties

Hybrids

MH-51 (2017) : Its vines are vigorous and dark green. Its fruits are round and netted with green sutures. Fruit flesh is thick, salmon orange, medium juicy and flavorsome with 12.2% TSS. Its average fruit weight is 890 g. It is an early maturing hybrid and can be harvested after 62 days of transplanting. Its average fruit yield is 89.0 q/acre.

MH - 27 (2015) : Its vines are vigorous and dark green. Fruit is round, light yellow, sutured and netted. Flesh is thick, salmon orange, medium juicy with 12.5 per cent TSS. The fruits develop 'full slip' stage. Its first picking is after 63 days of transplanting. Average fruit weight is 860 g. It is tolerant to wilt and root knot nematodes. The yield is 87.5q/acre. It has long shelf life and suitable for distant transportation.

Punjab Hybrid (1981): Its vines are vigorous and dark green. The fruit setting takes place close to the base of the vine and it is early in maturity. The fruit is round, light yellow, sutured and netted. Flesh is thick, orange coloured, juicy and having excellent flavour with 12 per cent TSS. The fruits develop 'full slip' stage. Average fruit weight is 800g. It is moderately resistant to powdery mildew and resistant to fruit fly. The yield is about 65 q/acre.

Varieties

Punjab Sunehri (1974) : This variety has medium vine growth. The fruit weighs about 700-800g and is globular round with its rind intensely netted and light brown. It has thick orange flesh and is medium in juiciness. It is moderately sweet (TSS 11 per cent). The inside of the rind separating it from the orange flesh, is green. The fruits develop 'full slip' stage. The crop matures about 12 days earlier than *Hara Madhu*. This variety has good keeping quality. It is highly resistant to the attack of fruitfly. It yields about 65 q/acre.

Hara Madhu (1967) : This variety is somewhat late in maturity. The fruit is large (average weight one kg.), round and slightly tapering towards the stalk end. It is very sweet (TSS 13 per cent). Its skin is light yellow with green sutures. Its flesh is thick, green and juicy. The seed cavity is small. The average yield is about 50 q/acre.

Agronomic Practices

Sowing Time : The mid February is the best sowing

- **For early marketing of muskmelon, sow the nursery in mid-January.**
- **Transplant the nursery in end of February to first week of March.**
- **Fruits are ready for early marketing in 65 days.**

time. However, if the crop is raised by providing a suitable mulch or any other type of cover during winter, premium of early market can be captured. Early planting under cover saves the crop from the attack of red pumpkin beetle also.

Seed Rate : With careful planting on hills by dibbling, 400g of seed is sufficient for one acre.

Method of Sowing : Prepare beds 4 metre wide for *Hara Madhu* and 3 metre for others. Sow two seeds per hill on both sides of beds at a distance of 60 cm between hills. Early crop raised from seedlings grown in polythene bags matures 15-20 days earlier than directly seeded crop. The polythene bags of 15cm×10cm size and 100-gauge thickness punched at the base should be filled with a mixture of soil and well-rotten farmyard manure in equal proportions or with soil, well-rotten farm yard manure and silt in equal proportions when soil is sandy. Five to six kg. bags are required to raise seedlings for an acre. The seed should be sown in the bags in the last week of January or in the first week of February. Seedlings should be protected from cold winds. The bags should be placed near the wall facing the sun. The seeds should not be sown deeper than 1.5 cm. After sowing, water should be applied daily in the afternoon, preferably with a sprinkling cane. Transplanting should be done by the end of February or by the first week of March when the seedlings are 25-30 days old and have two true leaves.

Two days before transplanting, stop watering the bags. At transplanting, a cut is given on the side of bag with a sharp knife and the bag is removed. The earthen ball should not be allowed to break and placed in the hill very carefully. Irrigation is applied immediately after transplanting. With this method, the fruits mature by 2nd or 3rd week of May.

Manures and Fertilizers : Apply 10 to 15 tonnes of farmyard manure, 50 kg of N (110 kg of Urea), 25 kg of P₂O₅ (155 kg of Single Superphosphate) and 25 kg of K₂O, (40 kg of Muriate of Potash) per acre to the directly seeded crop. The farmyard manure should be added 10-15 days before sowing. Whole P₂O₅ and K₂O alongwith one third of N should be applied in two parallel bands 45 cm apart and the channel should be prepared in between the

fertilizer bands, before the sowing of seeds. The remaining dose of N should be applied to the vines near the base (but not touching it) and should be mixed with the soil during the early part of the growing season to ensure the maximum growth, early fruit set and maturity.

Under the transplanting technique, the row to row and the plant-to-plant distances are the same as in the above method. Locate the planting spots for the plants and dig 15-20 cm deep pits for receiving the plants. Fill each pit with a mixture of 1 kg of farmyard manure, 15g CAN or 7-8 g of Urea, 40g of Single Superphosphate and 10g of Muriate of Potash before planting. About a month after; apply another dose of 15g CAN or 7-8g of Urea to each plant. In this way 5-7 tonnes of farmyard manure, 20 to 30 kg N (45 to 65 kg. Urea), 20-25 kg. P₂O₅ (125 to 155 kg. Single Superphosphate) and 20-25 kg. K₂O (30-40 kg. Muriate of Potash) is required per acre.

Irrigation: During summer, irrigate the crop every week. At the time of fruit maturity, water should be given when it is absolutely necessary. The over-flooding of the field should be avoided. In no case, water should be allowed to come in contact with fruits. Depending upon soil type and weather conditions, irrigate the fields 9-11 times.

Harvesting, Care and Marketing

The fruits of *Hara Madhu* should be harvested when it turns yellow. Other varieties should be picked at mature green stage for distant marketing and at 'half slip' stage for local market. To avoid fruit-rot during development and maturity, turn the fruits, particularly after rain or flooding when the soil is wet. Place dry grass below the fruits or place the fruits on the vines themselves.

Seed Production

Land should be free from volunteer plants of the same crop or other crossable species. A seed crop field must be isolated all around to a minimum distance of 1000 metre and 500 metre for foundation and certified seed, respectively. A muskmelon seed field should be isolated from snapmelon (*Phut*), longmelon (*Tar*), wanga and wild melon (*Chibber*). Systematic and timely

field inspections at different stages of plant growth are essential to ensure the production of genetically pure seed. A minimum of three field inspections viz., during flowering, fruiting and finally at fruit maturity are required. In case of muskmelon, edible fruit should be examined for internal fruit characters and sweetness. Muskmelon fruit is ready for seed harvest at its peak of edibility. In most of the cultivars, a crack develops at the point of attachment of the fruit with the stem. The fruit gets easily detached from the vine.

The muskmelon fruits are cut into half and the seed is scooped out of the fruit and placed in non-corrosive metallic trough, earthen pot, wooden barrel or plastic bag. The muskmelon seed is left for fermentation for a day or two. After the fermentation is completed, the seed mixture is washed with water to float off the placental debris or pass it through the wire-mesh to get clean seed. Fermented seed is superior in germination to mechanically cleaned seed or the seed separated immediately after fruit harvest. The seed should be dried properly before packing.

3. WATERMELON

Climate and Soil

It is a warm season crop mainly grown in tropical and subtropical regions. Generally, a long period of warm, preferably dry weather with abundant sunshine is required. It is susceptible to frost. Excess humidity will promote the attack of diseases and insect-pests. For good quality and sweetness, dry weather during the fruit development is necessary. It requires tropical climate and fairly high temperature (35-40°C) during fruit development. Cool nights and warm days are ideal for accumulation of sugars in the fruits. Maturity is hastened if nights are warm. The average temperature for growth should be around 30-35°C with maximum around 40°C and minimum between 20 and 25°C. The optimum temperature range of 18-25°C is required for germination.

A well drained loamy soil is preferred. Light soils that warm quickly in spring are usually used for early maturity. In heavier soils, vine growth is high and fruits mature late. The soil in which it is grown should not crack in summer and water log in rainy season. It prefers a soil pH of 6.0-7.0. It is slightly more tolerant to medium salt concentrations.

Improved Variety

Sugar Baby (Before 1962) : This variety produces small to medium sized fruits with dark green skin. The flesh of the fruit is deep red and very sweet having 9-10 per cent TSS. It yields 72 q/acre.

Agronomic Practices

Sowing Time :

- (i) Mid January to March
- ii) November to December (Under protection)

Seed Rate : Use 1.5 Kg seed for small seeded varieties and 2.0 kg seed for large seeded varieties per acre.

Spacing : Prepare 2.5-3.0 metre wide beds. Seeds should be sown on both sides of the beds at a distance of 60 cm between the plants.

Manures and Fertilizers : Apply 8-10 tonnes of farmyard manure along with 25 kg of N (55 kg. of Urea) 16 kg of P₂O₅ (100 kg of Single Superphosphate) and 15 kg of K₂O (25 kg of Muriate of Potash) per acre in the same way as in the case of muskmelon.

Irrigation : During initial stages of growth irrigate weekly. Later the irrigation should be given at 9-13 days interval. Towards maturity irrigation should be given at longer interval. Total number of irrigations would be 7 to 9.

Harvesting, Care and Marketing

The crop would be ready for harvest in 95-120 days after seed sowing depending upon the cultivar. The fruits should be harvested when fully developed and mature. Signs of maturity are drying of tendrils, change in colour of ground spots to yellow and thumping of matured fruits give dull sound.

Seed Production

Land should be free from volunteer plants of the same crop or other crossable species. A seed crop field must be isolated from other varieties all around to a minimum distance of 1000 metre and 500 metre for foundation and certified seed, respectively. Systematic and timely field inspections at different stages of plant growth are essential to ensure the production of genetically pure seed. A minimum of three field inspections viz., before flowering, during flowering and fruiting and finally at fruit maturity are required. The edible fruit should be examined for internal fruit characters and sweetness.

Watermelon fruit is ready for seed harvest at its edible stage of maturity. Harvesting can be delayed for a few days after the fruit reaches edible stage. Dryness of the tendrils at the point of attachment of fruit to the vine and change of belly colour from green to yellow are the other important criteria for judging the fruit maturity. The seeds may be harvested from the over-ripe fruits but in order to correctly inspect the interior fruit quality, it should be harvested at the time of its edible stage. The seeds are removed from the flesh, washed with water and dried in shade before packing.

4. SUMMER SQUASH

Climate and Soil

It requires warm growing season with a temperature ranging between 18-30°C. It can be grown in various kinds of soils but sandy loam to loamy soils are ideal.

Improved Variety

Punjab Chappan Kadoo-1 (1982): It is an early maturing variety and is ready for first harvest in 60 days after sowing. Plants are bush type, with thick and erect foliage, leaves non lobed and green without white specks; petiole and leaves hairy; fruits attractive green; disc shaped, mildly ribbed with flat stem-end and attractive. This variety has field resistance to downy mildew and tolerant to virus, powdery mildew and red pumpkin beetle. It has a high female to male ratio. Average yield of fruits is 95 q/acre.

Agronomic Practices

Sowing Time :

1. Mid-January to March
2. October to November (under protection)

Seed Rate : Use 2.0 kg of seed per acre.

Spacing : Prepare 1.25 m wide beds and sow two seeds/hill at a distance of 45 cm apart on both sides.

Manures and Fertilizers : Apply 15 tonnes of farmyard manure per acre before preparation of beds. Add 40 kg of N (90 kg of Urea), 20 kg P_2O_5 (125 kg of Single Superphosphate) and 15 kg K_2O (25 kg Muriate of Potash) per acre in two parallel bands at 45 cm apart and the channel should be prepared in between these fertilizer bands before sowing of the seed. Apply half of N alongwith whole of P_2O_5 and K_2O at the time of land preparation. Rest half of N should be applied as top dressing one month after sowing.

Irrigation: First irrigation should be given immediately after sowing to facilitate germination. Subsequent irrigations should be given at 6-7 days interval depending upon season. Total number of irrigations would be 9-10.

Harvesting, Care and Marketing

The crop will be ready for first picking 60-80 days after sowing depending upon variety and season. Fruits become fit for harvesting after 7 days of fruit setting. The interval of pickings should be 2-3 days.

Seed Production

A seed crop field must be isolated all around to a minimum distance of 800 metre from other varieties of this crop. A minimum of three field inspections should be conducted to produce true to type seed. The first inspection should be done before flowering, second at flowering and fruiting and third before harvesting of the crop. The off type and diseased plants should be rogued off. The fruits turn bright yellow to orange at seed harvesting stage. The harvested fruits are cut into two halves and seed is scooped out by hand. The seed is washed in water and fruit flesh is poured off. The extracted seed is dried immediately. The seed yield is 2.0 to 2.5 q/acre.

5. PUMPKIN

Climate and Soil

It is a warm season crop and requires dry weather with abundant sunshine. The soil should be well drained, loamy and rich in organic matter to get good yield. The soil pH of 6.0-7.0 is best for its cultivation.

Improved Hybrids/Varieties

Hybrids

PPH - 1 (2016) : Vines of this hybrid are dwarf, internodal length short and leaves dark green. Its fruits are small, round, mottled-green at immature stage and mottled-brown at mature stage. Fruit cavity is small and flesh is golden yellow. It is extra-early in maturity and gives 206 q/acre yield.

- PAU Magaz Kadoo -1 seed rich source of omega-6 and protein and can be used as 'Magaz' and snacks
- For early marketing, sow PPH-1 and PPH-2 hybrids of Pumpkin in February-March on beds.
- Prepare 1.5 metre wide bed and sow seed at 45 cm spacing.
- Fruits are ready for marketing after 40 days of transplanting

PPH - 2 (2016) : Vines of this hybrid are dwarf, internodal length short and leaves green. Its fruits are small, round, light green at immature stage and smooth-brown at mature stage. Fruit cavity is small and flesh is golden yellow. It is extra-early in maturity and gives 222 q/acre yield.

Varieties

Punjab Nawab (2019) : Its leaves are dark green and vines medium with intermediate internodal length. Its fruits are medium sized, flat-round, mottled-green at immature stage and mottled-brown at maturity. Fruit cavity is medium, flesh thick and golden-yellow. It is tolerant to pumpkin yellow vein mosaic virus disease and gives 137 q/acre yield during rainy season.

PAU Magaz Kadoo -1 (2018) : It is an edible seeded variety. Its seeds are hull-less (without testa) and can be used as 'Magaz' and snacks. Its vines are dwarf and leaves are dark-green. Its fruits are of medium sized, round and turn golden yellow at maturity. Its

seeds contain 32% omega-6, 3% protein and 27% oil content. Its seed yield is 2.9 q/acre.

Punjab Samrat (2008) : Its vines are medium long, stems angular and leaves are dark green. Its fruits are medium in size, nearly round, mottled-green and turn pale-brown at maturity. The fruit flesh is thick and golden-yellow. It is early in maturity, rich in vitamin-A. Its average yield is 165 q/acre.

Agronomic Practices

Sowing Time : February-March
June-July (Punjab Nawab).

Seed Rate : Use 1.0-1.5 kg of seed per acre.

Spacing : Prepare 2-2.5 metre wide beds and sow two seeds per hill at 60 cm spacing on both sides of the beds. PAU Magaz Kadoo-1 and Hybrids (PPH-1 and PPH-2) should be planted on both sides of 1.5 meter broad bed at 45 cm spacing.

Manures and Fertilizers : Apply 8-10 tonnes of well rotten farmyard manure per acre before preparation of the beds. Add 20 kg of N (45 kg Urea) before sowing and another 20 kg of N (45 kg Urea) as top dressing with in one month.

Irrigation : First irrigation should be given immediately after sowing to facilitate seed germination. Subsequent irrigations should be given at 6-7 days interval depending upon the season. Total number of irrigations would be 8-10.

Harvesting, Care and Marketing

The fruits are ready for harvesting when skin turns pale-brown and flesh becomes golden-yellow. The mature fruits have good storage capacity and it is always better to reduce frequency of irrigation before fruit picking. The immature fruits can be harvested for sale also.

Seed Production

The isolation distance of pumpkin seed plot from other varieties should be 1000 metre for foundation and 500 metre for certified seed production. Off type and diseased plants are roughed out at vegetative, flowering and fruiting stages. When skin of the fruits turn hard and attain yellow brown colour then they are ready for harvesting and seed extraction. Then clean, grade and dry the seed to 8% moisture before storage.

6. BOTTLE GOURD

Climate and Soil

It requires warm growing season with a temperature ranging between 18-30°C. It can be grown in various kinds of soils but sandy loam to loamy soils are ideal.

Improved Varieties

Punjab Bahar (2017): Its vines are medium long and pubescent. Fruits are nearly round, medium sized, light green, shining and pubescent. Its vines bear average of 9 to 10 fruits. Its average yield is 222 q/acre.

Punjab Barkat (2014): The vines are vigorous in growth and profusely branched. Stem is pubescent. Fruits are long, cylindrical, shining, tender and light green in colour, It is moderately resistant to mosaic disease. Its average fruit yield is 226 q/acre.

Punjab Long (1997) : The plants are vigorous, profusely branched bearing cylindrical light green and shining fruits. It is suitable for packaging and long distance marketing. Average yield is 180 q/acre.

Punjab Komal (1988) : It is an early maturing variety. The first fruit attains marketable maturity in about 70 days after sowing. It bears oblong, medium sized, light green, pubescent, 10-12 fruits per vine. Fruits are tender and borne on medium, long, thin pedicel on 4th or 5th node onwards. It is tolerant to cucumber mosaic virus (CMV). Average yield is about 200 q/acre.

Agronomic Practices

Sowing Time :

1. February- March
2. June-July
3. November-December (Under protection)

Seed Rate: Use 2.0 kg. of seed per acre.

Spacing: Prepare 2.0 to 2.5 metre wide beds and sow seed on both the sides of beds at a distance of 45-60 cm.

Manures and Fertilizers : Apply 20-25 tonnes of farmyard manure per acre before preparation of beds. Add 14 kg N (30 kg. Urea) at sowing and another 14 kg N (30 kg. Urea) at first picking stage.

Irrigation: First irrigation should be given just after sowing. Crop requires frequent irrigations. Summer season crop requires irrigation at 6-7 days interval whereas sparingly during rainy season. Total number of irrigations would be 8-9.

Harvesting, Care and Marketing

The crop is ready for harvesting in about 60-70 days after sowing depending upon variety and season. Harvest only tender and medium sized fruits which are still tender and shining in colour. In peak season, picking should be done every 3 or 4 days.

Seed Production

A seed crop field must be isolated all around to a minimum distance of 800 metre from fields of other varieties of his crop. A minimum of three field inspections should be conducted to produce true to type seed. The first inspection should be done before flowering, second at flowering and fruiting and third before harvesting of the fruits. The off type and diseased plants should be rogued off. The fruits turn green dull at seed harvest stage. The harvested fruits are dried and seed is extracted. The seed is graded and packed.

7. BITTER GOURD

Climate and Soil

Though it has a wide range of adaptability, yet it thrives best in warm humid regions. It cannot tolerate frost. Though it can be grown on all types of soils, yet well drained loam soil rich in organic matter is best suited for its cultivation. For getting early crop, sandy or sandy loam soils are preferred but they should be manured well and good amount of chemical fertilizers should be added in the soil.

Improved Varieties

Punjab Karela-15 : Its leaves are green, smooth and serrated. Stem is pubescent and green. Vines are long with dark green, smooth and serrated leaves. Fruits are dark green and with matt appearance. It is moderately resistant to yellow mosaic disease of bitter gourd. The average yield is 51q/acre.

Punjab Jhaar Karela-1 (2017) : Its vines are medium long with green serrated leaves. Fruits are attractive green, tender, spindle shaped and suitable for cooking by chopping. It is resistant to root knot nematode and virus diseases. Its average yield is 35 q/acre.

Punjab Kareli-1 (2009) : Vines are long. Leaves are green, smooth and serrated. Its fruits are long thin, green and ridged. It takes 66 days for first fruit harvest. One fruit weighs about 50g and average yield is 70 q/acre.

Punjab -14 (1985): It has small vines. Fruit weighs about 35g and is light green. Suitable for sowing during spring and rainy seasons. Average yield is about 50 q/acre.

Agronomic Practices

Sowing Time :

1. February-March
2. June-July

Seed Rate: Use 2.0 kg of seed per acre.

Spacing: Sowing should be done on both sides of 1.5m wide beds keeping plant to plant distance of 45 cm.

Manures and Fertilizers : Apply 10-15 tonnes farmyard manure 10-15 days before sowing and also apply 40 kg of N (90 kg of Urea), 20 kg of P_2O_5 (125 kg of Single Superphosphate) and 20 kg of K_2O (35 kg of Muriate of Potash) per acre. Whole P_2O_5 and K_2O along with one third of N should be applied in two parallel bands 45 cm apart and a channel should be prepared in between the fertilizer bands before sowing of seed. The remaining N should be applied one month after sowing.

Irrigation: First irrigation should be given after sowing. During summer season, crop may be irrigated after 6-7 days whereas during rainy season only when needed. Total number of irrigations would be 8-9.

Harvesting, Care and Marketing

The crop will be ready for harvesting in about 55-60 days after sowing depending upon variety and season. The picking should be done at 2-3 days interval.

Drying of Bitter gourd slices : Bitter gourd slices of 1-2 cm thickness can be optimally dried after blanching (5% NaCl, 2 minute in boiling water) with acceptable quality at 65 °C for 2 hour; 55°C for 7 hour and 40°C for 3 hour followed by equilibration at ambient conditions.

Seed Production

For seed production, the crop is grown just like market crop. To produce pure seed, genetic purity of the variety must be maintained and off-type plants must be removed. The roguing should be done thrice i.e. at vegetative phase, at flowering stage and at fruiting stage. Isolation distance of 1000 metre should be kept between different varieties. Keep one honey bee colony per acre to produce good seed yield. When the colour of the fruits turn dark yellow to orange, they should be harvested. The seed should be separated from fruits and pulp and should be cleaned and dried in shade.

8. SPONGE GOURD

Climate and Soil

Sponge gourd can be grown in tropical and sub-tropical climate. It grows well under warm and humid conditions. It is very sensitive to frost and low temperature. It can be grown in all types of soils, but sandy loam soil is ideal for its cultivation.

Improved Varieties

Punjab Nikhar (2020) : The vines are medium long with intermediate internodal length. Leaves are medium in size and green. Fruits are slender, smooth, tender, long, light green and produce creamish white seed. It takes 43 days from transplanting to first picking. Its average fruit yield is 82 q/acre yield.

PSG-9 (2005) : The vines are medium long with dark green leaves. The fruits are smooth, long, tender and dark green. It takes 60 days from transplanting to first picking. Average fruit weight is 65 g and yield is 65 q/acre.

Agronomic Practices

Sowing Time :

1. Mid February to March
2. Mid May to July.

Seed Rate: Use 2.0 kg of seed per acre.

Spacing: Sow atleast two seeds per hill on one side of 3 metre wide beds at a spacing of 75-90 cm.

Manures and Fertilizers : Apply 40 kg of N (90 kg of Urea), 20 kg of P_2O_5 (125 kg of Single Superphosphate) and 20 kg of K_2O (35 kg of Muriate of Potash) per acre. Apply 1/3 N, whole P_2O_5 and K_2O at the time of sowing. Apply remaining N in two equal splits one and two months after sowing.

Irrigation: The first irrigation should be given just after seed sowing. During summer season, irrigate the crop at 7-10 days interval. The crop can be grown during rainy season with limited irrigation. Total number of irrigations would be 7-8.

Harvesting, Care and Marketing

The crop is ready for harvest in about 70-80 days after sowing. The picking should be done at an interval of 3-4 days. Harvest only tender and medium sized fruits.

Seed Production

The raising of seed crop is similar to that of crop grown for table purpose, except that of difference in harvesting stage of the fruit. The best time for raising the seed crop is February-March rather than the rainy season, since harvesting and extraction of seed is convenient in the dry spell. A minimum isolation distance of 1000 metre between two varieties of sponge gourd is required. The undesirable or off-type plants are removed before flowering, during flowering, fruiting and maturity stages. Fruits are allowed to mature physiologically on plant rather than harvesting at horticultural maturity. Seeds are extracted when fruits are dry and seeds rattle inside the shell. After cleaning, dry seed is packed and stored under low temperature and low humidity conditions.

9. ASH GOURD

Climate and Soil

Ash gourd is a warm season crop and grows well in temperature range of 22-35°C. It is sensitive to frost and low temperature conditions. It can be grown in all types of soils, but sandy loam soil is ideal for its growth. The pH range is 6.5-7.5.

Improved Variety

PAG-3 (2003) : The vines are medium long with green leaves. Fruits are attractive, globular and medium sized. It take 145 days from transplanting to harvesting. The average fruit weight is 10 kg. and average yield is 120 q/acre.

Agronomic Practices

Sowing Time : 1. February-March 2. June-July

Seed Rate: Use 2.0 kg of seed per acre.

Spacing: Sow atleast two viable seeds per hill on one side of 3 m wide beds at a spacing of 75-90 cm.

Manures and Fertilizers : Apply 8-10 tonnes of farmyard manure and 40 kg of N (90 kg Urea), 20 kg of P₂O₅ (125 kg Single Superphosphate) and 20 kg of K₂O (35 kg Muriate of Potash) per acre. Apply FYM, 1/2 N and whole of P₂O₅ and K₂O in a band before preparation of beds. Apply rest 1/2 N at flowering stage.

Irrigation: Irrigate the crop at 7-10 days interval.

Harvesting, Care and Marketing

The fruits are ready for picking after 120-150 days of sowing.

Seed Production

The best time for raising the seed crop is February-March by keeping minimum isolation distance of 1000 between two varieties. The undesirable or off-type plants are removed before flowering, during flowering, fruiting, and maturity stages. Harvest fruit when white waxy surface appears on the fruits and stem surface. Separate seed from pulp by washing. Pack the dry seed and stored under low temperature and low humidity.

10. CUCUMBER

Climate and Soil

Cucumber is a warm season crop and very sensitive to frost. Excessive humidity promotes diseases like powdery mildew and downy mildew. The optimum temperature for cucumber production is 26.4°C. Seed of cucumber germinates well at 25°C. A well drained loamy soil is preferred for cucumber production.

Improved Variety

Punjab Kheera – 1 (2018) : It is suitable for poly-net house only. Plant are vigorous, bearing 1-2 fruits per node. Flowers are parthenocarpic and fruits are dark green, seedless, bitter free, medium sized (125 g), 13-15 cm long and do not require peeling. First fruit picking is possible after 45 and 60 days of sowing for September and January sown crop, respectively. Its average yield is 304 q/acre and 370 q/acre for September and January sown crop, respectively.

Punjab Naveen (2008) : The plants have dark green leaves with rough surface. Fruits are cylindrical with smooth surface, light green in colour, bitter free, very crispy having soft seed at edible maturity. It is better in quality having high dry matter and vitamin C. It takes 68 days from the transplanting to harvesting. The variety is excellent in taste, appearance, colour, size and texture. Its average yield is 70 q/acre.

Agronomic Practices

Sowing Time :

- (i) February-March (open field conditions)
- (ii) September and January (for poly net house)
- (iii) Mid November (Low tunnel)

Seed Rate : Use 1.0 kg seed for open field conditions and about 13000 seeds per acre for poly net house cultivation.

Spacing : The seeds are sown on both sides of the beds of width 2.5 metre at a distance of 60 cm between seed. Sow two seeds at one place to ensure good stand.

Cultivation of cucumber in soilless media under naturally ventilated polyhouse and low tunnel : (See on Page No. 141)

Manure and Fertilizers : It requires 40 kg N (90 kg of Urea), 20 kg P_2O_5 (125 kg of Single Superphosphate) and 20 kg K_2O (35 kg Muriate of Potash). Apply $1/3$ N along with whole P_2O_5 and K_2O at the time of sowing in two parallel bands 15 cm away from the bed mark. Apply rest of the N during the early period of vine growth i.e. one month of sowing.

Irrigation : Sowing is done on the pre-irrigated furrows on top of the ridge on both sides of the beds. subsequently irrigation is applied second or third day of sowing. The crop is irrigated at 4-6 days interval. Total number of irrigations would be 10-12.

Harvesting, Care and Marketing

Fruits are picked when tender and young when seeds inside the fruit are still soft. Fruits must be picked before change in colour from green to yellow.

Seed Production

For seed production the fruits should be picked when brown in colour. A minimum of 1000 metre isolation distance from different varieties of cucumber should be kept to produce true to type seed. Three field inspections should be done, first before flowering, second at flowering and fruiting and third before harvesting of the seed crop. All off type and diseased plants should be rogued off. For extraction of seed, the pulp of the fruit is taken out in fresh water. It is kept for one to two days to allow the seed to separate from the pulp. The seed is rubbed with hand. Heavy seeds settle down in water and are retained.

11. LONG MELON

Climate and Soil

Long melon is a warm season crop. It can also be grown under protected conditions to get early yield. The crop can be grown in wide range of soils ranging between sandy loam to heavy soil.

Improved Variety

Punjab Long Melon-1 (1995) : Its vines are long, stem pubescent, angled and light green. It is an early maturing variety. Its fruits are long, thin and light green. Average yield is 86 q/acre.

Agronomic Practices

Sowing Time : February-March.

Seed Rate : Use 1.0 kg of seed per acre.

Spacing : Seeds are sown on both sides of the bed of width 2.5 metre at a distance of 60 cm. Sow at least two seeds at one place to ensure good stand.

Manure and Fertilizers : It requires 40 kg N (90 kg Urea), 20 kg of P_2O_5 (125 kg of Superphosphate) and 20 kg of K_2O (35 kg of Muriate of Potash). Apply 1/3 N along with whole of P_2O_5 and K_2O at the time of sowing in two parallel bands 15 cm away from the bed mark and prepare the ridges. Rest of the N is applied after one month of sowing.

Irrigation : Irrigate immediately after sowing the seeds on the beds. Irrigation may be given at 4-5 days interval in summer season. In the rainy season, apply irrigation whenever required.

Harvesting, Care and Marketing

Long melon fruits are ready for picking in about 60-70 days. Fruits should be picked when attain the marketable size and are tender. In peak season harvest the fruits at 3-4 days interval.

Seed Production

Long melon field should be minimum 1000 metre isolated from other varieties of longmelon, muskmelon, snapmelon and wild melon. The undesirable or off type plants are rogued out

before flowering, during flowering and fruiting stages. Three field inspections should be conducted, first before flowering, second at flowering and fruiting and third before harvesting of the seed crop. The mature fruits are picked and pulp is taken out in fresh water. It is kept for one or two days for separation of seed from the pulp. The seed is rubbed with hands. Heavy seeds settle in water and are retained.

12. ROUND GOURD

Climate and Soil

It is mainly a warm and dry season crop. The vines do not grow well in cool or humid weather. The seeds require soil temperature of 21-35°C to germinate. It likes warm, sunny conditions of 25-30°C at daytime and 18°C or more during night. Well drained, fertile, sandy or loamy soils are ideal for the crop. But it prefers light or sandy soils where its roots can penetrate easily.

Improved Variety

Punjab Tinda -1 (2018) : It is an early maturing variety and is suitable for sowing in spring season. Its leaves are green and moderately lobed. Fruits are round, shining, green, pubescent, white fleshed with average fruit weight of 60 g (immature stage). First picking is possible 54 days after sowing. Its average yield is 72 q/acre.

Tinda 48 : Its vines are 75-100 cm long. Leaves are light green and deeply lobed. Fruits are medium sized with an average weight of 50 g each. Their shape is flat round, pubescent and shining light green in colour. Flesh is white. It yields 25 q/acre.

Agronomic Practices

Sowing Time :

1. February-March
2. June-July

Seed rate : Use 1.2 kg for Punjab Tinda 1 and 1.5 kg for Tinda 48 seed per acre.

Spacing : The seeds are sown on both sides of the beds of width 1.5 m at a spacing of 45 cm. Seeds may be soaked overnight in water to ensure proper germination. Sow at least two seeds at one spot.

Manure and Fertilizers : It requires 40 kg N (90 kg Urea), 20 kg of P₂O₅ (125 kg of Single Superphosphate) and 20 kg of K₂O (35 kg of Muriate of Potash). Apply 1/3 N along with full

dose of P_2O_5 and K_2O at the time of sowing. Apply rest of the N during the early period of the growth.

Irrigation : The seeds are sown on the pre-irrigated furrows on the top of ridge on both sides of the beds. Subsequent irrigation is applied on second or third day after sowing. During summer, irrigate after 4-5 days. In rainy season, irrigation is applied depending on intensity of rains.

Harvesting, Care and Marketing

The first flush of fruits is borne very early. These fruits remain very small, are unmarketable and therefore should be removed as soon as they appear for proper vegetative growth. The fruits of the later flush attain marketable size and are harvested when still tender and hairy. The marketable fruits are ready for first picking after 54-60 days of sowing depending upon the variety. The later pickings should be done at 2-3 days interval.

Seed Production

For seed production, an isolation distance of 800 metre is maintained from other varieties of round melon. Three field inspections should be conducted, first before flowering, second at flowering and fruiting and third before harvesting of the seed crop. All off type and diseased plants should be rogued off. The mature fruits turn their colour into dull. These are picked and crushed with hands in fresh water so as to separate the seeds from the pulp. The heavier seeds settle at the bottom and are retained.

Table 1 : Tips for cucurbits cultivation

Name of Vegetable	Time of sowing	Bed spacing (m)	Plant spacing (cm)	Seed rate (kg/ acre)	Harvesting (days)
Muskmelon	Mid February	3 or 4	60	400 gm	65
Watermelon	Mid January - March *November-December	2.5-3.0	60	1.5 - 2.0	100
Summer squash	Mid January - March *October - November	1.25	45	2.0	60
Pumpkin	February - March June-July	3.0	60	1.0	90
Hybrids & PAU Magaz Kadoo-1	February - March	1.5	45	1.5	65
Bottle gourd	February - March June - July *November-December	2.0-2.5	45-60	2.0	60
Bitter gourd	February- March June - July	1.5	45	2.0	60
Sponge gourd	Mid February - March Mid May - July	3	75-90	2.0	60
Ash gourd	February - March June - July	3	75-90	2.0	120
Cucumber	February - March *September and January	2.5 2.5	60 45	1.0	68
Long melon	February - March	2.5	60	1.0	60
Round Gourd	February - March June - July	1.5	45	1.2-1.5	60
Wanga	February - March June - July	2.5	60	1.0	90

*Under protected/polynet condition

13. WANGA

Climate and Soil

Wanga can be grown in summer as well as in rainy season. It is a crop of dry area and can be successfully grown in Fazilka, Abohar and Faridkot areas. It is grown in sandy soils which are rich in organic matter.

Improved Variety

Punjab Wanga-1 (1995) : Its vines are medium long with angular and hairy stem. The leaves are serrated, dark green in colour. Male and bisexual flowers are borne on the same vine. Fruits are oval shaped, smooth and ready for picking after 88 days of sowing. Its average yield is 45 q/acre.

Agronomic Practices

Sowing Time : 1. February-March 2. June-July

Seed Rate : Use 1.0 kg of seed per acre

Spacing : The seeds are sown on both sides of the beds of width 2.5 metre at a spacing of 60 cm. Sow at least two seeds at one place to ensure good stand.

Manure and Fertilizers : It requires 40 kg N (90 kg of Urea), 20 kg of P_2O_5 (125 kg of Single Superphosphate) and 20 kg of K_2O (35 kg of Muriate of Potash). Apply $1/3$ N and whole of P_2O_5 and K_2O at the time of sowing in two parallel bands 15 cm away from bed mark. Apply rest of the N during the early period of vine growth i.e. one month of sowing.

Irrigation : The seeds are sown on the pre-irrigated furrows on the top of the ridge on both sides of the beds. Subsequently the irrigation is given second or third day after sowing. During summer, irrigate after 5-6 days. In rainy season irrigation is applied as per the intensity of rains. Total number of irrigations would be 8-10.

Harvesting, Care and Marketing

Picking should be done when fruits are medium sized and

tender. The first picking is done about 90 days after sowing. Picking is done at an interval of 3-4 days.

Seed Production

For seed production, the fruits turn light green in colour and are soft to touch. A minimum of 1000 metre isolation distance from different varieties of wanga, snapmelon, wildmelon and muskmelon should be kept to produce true to type seed. Three field inspections should be conducted, first before flowering, second at flowering and fruiting and third before harvesting of the seed crop. All off type and diseased plants should be rogued off. For seed extraction, the pulp of the fruit is kept in water for two days. Seed separates from the pulp and settle down in water and is retained.

Plant Protection

(Muskmelon, Watermelon and other Cucurbits)

A. Insect pests

Pests and Symptoms	Control Measures	Precautions
1. Red pumpkin beetle (<i>Aulacophora foveicollis</i>) attacks the crops at the seedling stage. In case of a severe attack, the crop is totally destroyed.	After germination, dust dung ash on the plants 3-4 times at weekly interval during initial days of crop growth.	i) Sow the crop in November to avoid the damage from this insect.
2. Aphid causes damage in Feb.-March by sucking the sap from the foliage. The aphids also spread virus diseases.	Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/canals as they serve as reservoir for aphids.	Use fertilizers judiciously, as aphid populations tend to be higher in plants that are fertilized liberally with nitrogenous fertilizers.
3. Whitefly: Nymphs and adults suck sap from the foliage and reduce the yield.	In the beginning of crop season on appearance of whitefly, give 1-2 sprays of *PAU Neem Extract @ 1200 ml per acre in 100-125 litre of water.	i) Regular monitoring of the main crop and alternate host crops should be carried out to check whitefly infestation for and its timely management.

	<p>*Method of preparation of PAU Neem Extract: Boil 4.0 kg terminal parts of the shoots of Neem trees including leaves, green branches and fruits in 10 liters of water for 30 minutes. Then filter this material through muslin cloth and use the filtrate for spraying at the recommended dose.</p>	<p>ii) Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/canals to avoid further spread of whitefly. iii) Harvest the ripe fruit before spray.</p>
<p>4. Red spider mite (<i>Tetranychus</i> spp.) attacks the leaves and sucks the plant sap.</p>		
<p>5. Fruit flies (<i>Bactrocera cucurbitae</i>) puncture tender fruits and spoil them. Their attack is serious in longmelon, luffa, bittergourd, tinda, bottle gourd and muskmelon.</p>	<p>(i) Apply the bait spray containing 20 ml Malathion 50 EC and 200g gur/sugar in 20 litres of water on the lower surface of the leaves of maize plants grown in rows at distance of 8-10m as trap crop has been found to be effective as the flies have the habit of resting on such tall plants.</p> <p>(ii) For sponge gourd, use PAU fruit fly trap @16 trap per acre during 3-4th week of April for spring and 4th week of June for rainy season crop.</p> <p>(iii) For the management of fruit fly of bitter gourd, use PAU fruit fly trap @ 16 trap per acre during 3-4th week of March for spring and 4th week of June for rainy season crop.</p>	<p>(i) Collect the infested fruits and destroy them by burying them deep in soil.</p> <p>(ii) Recharge the traps after 25-30 days, if required</p>

B. Diseases

Diseases	Symptoms	Control Measures
1. Powdery mildew (<i>Sphaerotheca fulginea</i>)	The fungus forms a white floury coating on leaves, stem and other succulent parts of the plant, develops in dry weather. Fruits remain poor in quality and flavour.	
2. Downy mildew (<i>Pseudoperonospora cubensis</i>)	On most of the host plants, the first visible symptoms are the appearance of small water soaked lesions on the leaves. These lesions appear yellow on the upper surface. Greyish downy growth of fungus develops on underside of the leaves. Lesions turn brown in the centre and veins are blighted.	i) Destroy over wintering vines of cucurbits. ii) Avoid flood irrigations.
3. Collar rot (<i>Rhizoctonia solani</i>)	At soil level, the stem shows brown to dark brown lesions. The plant is eventually killed. Damping off of seedlings also takes place.	Use disease free seed.
4. Pythium rot (<i>Pythium butleri</i>)	Water soaked lesions girdle the stem, later extending upwards and downwards. The affected tissues rot and even grown up plants collapse. This fungus also causes fruit rotting.	Avoid flood irrigations.
5. Alternaria blight (<i>Alternaria cucumerina</i>)	Yellow spots appear on the leaves which turn dark brown and finally black with age. They usually start from the margin & produce concentric rings; severely infected vines look like burnt charcoal. The disease is more severe on watermelon.	
6. Mosaic (<i>Virus</i>)	The appearance of dark green and light green patches on the leaves; leaves become chlorotic, reduced in size and deformed into finger like structures in squash, bottle gourd and sponge gourd, at the end of season. The virus is transmitted through seeds and aphids.	i) Collect seeds from virus free plants. ii) Rogue out the virus affected plants. iii) Spray the crop with insecticides recommended for the control of aphids.

<p>7. Root knot nematode (<i>Meloidogyne incognita</i>)</p>	<p>Poor and patchy growth of crop. Leaves become yellow and reduced in size. Formation of knots on roots. Severely infected vines dry up and die earlier than healthy ones. Infected vines wilt easily during day. Disease is soil borne.</p>	<p>i) Give frequent cultivation in May-June to expose the soil to the Sun.</p> <p>ii) Follow rotations with rice, oat, wheat and <i>taramira</i> in nematode infested soils.</p> <p>iii) For the integrated management of root knot nematode in infested poly/net houses apply Mustard Cake @ 1 t/ha and Neem Cake @ 1t/ha mixed with FYM @ 2.5t/ha ten days before sowing of cucumber.</p>
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14. TOMATO

Climate and Soil

Tomato is a warm season crop and requires a relatively long growing season with plenty of sunshine and moderate day temperature of 20–28°C. It is sensitive to frost. Under low temperature, the plant growth is restricted and fruit setting is low. The critical factor in the setting of fruits is the night temperature, the optimum range being 15–20°C. The red pigment in the fruit will develop only when the temperature is between 15°C-30°C. Above this range of temperature, only the yellow pigment formed. When the temperature exceeds 40°C, no pigment will be formed.

Tomato can be grown in all types of soils, but the soil should be friable. However, it grows best in light soils ranging from sandy loam to loam.

Improved Hybrids/Varieties

Hybrids

PTH-2 (2019) : The plants are determinate with dark green foliage and first picking is possible after 114 days of transplanting. Fruits are round, deep red, medium sized (75g) and firm with 3-4 locules. The hybrid has TSS content of 4.2% and lycopene content of 4.7%. The hybrid is resistant to late blight and root knot nematodes. The hybrid is suitable for processing purposes and its average yield is 270 q/acre.

TH-1 (2003) : It is a determinate hybrid which is cross between W-321×1-181. Its foliage cover is dense that protects the fruits

- Sow virus tolerant variety of tomato, viz., Punjab Varkha Bahar - 4, Punjab Varkha Bahar-2 and Punjab Varkha Bahar-1 during rainy season.
- For early and higher yield, sow nursery of PTH-2 and TH-1, Punjab Ratta, Punjab Upma, Punjab Chhuhara and Punjab NR-7 in October-November.
- Punjab Swarna, Punjab Gaurav, Punjab Sartaj, Punjab Sona Cherry, Punjab Kesar Cherry and Punjab Red Cherry are suitable for protected cultivation.
- Transplant the nursery in November-December and save the crop from frost during winter by covering with polythene/sarkanda.

from sun scalding. Fruit colour is deep red, shape is round and average fruit weight is 85 g. Its fruits are firm, average TSS is 5% and is thus recommended both for fresh market and processing. It has better shelf life and can be transported to distant markets. TH-1 is moderately resistant to late blight. Average yield is 245 q/acre.

Varieties

(a) Rainy Season Varieties

Punjab Varkha Bahar-4 (2015): It is a determinate variety with green and dense foliage. Average plant height is 85 cm. The fruits are firm, round and uniform in ripening with an average weight of 90 g. First picking is possible 88 days after transplanting. It is suitable for cultivation in rainy/autumn season. It is resistant to leaf curl virus. Its TSS is 3.8% and lycopene content is 3.13 mg/100g of fresh weight. Average yield is 245 q/acre.

Punjab Varkha Bahar-1 (2009) : The plants are semi determinate, foliage cover is dense and dark green. Fruits are round and medium firm. It takes 90 days for maturity after transplanting. It is moderately resistant to leaf curl virus. The variety is suitable for cultivation during the rainy season. Its average yield is 215 q/acre.

Punjab Varkha Bahar-2 (2009) : The plants are determinate, foliage cover is dense and light green. Fruits are round and medium firm. It takes 100 days for maturity after transplanting. It is moderately resistant to leaf curl virus. The variety is suitable for cultivation during the rainy season. Its average yield is 216 q/acre.

(b) Winter and Spring Season Varieties

Punjab Ratta (2009) : The plants are determinate, foliage cover is dense and dark green. It takes 125 days from transplanting to first picking when transplanted during the last week of November. The fruits are oval, medium sized, very firm and deep red (average lycopene content 8 mg/100g). It is suitable for processing and the average yield is 225 q/acre.

Punjab Upma (2000) : The plants are determinate, foliage cover is dense & leaflets are broad. The fruits are oval, medium in size, firm deep red in colour and is suitable for fresh market and

processing. The average yield is 220 q/acre and 300 gm seed can be extracted from one quintal fruit.

Punjab NR-7 (1985) : Its plants are dwarf, foliage is medium dense, fruits are flat round, medium sized (70g), uniform red, multilocular and juicy. It is highly resistant to root knot nematodes (*Meloidogyne incognita* and *M. javanica*) and resistant to *Fusarium* wilt (*Fusarium oxysporum* f. *lycopersici*). Average yield is 175-180 q/acre.

Punjab Chhuhara (1975) : The plants are dwarf, being about 60 cm tall. Its dense foliage protects the fruits from sunburn. The fruit is pear shaped, small to medium with fewer seeds. Its fruits ripen uniformly. It yields about 320 q/acre.

(c) Varieties for Polynet/Nethouse

Tomato hybrids, NS-4266, Himshekhar and Punjab Sartaj can be grown in soilless medium under protected cultivation.

Punjab Swarna (2018) : Plants are indeterminate in growth habit with dark green foliage and suitable for cultivation under protected conditions. Fruits are firm, medium size, oval, with pointed tip and 2-3 locules, orange in colour. Fruits are borne in clusters of 8-10 having TSS of 4% and carotene content of 14mg per 100g of fresh weight. First picking is possible 120 days after transplanting. It gives early average yield (harvested till end March) of 166 q/acre and average yield of 1087 q/acre. It is suitable for table purpose.

Punjab Gaurav (2015): Plants are indeterminate in growth habit. Fruits are oval, medium sized (90 g), very firm with pointed tip and 2-3 locules. Fruits are borne in clusters of eight to nine with TSS content of 5.5% and lycopene content of 4.9 mg per 100 g. First picking is possible 120 days after transplanting and it gives early yield (harvested till end March) of 247 q/acre and total yield of 934 q/acre. The fruits have a shelf life of six days under ambient conditions and are suitable for both local and distant markets. The variety is suitable for protected cultivation under polynet house.

Punjab Sartaj (2015) : Plants are indeterminate in growth habit with dark green foliage. Fruits are round, medium sized (85

g) and firm with 3- 4 locules. Fruits are borne in clusters of five to six with TSS content of 5.7% and lycopene content of 5.3 mg per 100 g. First picking is possible 117 days after transplanting and it gives early yield (harvested till end March) of 254 q/acre and total yield of 898 q/acre. The fruits have a shelf life of five days under ambient conditions and are suitable for both local and distant markets. The variety is tolerant to leaf curl virus and is suitable for protected cultivation under polytunnel house.

Besides these, three Cherry Tomato Varieties have also been recommended.

Punjab Sona Cherry (2017): Plants are indeterminate in growth habit. Fruits are oval, yellow in colour and first picking is possible after 112 days of transplanting. Fruits are borne in clusters of 20-25 with average fruit weight of 11g. Its TSS content is 7.5% and carotene content is 13 mg per 100 g of fresh weight. It gives early yield of 148 q/acre (end March) and total yield of 425 q/acre. The variety has a shelf life of five days and is suitable for protected cultivation.

Punjab Kesar Cherry (2017) : Plants are indeterminate in growth habit. Fruits are oval, orange in colour and first picking is possible after 115 days of transplanting. Fruits are borne in clusters of 18-23 with average fruit weight of 11g. Its TSS content is 7.6%, lycopene content is 1.8 mg per 100 g and carotene is 13 mg per 100 g of fresh weight. It gives early yield of 138 q/acre (end March) and total yield of 405 q/acre. The variety has a shelf life of six days and is suitable for protected cultivation.

Punjab Red Cherry (2015) : Plants are indeterminate in growth habit with dark green foliage. Fruits are round, deep red and first picking is possible 120 days after transplanting. Fruits are borne in clusters of eighteen to twenty with average fruit weight of 12 g. Its TSS content is 6.3% and lycopene is 4.9 mg per 100 g of fresh weight. It gives early yield (harvested till end March) of 156 q/acre and total yield of 437 q/acre. It is tolerant to leaf curl virus and is suitable for protected cultivation.

Agronomic Practices

Seed rate : Seed rate is 100g/acre when sown in the nursery. Sow nursery in two marla (50 m²) area to transplant one acre.

Sowing time : For winter planting, sowing should be done in October and transplanting in November-December. *Sarkanda* cover should invariably be provided during winter to protect the plants against frost. However, dwarf varieties can be successfully and economically covered with polythene bags of 35 cm×25 cm size and of 100- gauge thickness.

The transplanting of tomato can also be done in February. For February planting, sow seed in the end of November and protect seedlings from frost in the nursery beds by covering with polythene sheets or *sarkanda* thatch. However, the yield obtained would be comparatively lower from February planted crop than from November planted crop. To ensure successful growing of healthy seedlings from costly hybrid seeds of tomato, grow nursery of this crop under polyhouse (size 24'×13'×6') made of UV stabilized low density polyethylene film of 200 microns (800 guage) thickness.

Time of sowing under polyhouse	Time of transplanting
Main season crop	
a) 1st week of November	End of November
Spring season crop	
b) Last week of December	Mid February

The sowing of Punjab Varkha Bahar-4, Punjab Varkha Bahar-1 and Punjab Varkha Bahar-2 can be done in second fortnight of July and their transplanting can be done in second fortnight of August. Transplant two seedlings per hill.

Nursery Raising : Prepare 1.5 m wide and 20 cm high beds in an area of about two marlas (50 m²) to raise seedlings for an acre. Mix 5 quintals of well rotten farmyard manure with the soil and water the beds at least 10 days before sowing. Drench the beds with Formalin (15 to 20 ml per litre water) by applying 4-5 litres of solution per square metre. Cover beds with a plastic sheet/tarpaulin for 48-72 hours. Turn the soil in beds once a day for 4 to 5 days to eliminate Formalin. Treat the seed with 3 g Captan per kg of seed. Sow seeds 1 to 2 cm deep in lines with 5 cm spacing. Drench the nursery plants with Captan (4g/litre of water) after 5 to 7 days of germination. Repeat after 7 to 10 days. The seedlings become 15 to 20 cm tall in four to six weeks. After lifting the seedlings, wrap them in a wet paper for carrying to the transplanting site.

Spacing : Dwarf varieties require a close spacing of 75 cm×30 cm. Rainy season varieties should be planted at a spacing of 120-150×30 cm.

Manures and Fertilizers : Apply 10 tonnes of well rotten farmyard manure and plough it into the soil. Add 25 kg of N (55 kg of Urea) along with 25 kg of P₂O₅ (155 kg of Single Superphosphate) and 25 kg of K₂O (45 kg of Muriate of Potash) per acre in a band at 15 cm on one side of the bed mark and prepare the channels. After removing sarkanda/polythene bag cover by mid February, apply 35 kg of N (75kg of Urea) per acre in the rows, but not touching the base of the vines. Mix it with the soil and earth up. In the sandy soils, apply N in three split doses. The first part should be applied alongwith phosphorus and potash. The second dose should be applied just before the plants take up active growth and the third dose when the first flower clusters have started setting fruits. Under high fertility conditions, the application of N should be reduced, as the blossoms may fail to set fruit due to the unfavourable carbohydrate nitrogen ratio within the plant.

Weed Control : Spray Sencor 70WP (metribuzon) 300g/acre using 200 litre water on moist, prepared seed bed at 3-4 days before transplanting and give one hoeing afterwards.

Growth Regulator : To increase the yield of tomato, spray 'Vipul Booster' @ 1 ml/litre of water in the nursery beds at least a week before transplanting. Repeat the spray of @ 0.5 ml/litre of water five times at fortnightly intervals. The first foliar spray after transplanting should be started a week after transplanting. Each spray application requires 100 litres of water for which 50 ml of the chemical is needed. This growth regulator increases the yield by 16-18 per cent in November transplanted crop and about 12 per cent in the February transplanted crop.

Irrigation : First irrigation should be given immediately after transplanting. Subsequent irrigations may be given after 6-7 days during summer and 10-15 days during winter months. Total number of irrigations required are 14 to 15.

Harvesting, Care and Marketing

Harvesting should be done according to distance of markets. For long distance markets pick mature green fruits whereas for

local market pick at red stage. For processing, pick when fruits are fully red. While picking for long distance markets remove rotten, over-ripe and borer infested fruits. The fruits should be pre-cooled at 13°C immediately after harvesting. Packaging of tomatoes in paper moulded trays followed by wrapping with shrink and cling film extends its marketing period with acceptable quality for 6 days.

The plastic crate of internal size 465 mm × 290 mm × 140 mm can hold about 10 kg of tomato, while corrugated fiber board box of internal size 335 mm × 215 mm × 185 mm (3-5 ply) can carry 5 kg tomato for distant and domestic marketing with minimum loss.

Punjab Varkha Bahar-4 is ready for harvesting in second fortnight of November whereas Punjab Varkha Bahar-1 is ready for harvesting at the end of November. The harvesting of Punjab Varkha Bahar-2 should be started from first fortnight of December. Winter season tomatoes, free from bruises and diseases, packed in plastic crates lined with news paper can be ripened in 7-10 days in ventilated polyhouse conditions or ripening chamber at 20°C temperature and 85-90 per cent RH. The fruit attains uniform colour and quality during ripening.

Seed Production

The tomato should be grown at the isolation distance of atleast 50 metre from other varieties to avoid any chance of contamination. Minimum three field inspections should be made for getting the true to type seed. The first inspection should be made at vegetative phase, second at flowering and fruiting and third before harvesting of fruits. Any off type and diseased plants should be removed. The extraction of seed from the ripe fruits is done by fermentation method and acid method. In fermentation method, the crushed fruits are allowed to ferment for 1 to 2 days and then put in water where pulp and skin float and the seeds settle down at the bottom. In Acid method, about 100 ml of commercial hydrochloric acid is thoroughly mixed to 14 kg of crushed tomato fruits. The seeds is separated out from the pulp within half an hour which may be cleaned, dried and packed.

Plant Protection

A. Insect Pests

Pests and Symptoms	Control Measures	Precautions
1. Whitefly <i>(Bemisia tabaci)</i> and Aphid <i>(Aphis gossypii)</i> They suck the sap from leaves and lower the yield	For whitefly, spray 400 ml of Malathion 50 EC in 100 litres of water before fruiting. Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/canals as they serve as reservoir for whitefly and aphids.	Use nitrogenous fertilizers judiciously, as their excessive use encourages multiplication of these insect pests.
2. Fruit borer <i>(Helicoverpa armigera)</i> The larva attacks the fruits and cause, holes and rotting afterwards	Give three sprays at 2 week intervals starting from the initiation of flowers with any of the following insecticides using 100 litres of water per acre. i) 60 ml Coragen 18.5 SC (chlorantraniliprole) ii) 200 ml Indoxcarb 14.5 SC iii) 30 ml Fame 480 SL (flubendiamide)	i) Regularly collect the infested fruits and destroy them by burying deep in soil ii) Ripe fruit should be picked before spray. iii) Observe the waiting period of one day after spray of Coragen and 3 days after spray of Fame.

B. Diseases

Diseases	Symptoms	Control Measures
1. Early blight <i>(Alternaria solani)</i>	Concentric, dark brown spots appear on leaves and induce yellowing & shedding of leaves. The fruits are also affected and show dark circular areas followed by rotting.	i) Obtain the seed from healthy fruits only. ii) Treat the seed before sowing with 3g Captan per kg of seed. iii) After transplanting, spray the crop with 600g Indofil M45 per acre at an interval of 7 days.
2. Late blight <i>(Phytophthora infestans)</i>	Dark water-soaked patches appear on leaves and stem. The fruit is also affected. Crop is rapidly destroyed if rains occur during February.	i) Spray the crop as recommended under early blight during February-March just after rains. Repeat after 7 days intervals. ii) Grow resistant hybrids PTH-2 and TH-1

<p>3. Damping-off (<i>Pythium</i> spp. <i>Rhizoctonia</i> sp. <i>Fusarium</i> sp.)</p>	<p>Cause pre and post-emergence death of seedlings in nursery beds.</p>	<p>i) Treat the seed with 3g Captan per kg of seed ii) Drench the nursery beds with Captan (400g in 100 litres of water) 5 to 7 days after germination. Repeat the drenching after 7-10 days, if necessary.</p>
<p>4. Leaf curl (Virus)</p>	<p>Stunting of plants with downward rolling and crinckling of leaves, plants bear few flowers and fruits. Transmitted through whitefly.</p>	<p>i) Grow leaf curl resistant varieties. ii) Rogue out and burn the affected plants. iii) Protect the crop in the nursery beds and fields from insect vector (whitefly) by spraying recommended insecticides.</p>
<p>5. Mosaic (Virus)</p>	<p>Leaves of the affected plants exhibit mottling with raised dark green areas. Distortion and malformation of leaves is common. Transmitted through seed/aphids.</p>	<p>i) Collect the seed from virus free plants. ii) Avoid unnecessary touching of plants. iii) Spray the crop with recommended insecticides.</p>
<p>6. Root knot nematodes (<i>Meloidogyne incognita</i> and <i>M. javanica</i>)</p>	<p>Yellowing of leaves patchy & unthrify growth of plants, knot like swellings galls are formed in roots. Nematodes survive in soil for a long period.</p>	<p>i) Grow nematode resistant variety PTH-2 and Punjab NR-7 in infested fields. ii) Solarize water saturated nursery bed using transparent polythene sheet (50 micron) for 40 days in the months of May-June for the control of root knot nematode in nursery beds. iii) Incorporate 40 days old <i>Toria</i> and <i>Taramira</i> crops into tomato nursery beds 10 days before sowing and turn the soil 3-4 times before sowing of tomato. iv) Grow garlic in root knot nematode infested fields in rotation with other vegetable crops. v) Green manure with sunhemp (50 day old crop) or marigold (60 days old crop) in root knot nematode infested fields. vi) Do not green manure with <i>Dhaincha</i> in root knot nematode infested fields.</p>

Note: Dip treatment should be conducted in shade and stems should not be immersed in solution.

15. BRINJAL

Climate and Soil

Brinjal requires a long and warm growing season. The plant is sensitive to frost injury. Chilling weather for a long time may also damage the crop. A well drained and fertile soil is desirable for growing brinjal. It is a hardy plant and can be grown on different kinds of soil but does best on silt loams and clay loams. However to raise an early crop sandy or sandy loam soil is preferred.

Improved Hybrids/Varieties

Round Fruited

Punjab Neelam (1998) : It is ready for first picking in 65 days after transplanting. Plants are medium in height erect, thornless, foliage is green with purple tinge, fruits are oval-round, medium-sized and shining dark purple in colour. It is suitable for transplanting in February and August. Average yield is 140 q/acre.

Oblong Fruited

PBHR-41 (2016) : Plants are medium-tall, thornless, green foliage with purple, tinge. Flowers are purple and borne solitary. Fruits are round, medium-large in size, shining, deep purple with purple green calyx. It matures in 65 days and average yield is 269 q/acre.

PBHR-42 (2016) : Plants are medium-tall, thornless and foliage green. Flowers are purple and borne solitary. Fruits are oval-round, medium in size, shining, purple-black with green calyx. It matures in 65 days and average yield is 261 q/acre.

BH-2 (1994) : Leaves of this hybrid are green and purplish. Plants are medium, erect, spreading and thornless. Its fruits are oblong and deep purple. Average weight per fruit is 300 g. It is highly suitable for cooking as 'bhartha'. It is tolerant to fruit borer. Average yield is 235 q/acre.

Long Fruited

Punjab Raunak (2018) : It is an early maturing variety. Its plants are medium in height, compact, thorn-less with green

foliage. Flowers are purple, borne in cluster and solitary. Fruits are long, medium, thin, shining and deep-purple with green calyx. Its average yield is 242 q/acre.

PBH-5 (2017) : It is an early maturing F_1 hybrid of long fruit group of brinjal. Its plants are medium in height, compact, thorn-less with green foliage. Flowers are purple and borne in clusters. Fruits are long, medium-sized and shining-purple with green calyx. Its average yield is 255 q/acre.

PBH-4 (2015) : Plants of this hybrid are medium tall, compact and thornless. Foliage green, flowers purple and borne in cluster and solitary. Fruits are long, medium sized, shining and purple-black with green calyx. It is early in fruiting and average yield is 270 q/ acre .

Punjab Barsati (1987) : This variety takes about 64 days from transplanting to the first harvesting. Its plants are dwarf, erect and thornless. The leaves are medium-long and shining purple. Its average yield is 140 q/acre. It is more tolerant to fruit-borer and is most suitable for transplanting in rainy season.

Punjab Sada Bahar (1987) : This variety takes about 76 days from transplanting to the first harvesting. Its plants are dwarf, erect and thornless. The leaves are green. The fruits are long, thin and deep purple. Its average yield is 125 q/acre. It is good for summer, autumn and also as ratoon crop. It is comparatively tolerant to fruit-borer.

Small Fruited

Punjab Bharpoor (2020) : Its plants are medium-tall, compact, thorn less with green foliage. Flowers are purple, borne in heavy clusters. Fruits are small-oblong, shining, deep purple with green calyx and borne in cluster. It is resistant to bacterial wilt disease. Its average yield is 224 q/acre.

PBH-3 (2013) : The plants of this hybrid are medium in height, compact and thornless. Foliage is green with purple tinge. Flowers are purple and borne in clusters. Fruits are shining purple of small size and oblong shape. It is comparatively tolerant to fruit borer. It is early in fruiting and gives 257 quintal per acre yield.

Punjab Nagina (2007) : Its plants are dwarf, semi-erect with dark green and spineless leaves. Its flowers are light-violet in colour with green calyx. Its fruits are shining, purple black, small, round and borne in clusters. This variety gives first picking in 55 days after transplanting. The average yield is 145 q/acre.

Agronomic Practices

Seed Rate : To plant an acre 300 to 400 g of seed is grown in one *marla* (25m × 1m) on raised beds.

Sowing Time : The sowing time of four successive crops of brinjal is given below :

1. The nursery for the first crop is sown in October and seedlings are transplanted in November.
2. The nursery for the second crop is sown in November. It gives seedlings for transplanting in the first fortnight of February. The seedlings of this nursery are required to be protected against frost.
3. The seed for the third crop is sown in nursery beds in February-March. The seedlings are transplanted before the end of April.
4. The seed for the fourth crop is sown in the nursery beds in July and transplanting is done in August.

Low tunnel technology : (see on page no. 141)

Spacing : Rows are spaced 67.5 cm apart and plants are spaced 30-45 cm apart in the row.

Manures and Fertilizers : Apply 10 tonnes of well rotten farmyard manure. Apply 25 kg of N (55 kg of Urea) 25 kg of P₂O₅ (155 kg of Single Superphosphate) and 12 kg of K₂O (20 kg of Muriate of Potash) per acre. Apply all the fertilizers at transplanting. After two pickings, again apply 25 kg of N (55 kg of Urea) per acre.

Irrigation : 1. Furrow Irrigation : First irrigation should be given immediately after transplanting. During summer irrigate the crop at 4-6 days interval whereas during winter season irrigate at 10-14 days interval depending on soil type. It requires 10-16 irrigations.

2. Drip Irrigation: Drip irrigation and mulching in brinjal results in saving of 50% water over conventional method of irrigation. Under this system, irrigation should be applied an interval of two days. For this system, broad beds are prepared at 1.20 m apart from centre to centre of furrow. These beds are 80 cm wide on the top and the furrows between the two beds are 40 cm wide. The beds are covered with plastic film (silver or black) of 25 micron thickness. Seedlings are transplanted on the bed at spacing of 60 cm and plant to plant spacing of 45 cm. One lateral pipe is used to irrigate two rows of plants. The drippers are spaced 30 cm apart and are operated at a discharge of 2.2 liters per hour as per following schedule:

Month	Time of irrigation (minutes)*
August	36
September	40
October	60
November	68

*If discharge rate is different, time of irrigation may be adjusted proportionally by the formula:-

$$2.2 \times \text{Time of irrigation} \\ = \frac{\text{Discharge of dripper}}{\text{Discharge of dripper}}$$

Fertigation saves 20% fertilizer. Apply 80 kg of Urea, 33 kg of Mono ammonium Phosphate (MAP) and 16 kg of Muriate of Potash (MOP) per acre. Start fertigation within first week of transplanting. 25% of the fertilizer should be applied during the first month in seven equal splits with every second irrigation (at four days interval). Remaining amount of fertilizer should be applied in 20 splits in equal doses from second month onwards.

Harvesting, Care and Marketing

Fully developed and tender fruits are harvested at weekly interval in the peak season. Packaging of brinjal fruits in paper moulded trays followed by wrapping with shrink and cling film improves the shelf life and maintains the quality under ordinary market for one week.

Seed Production

The brinjal variety should be grown at least 200 metre apart from other brinjal varieties. Minimum three field inspections should be made, first at vegetative phase, second at flowering and fruiting and third before harvesting of fruits. Any off type and diseased plants should be removed. For seed production, the ripe fruits which turned yellow are crushed and stored overnight. The seeds are separated after washing with water and is finally sieved and dried. The washing is usually done in the morning so that the seed is dried during the day. The dried seed is packed and labelled.

Plant Protection

A. Insect Pests

Pests and Symptoms	Control Measures	Precautions
<p>1. Jassid (<i>Amrasca biguttula</i>), Hadda beetle (<i>Epilachna</i> sp.) and brinjal shoot and fruit borer (<i>Leucinodes orbonalis</i>) cause damage during May to September. Plants attacked by jassid become pale and finally bronze. A large number of greenish adults and nymphs are seen on the lower surface of leaves. Hadda adults and grubs feed on the leaves. Shoot infested with borer droop downwards and dry up. Infested fruits have a varying number of holes.</p>	<p>To control brinjal shoot and fruit borers, spray 3-4 times at 14-days interval using 100-125 litres of water/acre with any one of the following insecticides as soon as the attack starts.</p> <p>i) 80 ml Coragen 18.5 SC (chlorantraniliprole) ii) 80 g Proclaim 5SG (emamectin benzoate) iii) 100 ml Somicidin 20 EC (fenvalerate) iv) 200ml Ripcord 10E (cypermethrin) v) 160ml Decis 2.8 EC (deltamethrin)</p> <p>• For the management of hadda beetle, regularly collect and destroy egg masses and skeletonised leaves with adults and grubs.</p>	<p>i) Pick regularly all ripe fruits before spraying. ii) All the infested fruits should be picked and destroyed. iii) Do not ratoon the brinjal crop. iv) For the control of brinjal fruit and shoot borer, insecticides of the same group should not be used repeatedly in order to avoid the development of pesticide resistance and appearance of secondary pests. v) A waiting period of 3 days for Proclaim and 7 days for Coragen should be observed after the spray. vi) Judicious use of nitrogenous fertilizers, as higher doses make the plant prone to jassid attack.</p>

<p>2. Whitefly : Whitefly causes maximum damage during July-September. Its adults and nymphs suck sap from leaves and excrete honey dew on leaves which become sticky. Affected leaves turn black due to development of sooty mould.</p>	<p>In the beginning of crop season on appearance of whitefly, 1-2 sprays of 1200 ml *PAU <i>Neem</i> Extract or 1500 ml maize or sorghum or bajra juice per acre should be given. If the attack is severe, spray 200 g Pegasus 50WP (diafthiuron) per acre in 100-125 litres of water.</p> <p>*Method of Preparation of PAU <i>Neem</i> Extract: Boil 4.0 kg terminal parts of the shoots of <i>Neem</i> trees including leaves, green branches and fruits in 10 liters of water for 30 minutes. Then filter this material through muslin cloth and use the filtrate for spraying at the recommended dose.</p>	<p>i) The decision regarding spray of insecticides should be taken based on Economic Threshold Level (ETL). Record the whitefly population from three leaves one each from top, middle and bottom canopy from 10 randomly selected plants from middle in each of the four quarters of one acre before 10 AM. In case, the mean whitefly population reaches economic threshold level of nine adult per leaf, spray the crop with recommended insecticides.</p> <p>ii) Regularly pick all ripe fruits before spraying.</p> <p>iii) A waiting period of 1 day for Pegasus 50WP should be observed after the spray.</p> <p>iv) Regular monitoring of the crop should be done to check for whitefly infestation.</p> <p>v) Regular surveillance on alternate host crops should be carried out for timely management of whitefly.</p> <p>vi) Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/canals to avoid further spread of whitefly to brinjal fields.</p> <p>vii) Avoid usage of synthetic pyrethroids to minimize the whitefly resurgence.</p>
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<p>3. Spider mites (<i>Tetranychus urticae</i>) attack during April-June and are very serious when the conditions are hot and dry. Initially yellowish-white specks appear on the leaves followed by scorching and leaf fall. Mite attacked leaves attract lot of dust particles.</p>	<p>Spray 300 ml Omite 57 EC in 100-150 litres of water per acre.</p>	<p>i) Do not keep brinjal as ratoon crop. ii) Do not delay or withhold irrigation during April-June. iii) Sprays of pyrethroid should be done only on need basis.</p>
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B. Diseases

Diseases	Symptoms	Control Measures
<p>1. Phomopsis blight (<i>Phomopsis vexans</i>)</p>	<p>Straw-brown to deep brown spots develop on the leaves and fruits. The infected areas of the fruits begin to rot.</p>	<p>Collect seed from healthy fruits. Treat seed with Captan 3g per kg. of seed before sowing. Spray 200g Zineb in 100 litres of water per acre at weekly interval after transplanting.</p>
<p>2. White rot (<i>Sclerotinia sclerotiorum</i>)</p>	<p>Disease appears as light pinkish brown water soaked irregular areas on leaves which become covered with white mycelium under humid and cool weather conditions. Hard black bodies (sclerotia) are formed intermingled with cottony growth on the leaves. The stem infection develops as pale or dark brown lesions. The sclerotia are formed either internally in the stem or intermingled with white mycelium on outside of stem. The fungus also causes wet rot on fruits. The infected portion rots in the later stage of infection. Black sclerotia intermingled with white mycelium are formed on the infected portion. The disease is severe at flowering and fruiting stage of the crop</p>	<p>i) Avoid growing of brinjal, after the susceptible crops like peacauliflower, carrot and binjal, instead tomato and chilli can be grown. This will help in reducing the disease and spread of inoculum in the field. ii) The plant debris of crop should be collected and burnt. iii) Avoid growing of main season crop (July-February) in the disease prone fields.</p>

<p>3. Little leaf (<i>Mycoplasma like organisms</i> (MLO))</p>	<p>Leaves are reduced in size. Affected plants give rosette appearance. Plants fail to produce flowers and fruits. Transmitted by jassid. It is more severe in ratoon crop.</p>	<p>i) Rogue out the affected plants. ii) Keep the jassid under check by spraying recommended insecticides in nursery and field.</p>
<p>4. Root knot nematode (<i>Meloidogyne incognita</i>)</p>	<p>Yellowing of leaves, patchy and unthrifty plants, knot like swelling/galls are formed on roots.</p>	<p>i) Solazie water saturated nursery bed using transparent polythene sheet (50 micron) for 40 days in the months of May-June for the control of root knot nematode in nursery beds. ii) Grow garlic in root knot nematode infested fields in rotation with other vegetable crops. iii) Green manure with sunhemp (50 days old crop) in root knot nematode infested fields. iv) Do not green manure with <i>Dhaincha</i> in root knot nematode infested fields.</p>

16. CHILLI

Climate and Soil

Chilli performs well under humid climate. It is photo-insensitive and day length neither affects flowering nor fruit setting. A frost free period of about 130-150 days with temperature range of 15-35°C is optimum for chilli production. Generally chilli will not set fruit when night temperature is above 30°C. Temperature beyond 40°C result in poor fruit set and increased fruit drop. This is further aggravated if the relative humidity is low and is accompanied by dry winds.

Chilli can be grown on a wide range of soils but well drained loamy soil rich in organic matter is best suited for its cultivation. It can not withstand water-logged conditions for more than a day. Although chilli can be grown on soils with a pH range of 5.0 to 8.0 but it performs best at a soil pH of about 6.5.

Improved Hybrids/Varieties

Hybrids

CH-52 (2021): It is a hybrid between MS-13A x IS-261. The plants are dark green, spreading and tall. First picking is possible 112 days after transplanting. The fruits are long (9.8cm), thin skinned, pendent, borne singly, deep green in colour when immature and deep red on maturity. The fruits are pungent (0.9% capsaicin) and high in dry matter (25%). The hybrid is moderately resistant to leaf curl virus, fruit rot and root knot nematodes. The hybrid is suitable for cultivation under low tunnel and gives average yield of 255q/ha.

CH-27 (2015): It is hybrid between MS-12×S-343. The plants are spreading, tall and continue to bear fruits for a long time. Fruits are medium long (6.7cm), thin skinned, light green, when immature and deep red when mature. Fruits are pungent (0.7 capsaicin), high in dry matter (26 %) and rich in colouring matter (242 ASTA unit). The hybrid is resistant to leaf curl virus, fruit rot and root knot nematodes; and tolerant to sucking pests such as thrip and mite. Average fruit weight is 3.6 g and yield of red ripe fruit is 96 q/acre. It is suitable for processing/powder making.

CH-3 (2002) : This hybrid has been developed by crossing MS-12 × S-2530. It is an early maturing hybrid with dark green foliage and pendent fruits. The fruits are long (8.2 cm). The colour of immature fruit is dark green and turns dark red at maturity. The fruits are mild in pungency with 0.51% capsaicin content, high dry matter (22.5%) and good Vit. 'C' (109.95 mg /100g) content. The deep red coloured fruits make it specially suitable for making chilli paste for export purposes. The average yield of red ripe fruits is 110 q/acre.

CH-1 (1992) : It is a hybrid between MS12 × LLS. Its plants gain one metre height and more branching. Plants continue bearing fruits for a long time. Fruits are light green when immature and attain deep red colour at maturity. Fruits are of medium size (6.62 cm long) and weigh 2.7 g each. This hybrid is tolerant to viral and fungal diseases. Its fruits are highly suitable for drying and used as salad. Yield of red ripe chilli is 100 q/acre. Its fruits are used in processing industry. Fruits on an average have capsaicin content of 0.80%.

Varieties

Punjab Sindhuri (2013) : Plants are dark green, compact and medium tall. It is an early maturing variety and first picking (red fruits) is possible 75 days after transplanting. Fruits are long (7.14cm), thick skinned, dark green when immature and deep red when mature. Fruits are pungent (1% capsaicin content) and rich in Vitamin C content (155 mg/100g). Average yield of red ripe fruits is 76 q/acre. It is suitable for fresh market and distant transportation.

Punjab Tej (2013) : Plants are light green, spreading and medium tall. It is an early maturing variety and first picking (red fruits) is possible after 75 days of transplanting. Fruits are long (6.80 cm), thin skinned, light green when immature and deep red when mature. Fruits are highly pungent (1.32% capsaicin content) and rich in Vitamin C (115 mg/100g). Average yield of red ripe fruits is 56 q/acre. It is suitable for processing/powder making.

Punjab Surkh (1995) : Plants are medium tall, leaves dark green, fruits long (7cm), green when immature and dark red on maturity. It is a dual purpose variety which makes it suitable for

salad and drying. It is tolerant to fruit rot and moderately resistant to mosaic virus . It is an early bearing variety which yields 80 q/acre of red ripe fruits. Fruits have capsaicin content of 0.80% on dry weight basis.

Punjab Guchhedar (1995) : It is a selection from material introduced from Indonesia. Plants are tall. Fruits are small (5cm), erect and borne in clusters of 5-16. Fruits have destalking habit which leave the stalk while picking. It is tolerant to fruit rot, highly resistant to mosaic and tolerant to leaf curl virus. Fruits are late bearing and yield 60 q/acre. Fruits are rich in capsaicin (0.98%) and deep red in colour.

Agronomic Practices

Sowing Time : The seed is sown in nursery during end October to mid November. Transplanting is generally done in February – March.

Seed Rate : Seed rate is 200 g per acre when sown in the nursery. Sow nursery in one marla (25m²) area to transplant one acre.

Nursery Raising : Seed of chilli is sown on raised beds. The beds should be 1.25 metre wide with height of 15 cm. The soil is loosened with the help of *khurpa* or spade. Use well decomposed farmyard manure and incorporate well into the soil. Then soil is sterilized with formaldehyde (1.5-2.0%). For this Formalin of commercial grade is taken and 15-20 ml of Formalin is added in one litre of water. This solution is added in the beds at the rate of 4-5 litres m². so that it saturates upper 6 inches of the soil. The beds are then covered with polythene for a period of 48-72 hours. Afterward the covers are removed and soil is loosened so that fumes of the chemicals escape into air and do not hinder the germination of the seed. After removal of the cover, the sowing of seed is done after 3-4 days. Sowing should be done in rows drawn widthwise at a distance of 5 cm.

To ensure successful growing of healthy seedlings from costly hybrid seed of chilli, nursery should be grown under polyhouse (size 24' × 13' × 6') made of UV stabilized low density polyethylene film of 200 microns (800 gauge) thickness.

Time of sowing under polyhouse	Time of transplanting
a) Third week of November	Mid February
b) 1st week of February	End of April

Spacing : Thick and stout seedlings perform better than tall seedlings and should be planted on ridges at 75 cm apart with plant to plant spacing of 45 cm. In case of mechanized farming the wider spacing can also be done to facilitate weed control by the protected application of non selective herbicides between the rows.

Manures and Fertilizers : Apply well-rotten farmyard manure 10-15 tonnes or 6 quintal paddy straw compost per acre for improving the soil health and yield in chilli. The recommended doses of fertilizers are 25 kg of N (55 kg of Urea) and 12 kg of P_2O_5 (75 kg of Single Superphosphate) and 12 kg of K_2O (20 kg of Muriate of Potash) per acre. Whole P_2O_5 and K_2O together with 1/2 N should be drilled at transplanting and the remaining N should be top dressed after first picking. Apply 30 kg N (65 kg urea) per acre to hybrid chilli.

Growth Regulator : Due to high temperature in May-June dropping of flowers take place. Two foliar sprays of naphthalene acetic acid (NAA) at 10 day interval @4g after 45 and 55 days of transplanting to increases the green and red ripe fruit yield of chilli.

Dissolve 4g NAA in 10-15 ml of ethyl alcohol and make the volume one litre. At the time of spray use this one litre in 100 litres of water.

Irrigation : 1. Furrow Irrigation : First irrigation should be given just after transplanting. Subsequent irrigations should be given at 7-10 days intervals. Total number of irrigations required are 15-16. For saving of irrigation water, irrigate the crop in alternate furrow without affecting the crop productivity. With the use of paddy straw mulch @ 25 quintals per acre, the number of irrigations can be reduced to 9.

2. Drip Irrigation : Drip irrigation in chilli results not only increase in yield but also save 46% of water as compared to conventional method of irrigation. Under this system irrigation

should be applied at an interval of two days. While irrigating with drip irrigation, transplant two rows of chilli on 80 cm wide bed with row to row distance of 60 cm and plant to plant distance of 45 cm. Provide 40 cm space between the two beds. The chilli crop should be irrigated with one lateral pipe per bed having drippers spaced at 30 cm and discharge of 2.2 litres per hour as per the following schedule.

Month	Time of irrigation (minutes)
March	31
April	61
May	137
June	110
July	60
August	60

If discharge rate is less than 2.2 litres per hour, time of irrigation may be adjusted proportionally by the formula.

$$= \frac{2.2 \times \text{Time of irrigation}}{\text{Discharge of dripper}}$$

Fertigation saves 20% fertilizer. Apply 7.9 kg Urea, 3.2 kg Mono Ammonium Phosphate and 3.2 kg Muriate of Potash (white) per acre during first month of the transplanted crop in seven equal doses with every second irrigation (four days interval). The remaining amount of fertilizer 31.4 kg of Urea, 12.8 kg of Mono Ammonium Phosphate and 12.8 kg of Muriate of Potash (white) per acre should be applied in equal doses during the rest of crop season in 21 equal doses with every second irrigation.

Harvesting, Care and Marketing

For dry powder chilli should be allowed to turn red. Six or seven pickings will be required. More pickings are possible for harvesting of green chillies. Dry the red ripe chillies in the sunshine.

Seed Production

Chilli is an often cross pollinated crop so minimum isolation distance of 400 metre between two varieties of chilli and sweet pepper should be maintained. A seed crop should be inspected

at different stages of maturity to ensure the genetic purity. The first inspection should be done before flowering and off type/extra early plants should be removed. The second inspection should be conducted at full bloom and fruiting stage and the plants which do not conform to the varietal purity such as fruit shape, colour, position of the fruit, flower colour, plant spread and leaf characteristics like leaf colour and shape etc. should be removed. The third inspection should be done just before fruit picking and only true to type plants are retained for seed harvest. Red ripe fruits are harvested and dried under sun. The seeds are extracted manually on small scale. However on a large scale, the seed can be extracted with PAU Axial - Flow Vegetable Seed Extraction Machine.

Plant Protection

A. Insect pests

Pests and Symptoms	Control Measures	Precautions
<p>1. Fruit borer: The larvae cause damage by making holes in the fruits and make them unfit for human consumption.</p>	<p>Spray 50 ml Coragen 18.5 SC (chlorantraniliprole) or 50 ml Tracer 45 SC (spinosad) in 100 litres of water per acre.</p>	<p>i) Pick regularly all ripe fruits before spraying. ii) All the infested fruits should be picked and destroyed.</p>
<p>2. Thrips, mites, aphids and whitefly are the serious pests of these crops. They suck the sap from leaves and lower the yield.</p>	<p>For mites management, spray *<i>Neem</i> fruit aqueous extract @ 5 % or Omite 57EC (Propargite) @ 200ml or Oberon 22.9SC (Spiromesifen) @ 100 ml per acre *Method of preparation <i>Neem</i> fruit aqueous extract: Take fresh neem fruits, dry in shade and make a coarse powder by grinding. Mix 5 kg of fruit extract powder in 100 litre of water and keep it for 12 hours. Filter the material in muslin cloth and spray it.</p>	<ul style="list-style-type: none"> • Keep waiting period of 7 days after spray of acaricides • Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/canals as they serve as reservoir for these pests • Judicious use of nitrogenous fertilizers, as higher doses make the plant prone to attack

B. Diseases

Diseases	Symptoms	Control Measures
1. Fruit rot and Die-back <i>(Colletotrichum capsici)</i>	<p>The tips of fruit bearing branches start drying soon after the fruits begin to ripe.</p> <p>Dark sunken spots covered with dark or pinkish fructifications scattered or arranged in concentric rings, appear, especially on the fruit.</p>	<p>i) Use disease free healthy seed.</p> <p>ii) Spray the crop with 250 ml Folicur or 750g of Indofil M-45 or Blitox in 250 litres of water/acre at 10 days interval. Give first spray at the start of disease. (first week of July) followed by 3 more sprays)</p>
2. Wet rot <i>(Choanephora cucurbitarum)</i>	<p>Young branches, flower and fruits are attacked, conspicuous black pin heads of the fungus are seen on rotten parts. This disease is severe after heavy rains.</p>	<p>Same as for fruit rot and die-back.</p>
3. Leaf curl (Virus)	<p>Affected plants become stunted and have rosette appearance Leaves roll downwards. This virus is transmitted by whitefly.</p>	<p>i) Grow resistant hybrid CH-27.</p> <p>ii) Rogue out and destroy the virus infected plants.</p> <p>iii) Spray with recommended insecticides for control of whitefly in nursery and field.</p>
4. Mosaic (Virus)	<p>Leaves show mottling and blistering. Plants become chlorotic and stunted. Virus is transmitted by aphids.</p>	<p>i) Rogue out the infected plants.</p> <p>ii) Collect seed from virus free plants.</p> <p>iii) Avoid unnecessary touching of plants.</p> <p>iv) Spray with recommended insecticides for control of aphid.</p>

17. SWEET PEPPER

Climate and Soil

Sweet pepper is more sensitive to unfavourable environment. The optimum night temperature for quality fruit production is 16-18°C. When the temperature falls below 16°C for extended periods, growth and yields usually decrease. It can tolerate day temperature over 30°C and night temperature 21-24°C. High temperature and dry winds result in flower and fruit drop. Sweet pepper is insensitive to photoperiod and humidity.

Sweet pepper grows better in a loam or sandy loam soil with good water holding capacity. They can be grown on all types of soils, as long as it is well drained. Soil pH should be between 5.5-6.8.

Improved Varieties

PSM-1 (2019) : Its plants are vigorous, spreading, tall and prolific bearer. The fruits are uniform, blocky with 3 distinct lobes having thick flesh and firm pericarp. Fruits are uniform, non-pungent, sweet flavored, each weigh 82g under polynet house and 75g under low tunnel, dark green in color at immature and deep red at maturity. It is early maturing variety and first picking is possible 109 days days after transplanting under polynet house and 120 days after transplanting under low tunnel cultivation. The variety is tolerant to high temperature and it gives average yield of 246 q/acre under polynet house and 82 q/acre under low tunnel cultivation. The variety has shelf life of 4 days at ambient temperature and is suitable for fresh market and distant transportation.

Agronomic Practices

Sowing Time : Seeds are sown in the nursery beds in the end of October. The seedlings are protected from frost during December-January by covering with polythene sheet or sarkanda cover and transplanted in mid February. To raise early crop, the seed can also be sown in nursery in mid October and transplanted in end November. This crop is protected with polythene or *sarkanda* cover in the field during the period of frost.

Seed rate : Use 200 g of seed per acre.

Low tunnel technology : (see on page no. 142)

Spacing : The seedlings are planted on ridges 67.5 cm apart with a plant to plant distance of 30 cm.

Manures and Fertilizers : This crop is a heavy feeder, therefore, loam to clay loam soils are preferred for higher yield. Farmyard manure at the rate of 20-25 tonnes/acre is applied at the time of preparation of the soil. The inorganic fertilizers at the rate of 50 kg N (110 kg of Urea), 25 kg P₂O₅ (175 kg of Superphosphate) and 12 kg K₂O (20 kg Muriate of Potash) should be applied per acre. Whole P₂O₅, K₂O, and 1/3 of N are applied at the time of planting and rest of N is supplied in two equal doses one and two months after transplanting.

Irrigation : First irrigation should be given immediately after transplanting. Afterwards irrigation is given at 4 to 5 days interval during hot weather and 7 to 8 days during cold weather.

Harvesting, Handling and Marketing

The crop is ready for harvest in about 3 months after transplanting. Pick the fruits when they are fully developed but still green and shining. Pack bell pepper in paper moulded trays and wrap with heat shrinkable or cling film. It improves the shelf life and retains the quality for 10 days in super market (18-20°C) and 7 days in ordinary market (28-30°C) conditions.

Seed production

Bell pepper requires a frost-free, moderately cool climate for 4-5 months. In the plains of North India, the crop is sown in early September and transplanted in mid October under poly-net house. Optimum temperature for seed germination is 30°C and for plant growth 24-27°C with a maximum of 32°C. *Capsicum* is preferably transplanted at a spacing of 90×30 cm plant to plant and row to row. The cultural practices for seed production plots are almost the same as those adopted for the commercial crop.

Seed crop needs at least three field inspections during the vegetative growth period to rogue out off types, diseased plants, and those showing poor growth. In the early period of growth,

inspection may be based on leaf and stem characters. Second inspection may be based on fruiting habit, fruit size, shape and colour. Rogue out the plants showing different fruit types and pinch off the undesirable small fruits that set after the main setting of 7-8 fruits per plant. Third inspection may be done at the time of harvesting ripe fruits. True to type fruits (depending upon shape, size, colour, and free from insect and disease) should be only kept for seed extraction. However, during seed extraction one more selection can be made to remove deformed, diseased or very small fruits and the ones in which the placenta has turned brown, black or mouldy.

Sweet peppers do not dry well, and seeds should be extracted only from fresh fruit. First harvesting of red ripe fruits may be possible by end March in plains of Punjab. The right stage of bell pepper maturity is development of red colour and the skin begins to wrinkle. Generally, harvesting is done at 5-10 day intervals for a period of 1.5-2 months. Fruits should be after-ripened for 1-2 days in the shade, and then seed is extracted from the red ripe fruits. On an average 70-80 seeds are obtained from a single fruit with an average yield of 350-400 gram of seeds from 100 kg fruits. The variety PSM-1 yields approximately 20 kg seed from an acre.

Plant Protection : See under Chilli.

18. OKRA

Climate and Soil

Okra is a crop of tropical and subtropical climate. It requires a long warm and humid growing season. The crop growth is vigorous during rainy season compared to spring summer. Seeds of okra fail to germinate below 20°C temperature and optimum temperature for seed germination is 29°C.

Okra can be grown on all types of soils, but the soil should be friable. However, it grows best in light soils ranging from sandy loam to loam. Okra can tolerate slightly acidic soil reaction (pH 6.8 to 6.0)

Improved Varieties

Punjab Suhawani (2017) : Plants are medium tall, leaves deeply lobed, dark green with serrated margins. Fruits are medium long, dark green, tender and five ridged. It has tolerance to yellow vein mosaic disease. Its average yield is 49 q/acre.

Punjab-8 (1995) : Plants are medium tall with splashes of purple pigmentation present on the stem. Leaves are deeply lobed and less serrated. Leaves, stem and petiole are less hairy. Fruits are thin, long, dark green and five ridged. It has resistance to yellow vein mosaic virus and tolerant to jassid and borer. It is suitable for processing. Average marketable yield is 55 q/acre. It is suitable for February-March as well as June-July sowings.

Punjab-7 (1986) : The plants are medium tall with splashes of purple pigmentation present on the stem. Leaves are deeply lobed up to the base of the petiole and the margins are less serrated. The basal portion of the petiole is deeply pigmented. Leaves, stem and petiole are sparsely hairy. Fruits are medium long, green tender and five ridged. Fruit tip is slightly furrowed and blunt. It carries resistance to yellow vein mosaic virus. Average marketable yield is 45 q/acre. It can be sown in February-March as well as in June-July.

Punjab Padmini (1982) : Plants are taller than those of Pusa Sawani and with purple tinge on the stem and petiole, leaves deeply lobed and hairy, fruits quick-growing, dark-green, thin, long, five ridged and remain tender for a longer period. It has field

tolerance to yellow vein mosaic virus. Low intensity of virus symptoms appear only on the new shoot growth quite late in the season. It is ready for first picking in 60 days. It is high yielding with an average yield of 45 q/acre. It is suitable for sowing in spring and rainy season.

Agronomic Practices

Sowing Time : In north Indian plains, spring crop is sown in February-March whereas the rainy season crop is sown in the month of June-July throughout India. The optimum sowing time of seed crop is middle of June.

Seed Rate : Fifteen to eighteen kg of seed per acre is required for sowing up to 15th February, 8-10 kg for March sowing and 4-6 kg for the June-July sowing. Soak the seed in water for 24 hours before sowing. Sowing should be done on ridges in February-March and on flat in June-July.

Spacing : The row to row spacing should be 45 cm and plant to plant 15 cm. Progressively wide spacing may be adopted for late sowing.

Manures and Fertilizers : 15-20 tonnes of well rotten farmyard manure should be incorporated into the soil before sowing. Apply 36 kg of N (80 kg of Urea) per acre on soils of average fertility. Apply half of the N at sowing and the rest as top-dressing after first picking of fruits.

Weed Control : To keep weeds under control, give three to four hoeings. The first hoeing may be given when the seedlings are two weeks old and subsequent hoeings at fortnightly intervals.

Irrigation : Seed should be sown in proper soil moisture conditions. First irrigation should be given after 4-5 days of sowing. Further irrigations should be given after 10-12 days whereas during the rainy season, less irrigations are required. Total 10-12 irrigations are required.

In light textured soils, use saline-sodic ground water alternatively with good quality canal water along with incorporation of 24 q/acre rice straw mulch.

Harvesting, Care and Marketing

The crop will be ready for harvest in about 45-50 days depending upon season and variety. Fruits should be picked tender

(10 cm long). Frequent pickings would be required during peak season and 10-12 pickings are done.

Seed Production

For seed production of okra, minimum isolation distance of 200 metre between two cultivars is required. It requires a seed rate of 5-6 kg/acre which should be sown on flat soil maintaining a distance of 60 cm and 25 cm between rows and plants, respectively. A minimum of three field inspections should be conducted to produce true to type seed. The first inspection before flowering, second at flowering and fruiting and third before harvesting of the crop. The off type and diseased plants should be rogued off. The seed crop matures in 90-100 days. The pods are picked 3-4 times due to uneven maturity. The harvested pods are dried in the sun threshed and the seeds are cleaned. The average seed yield is 5-6 quintals per acre.

Plant Protection

A. Insect Pests

Pests and Symptoms	Control Measures	Precautions
(For vegetable crop only)		
<p>1. Jassid (<i>Amrascabiguttula</i>) cause damage during May-September. Plants attacked by jassid show yellowing and curling along the margins, turn pale to bronze colour and finally premature defoliation occurs. A large number of greenish adults and nymphs are seen under the leaves.</p>	<p>(For vegetable crop only) Spray the crop with any of the following insecticides in 100- 125 litres of water per acre. i) 80 ml Ecotin 5% (Neem based insecticide) ii) 2000 ml *PAU Homemade Neem Extract iii) 40 ml Confidor 17.8 SL (imidacloprid) iv) 40 g Actara 25 WG (thiamethoxam) v) 560 ml Malathion 50 EC vi) 100 ml Sumicidin 20 EC (fenvalerate)</p> <p>(For seed crop only) Spray 250 ml Rogor 30 EC (dimethoate) in 100-125 litres of water/acre. Repeat the spray after 15 days if necessary.</p>	<p>In okra economic threshold level for jassid is 4 nymphs/ leaf. Record the jassid nymphs population after germination from three leaves one each from top, middle and bottom canopy from 10 randomly selected plants from middle of the four quarters of one acre. In case jassid population exceeds economic threshold level of 4 nymphs per leaf, spray any of the given insecticide.</p> <p>(For vegetable crop only) i) Pick all fruits before spraying</p>

	<p>*Method of Preparation of PAU <i>Neem</i> Extract: Boil 4.0 kg terminal parts of the shoots of <i>Neem</i> trees including leaves, green branches and fruits in 10 liters of water for 30 minutes. Filter the material through muslin cloth and use the filtrate for spraying.</p>	<p>ii) A waiting period of one day for Confidor and Actara should be observed after the spray.</p> <p style="text-align: center;">(For seed crop)</p> <p>iii) Do not apply insecticides recommended for seed crop to the crop meant for use as vegetable.</p>
<p>2. Whitefly (<i>Bemisia tabaci</i>): It causes maximum damage during July-September. Its adults and nymphs suck sap from leaves and excrete honey dew on leaves which become sticky. Affected leaves turn black due to development of sooty mould.</p>	<p>Spray 80 ml Ecotin 5% (Neem based insecticide) or 2000 ml *PAU <i>Neem</i> Extract.</p>	<p>i) Pick regularly all ripe fruits before spraying.</p> <p>ii) Regular monitoring of the crop should be done to check for whitefly infestation.</p> <p>iii) Regular surveillance on alternate host crops should be carried out for timely management of whitefly.</p> <p>iv) Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/ canals to avoid further spread of whitefly to okra fields.</p> <p>v) Avoid usage of synthetic pyrethroids to minimize the whitefly resurgence.</p>
<p>3. Spotted bollworms (<i>Earias</i> sp.) cause damage during May-September. Shoots infected with borer droop downwards and dry up. Infested fruits have a varying number of holes.</p>	<p>Spray the crop with any of the following insecticides in 100-125 litres of water/ acre</p> <p>i) 50 ml Coragen 18.5 SC (chlorantraniliprole)</p> <p>ii) 200 ml Sumipleo 10EC (pyridalyl)</p> <p>iii) 70 g Proclaim 05 SG (emamectin benzoate)</p> <p>iv) 100 ml of Sumicidin 20 EC (fenvalerate)</p>	<p>i) In okra economic threshold level for spotted bollworm is 1% infested fruits. Observe regularly the incidence of spotted bollworm from 10 randomly selected plants in each of the four quarters of one acre. In case spotted bollworm infestation reaches economic threshold level of 1 per cent fruit infestation in the field, spray the crop with any of the given insecticides.</p>

	<p>(For seed crop only) Spray the crop when 20-30% shoots show borer damage with any of the following insecticides using 100-125 litres of water/acre.</p> <p>i) 100 ml Somicidin 20EC (fenvalerate) ii) 80 ml Cymbush 25EC (cypermethrin) iii) 160 ml Decis 2.8 EC (deltamethrin)</p>	<p>ii) Pick all fruits before spraying iii) Uproot hollyhock and the ratooned cotton, which are host plants for bollworms. iv) A waiting period of one day for Coragen should be observed after the spray. v) Remove regularly the attacked fruits and bury deep in the soil.</p>
<p>4. Red spider mites: attack the leaves, suck the cell sap and ultimately cause webbing, necrosis and defoliation.</p>	<p>Spray *PAU Dharek extract @ 1600 ml or Oberon 22.9 SC (Spiromesifen) @ 150ml/acre</p> <p>*Method of preparation of Dharek extract: Four kg of green branches, leaves and fruits of dharek tree were boiled in 10 liters of water for 30 minutes. Filter the material through muslin cloth and use the filtrate as spray.</p>	<p>i) Keep waiting period of one day after spray of Oberon</p>

Note : To determine percentage of shoot infestations, regularly observe 20 plants from each of the 5 rows selected at random in field at 5-7 days interval.

B. Diseases

Diseases	Symptoms	Control Measures
<p>1. Yellow vein mosaic (<i>Virus</i>)</p>	<p>First veins turn yellow and later on all the leaves show severe yellowing. Fruiting is reduced.</p>	<p>i) Sow resistant variety, Punjab Padmani, Punjab-7 and Punjab-8. ii) Control whitefly (the virus vector) by spraying recommended insecticides.</p>
<p>2. Damping off (<i>Pythium</i> sp. <i>Rhizoctonia</i> sp. <i>Fusarium</i> sp.)</p>	<p>Both pre and post emergence mortality of plants occurs.</p>	<p>Use disease free seed.</p>
<p>3. Cercospora leaf spot (<i>Cercospora hibisci</i>)</p>	<p>Small, brown to sooty black, vein-limited spot appear on both the surfaces of leaves. The older spots may coalesce. The infection results into premature defoliation.</p>	

19. COWPEA

Climate and Soil

It is a warm season crop and can not withstand cold weather. Continuous rainfall is also harmful for its growth. It can withstand a considerable degree of drought. But under very dry conditions, it will produce a poor crop. Different varieties respond differently to temperature and day-length. The rainy season variety, if sown in summer, may give only vegetative growth. The germination is better at 12-15°C temperature and the crop thrives best between temperature 21°-35°C. It can tolerate partial shade.

It can be grown almost in all kinds of soils, provided there is no problem of bad drainage, but these should be rich in organic matter. Saline or alkaline soils are not good. The field should be well pulverized and well levelled by planking.

Improved Variety

Cowpea 263 (1988) : This variety is suitable for both spring and rainy season crop. Its pods are medium green, thick, meaty, tender and about 20 cm long. It is an early maturing variety. It is comparatively resistant to mosaic virus and free from golden mosaic virus. Average yield is 35 q/acre.

Agronomic Practices

Seed Rate and Sowing : Sow 8-10 kg of seeds per acre. Sow spring crop in February and rainy season crop in June-July.

Spacing : Keep distance of 45 cm between rows and 15 cm between plants.

Manures and Fertilizers : Apply 20 kg of N (45 kg of Urea) 16 kg P₂O₅ (100 kg of Single Superphosphate) and 10 kg of K₂O (16 kg Muriate of Potash) per acre at sowing.

Irrigation : Irrigate the crop at 4-5 days interval in summer months and 10-12 days interval in rainy season. Adequate drainage results in a good yield.

Harvesting, Care and Marketing

Marketable pods are available after 45-50 days of sowing. Tender pods are harvested for marketing. Frequent pickings

should be done before the pods become fibrous or the seeds in the pods gain prominence.

Seed Production

There is no difference between the methods of raising crop for production of both green pods and seeds. In case of seed crop, land in which one cultivar of cowpea was grown in the previous year should not be used for growing another cultivar in the following year to avoid contamination with the self sown plants from the previous crop. Cowpea is a self-pollinated crop. An isolation distance of 10 metre for the production of foundation seed and 5 metre for the production of certified seed should be kept between fields of two cultivars. Ripe and dry pods harvested by hand picking or by cutting the plants in case of last flush. To avoid shattering of seeds, harvesting should be done when half to two-thirds of pods have matured. Threshing is done by a thresher. When cowpea is grown for seed, extreme care should be taken during threshing to prevent injury to the seed. For seed purpose, the harvested pods are dried for a few days before threshing. The threshed seeds are also dried sufficiently before storage in a cool and dry place. The seeds maintain viability for two years under normal storage conditions.

Plant Protection

A. Insect Pests

Pests	Symptoms
1. Jassids/aphids	These insects suck the cell sap and damage the crop.
2. Pod borer or Blue butterfly	These pest damage the pods and lower the yield.

B. Diseases

Diseases	Symptoms	Control Measures
1. Seed and seedling rot (<i>Pythium</i> spp., <i>Colletotrichum</i> spp, and <i>Fusarium</i> spp.)	Seeds rot in soil particularly in the rainy season. Seedlings are killed before they emerge out of soil and cause poor stand of the crop.	Use disease free seed.

<p>2. Cercospora leaf spot (<i>Cercospora canescens</i> and <i>Cercospora cruenta</i>)</p>	<p>The spots generally appear after flowering. Rough circular cherry red to dark red spots variable in size are formed by <i>C. canescens</i>. In case of <i>cruenta</i>, black mats due to mouldy growth of the fungus are formed. Defoliation occurs in both the cases. At maturity infected pods show black sporulation of the fungus.</p>	
<p>3. Mosaic (Virus)</p>	<p>Wide spread mosaic mottling, interveinal chlorosis and vein bending takes place Distortion of leaf lamina in certain cases also occurs.</p>	<p>(i) Obtain seed from healthy plants. (ii) Spray recommended insecticides for insect vector control.</p>

20. ONION

Climate and Soil

Onion can be grown under wide range of climatic conditions, but it grows best under mild climate without extreme heat or cold, or excessive rainfall. Very low temperature at early stage results in bolting and sudden rise in temperature favour early maturity and small sized bulbs. The soil for onion cultivation should be rich in organic matter, free from diseases, weeds and should be well drained. Alkaline and low lying soils are not suitable for onion cultivation.

KHARIF ONION

Improved Varieties

Agri Found Dark Red (AFDR) : The bulbs are medium large (70-80g), deep dark red with an average yield potential of 120 q/acre. It is suitable for sowing in *kharif* season.

Agronomic Practices

Sowing Time : The best time for sowing *kharif* onion nursery is middle of June, whereas to produce bulb sets it is middle March.

Nursery Raising : Nursery beds should be raised 20 cm above the ground level and 1 to 1.5 metre wide area of the nursery beds depends upon the number of seedlings required. Keep nursery bed and field area ratio of 1:20. Nursery soil should be well prepared and mixed with well rotton 125 kg farmyard manure per marla (25 sq. m.). The plot should be leveled and the nursery beds should be prepared accordingly. Continuously sowing of nursery on the same site should be avoided. Treat the seed before sowing with 3g of Thiram/Captan per kg of seed. Sow seed 1 to 2 cm. deep in lines with 5 cm. spacing. The seed should be sown uniformly in these lines and covered with a thin layer of well rotten farmyard manure. The seed

- **For *Kharif* onion, sow Agri Found Dark Red variety.**
- **In Middle of March, the bulb-sets become ready for transplanting and plant these bulb sets in the second fortnight of August.**
- **Bulb sets become ready for marketing as green onion in November – December and give higher income.**

should be sown in the proper moisture condition. First irrigation should be given just after sowing with the help of sprinkler. The nursery beds should be irrigated twice a day, i.e. in the morning and in the evening. The nursery bed should be protected from high temperature by covering it during day time. A shade structure of straw or any other crop material should be placed at 1.5m. height over nursery beds of 1.5 metre width preferably in North-South direction. Remove this structure after one month when the seedlings have established.

Bulb Set Technique : To grow *kharif* onion crop successfully and avoid failure of seedling during June, planting with bulb sets is economical. To raise bulb sets, sow 5 kg. seed in beds of 8 marla (200 sq.m.) in middle of March. Irrigate the seedlings twice a week. Medium sized bulb sets of 1.5-2.5 cm diameter give highest marketable yield. In the last week of June, uproot the bulb sets and store in a well ventilated dry room in baskets. Plant these bulb sets in the field in second fortnight of August. Bulb crop would be ready for harvesting by the end of November.

Manures and Fertilizers : Add 20 tonnes of farmyard manure with 40 kg of N (90 kg of Urea) , 20 kg of P_2O_5 (125 kg of Single Superphosphate) and 20 kg of K_2O (35 kg of Muriate of Potash) per acre. Apply whole farmyard manure, P_2O_5 and K_2O and half N before transplanting and remaining dose of N after 4-6 weeks of transplanting.

Transplanting : The nursery is ready for transplanting after 6 to 8 weeks of sowing. The seedlings should be transplanted in the first week of August. Planting at 15 cm between rows and 7.5 cm between plants in the rows is most conducive for high yield. The bed planting of sets improves the bulb size of *kharif* onion. Plant three rows on each bed of 60 cm size. This practice is highly suitable under conditions where drainage is a problem. The transplanting should always be done in the evening. Irrigation should be given immediately after transplanting and subsequent irrigations should be given as and when required.

Weed Control : Weed control is same as in rabi onion.

Harvesting

The crop is ready for harvesting in December. There is no serious problem of pests or diseases in this crop.

RABI ONION

Improved Hybrid/Varieties

Hybrid

POH-1 Hybrid (2020) : The plants of this F₁ hybrid are medium-tall, leaves green and upright. Bulbs are round, large and light-red. It takes 142 days to harvesting and gives average yield 221 q/acre. It has tolerance to bolting and longer storage life.

Varieties

PRO-7 (2019) : The plants are medium-tall with green and upright leaves. Bulbs are red, medium-large and round with thin tight neck. It takes 120 days from transplanting to harvesting. It has good keeping quality and tolerance to bolting. The average yield is 159 q/acre.

PYO-102 (2019) : The plants are medium-tall with green and upright leaves. Bulbs are yellow, large and globular with tight neck. It takes 141 days from transplanting to harvesting. It has good keeping quality and tolerance to bolting. The average yield is 164q/acre.

PWO-35 (2019) : The plants are medium-tall with green and upright leaves. Bulbs are white, medium-large and round with tight neck. It takes 139 days from transplanting to harvesting. It has good keeping quality and tolerance to bolting. The average yield is 155q/acre.

PRO-6 (2003) : The plants are medium tall, leaves are green, bulbs are deep red, medium to large, round with thin tight neck. It takes 120 days from the transplanting to harvesting. It has good keeping quality and less bolting. The average yield is 175 q/acre.

Punjab White (1997) : The bulbs are medium large, round white with tight neck. It has high TSS (15%) and is suitable for dehydration. Its average yield is 135 q/acre.

Punjab Naroya (1995) : Its plants are medium tall, green and bulbs are red, medium to large, round with close neck. It takes 145 days from transplanting to harvesting and average yield is 150 q/ acre. It is tolerant to purple blotch disease both in seed and

bulb crop production and is also tolerant to the attack of thrips and Heliothis.

Agronomic Practices

Sowing and Transplanting Time : Sow nursery from mid-October to mid-November and transplant from the middle of December to middle of January. Large (10 to 15 cm) and healthy seedlings are better to get higher yields.

Seed Rate and Nursery Raising : Sow 4 to 5 kg seed to raise seedlings for transplanting in an acre. Prepare 15 to 20 cm high beds in 8 marlas (200 sq.m). Mix 125 kg well rotten farmyard manure per marla and irrigate atleast 10 days before sowing to allow complete germination of weeds. Sow seed thinly at one to two centimetre depth in 5 cm apart lines. Transplant the seedlings in a watar field soon after uprooting from the nursery beds.

Spacing : Close planting at 15 cm between rows and 7.5 cm between plants is most conducive for high yields.

Manures and Fertilizers : Add 20 tonnes of farmyard manure, together with 40 kg of N (90 kg of Urea), 20 kg of P_2O_5 (125 kg of Superphosphate) and 20 kg of K_2O (35 kg of Muriate of Potash) per acre. Apply whole farmyard manure, P_2O_5 and K_2O and half of N before transplanting and remaining dose of N after 4-6 weeks of transplanting.

Weed Control : Weeds are controlled by giving 3-4 hoeing. Give first hoeing after 3 weeks of transplanting. Apply Goal 23.5 EC (oxyfluorfen) 380 ml/acre as early post-emergence (within 7 days after planting) using 200 litre of water followed by one hand weeding at 90-100 days after planting of onion nursery, for effective weed control.

Irrigation : 1. Furrow Irrigation : Irrigate immediately after transplanting for proper establishment of seedlings. Depending upon the soil and weather conditions irrigate the crop at 7-10 day intervals. Stop watering atleast a fortnight before harvesting to prolong storage life of bulbs. The total number of irrigations would be 10-15.

2. Drip Irrigation : Drip irrigation in onion results not only increase in yield but also save 43.88% of water as compared to

conventional method of irrigation. While irrigating with drip irrigation, transplant six rows of onion at 13 cm row to row distance and 7.5 cm plant to plant on 100 cm wide bed. Provide 40 cm space between the two beds. The onion crop should be irrigated with two lateral pipes per bed having drippers spaced at 30 cm and discharge of 2.2 litres per hour as per the following schedule and under this system irrigation should be applied at an interval of two days.

Month	Time of irrigation (minutes)
January	15
February	25
March	30
April	35

If discharge rate is less than 2.2 litres per hour, time of irrigation may be adjusted proportionally by the formula.

$$= \frac{2.2 \times \text{Time of irrigation}}{\text{Discharge of dripper}}$$

Fertigation saves 20% fertilizer. Apply 32 kg Urea, 13.12 kg Mono Ammonium Phosphate and 13.44 kg Muriate of Potash (white) per acre during first month of the transplanted crop in seven equal doses with every second irrigation (four days interval). The remaining amount of fertilizer 127 kg of Urea, 52.5 kg of Mono Ammonium Phosphate and 54.06 kg of Muriate of Potash (white) per acre should be applied in equal doses during the rest of crop season in 20 equal doses with every second irrigation.

Harvesting and Storage

Harvest onion when tops dry up and fall. After harvesting cure the bulbs under shade and then cut the leaves 1-2 cm. above the bulb. Store in a well ventilated and dry place. Turn the bulbs once in a fortnight during storage and sort out and discard injured ones.

Storage of Onion to restrict germination : The germination of the onion can be checked by storing at 30°C for 9 days after

harvesting with this technology we can store onion at room temperature for three months.

Seed Production

1. Bulb to Seed Method

Onion seed is raised from the bulbs produced during the previous year. 8-10 quintals of graded mother seed bulbs are required for an acre. The bulbs are planted at 60 cm × 45 cm in first fortnight of November. The isolation distance between different varieties of onion should be 1000 metre. Extra early and late bolter should be removed. Depending upon size and variety of onion each bulb produces 5-12 flowering stalks. A minimum of three field inspections should be conducted to produce true to type seed. The first inspection before flowering, second at flowering and fruiting and third before harvesting of the seed crop. The off type and diseased plants should be rogued off. All the flowering stalks do not mature at one time. The primary head generally matures first, followed by secondary and tertiary umbels. Therefore, when the seed turn black, harvesting is done in atleast 3 rounds.

2. Seed to Seed Method

Seed to seed method can be followed for commercial seed production in onion. In this method, seeds should be sown in nursery beds during last week of August to first week of September and seedlings should be transplanted in last week of October to first week of November at a spacing of 15 cm between rows and 10 cm plants. It will save one year time of bulb production and cost involved in storage of onion bulbs.

Plant Protection

A. Insect Pests

Pests and Symptoms	Control Measures
<p>1. Onion thrips (<i>Thrips tabaci</i>) : Minute pale insects feed on foliage during Feb.-May and produce whitish spots followed by curling-a condition known as “silvertop”. This pest is very injurious at the time of flowering and impairs seed production.</p>	<p>Spray 30g Jump 80 WG (fipronil) or 250 ml Rogor 30 EC (dimethoate) in 100 litres of water per acre.</p>

<p>2. Onion maggot (<i>Delia antiqua</i>) appears in a serious form in some fields during January-February. Infested plants and leaves turn brown from the tip downwards. The bulb and the base of leaves become flaccid and watery and contain about 1/2 cm long maggots which taper towards one end.</p>	<ul style="list-style-type: none"> • Rogue out and destroy the infested plants having onion maggots • Remove plant debris and onion culls
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B. Diseases

Diseases	Symptoms	Control Measures
<p>1. Purple blotch (<i>Alternaria porri</i>)</p>	<p>The fungus causes purple spots on leaves and the seed stalks. It also infects the inflorescence and seed.</p>	<p>i) Use disease free seed. ii) Spray the crop with 300g Caviet 25 WG or 600 g of Indofil M-45 and 200 ml of Triton or linseed oil (as sticker) in 200 litres of water/acre as soon as first symptoms of the disease appear. This should be followed by three or more sprays at 10 day intervals.</p>
<p>2. Downy mildew (<i>Peronospora destructor</i>)</p>	<p>Oval to cylindrical pale greenish lesions with white to purplish downy growth which turn into large elliptical dark brown depressed spots on umbel stalks. The infected weak stalks break and the crop gives a blighted appearance.</p>	<p>Same as in purple blotch</p>

21. GARLIC

Climate and Soil

Garlic is a cool season crop and it succeeds best in mild season without extremes of heat and cold. Short days are favourable for bulb formation. Sandy loam and silt loam soils are best suited for garlic.

Improved Varieties

PG 18 (2015) : Plants have soft-neck (non-bolting) with green leaves. Bulbs are large (4.55 cm diameter), attractive and white with average bulb weight of 28.4 g. Cloves are medium to large sized, white and average clove number of 26 per bulb. It has dry matter of 38% and allicin content of 1.15%. Average yield is 51 q /acre.

PG 17 (2005) : Its plants have dark green leaves. The bulbs are attractive and white. The cloves are bold, white and vary from 25-30 per bulb. It takes 165-170 days for maturity. Its average yield is 50 q/acre.

Agronomic Practices

Sowing Time: The optimum time of sowing is from last week of September to the first week of October.

Seed Rate: For sowing an acre, 225-250 kg of healthy cloves are needed.

Method of Sowing: For kitchen gardening and small scale sowing, dibble the cloves. In case of commercial planting, sow garlic by 'kera' method. Put the cloves at 3 to 5 cm depth. Sowing of garlic can also be done by manually operated garlic planter. Depth of planting with the machine should be maintained at about one inch. It covers about 0.5 acres per day with the help of 2-3 persons.

Spacing: Close planting at 15 cm between rows and 7.5 cm between plants in the row is most conducive.

Manures and Fertilizers : Twenty tonnes of farmyard manure/ compost per acre may be applied about 10 days before sowing. In addition, apply 50 kg N (110 kg. Urea) and 25 kg P₂O₅ (155 kg Single Superphosphate). Whole P₂O₅ should be applied

before sowing. Apply N in three equal splits, 30, 45 and 60 days after sowing.

Irrigation: First irrigation should be given immediately after planting. Subsequent irrigations should be given at 10-15 days interval depending upon soil type and weather conditions. The total number of irrigations required are 10-12.

Weed Control: Hand hoeing helps in controlling weed in garlic. The weeds in garlic can also be managed by applying 25 q/acre paddy straw after sowing.

Harvesting and Storage

At maturity the tops dry. Stop irrigation atleast a fortnight before harvesting to prolong storage life of bulbs. After harvesting cure the plants in a dry and shady place, for 5 to 7 days. Tie in small bundles and store in a well ventilated dry place. Sort out bulbs with dried cloves during storage.

Plant Protection : See under Onion.

22. PEA

Climate and Soil

Pea is a cool weather loving plant. It can germinate even at 4-5°C and can tolerate frost. However, under severe continuous frost, its flowers and young pods are likely to be damaged. Optimum germination takes place at 20-25°C. At temperature of 30°C and above, the germinating or emerging seedlings get killed. The high temperature conditions prevailing at the time of planting results in the build up of wilt and stem fly complex which results in considerable losses in yield. Hence pea attain an ideal growth and development in areas where there is a slow transition from cool to warm weather. It can be grown on all types of soils but well drained fertile loamy soils are best for the crop. Peas do best in soils having pH 6.0 to 7.5.

Improved Varieties

Early Maturing

AP-3 (2016) : This variety derived from the cross of Azad P-1 × Arkel through pedigree method. Plants are dwarf and straight. The pods are of medium length (8.85 cm), deeply curved near distal end and are borne singly or in doubles. Each pod contains 7-8 grains and shelling out turn is 50 per cent. Seeds are bold, wrinkled with green seed coat. It is an early maturing variety and gives first picking in 60-65 days after sowing, if sown in the second week of October. Its green pod yield is 31.5 q/acre.

Matar Ageta-7 (2014)

: The plants are vigorous with 15-18 well filled pods having 7-9 grains per pod. The pods are of medium

- For early maturity, sow pea variety AP-3, Matar Ageta-7, Matar Ageta-6 and Arkel and for main season Punjab-89.
- Use seed 45 kg for early maturing and 30 kg for main season variety per acre.
- For wilt control, treat the seed with Bavistin 1g or Captan 2g per kg of seed.
- For quick growth and higher yield, treat the seed with *Rhizobium* culture before sowing.

length (9.57 cm), slightly curved from tip and are borne singly or in doubles. Its shelling out turn is 48 per cent. It is an early maturing variety which gives first picking in 65-70 days after sowing. Average green pod yield is 32q/acre.

Matar Ageta-6 (1989) : Its plants are dwarf (40 cm), erect, vigorous and green. It can tolerate high temperature and can be sown early in the season. First picking is possible after 7 weeks of sowing. Each plant bears 12-15 pods. One or two pods are borne per bunch. Each pod contains up to 6 grains and shelling out turn is 44.6 per cent. Grains have high protein and dry matter content. On drying, per cent seeds are light green, smooth with slight dimples. This variety gives 50 per cent of the total production in the first picking. Its green pod yield is 24 q/acre.

Arkel (1985): Arkel is an early maturing variety and takes about 60-65 days from sowing to marketable green pod stage. It is suitable for sowing in the first week of October under the irrigated conditions. Plants are dwarf (30-45 cm). Pods are borne both in double and single and are attractive, dark green, well filled, 8-10 cm long and each contains 7 to 8 dark green grains with a shelling percentage of 40. Dry seeds are light green and wrinkled. It is good for dehydration. Its green pod yield is 18 to 20 q/acre and seed yield is 3.5 q/ acre.

Main Season

Punjab 89 (2007) : The plants of this variety are medium dwarf, vigorous, having more number of well filled pods (28-30 per plant). The pods borne in doubles and are dark green, long, very attractive having 9-10 grains per pod. It takes about 85-90 days for first picking. Shelled peas are very sweet and the shelling out turn is more than 55 per cent. Average green pod yield is 60 q/acre.

Mithi Phali (1994): It is an edible podded variety and its shelling is not required. Plants are tall (140 cm) with green foliage. The first picking takes place 90 days after sowing and subsequent pickings at 15 days interval. Pods are light green and 12-13 cm long. Its consumable yield is double than that of standard shelled pea varieties. It is rich in protein and total sugar. Average green pod yield is 47 q/acre.

Agronomic Practices

Sowing and Seed Rate : Since the incidence of wilt in September is very high, some what late sowing from mid-October to mid-November give the best crop in the plains. Seed rate is 45 kg for early maturing varieties and 30 kg for main season varieties per acre. Line×Plant spacing should be 30×7.5 cm for early and 30×10 cm for main season varieties.

The sowing of pea can also be done with Seed-cum- Fertilizer pea drill on ridges which are 60 cm wide. This drill sows two rows of pea which are 25 cm apart on each ridge. This drill can sow one acre per hour.

Inoculation : In areas where pea crop has not been sown earlier, it is advisable to treat the seed with bacterial culture (*Rhizobium leguminosarum*) to ensure nodule formation and quick growth. It increases the yield and quality of pods. The culture is available in the Department of Microbiology, Punjab Agricultural University, Ludhiana. One acre culture packet should be mixed with half litre of water. Rub the mixture thoroughly on seed to give a fine covering of the culture to every seed. Thereafter, spread the seed in shade for drying and sow it immediately afterwards.

Manures and Fertilizers : Apply 8 tonnes of farmyard manure, 20 kg of N (45 kg Urea) and 25 kg P₂O₅ (155 kg Superphosphate) per acre before sowing.

Weed Control : The field should be kept free from weeds by giving two hoeings after four and eight weeks of germination respectively. For chemical weed control use Stomp 30 EC (pendimethalin) @1.0 litre per acre within 2 days of sowing. Dissolve the herbicide in 150-200 litres of water and spray uniformly over the entire field. Application of this herbicide control many of the annual broad leaved and grass weeds, including *guli danda* (*Phalaris minor*).

Irrigation : 1. Furrow Irrigation : Seed should be sown in proper soil moisture condition. First irrigation should be given after 15 days of sowing. Next irrigation should be given at flowering and then at fruit set if necessary. Pea can be grown as rainfed crop with limited irrigations. The total number of irrigations required are 3-4 depending upon the soil type and weather conditions.

2. Drip irrigation : Drip irrigation in pea not only increases the yield but also saves 30% water as compared to conventional method of irrigation. For drip irrigation, sow two rows of pea at 25 cm row to row distance on 60 cm wide bed. Under this system, irrigation should be applied at an interval of 3 days. Do not apply irrigation before 15 days of sowing and before 10 days of harvesting of crop. The crop should be irrigated with one lateral pipe per bed and keep distance lateral and dripper to dripper 30 cm having discharge of 2.2 litres per hour as per the following schedule:

Month	Time of irrigation (minutes)
November	15
December	15
January	20
February	25

If discharge rate is less than 2.2 litres per hour, time of irrigation may be adjusted proportionally by the formula

$$= \frac{2.2 \times \text{Time of irrigation (minute)}}{\text{Discharge of dripper (litre/hour)}}$$

Fertigation: Apply 33 kg and 42 kg Mono Ammonium Phosphate per acre. The 20% of the fertilizer should be applied during the first month after germination in 5 split doses. The remaining amount of fertilizer should be applied in nine equal doses during the second month. Fertigation saves 20% fertilizer.

Harvesting, Care and Marketing

Harvest the crop at the proper edible maturity and do not allow the pods to over mature which impairs its quality. Harvesting is to be completed in number of pickings depending upon the maturity group of peas.

Seed Production

For seed production, seed rate and spacing are same as for table crop. Sow seed crop in second fortnight of November. An isolation distance of 5 metres is kept between two varieties grown for seed production.

Plant Protection

A. Insect Pests

Pests	Symptoms	Control Measures
1. Pea thrips (<i>Thrips indicus</i>)	They cause severe damage to the young crop by sucking the cell sap.	<ul style="list-style-type: none"> Remove weeds growing in and around the field Avoid excessive use of nitrogenous fertilizers
2. Pea-leaf miner (<i>Chrotomyia horticola</i>)	The larvae feed by making tunnels in the leaves. These cause serious damage during December-March.	<ul style="list-style-type: none"> Maintain good plant health with judicious use of fertilizers
3. Pea-aphid (<i>Acyrthosiphon pisum</i>)	Aphid sucks the cell sap, owing to which the leaves turn pale and dry.	<ul style="list-style-type: none"> Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/canals as they serve as reservoir for aphids Use fertilizers judiciously, as aphid populations tend to be higher in plants that are fertilized liberally with nitrogenous fertilizers
4. Pea-stem fly (<i>Ophiomyia phaseoli</i>)	Pea-stem fly sometimes causes serious damage at the seedling stage.	<ol style="list-style-type: none"> Apply 10 kg Furadan 3G (carbofuran) granules per acre in furrows at sowing. Sow the crop in the second fortnight of October to escape the damage by the pest. Avoid direct contact with chemicals while treating the seed. Use rubber gloves for application of granules.

B. Diseases

Diseases	Symptoms	Control Measures
1. Powdery mildew (<i>Erysiphe polygoni</i>)	White floury patches covering large areas, appear on stem, branches, leaves and pods.	Spray the crop with 600 g Sulfex in 200 litres of water per acre. Three sprays may be given at 10 days interval.

<p>2. Wilt, root rot and collar rot (<i>Fusarium oxysporum</i> and <i>Rhizoctonia solani</i>)</p>	<p>Root rotting and yellowing of lower leaves, followed by wilting. Reddish brown cankers may appear in the collar region.</p>	<p>i) Avoid early sowing in badly infested areas. ii) Treat the seed with 15 g Talc based formulation of <i>Pseudomonas fluorescens</i> per kg seed before sowing.</p>
<p>3. Rust (<i>Uromyces viciae fabae</i>)</p>	<p>Yellowish, reddish-brown, spherical, raised postules appear mainly on the lower side of leaves during December-January. This disease is more serious in the late sown crop.</p>	<p>i) Keep the field free from <i>Rewari</i> weed which serves as a source of inoculum. ii) For controlling of powdery mildew and rust together 200g Sulfex in combination with 400g Indofil M-45 per acre.</p>
<p>4. White rot (<i>Sclerotinia sclerotiorum</i>)</p>	<p>Disease appears as irregular shaped water soaked spots on leaves, stem and pods; However, the disease is most frequently observed on pods which turn papery brown in colour in the later stage. White mycelial growth appears on the infected portion under wet and cool weather. Black hard sclerotial bodies embeded in mycelium are formed within the pods. The disease is high at flowering and pod formation stage.</p>	<p>i) Avoid growing of pea after the susceptible crops like brinjal, cauliflower, carrot and pea, instead tomato and chilli can be grown. This will help in reducing the disease and spread of inoculum in the field. ii) The plant debris of the crop should be collected and burnt.</p>

C. Rodents : For managing rodents in pea crop, regularly remove weeds from the field along with manual killing of rats coming out of flooded burrows during irrigation. If the rodent burrows are more than five/acre, do single burrow baiting with 0.005% bromadiolone bait as given in Chapter No. 45.

23. CARROT

Climate and Soil

Carrot requires a relatively long growing season than the other root crops. The optimum temperature is 7.2-23.9°C for germination and 18.3-23.9°C for growth. The best root colour develops at 15-20°C. Temperature higher than 30°C, particularly in later stages of development, induces undesirable strong flavour and coarseness in the roots. Temperate types need low temperature of 5-8°C for 40-60 days before flowering to break dormancy.

Carrot needs a deep, loose loamy soil for best root development. Heavy soils check root development and promote forking. A soil pH of 6.5 is desirable for obtaining higher yield of better quality roots.

Improved Varieties

PC-161 (2020) : This is a tropical variety and its roots mature in 90 days after sowing. Its foliage is dark green. Roots are deep red in colour, 30 cm long, slender and 2.84 cm in diameter. The roots have more juice content (575.50 ml/kg), sweet (TSS 9.5% and Sugar content 8.75%) and rich in β -carotene (8.88 mg/100g).

Average root yield is 256 q/acre.

- Sow Punjab Carrot Red and Punjab Black Beauty variety of carrot.
- Ridge planting is recommended for carrot raising.
- Punjab Black Beauty has high nutraceutical value and protects from cancer.
- Always apply potash to carrot for proper development of fruit colour.

Punjab Carrot Red (2014) : This is a tropical variety and its roots mature in about 85-90 days after sowing. Its leaves are dark green and average plant height is 65 cm. Roots are dark red in colour, 27 cm long and 3.40 cm in diameter. This variety has an excellent quality characters. Roots have high juice content (515 ml/kg of roots), sweet (TSS 9.2%, sugar content 8.04%), rich in β -carotene (8.44mg/100g) and dry matter content (11%). Average root yield is 230 q/acre.

Punjab Black Beauty (2013) : It is a tropical variety and roots attain edible maturity after 90-95 days of sowing. Leaves are dark green and petioles are purple in colour. Roots are purple-black, 26 cm long and 3.20 cm in diameter. Roots have ability to stay in the field over a fortnight after reaching edible maturity. This variety has high nutraceutical values and excellent quality characters. It is rich in anthocyanins (182 mg/100g) and phenols (73 mg/100g) which protect us from various forms of cancers. It has high juice content (580 ml/kg), calcium (50mg/100g), iron (1.10mg/100g), TSS (7.5 per cent) and dry matter (11 per cent). Fresh carrots are suitable for salad, juice, pickle and *kanji*. Average root yield is 196 q/acre.

PC-34 (2005) : It takes on an average 90 days to mature after sowing. The leaves are dark green and the average plant height is 62 cm. The roots are red in colour. The average length of root is 25 cm with a small core i.e. 0.95 cm. The root diameter is about 3.15 cm. The dry matter is 13.3 per cent and juice yield is 480 ml/kg. The TSS is 8.8 per cent, total sugars 5.81 g/100g, reducing sugars 2.17 g/100g and alcohol insoluble solids are 60.8 g/100g. The β -carotene content is 8.86 mg/100g. Its average yield is 204 q/acre.

Agronomic Practices

Sowing and Seed Rate : For desi varieties of carrot, August-September is the best time of sowing. European types should be sown in October-November. A seed rate of 4 to 5 kg. for carrot is sufficient for one acre.

Method of Sowing : For small scale, spacing of 45 cm between ridges and 7.5 cm between plants is kept. The plant spacing is maintained by thinning at the time of true leaf formation. Thinning is very important for producing superior quality roots. For large scale, tractor operated inclined plate planter can be used for direct planting of carrot seeds on beds at 67.5 cm spacing. The machine plants 4 rows on each bed with 10 cm spacing between rows and 8 cm between plants. Moreover, there is no need of thinning.

Manures and Fertilizers : Apply 15 tonnes of farmyard manure, 25 kg of N (55 kg of Urea), 12 kg of P_2O_5 (75 kg of Single Superphosphate) and 30 kg of K_2O (50 kg of Muriate of Potash)

per acre. Apply all fertilizers at sowing. In the absence of potash, root colour development is very poor. Always apply well rotten farmyard manure.

Weed Control: Carrot grows slowly in the beginning and cannot compete with weeds. Removal of weeds is necessary especially in the early stages of growth. Apply 2-3 hoeing for effective weed control.

Weeding and Earthing up : One weeding followed by earthing up about 4-5 weeks after sowing should be done.

Irrigation: First irrigation should be given immediately after sowing of seed and total of 3-4 irrigation are required. Excessive irrigations result in misshapen roots, poor colour development and numerous hair growth.

Harvesting, Care and Marketing

Carrots are ready for harvesting in about 90-100 days after sowing depending upon the variety. Carrots can be harvested when roots have developed marketable size and attractive deep red/orange/black colour. In large scale, harvesting can be done by tractor operated machine which harvest 0.62 acre in one hour.

Processing

The fermentation process of Low Alcoholic Naturally Carbonated (LANC) beverage from carrot and amla with yeast *Clavispora lusitaniae* has been optimized. The beverage can be prepared at small and large scale with shelf life of 3 months. This technology is useful for reducing the carrot glut in the market, thus making the availability of nutrients in the form of effervescent beverage for long period.

Seed Production

Follow the same practices as for table crop for raising roots. Roots raised in one acre are sufficient to plant four acres of seed crop. Transplant seedlings at 45×30 cm in the second fortnight of December. Apply 30 kg N (65 kg Urea) and 8 kg P₂O₅ (50 kg Superphosphate) per acre. Apply whole of P₂O₅ and half of N before transplanting and the rest half of the N after 30 days of transplanting.

24. CAULIFLOWER

Climate and Soil

Cauliflower grows well on wide range of soils from sandy loam to clay. The optimum pH is between 6.0 and 7.0. Cauliflower is a thermo sensitive crop and temperature plays an important role influencing vegetative, curding and reproduction phases of plant. The optimum temperature of growth for young seedlings is around 23°C which at later growing stage drops to 17-20°C. The tropical cultivars grow even at 35°C, however, temperate cultivars grow well between 15°C to 20°C.

Improved Varieties

Late Season

Pusa Snowball-1 (1994) : Outer leaves are upright and inner leaves cover the curd initially. Curd is compact, medium sized and snow white. Curd is ready for harvest in about 100 days after transplanting. Curd yield is 90 q/acre.

Pusa Snowball K-1 (1994) : Outer leaves are upright and inner leaves cover the curd tightly. Curd is compact, snow white and slightly raised in the centre. The maturity is late by one week than Pusa Snowball-1. Curd yield is 90 q/acre.

Agronomics Practices

Sowing and Seed Rate : The best transplanting time is June-July for the early varieties, August to mid-September for the main season varieties and October to first week of November for the late season varieties. The seed rate for main and late season varieties is 250 g per acre, whereas, for early season varieties 500 g seed is required.

To check bolting and buttoning, sow the recommended varieties at their proper time. To minimise mortality of early sown nursery and transplanted crop, apply heavy dose of well rotten farmyard manure and irrigate frequently. Protect seedlings in the nursery beds against sun stroke with sarkanda thatch. Transplant seedlings in a cool 'wattar' field in the afternoon and irrigate immediately.

Spacing : The spacing for the main-season crop is 45×45 cm. and 45×30 cm for early and late-season crops.

Manures and Fertilizers : 40 tonnes of farmyard manure, with 50 kg of N (110 kg of Urea), 25 kg of P₂O₅ (155 kg of Single Superphosphate) and 25 kg of K₂O (40 kg of Muriate of Potash) per acre is the optimum fertilizer dose for all these varieties. Apply whole of farmyard manure, P₂O₅ and K₂O and half N before transplanting and the remaining half of N as top-dressing four weeks after transplanting.

Irrigation : First irrigation should be given just after transplanting. Subsequent irrigations can be given at an interval of 7-8 days during summer and 10-15 days during winter depending upon soil type and weather. The total number of irrigations required are 8-12.

Harvesting, Care and Marketing

The curds should be harvested at the marketable stage. Delay in harvesting causes loosening of the curd. The curds should be sent to markets in baskets after proper grading and packing.

Seed Production

For seed production crop is grown just like market crop. After curd formation seed of early and main season varieties can be produced in the plains, however, the seed of late season varieties can only be produced in the hills because during flowering and seed setting stage moderate temperature is available in the hills. To produce genetically pure seed, the off-type plants must be removed thrice during vegetative phase, curd formation stage and flowering stage. Isolation distance of 1600 metre should be kept between different cole crops and different varieties of cauliflower. When pods turn brown they should be harvested two or three times. After curing they should be thrashed and cleaned.

25. CABBAGE

Climate and Soil

It grows best in cool moist climate and is very hardy to frost even at head formation stage. In dry climate its quality becomes poor and much of its delicate flavour is lost. It is grown mainly as winter crop. It can tolerate high or low temperatures as compared to cauliflower.

It can be grown almost on all types of soils, Sandy loam soil is considered best for early crop but where high yield is the main criterion, clay loam or silt loam soils are preferred. Before transplanting the soil is prepared well to make it loose friable and retentive of moisture.

Agronomic Practices

September to October is the ideal planting time in the plains. Optimum seed rate is 200-250 g per acre. A spacing of 45×45 cm. and 67.5×45 cm are optimum for the early and the late maturing varieties, respectively.

To get early yield of cabbage, direct sowing on ridges at 60 cm apart maintaining a distance of 15-20 cm between plants may be practiced. It yields about two week earlier than the transplanted one. A seed of 325 g/acre is sufficient for direct sowing.

Manures and Fertilizers

Manurial requirements of this crop are the same as those of cauliflower.

Irrigation : First irrigation should be given immediately after transplanting. The subsequent irrigations should be given at 10-15 day intervals. The total number of irrigations required are 8-12.

Harvesting, Care and Marketing

Harvesting should be done as soon as heads reach marketable size and become hard. The heads should be properly packed and sent to market after cutting stumps. Packaging of cabbage with shrink and cling film extends its retail marketing period with acceptable quality for 15 days.

26. BROCCOLI

Nutrition

It is most nutritious of the cole crops, especially in vitamins, iron and calcium content. It contains 3.3 per cent protein and high content of vitamin A & C and appreciable quantity of thiamine, niacin and riboflavin. Several flavouring compounds are found in broccoli. The glucosinolate content of purple-headed broccoli has been found in the range of 72-212 mg/100g. It also contains high concentration of carotenoids which are believed to be chemopreventive and associated with a decreased risk of human cancers. Broccoli may play role in reducing levels of serum cholesterol. Besides, it is also rich source of sulphoraphane (singrin) compound associated with reducing risk of cancer. It is marketed as fresh, frozen and also used in salads.

Climate and Soil

It thrives best in a cool and moist climate. It cannot tolerate very high temperature as it produces poor quality sprouts. The optimum temperature to grow is between 17-23°C. Temperature below optimum during growing time delays maturity and small sprouts may be formed.

It can be grown on a wide range of soils provided they are rich in nutrients, have adequate soil moisture and possess good drainage. The soil should contain plenty of organic matter. It must be thoroughly prepared so that it becomes loose, friable and retentive of moisture.

Improved Variety

Palam Samridhi (2015) : Plant growth is semi-spreading, leaves are smooth, large and dark green. Head is round, compact and green with average weight of 300 g. It takes 70-75 days from transplanting to harvesting. Average yield is 72q/acre.

Punjab Broccoli –1 (1996) : Leaves are smooth, wavy and dark green. Main as well as secondary sprouts are dark green. The leaves as well as sprouts have slightly bluish tinge. The sprouts are also compact, attractive and succulent. The main sprouts are ready for harvest in about 65 days after transplanting. This variety

is suitable for both salad as well as cooking purposes. Its average yield is 70 q/acre.

Agronomic Practices

Sowing and Seed Rate : The best time for sowing seed in nursery is mid August to mid September. When the seedlings are one month old, transplant them in the field. A seed rate of 250g is sufficient for one acre. To check bolting and buttoning sow the crop at proper time. Transplant the seedlings in proper ‘Wattar’ and irrigate the field immediately after transplanting.

Spacing : A spacing of 45×45 cm should be followed between lines as well as plants.

Manures and Fertilizers : Apply 40 tonnes of farmyard manure with 50 kg of N (110 kg Urea), 25 kg of P₂O₅ (155 kg of Single Superphosphate) and 25 kg of K₂O (40 kg of Muriate of Potash) per acre. Apply whole of farmyard manure, P₂O₅ and K₂O and half N before transplanting and remaining half N as top dressing one month after transplanting.

Weed Control and Irrigation : Use the herbicides as have been recommended for cauliflower. Its irrigation requirement is also similar to those of cauliflower.

Harvesting, Care and Marketing

As soon as sprouts are of marketable size they should be harvested. They should be marketed as soon as possible because they cannot be stored for a long time. After harvesting the central sprout, axillary sprouts become ready for harvest again in about 10-12 days.

Seed Production

For seed production the crop is grown just like the market crop. After formation of sprouts the plants are left in situ for seed production. To produce genetically pure seed the off-type plants must be removed thrice during vegetative, sprout formation and flowering stage. Isolation of 1600 metre should be kept between different cole crops and different varieties of broccoli. When pods turn brown they should be harvested two or three times. After harvesting they should be thrashed and cleaned.

27. CHINESE CABBAGE

Climate and Soil

Chinese Cabbage is a winter season crop. It thrives best at temperature from 15-21°C. The crop can be grown on a wide range of soils ranging from sandy loam to heavy soils.

It is a non-heading strain of Chinese Cabbage which makes a high quality 'saag' due to its tender and succulent leaves. Its first cutting is ready by the middle of November.

Improved Varieties

Saag Sarson (2013) : The plants are medium tall (47 cm height) with light green serrated leaves, leaf surface smooth and glabrous (non hairy), petiole thick and light green. The variety has erect bearing leaves which escapes them from sticking the soil during rains. Its leaves are low in oxalates and rich in vitamin C. The first picking is ready after 30 days of transplanting and it gives six pickings. Its average yield is 205 q/acre. The saag prepared from this variety has excellent flavour, taste and consistency.

Chini Sarson-1 (1986) : The plant is non-heading with semi-erect plant habit. It gives light green, broad, puckered and 12-15 leaves per plant. The leaf mid-rib is whitish, tender and succulent. It has quick growth habit and six to eight cuttings can be obtained. The first cutting can be had 30 days after transplanting. Average yield is 155 q/acre.

Agronomics Practices

Sowing and Seed Rate : Sow the seed in raised nursery beds in mid September. Transplant the seedlings in the second fortnight of October. For sowing nursery, use 200g of seed and for direct sowing, 1 kg seed per acre.

Spacing : Row to row and plant to plant spacing should be kept at 30-45 cm.

Manures and Fertilizers : Apply 15-20 tonnes of farmyard manure with 50 kg of N (110 kg of Urea) 25 kg of P₂O₅ (155 kg of Single Superphosphate) and 25 kg of K₂O (40 kg of Muriate of Potash) per acre. Apply the whole of farm yard manure, P₂O₅ and

K₂O and 1/3 N before transplanting or sowing and the remaining 2/3 N as top dressing in equal proportion after the second and fourth cuttings for the growth of plants.

Harvesting, Care and Marketing

Harvest complete, fully developed leaves near the base without injuring the central bud point. Stop taking cutting by the end of December to get seed. Bolting starts in the last week of January. Harvest the seed by the end of April or early May.

Seed Production

A minimum isolation distance of 1000 metre should be maintained from other varieties of chinese cabbage, sarson and turnip. One month old seedlings should be transplanted at spacing of 60 cm×45 cm. Minimum three field inspections should be done for getting the true to type seed. The first inspection should be done at vegetative phase, second at bolting stage and third before harvesting of the crop. Any off type and diseased plants should be removed. The plants showing variation in leaf characters as well as early and late bolters should be removed.

The crop should be harvested when most of the ripening seed stalks turn brown. Care should be taken to avoid shattering of seeds. After harvesting, the crop should left in the field for curing and drying for about a week before the seed threshing.

28. RADISH AND TURNIP

Climate and Soil

Radish main season varieties develop best flavour, texture and root size when the temperature is between 10-15°C. Maximum root growth occurs initially at 20-30°C and later at 10-14°C. More foliage growth is favoured at temperature above 20°C. In hot weather, roots become pungent and tough before attaining marketable maturity.

Turnip roots develop best flavour, texture and size at 10-15°C. Long days and high temperature induce early bolting even without adequate development of roots. In hot weather, roots become fibrous, tough and pungent. The Asiatic types can tolerate fairly high temperature but flourish under cool weather.

Radish and turnip can be grown on all types of soil but a sandy loam, friable soil is considered best. These crops can be grown in fairly acidic soils having pH 5.5-6.8. Sandy loam soil is ideal for quick growth of roots. Soils with high clay content are not desirable, as they tend to produce misshapen roots with numerous small laterals.

Improved Varieties

Radish

Punjab Safed Mooli - 2 (2015) : Leaves are green with cut leaf lamina, roots long, semi stumped cylindrical, smooth, crisp and white in colour. Root length is about 34 cm. It takes about 47 days for first harvest when sown during first week of October. It is mildly pungent and remains non pithy until 65 days of sowing. Average yield is 261 q/acres.

Punjab Pasand (1997) : It is an early maturing variety and roots attain edible maturity after 45 days of sowing. Roots are long, pure white, semi-stumped and free from hair. Its top is light, erect and leaves have complete lamina. It is suitable for sowing in main season and gives an average yield of 215 q/acre. During off season it gives 140 q/acre yield.

Pusa Himani (1995): It is a temperate variety suitable for sowing in second fortnight of January. Roots are white, semi-stumped with green shoulder. Roots are fleshy, crisp, mildly pungent, 30-35 cm. in length and 10-12 cm in girth. Roots are ready for harvest 60-65 days after sowing. It yields 160 quintals of roots per acre.

Pusa Chetki (1988) : Roots snow-white, smooth, medium long (15.5 cm), thick (3.5 cm), stumpy and mildly pungent. Leaves medium sized (40.5 cm) with complete lamina. Leaf root ratio is 1:1.5. An early maturing with good seed setting under Punjab conditions. This variety is most suitable for sowing from April to August. The average root yield is 105 q/acre and seed yield is 4.5 q/acre.

Japanese White (1962) : It is an introduction from Japan and is recommended for late sowing in the main season in north Indian plains and July to September in hills. Its top is medium and leaves have deep cuts. The roots are cylindrical, pure white with blunt end. Average yield is 160 q/acre.

Turnip

L-1 (1974) : The roots are round, pure white, smooth rat-tailed and crisp with mild flavour. It can be harvested between 45 to 60 days of sowing. It yields about 105 quintals of roots per acre.

Agronomic Practices

Sowing Time and Seed Rate: Although radish is a winter season crop but varieties have been developed that can be grown in summer and spring seasons. Except Pusa *Chetki*, other varieties do not tolerate high temperature if planted early in the season. Asiatic varieties if planted late in the season, start bolting without forming edible roots. With careful selection of varieties, radish can be grown almost throughout the year. The schedule of sowing radish varieties and their root availability is given as under:

Variety	Sowing time	Root availability
Pusa Himani	January-February	February-April
Punjab Pasand	Second fortnight of March	End April-May
Pusa Chetki	April-August	May-September
Punjab Safed Mooli 2, Punjab Pasand, Japanese White	Mid September-Oct.	October-December
Japanese White	November-December	December-January

For desi varieties of turnip, August-September is the best time of sowing. European types should be sown in October-November. A seed rate of 4 to 5 kg. for radish and 2-3 kg for turnip is sufficient for one acre. A spacing of 45 cm between ridges and 7.5 cm between plants in the row is common for these crops. The plant spacing is maintained by thinning at the time of true leaf formation. Thinning is very important for producing superior quality roots.

Manures and Fertilizers : 15 tonnes of farmyard manure, 25 kg. of N (55 kg of Urea) and 12 kg. of P₂O₅ (75 kg. of Single Superphosphate) per acre is the common fertilizer dose. Apply all fertilizers at sowing and always apply well rotten farmyard manure.

Weeding and Earthing up: In radish and turnip, one weeding about 2-3 weeks after sowing is sufficient. Weeding is immediately followed by earthing up especially in desi varieties of radish where roots have tendency to protrude above soil surface.

Irrigation: First irrigation should be given immediately after sowing of seed. Subsequent irrigations should be given at 6-7 days interval during summer and 10-12 days during winter, depending upon soil type. Radish requires 5-6 irrigations. Excessive irrigation results in misshapen roots and numerous hair growth. Pre-harvest light irrigation is useful for summer crop of radish because this keeps the roots fresh and reduces pungency.

Harvesting, Care and Marketing

Radish and turnip are harvested when roots are tender. A few days delay in harvesting particularly of European types, render the roots pithy and unfit for consumption. Punjab *Pasand*, a quick

growing main season variety and Pusa *Chetki*, an early season variety attains marketable maturity 45 days after sowing. Other varieties of radish and turnip are ready for harvest in about 45-60 days depending upon variety and season.

Seed Production

Radish: Roots raised in one acre are sufficient to plant 4 to 5 acres of seed crop. Sow Pusa *Chetki* in August, Punjab Pasand in September and Japanese White in October for raising roots for seed production. Transplant stecklings of Pusa *Chetki* in September and Punjab Pasand, Japanese White and Punjab Safed Mooli-2 after middle of November. Transplant stecklings of $\frac{3}{4}$ root length at 60 × 22 cm spacings. Apply 30 kg N (65 kg Urea) and 8 kg P₂O₅ (50 kg. Superphosphate) per acre. Add whole of P₂O₅ and half of N before planting and the remaining half of N after 30 days of planting.

Turnip: Roots raised in one acre are sufficient to plant 3 to 4 acres of seed crop. Seed of L-1 can be produced by sowing in mid September and transplanting in the first week of December. Select roots having diameter more than 5 cm for seed production. Keep rows 45 cm and plants 15 cm apart. Apply same fertilizers as in case of radish.

Plant Protection

(Cauliflower, Cabbage, Broccoli, Chinese Cabbage, Radish and Turnip)

A. Insect Pests

Pests and Symptoms	Control Measures	Precautions
A. Early-Season Crop (July-October)		
<p>1. Stem borer (<i>Hellula undalis</i>) is serious during July-August. The larvae bore into the central shoots and the plant is unable to bear the flower head. The attack is mostly on young plants in the nursery and the fields.</p>	<p>Pick the infested fruits and destroy them completely.</p>	<ul style="list-style-type: none"> • Regular monitoring of young plants in nursery and after transplanting for any attack should be done • Use clean, healthy, vigorous insect free seedlings for transplanting

<p>2. Diamond-back moth (<i>Plutella xylostella</i>). is serious during August-September. Larvae feed on the leaves, leaving intact the parchment like epidermis, sometimes they produce shot holes in leaves. The growth of young plants is greatly inhibited.</p>	<p>Give need based sprays of Bt based insecticides Dipel 8L (<i>Bacillus thuringiensis sp. kurstaki</i>) @ 300 ml or Delfin/ Halt WP (<i>B. thuringiensis sp. kurstaki</i>) @ 300 g per acre at 7 days interval (spray in the evening) or 240 ml Success 2.5 SC (spinosad) or 70 g Proclaim / Egao 5 SG (emamectin benzoate) or 130 ml Avaunt 15.8 EC (indoxacarb) or 150 ml Rimon 10 EC (novaluron) or 100 ml Sumicidin 20 EC (fenvalerate) using 80-100 litres of water. Repeat the spray after 10 days, if necessary.</p>	<p>Prefer to use Dipel 8L or Delfin/Halt WP in the initial sprays as these are safe to non target organisms.</p> <p>Follow the waiting period of 3 days for Avaunt 15.8 EC on both cabbage and cauliflower crops. For success 2.5 SC, follow 5 days waiting period for cabbage and 7 days for cauliflower crop. While, for Proclaim/Egao 5 SG, follow 3 days waiting period for cabbage and 5 days for cauliflower crop.</p>
<p>3. Tobacco caterpillar (<i>Spodoptera litura</i>) serious during August-October. It is a sporadic pest. If it is not controlled, it may completely damage the leaves. Young stages of the caterpillar feed gregariously.</p>	<p>i) Remove the egg masses and clusters of larvae and destroy them.</p>	<ul style="list-style-type: none"> • Regular monitoring of young plants in nursery and after transplanting for any attack should be done • Use clean, healthy, vigorous insect free seedlings for transplanting
<p>B. Mid-Season Crop (September to December)</p>		
<p>The main-season crop is seldom severely attacked by any of the above mentioned insect pests. The incidence of tobacco caterpillar may sometimes become severe and extend upto October. Diamond back moth also attack the crop in October-November.</p>	<p>Spray the crop as given under early crop.</p>	<p>Prefer to use Dipel 8L or Delfin/Halt WP in the initial sprays as these are safe to non target organisms.</p> <p>Follow the waiting period of 3 days for Avaunt 15.8 EC on both cabbage and cauliflower crops. For success 2.5 SC, follow 5 days waiting period for cabbage and 7 days for cauliflower crop. While, for Proclaim/Egao 5 SG, follow 3 days waiting period for cabbage and 5 days for cauliflower crop.</p>

C. Late-Season Crop (December to March)		
<p>1. Aphid : Mainly attacked by <i>aphids</i> (<i>Lipaphis erysimi</i>). Serious during January to February. They suck the sap from leaves and the growth of young plants is checked.</p>	<p>Spray 250-500 ml Malathion 50 EC in 80-100 litres of water per acre. Repeat the spray after 10 days, if necessary.</p>	<ul style="list-style-type: none"> • Harvest the marketable vegetables before spraying. • Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/ canals as they serve as reservoir for aphids • Use fertilizers judiciously, as aphid populations tend to be higher in plants that are fertilized liberally with nitrogenous fertilizers
<p>2. Diamond Back Moth : Besides aphids, the population of diamond back moth may sometimes build up during February-March.</p>	<p>Control measures are the same as given under early-season crop.</p>	<p>Prefer to use Dipel 8L or Delfin/Halt WP in the initial sprays as these are safe to non target organisms.</p> <p>Follow the waiting period of 3 days for Avaunt 15.8 EC on both cabbage and cauliflower crops. For success 2.5 SC, follow 5 days waiting period for cabbage and 7 days for cauliflower crop. While, for Proclaim /Egao 5 SG, follow 3 days waiting period for cabbage and 5 days for cauliflower crop.</p>
<p>3. Cabbage Caterpillar (<i>Pieris brassicae</i>) Serious during October-April. Young larvae just scrap the leaf surface, whereas the subsequent instars eat up leaves from the margins inwards, leaving intact the main veins. In case of severe attack entire plants are eaten up. Young stages of the caterpillar feed gregariously.</p>	<p>Remove the egg masses and clusters of larvae and destroy them.</p>	<ul style="list-style-type: none"> • Regular monitoring of young plants in nursery and after transplanting for any attack should be done • Use clean, healthy, vigorous insect free seedlings for transplanting

B. Diseases

Diseases	Symptoms	Control Measures
1. Damping off (<i>Pythium sp.</i> , <i>Rhizoctonia sp.</i> and <i>Fusarium</i> <i>sp.</i>)	Pre and post emergence death of seedlings occurs.	i) Treat the seed before sowing with 3g of Captan per kg seed. ii) Drench the soil around the seedlings with 200g of Captan per 100 litres of water twice, viz. on the 7th & 15th days after sowing.
2. Crown rot of turnip (<i>Alternaria brassicae</i>)	Lesions appear in the collar region particularly in turnip on young seedlings. Lesions become black and corky with cracks on the root crown. Leaves, slowly dry up.	Same as given under damping off.
3. Black rot (<i>Xanthomonas campestris</i>)	‘V’ shaped yellow lesions on margins of leaves, turn brown. The veins blacken, leaves malformed, dry up and die. Curds are also infected and become rotten.	i) Take seed from the bacterium-free areas from the plants free of disease. ii) Treat the seed before sowing with hot water at 50°C for 30 minutes and dry. iii) Use sanitary measures. Destroy the diseased debris in the field after harvesting.
4. Alternaria blight (<i>Alternaria brassicae</i> and <i>A. brassicicola</i>)	Concentric spots on the lower leaves. The curd also gets infected and rots. Brown spots are formed on pods in the seed crop.	i) Treat the seed before sowing with 3g of Captan per kg of seed. ii) Spray the crop with 500g Indofil M-45 in 200 litres of water per acre at 7 day intervals. iii) Destroy the affected plant debris.
5. Downy mildew (<i>Peronospora parasitica</i>)	The disease develops on leaves and curds. On leaves, the lesions are yellowish, irregular to angular with white ‘downy’ growth. The curd tops turn brown. The stems develop dark brown depressed irregular lesions/streaks with whitish ‘downy’ growth. The severely infected curds rot and fail to produce seeds.	Spray the crop with 500 g Indofil M-45 in 200 litres of water per acre at 7 day intervals.

<p>6. Stalk rot of cauliflower seed crop (<i>Sclerotinia sclerotiorum</i>)</p>	<p>Stem and inflorescence twigs become straw coloured and dry during March. Pith of infected plant portion is filled with black, hard sclerotia of variable sizes.</p>	<p>In disease prone areas use of FYM decreases the disease incidence and the number of sclerotia of the fungus.</p>
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29. PALAK

Climate and Soil

It is a winter season crop but can be grown throughout the year. It can also tolerate frost. It can be grown almost on all soils but sandy loam with pH 7.0 is the best for its cultivation.

Improved Variety

Punjab Green (1990) : The plants are semi-erect, foliage is shining dark green, thick, long, sweet, succulent and free from sourness. There is mild purple pigmentation on stem. It is ready for first cutting after 30 days of sowing and yields on an average 125 q/acre. It is slow bolter. It has low oxalic acid which is desirable trait in greens.

Agronomic Practices

Sowing Time and Seed Rate : Winter crop is sown during September-October and spring/summer crop from mid-February to April. Normally palak is grown almost throughout the year. For winter crop, use 4-6 kg. and for summer crop 10-15 kg. of seed per acre.

Spacing : Seed should be sown 3-4 cm deep in rows at 20 cm apart.

Manures and Fertilizers : Apply 10 tonnes of farmyard manure alongwith 35 kg of N (75 kg of Urea)and 12 kg of P_2O_5 (75 kg of Superphosphate) per acre to harvest a good crop. Apply whole of farm yard manure, P_2O_5 and half N before sowing and the remaining half N may be applied in two splits after each cutting followed by irrigation.

Irrigation : First irrigation should be given immediately after sowing. Subsequent irrigations should be given at an interval of 4-6 days during summer and 10-12 days during winter.

Harvesting, Care and Marketing

The crop will be ready for harvest in about 3-4 weeks after sowing. Subsequent cutting should be done at an interval of 20 to 25 days depending upon the variety and season. During summer only one harvesting should be taken.

Seed Production

A minimum isolation distance of 1000 metre should be maintained all around palak seed field from other varieties. For seed production, crop should be sown in second fortnight of october. To get maximum seed yield cutting should be done 30 days after sowing and then left for seed production. Row to row and plant to plant distance should be maintained at 50 cm × 30 cm. Skipping of one row after every five rows is very essential for field inspection. The minimum three field inspections should be made for getting the true to type seed. The first inspection should be made at vegetative phase, second at bolting stage and third before harvesting of the crop. Any off type and diseased plants should be removed. The plants showing variation in leaf characters as well as early and late bolters should be removed.

The crop should be harvested when most of the late ripening seed stalks turn brown. After harvesting, the crop should left in the field for curing and drying for about a week before the seed threshing.

Plant Protection

A. Insect Pests

Pest	Symptoms	Control Measures
1. Aphids (<i>Aphis sp.</i>)	Minute insects suck sap from the foliage resulting in twisting of leaves.	<ul style="list-style-type: none">• Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/canals as they serve as reservoir for aphids• Use fertilizers judiciously, as aphid populations tend to be higher in plants that are fertilized liberally with nitrogenous fertilizers

B. Diseases

Disease	Symptoms	Control Measures
1. Cercospora leaf spot (<i>Cercospora beticola</i>)	Small circular to sub-circular spot with grey centres surrounded by red margins appear on leaves. This disease is more pronounced on seed crop.	---

30. LETTUCE

Climate and Soil

Lettuce requires cool environment. The average mean temperature for growth and better taste is 13-16°C. High temperature promotes seed stalk and causes bitter taste of leaves. It performs well in sandy loam and silt loam soils.

Improved Variety

Punjab Lettuce-I (1991) : Its leaves are light green, shining and crispy. It is a non-heading type and bears loose leaves. It takes 45 days from sowing to first harvest of fully developed leaves and yield of green leaves is 35 q/acre. Harvesting of green leaves is possible from November to March.

Agronomic Practices

Sowing Time and Seed Rate : Sow the seed on 15-20 cm. raised nursery beds from mid September to mid November. Transplant 4-6 weeks old seedlings and irrigate at a weekly interval. To raise seedlings for an acre, sow 400g seed in 2 marla nursery beds.

Spacing : Keep the spacing between seedlings 30 cm and rows 45 cm.

Manures and Fertilizers : Apply 15 tonnes of FYM, 25 kg N (55kg Urea) and 12 kg P₂O₅ (75 kg of Single Superphosphate) per acre. Apply whole of superphosphate and 18 kg urea before transplanting and remaining 37 kg urea after six weeks.

Irrigation : First irrigation should be given immediately after transplanting. Subsequent irrigations should be given at an interval of 5-6 days on light soils but 8 to 10 days on heavy soils.

Harvesting, Care and Marketing

Harvest fully developed and tender leaves once a week regularly. Stop taking cuttings by the end of March or beginning of April when the plants attain milky stage. Bolting starts in the first week of April. Harvest seed crop in the middle of May. Seed yield per acre is 50 kg.

Seed Production

Lettuce is strictly self pollinated crop and require about 10 metre isolation to avoid mechanical mixture. Seed stalks should be harvested when seed is fully mature on the plants otherwise germination is affected.

31. CORIANDER

Climate and Soil

It requires cool climate in early stages and warm dry weather at maturity. Coriander can be sown on a wide variety of soil but it performs best in well-drained sandy loam to loamy soils.

Improved Variety

Punjab Sugandh (2008) : Its green plants are semi-erect, and produce profuse tillers. Leaves are medium in size, green, tender and excellent in aroma. It is late in bolting and give four cuttings of green leaves. The average green leaves yield is 150 q and of seed is 3.5 q/acre.

Agronomic Practices

Preparatory Tillage : Prepare a fine seed bed by giving two or three ploughings, each followed by planking.

Seed Rate : Use 8-10 kg of seed per acre.

Seed Preparation : Use healthy and disease free capsules (seeds). Rub the capsules gently to break them into 2 to 4 parts. Unrubbed capsules give very poor germination. Treat the seed with Thiram @ 2.5 g per kg of seed.

Time and Method of Sowing : Optimum period of sowing for green leaves is first week of October and for seed last week of October to the first week of November. However, it can be continued up to last week of December. Sow by pora method in rows 30 cm apart.

Weed Control : The slow growth of coriander in the initial stages poses a serious weed problem. Give two weedings, preferably with improved wheel hand hoe, the first about 4 weeks after sowing and the second 5-6 weeks thereafter.

Irrigation : Give four or five irrigations depending upon the soil and rainfall. The first irrigation may be given about 3 weeks after sowing. Subsequent irrigations may be given as and when required taking care that there is no moisture stress, particularly at flowering and seed development stages.

Manures and Fertilizers : Apply 40 kg N (90 kg Urea) in three split doses, one third at sowing and remaining in two equal splits after first and second cutting of green leaves. However, for seed crop apply 30 kg N (65 kg urea) per acre in two splits, half at sowing and the remaining half at flower initiation. There is no need of applying phosphorus to soils testing medium to high in this nutrient.

Harvesting, Threshing and Marketing

The green leaves are harvested on attaining 20-25 cm height. Therefore, 3-4 cuttings can be taken of green leaves. The crop is ready for harvest by the end of April. Harvest when the capsules are mature but green. The green coloured fetch a price premium over the brown coloured over-ripe capsules. Remove the harvested produce to a pucca threshing floor, allow it to dry and then thresh. Dry the capsules fully before storage.

Plant Protection

a) Insects

No serious insect-pests appear on this crop.

b) Diseases

Stem gall : The disease forms tumor like swelling on leaf veins, petioles, peduncles, stems and capsules. The fruits in the umbels may become enlarged. Remove and burn the diseased plants. Treat the seed with 2.5 g Thiram per kg of seed.

32. KASURI METHI

Climate and Soil

It requires cool climate in early stages and warm dry weather at maturity. It can be sown on a wide variety of soil but it performs best in well-drained sandy loam to loamy soils.

Improved Variety

Kasuri Supreme (2014) : Its plants are trailing type and produce profuse tillers. Stem is tender and leaves are broad, trifoliate and light green in colour. It is late in bolting and give three cuttings of green leaves. First cutting is possible 42 days after sowing. Average plant height is 27 cm. The average green leaves yield is 100 q/acre.

Agronomic Practices

Preparatory Tillage : Prepare a fine seed bed by giving two or three ploughings, each followed by planking.

Time and Method of Sowing: Optimum period of sowing for green leaves is first week of October and for seed last week of October to the first week of November. Sow by pora method in rows 20 cm apart.

Seed Rate : Use 10 kg of seed per acre. Treat the seed with Thiram @2.5 g per kg of seed.

Weed Control : The slow growth of kasuri methi in the initial stages poses a serious weed problem. Give two weedings, the first about 3 weeks after sowing and the second 5-6 weeks thereafter.

Irrigation: Sow the seed in water conditions. First irrigation should be given 7-10 days after sowing. Give four or five irrigations depending upon the soil and rainfall.

Manures and Fertilizers : Apply 30 kg N (65 kg Urea) in three split doses, half at sowing and remaining in two equal splits after first and second cutting of green leaves.

Harvesting, Care and Marketing

The green leaves are harvested on attaining 25 cm height. Therefore, 3 cuttings can be taken of green leaves. The seed crop is ready for harvest by mid of April. Harvest when pods turn brown and leaves get dry. Take the harvested produce to a pucca threshing floor, allow it to dry and then thresh. Dry the seed fully before storage.

33. POTATO

Climate and Soil

The crop is raised when maximum day temperature is below 30°C and night temperature is not above 20°C. Good crop growth is observed when days are sunny and nights are cool.

Potato thrives well in cool climate. The highest tuberization is obtained when day and night temperature is 20°C and 14°C, respectively. Potato can be grown on different types of soils. Well drained, loose, friable, non-saline and non-alkaline loamy sand to sandy loam soils are suitable for this crop. Soil pH should be in the range of 5.5 - 8.0.

Improved Varieties

Early Varieties

Kufri Surya (2000) : It is a heat tolerant high yielding medium maturing (90-100 days) white tuber variety having field resistance to late blight. It has very good keeping quality under ambient storage conditions. It is suitable for early planting (September) and heat stress conditions as it has ability to tuberise at higher temperatures. Its average yield is 100-125 q/acre.

Kufri Pukhraj (1998) : Plants are tall, vigorous and erect. It is an early bulking variety which gives economic yield quite comparable with Kufri Chandramukhi in 70 days. It is susceptible to late blight but escapes due to earliness. Its tubers are large uniform, oval, white with fleet eyes. It has dry matter content of 17-18 per cent. It yields 130 q/acre in 70-90 days.

Kufri Ashoka (1996) : Plants are tall, erect and medium compact with green foliage. It is an early bulking variety and matures in about 75-80 days under short day conditions. Its maturity is thus comparable with that of Kufri Chandramukhi. It is susceptible to late blight. However, it escapes late blight attack due to earliness. The tubers are large, smooth, oval long with white skin with fleet eyes. It has waxy texture and is easy to cook. It yields about 110 q/acre.

Kufri Chandramukhi (1968) : It is an early variety and matures in about 80-90 days. Its tuber is white, large, smooth,

oval and flattened, with white skin, fleet eyes and white flesh. The tubers, though up-to-date type, are smoother, more uniform and more attractive. The variety is capable of yielding about 100 q/acre. It is susceptible to late blight.

Mid Season Varieties

Kufri Pushkar (2006) : It is a high yielding medium maturing (90-100 days) white tuber variety having field resistance to late blight. It has very good keeping quality under ambient storage conditions. It gives higher yield than the other medium maturing cultivars. Due to its good keeping quality, it has wider acceptability. Its average yield is 160-170 q/acre.

Kufri Bahar (1980) : The plants are medium compact and vigorous with grey-green foliage. The tubers are large, round-oval with white flesh with medium deep eyes. It is a late blight susceptible variety, but capable of yielding about 125 q/acre in about 100-110 days. It is not suitable for processing.

Kufri Jyoti (1968) : Plants are tall, erect, compact with light green foliage. It matures in about 90-110 days and yields about 80-120 q/acre. Tubers are large, oval, white with fleet eyes and white flesh. Tubers show variable degree of cracking. The variety possesses moderate degree of resistance to late blight and slow rate of degeneration. It is suitable for planting in spring season.

Late Varieties

Kufri Badshah (1979) : The plants are vigorous with smooth leaves. The tubers are large, oval, white, smooth with fleet eyes and dull white flesh. Tubers tend to develop purple colour on exposure to light. It is a moderately resistant to late blight, resistant to PVX and matures in about 100-110 days, yielding on an average 130 q/acre. It is not suitable for processing.

Kufri Sindhuri (1967) : It is a medium late variety and takes 110-120 days to mature. The tuber is medium, smooth, round with light red skin, deep eyes and dull white flesh. The tubers have very good keeping quality. The variety yields about 120 q/acre. The tubers become hollow under very high fertility condition. It is not suitable for processing. It is moderately resistant to early blight and tolerant to leaf roll.

Processing Varieties

Kufri Frysona (2010) : It is medium maturing (90-100 days), resistant to late blight and good keeping quality. The tubers are long oval and white. Average yield is 160-170 q/acre. It is a variety suitable for processing into French fries due to long tubers with high dry matter (22%). It produces high proportion of French fry grade (75 mm) tubers.

Kufri Chipsona-3 (2006) : It is medium maturing (90-100 days), resistant to late blight and have good keeping quality. The tubers are oval and white. Tubers have low reducing content (100 mg per 100 g fresh weight) and high tuber dry matter (21.5%) which is required for producing light coloured chips. Average yield is 165-175 q/acre. It is a variety suitable for processing into chips.

Kufri Chipsona-1 (1998) : It is medium maturing (90-100 days), resistant to late blight and have good keeping quality. The tubers are oval and white. Tubers have low reducing sugar content (108 mg per 100 g fresh weight) and high tuber dry matter (21%) which is required for producing light coloured chips. Average yield is 170-180 q/acre. With this variety even North western plains can produce potato for processing. It is a variety suitable for processing into chips.

Seed Source : Obtain the seed from a reliable source. It is better to replace the seed every 3-4 years. The yield is reduced progressively if the same seed is used year after year.

Agronomic Practices

Green Manuring : Sow 20 kg of sunhemp (*Crotalaria juncea*) or Dhaincha for green manuring from end of June to first week of July. Burry the crop after 7-8 weeks of sowing to allow proper decomposition before potato planting.

Preparatory Tillage : Plough with a mould board or disc-plough, followed by the disc-harrow or the tiller, depending upon the soil type. In loamy sand soil, discing alone is sufficient. Apply farm yard manure after preparatory tillage just before planting as this practice is more beneficial than incorporating into the soil through cultivation. If weeds or stubbles of the previous crop are

not a problem, potato can be grown with minimum tillage without loss in yield.

Seed Rate : For autumn sowing 13-18 q/acre seed tubers of 40-50 g weight should be used for planting. Good quality and disease free seed should be used. The seed should be produced by using the seed plot technique. If the seed raised from autumn crop is to be used for spring planting, its dormancy should be broken by dipping cut tubers in a solution of 1% Thiourea and 1 ppm Gibberellic Acid (one ml per 100 litres of water) for an hour followed by air drying the treated tuber pieces for 24 hours in thin layers in shade.

Seed Potato Treatment and its Preparation : To control black scurf treat the tubers with 83 ml Emesto Prime 22.43 FS or 250 ml Moncoren 250 SL in 100 litres water for 10 minutes after taking out of the cold storage.

The seed potatoes obtained from the cold store, cannot be planted immediately. It should first be dried with the help of blowers. Keep the treated tubers in a cool place/shade exposed in diffused sunlight for 8-10 days which initiates sprouting and helps the sprouts to become strong.

Time of Sowing : The best time for sowing is last week of September to mid-October for the autumn crop and the second fortnight of January for the spring crop. However, the date of sowing in September would much depend upon the temperature prevailing at that time.

Method of Planting:

After the field has been prepared well, mark rows with a row marker. A ridger should be used for planting the crop manually. Make ridges at 60 cm apart and keep tuber to tuber distance at 20 cm. Semi-automatic or automatic planters are recommended where tractor power is available.

For mechanized planting, the spacing between the rows and tuber should be kept 65×18.5 cm or 75 cm×15 cm respectively depending upon the available machinery.

- **Treat the potato seed with fungicide for the control of black scurf disease.**
- **Timely spray recommended fungicides for the control of late blight disease.**
- **Use seed plot technique for the production of healthy virus free seed crop of potato.**

Manures and Fertilizers : Twenty tonnes of farmyard manure or green manuring alongwith 75 kg of N (165 kg of Urea), 25 kg of P₂O₅ (155kg of Single Superphosphate) and 25 kg of K₂O (40 kg of Muriate of Potash) per acre should be used. Application of paddy straw mulch @ 25 q/acre saves 18 kg nitrogen. Drill all P₂O₅ and K₂O and half N at sowing and the remaining N at the time of earthing-up. Higher doses of these nutrients can be applied if the soil test shows low to very low status of these nutrients.

Note: Application of N fertilizer more than recommended is no substitute for farm yard manure or green manure.

Application of Biozyme : Biozyme granule and liquid formulation should be applied along with fertilizers in order to increase the yield of potato. Apply 8 Kg granule per acre each at the time of planting and earthing up and spray of Biozyme liquid formulation at tuber initiation stage @200ml/acre increases the yield of potato.

Earthing-up : A double mould board plough or a ridger should be used for earthing up after 25-30 days of sowing.

Weed Control : Application of paddy straw mulch @ 24 q/acre immediately after planting provides affective control of annual weeds or any one of the following herbicides can be used for controlling weeds.

Herbicides	Dose per acre	Time of application
Sencor/Tanoshi 70 WP (metribuzin)	200 g	Pre-emergence application after the first irrigation but before the emergence of crop.
Gramoxone/Kabuto 24 SL (paraquat)	500-750 ml	Spray at 5-10 per cent emergence of the potato crop.

Irrigation : 1) Furrow Irrigation : The first irrigation should be given immediately after planting as it ensures better germination. The potato crop responds well to light and repeated irrigations. While applying irrigation avoid the over flooding of the ridges and the subsequent hardening of the soil surface which interferes with emergence, growth and development of tubers. The total number of irrigations will be 7-8. In light textures soils,

poor quality tubewell water can be used for irrigation in cyclic mode with good quality canal water for optimum tuber yield. Application of paddy straw mulch @ 25 q/acre improves tuber yield, soil health and saves two irrigation irrespective of water quality.

2) Drip Irrigation : Drip irrigation in potato results not only increase in yield but also saves 38% of water over conventional method of irrigation. Under this system, irrigation should be applied at two days interval. The potato crop should be irrigated with a lateral pipe having dripper discharge of 2.2 litre per hour and dripper placed at 30 cm apart the following schedule :-

Month	Time of irrigation (min)
October	20
November	25
December	45
January	20

*If discharge rate is less than 2.2 litre/ hour, time of irrigation may be adjusted proportionally by the formula :-

$$= \frac{2.2 \times \text{Time of irrigation}}{\text{Discharge of dripper}}$$

Fertigation saves 20% fertilizer. Apply 24.50 kg Urea, 6.6 kg Mono ammonium Phosphate and 6.7 kg Muriate of Potash (white) per acre during first month of the growing period of the crop in 7 equal doses with every second irrigation (4 days interval). The first fertigation should be started after germination of the crop. The remaining amount of fertilizer 97.5 kg Urea, 26.2 kg Mono ammonium Phosphate and 26.7 kg Muriate of Potash (white) should be applied in equal doses during rest of the crop season (before last irrigation) in 13 equal doses with every second irrigation (4 days interval).

Harvesting, Grading and Storage

Suitable tractor operated digger has been developed and is available in the market. There should be optimum moisture in the soil at the time of harvest. The clods affect the efficient functioning

of potato digger. Bullock drawn diggers can also be used. Keep the produce in the field after harvesting for 10-15 days.

Grading : After harvesting the potato should be graded. Four grades may be made :

- (i) Small size (below 25 g weight)
- (ii) Medium size (25-50 g weight)
- (iii) Large size (50-75 g weight)
- (iv) Extra large size (above 75 g weight)

Packaging and Storage of Potato : Leno bags can be used for potato storage by keeping quality intact. Leno –III bags with single fold double stitch, plain gauge weave of size 56 × 115 cm (width × length), weighing 50 gm (or more) can hold 50 kg potato safely during transportation and storage.

It should be stored in the cold storage where temperature is maintained at 2-4°C and relative humidity is 75-80%.

Storage of Ware Potato : Potato cultivars Kufri Chandramukhi, Kufri Jyoti and Kufri Chipsona-1 can be stored successfully for 5 months at 10±1°C and 90-95% RH with two consecutive foggings of CIPC at the rate of 40 ml per tonne. The first fogging is given at the initiation of sprouting (chitting) and second after 60 days of the first fogging. The stored potatoes maintain low reducing sugars (<0.25%) and are suitable for chipping and culinary purpose.

Seed Plot Technique : This technique aims at raising a healthy seed crop of potato in Punjab during the period of low aphid incidence. This pest is responsible for transmitting the viral diseases, like leaf-roll, PVX, PVY and PVA.

For the seed crop, healthy seed potato, free from viral infection should be obtained and planted in autumn i.e. in the first week of October at a spacing of 50×15 cm to ensure the development of large size seed tubers. For mechanize planting sow the seed crop at a spacing 65×15 cm or 75×15 cm depending upon the available machinery. An acre of the seed crop will produce enough seed for planting of 8 to 10 acres of the crop. Normal plant protection measures should be adopted to control aphids and other insect pests. Rogue out otherwise unhealthy plants noticed during the growing season to ensure the production for better quality seed.

Towards mid-December, irrigation may be restricted and later withheld completely so that the haulms wilt and fall down. As soon as there are 20 aphids per 100 leaves, cut the haulms. Allow the tubers to mature in soil for about 15 days. The harvested crop may be graded and transferred to cold storage for planting in the following autumn season.

Plant Protection

A. Insect Pests

Pests and symptoms	Control measures	Precautions
Autum Crop		
<p>1. Jassid (<i>Amrasca sp.</i>) : Leaves curl, turn pale bronze and dry up as a result of Jassid attack the crop is stunted and has blighted appearance.</p> <p>Aphid (<i>Myzus persicae</i>) : It appears late in the crop season. Besides sucking the cell-sap, it transmits viruses and lowers the quality of the seed crop.</p>	<p>Spray the crop with 300 ml Metasystox 25 EC (oxydemeton methyl) in 80-100 litres of water per acre as soon as aphid appears. Give another spray after 10 days.</p>	<p>Do not spray Metasystox within 3 weeks of harvest.</p>
Spring Crop		
<p>2. Cutworm (<i>Agrotis sp.</i>) causes considerable damage from February to March by cutting the young plants at the ground level and later on by making holes into the tubers.</p>	<p>Weed control in and around the field before planting reduce cutworm problems through reduction of early season host plants</p>	<ul style="list-style-type: none"> • Hot weather ploughing reduces the population of immature stages. A number of birds feed on insects that get exposed upon ploughing
<p>2. Aphids suck the sap and transmit viral diseases. Besides these hadda beetle and jassid may also cause damage.</p>	<p>Spray the crop with 300 ml Metasystox 25 EC (oxydemeton methyl) in 80-100 litres of water per acre at 10-15 days interval beginning soon after emergence.</p>	<ul style="list-style-type: none"> • Eradicate weeds growing on field bunds, waste lands, road side and irrigation channels/canals as they serve as reservoir for aphids • Use fertilizers judiciously, as aphid populations tend to be higher in plants that are fertilized liberally with nitrogenous fertilizers

B. Diseases

Disease	Symptoms	Control Measures
<p>1. Late blight (<i>Phytophthora infestans</i>)</p>	<p>Infected tubers from cold stores serve as primary source of disease. On emergence the sprouts and leaves get infected. Water-soaked spots appear on margins of leaves which later turn into black patches with whitish fungus growth visible on lower surface in the morning hours. Black patches may extend and kill the foliage in a few days if moist weather prevails. Decaying leaves emit an offensive odour. Brown depressed patches appear on tubers which finally rot in the soil before harvesting.</p>	<p>i) Use selected healthy tubers for planting.</p> <p>ii) Infected/rejected tubers taken out of cold stores should be buried and not left in the open.</p> <p>iii) Follow high ridge culture to avoid tuber infection.</p> <p>Spray the crop with 500-700g Antracol/ Indofil M-45/Mass M-45/Markzeb/Kavach or 750-1000g Copper oxychloride 50 WP/Mark copper per acre in 250-350 litres of water in the first week of November before the appearance of disease followed by 5 more sprays at 7 days interval. Under heavy disease risk situation instead of 3rd and 4th spray of Indofil M-45/ Mass M-45/Markzeb/Kavach/ Antracol, give two sprays of 700 g Melody Duo 66.75 WP or Ridomil Gold or Sectin 60 WG or Curzate M-8 or 250 ml Revus 250 SC or 200 ml Equation Pro per acre at 10 days interval. Subsequently give one spray of Indofil M-45/Kavach/Antracol.</p> <p>In late/spring sown crop if the previous crop is infected and disease risk is heavy due to humid weather, give first spray of 500 g Melody Duo 66.75 WP or Ridomil Gold/Sectin 60 WG/ Curzate M-8 or 250 ml Revus 250 SC or 200 ml Equation Pro per acre followed by three sprays of 700g Indofil M-45/Mass M-45/ Markzeb/Kavach/ Antracol per acre at 7 days interval.</p>

<p>2. Early blight (<i>Alternaria solani</i>)</p>	<p>The disease is inconspicuous and shows attack in light soils. Scattered brown spots appear on the leaves often at the top or on the margin. These spots later show concentric rings which give them a target board appearance. Older spots become dark brown.</p>	<p>Spray the crop with Indofil M-45 or Copper oxychloride as mentioned for late blight.</p>
<p>3. Black scurf (<i>Rhizoctonia solani</i>)</p>	<p>Diseased tubers have black rough incrustations. Plants raised from diseased tubers show wilting.</p>	<p>i) Use healthy disease free seed ii) Disinfect the tubers with 83 ml Emesto Prime 22.43 FS or 250 ml Moncoren 250 SL in 100 litres water for ten minutes. or Dip potato seed tubers in 10 g wet <i>Trichoderma</i> formulation and 20 g mollasses per litre water for 10 minutes. Keep treated seed in shade for 24 hours before sowing.</p>
<p>4. Mosaic and leaf roll (Different viruses)</p>	<p>Leaves show mottling varying from mild chlorosis to pronounced mosaic symptoms. In severe cases smalling, curling of leaves and dwarfing of plants occur.</p>	<p>i) Sow only certified and virus free seed tubers. ii) Raise virus free seed tubers by using the Seed Plot Technique and use for 3-4 years. iii) Control insect vector.</p>
<p>5. Common scab (<i>Streptomyces scabies</i>)</p>	<p>Affected tubers show deep, circular lesions about 0.5-1.0 cm in diameter.</p>	<p>i) Use disease free seed tubers. ii) Do green manuring before sowing of potatoes. iii) In scab infested fields, do green manuring with 7-8 week old sunhemp or summer moong before rice. iv) Prevent drying of soil by regular irrigation from tuberization to maturity.</p>

<p>6. Leaf spot (<i>Cercospora solani tuberosi</i>)</p>	<p>Small, circular to angular reddish brown spots of pin-head size appear first on lower and older leaves. Later they coalesce to form bigger irregular dark, brown to black spots with grey centre. Incidence is more on early sown crop.</p>	<p>Spray the crop as given under early blight.</p>
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34. ARUM (ARVI)

Climate and Soil

It is a warm season crop and requires rains ranging from 120-150 mm per annum. An assured irrigation is a pre requisite for the raising of successful crop.

Arvi can be cultivated in varied type of soils but it thrives best in sandy loam and loamy soils containing sufficient organic matter. Soil lacking in optimum fertility and moisture will result in low yield. The soils with poor drainage will produce corms of low quality. The land should be prepared thoroughly by 2-3 ploughings and plankings. Keep the field free from weeds and stubbles.

Improved Variety

Punjab Arvi-1 (2009) : The plants are tall, leaves are green, large and obliquely erect. Petiole is long and sheathing at the base. The corms are long and medium thick. The corm colour is brown and inner flesh is creamy. It takes 175 days for maturity. The average yield is 90q/acre.

Agronomic Practices

Sowing and Seed Rate : 300-400 kg of medium sized healthy corms are sufficient to plant one acre. The sowing of arvi can be done in first fortnight of February under Punjab conditions.

Method of Sowing : The corms are sown 6 to 7.5 cm deep by keeping 67.5×15 or 45×20 cm distance between rows.

Manures and Fertilizers : Arvi is a heavy feeder and requires 10-15 tonnes of well rotten farmyard manure which should be added in the field before sowing. In addition, 40 kg of N (90 kg of Urea), 20 kg P₂O₅ (125 kg Superphosphate) and 20 kg of K₂O (35 kg of Muriate of Potash) per acre should be applied. 1/2 N and whole of P₂O₅ and K₂O should be added at the time of sowing while remaining 1/2 N should be applied 35-45 days after sowing at the time of hoeing, weeding and earthing up.

Irrigation : Arvi requires regular irrigation for uniform sprouting, therefore, irrigate the field immediately after sowing and keep the field wet till the completion of germination. Irrigate

the field at 3-4 days interval during summer and as and when required, during rainy season.

Hoeing : Control weeds by giving one or two hoeings and earthing up should be done after each hoeing.

Harvesting, Care and Marketing

The crop becomes ready for harvesting 175-200 days after sowing when the leaves start becoming yellow, which is the sign of maturity. The corms from early harvest are comparatively soft and are suitable for table purpose but can not be stored for long. The moisture in the field should be sufficient at the time of harvesting for easy lifting of corms which can be done by spades or other hand tools. The corms should be cleaned after harvesting and separate the primary corms from the other corms.

Storage

The secondary corms which have been separated from the primary ones are used as seed which are stored. The seed corms should be stored at cool and dry place to avoid rotting. The seed corms can be stored in the pits or in the cold store.

35. TURMERIC

Climate and Soil

This crop requires hot and moist climate. It is recommended for cultivation in irrigated areas. Turmeric grows in all types of soils, but it thrives well in well drained sandy loam to loamy soils with moderate organic matter content.

Improved Varieties

Punjab Haldi 1 (2008) : Its plants are erect and medium in height. Leaves are green and medium in size. Rhizomes are long and medium-thick. Skin colour of rhizomes is brown and the flesh is dark yellow. It matures in 215 days and average yield is 108 q/acre.

Punjab Haldi 2 (2008) : Its plants are erect and tall. Leaves are light green and broad. Rhizomes are long and thick. Skin colour of rhizomes is brown and the flesh is yellow. It matures in 240 days and average yield is 122q/acre.

Agronomic Practices

Land Preparation : To get fine seedbed, 2 or 3 ploughings followed by planking are necessary. The field should be free from stubble and weeds.

Seed Rate : Turmeric is propagated through mother and primary rhizomes. Fresh, healthy and uniform sized rhizomes weighing 6-8 quintals are sufficient to plant an acre.

Sowing Time : For getting higher yield, crop is to be sown directly in the field by the end of April. In submontane and northern districts, the sowing can be delayed for a week. It can also be raised by transplanting upto first fortnight of June without losing much in yield. For this, rhizomes should be sprouted in the nursery by planting them in close spacing and 35-45 days old seedlings should be transplanted in the field.

Method of Sowing : Ridge planting improves the size of turmeric rhizomes. It is planted in lines, keeping 45 cm row to row spacing for manual operations and 67.5 cm for mechanical, whereas, plant to plant spacing is maintained at 15 cm. After

planting, apply straw mulch @ 2.5 tonnes per acre. Keep the soil moist until the sprouting of rhizomes.

Manures and Fertilizers : Turmeric responds favourably to organic manuring. Apply 10-12 tonnes of well-rotten farmyard manure per acre before planting. Turmeric does not need much nitrogen. A basal dose of 10 kg P_2O_5 (60 Kg Single Superphosphate) and 10 Kg K_2O (16 Kg Muriate of Potash) can be drilled at planting.

Irrigation : Turmeric takes a long time to sprout and needs frequent irrigation. Apply light and frequent irrigation.

Weed Control : In order to keep the free from weeds, 1 or 2 hoeing may be given. Uniform spreading of paddy straw mulch @ 36 quintals per acre over the entire field can also be used.

Harvesting, Care and Processing

Maturity of turmeric is indicated by the complete yellowing and drying up of the plants. The crop is ready for harvesting in the month of November-December. After digging, clean the rhizomes by removing roots and soil.

Processing : Boil the cleaned rhizomes in a vessel having narrow mouth after adding water sufficient to cover the rhizomes. Boiling should be continued for an hour till the rhizomes become soft. If boiling is to be done under pressure (15 lb/sq.inch), then 20 minutes are sufficient. Boiled rhizomes are dried in the sun. On a small scale, dried rhizomes are polished by rubbing them against a hard surface whereas on commercial scale, special polishing drums are available.

(i) Preparation of lacto-fermented turmeric beverage:
The bioprocess for the production of Lacto-fermented turmeric beverage was optimized by fermenting the blend of turmeric juice (turmeric juice 100 ml, ginger extract 1.5 ml, lemon juice 5.0 ml) water 1:3 and salt (condiment) @ 1.0% followed by pasteurization at 55°C for 15 seconds with functional starter culture (Consortia of ten allochthonous lactic acid bacteria @ 5.0% (w/v)) by incubating at 37°C for 24 hrs.

The parameters optimized for Lacto-fermented beverage from turmeric powder includes mixture of 4% of turmeric powder with

ginger (1.5%) and lemon juice (5%), and initiating the fermentation with functional starter culture after pasteurization.

(ii) Preparation of turmeric pickle: The bioprocess for the fermentation of Turmeric pickle; dip the 1 inch aseptically chopped turmeric pieces in 5% brine solution followed by the addition of actively grown functional starter culture (Consortia of ten LAB strains @ 5% w/v) and fermenting till 48 hrs at 37°C in tightly stoppered sterilized glass jar.

Seed Production

The fresh rhizomes are kept at a cool and dry place or preferably in cold storage for sowing in the next season. Alternatively, for field storage rhizomes are left in soil till late winter without giving the irrigation.

36. SWEET POTATO

Climate and Soil

Sweet potato requires a long warm growing season. Plenty of sunshine and moderate rainfall with warm night and days for four months are best suited for it. It is drought resistant vegetable and cannot stand frost. Sweet potato can be grown on a wide range of soils but loamy sand soils are invariably regarded as suitable for sweet potato. The optimum pH range is 5.8 to 6.7.

Improved Variety

Punjab Sweet Potato–21 : Vines are medium long in length. Leaves are dark green, broad, lobed with purple tinge. Stem is medium long and thick. Its internodal length is 4.5 cm and petiolar length is 9 cm. It matures in about 145 days. Tuber skin colour is deep red with white flesh. The tubers are 20 cm long with 4 cm width. Average tuber weight is 75 g. It has 35% dry matter and 81 mg/g starch. It gives about 75 quintals tuber yield per acre.

Agronomic Practices

Land Preparation : The land should be well prepared and of good tilth for sowing sweet potato. The field should be ploughed 3-4 times followed by plankings. The field should be free from weeds.

Seed Rate and Time of Planting : 25,000 to 30,000 cuttings of vines are sufficient for one acre. Use 35-40 kg tubers in half a kanal area during January to February for raising vines in nursery beds for planting one acre. The optimum time of planting is from April to July.

Spacing: The vines are planted with row to row distance of 67.5 cm and plant to plant distance of 30 cm.

Manures and Fertilizers : Apply 10 tonnes of farmyard manure with 30 Kg N (125 kg CAN) 25 Kg P₂O₅ (155 kg Single Superphosphate) and 20 Kg K₂O (35 kg Muriate of Potash) per acre.

Earthing up : Earthing up should be done after 40 days of planting.

Irrigation : Irrigation may be given at 14 days interval.

Table. 1 : Tips for vegetables cultivation

Name of Vegetables	Time of sowing	Row spacing (cm)	Plant spacing (cm)	Seed rate (kg/acre)	Harvesting (days)
Tomato	Oct. – Nov. (nursery) Nov. – Dec. (plant)	120-150	30	100 gm	65
Brinjal	Oct. (nursery) – Nov. (plant) Nov. (nursery) - Feb. (plant) Feb. (nursery) – Apr. (plant) July (nursery) – Aug. (plant)	67.5	30	350 gm	100
Chilli	End Oct.– mid Nov. (nursery) Feb.–Mar. (plant)	75	45	200 gm	80
Sweet pepper	End Oct. (nursery) Mid Feb. (plant)	67.5	30	200 gm	90
Okra	Feb. – Mar. Jun. – Jul.	45	15	15-18 8-10 4-6	50
Cowpea	Feb. and Jun.	45	15	8-10	45
Onion (<i>kharif</i>)	Mid Oct.- mid Nov. (nursery) Jan. (plant)	15	7.5	5	120
Onion (<i>rabi</i>)	Mid Oct.- mid Nov. (nursery) Jan. (plant)	15	7.5	5	165
Garlic	End Sept.- Oct.	15	7.5	240	120
Pea	Mid Oct.- mid Nov.	30 30	7.5 (early) 10 (late)	45 30	65 90
Carrot	August - November	45	7.5	5	90

Table. 2 : Tips for vegetables cultivation

Name of Vegetables	Time of sowing	Row spacing (cm)	Plant spacing (cm)	Seed rate (kg/ acre)	Harvesting (days)
Radish	September - October January - March	45	7.5	5 kg	45
Turnip	October - November	45	7.5	2 kg	45
Cauliflower	June - July August - September October - November	45 45 45	30 45 30	500 gm 250 gm 250 gm	70
Cabbage	September - October	67.5	45	225 gm	
Broccoli	Mid August - mid September	45	45	250 gm	72
Chinese cabbage	Mid September	30	45	200 gm	30
Palak	September - October	20	20	5 kg	30
Potato	October	65/75	20	12-18 q	100
Arvi	End September - mid October First fortnight of January	67.5 45	15 20	3-5 q	175
Turmeric	April	67.5	15	7 q	220
Sweet potato	April - July	67.5	30	35 kg	145
Coriander	October	30	-	8-10 kg	40
Kasuri methi	October	20	-	10 kg	42
Salad	Mid September -Mid November	45	30	400 gm	45

37. HYBRID SEED PRODUCTION

PAU has released hybrid cultivars of five vegetable crops, namely MH-51, MH-27 and Punjab Hybrid (Muskmelon); CH-27, CH-3 and CH-1 (Chilli); T H-1 (Tomato); PBHR-41, PBHR-42, BH-2 and PBH-3 (Brinjal); PPH-1 and PPH-2 (Pumpkin) and POH-1 (Onion). Hybrid seed requires seed replacement every season. Punjab Agricultural University encourages farmers to carry hybrid seed production of vegetables and supply the seed of parental lines to the farmers.

Muskmelon

Sow two rows of seed parent (MS-1) alternating with one row of pollen parent (*Hara Madhu*) for hybrid seed production of MH-51 and MH-27 and Punjab Hybrid. Bed width is 3.0 m and planting is done on both side. The hill are spaced 30 cm for MS-1 and 60 cm for male parent. Two seeds/hills are sown. About 500 g seed of MS-1 and 100 g seed of male parent is required for one acre hybrid seed production plot. Seed plot should be isolated 1000 m from other muskmelon varieties, long melon, snap melon and wildmelon. Direct sowing is completed in the first week of March. Cultural practices are same as adopted for cultivation of other muskmelon varieties for table purpose. Identification of male sterile plants during flowering is initiated every day between 5.30 to 9.30 in the morning. This is done by gently scrapping to external surface of anther lobe with the tip of needle. On the sterile plant, anther lacks pollen and remain poorly developed and gives full green appearance. Fertile plant produces yellow pollens. Male sterile plants are tagged and fertile plants are removed. The identification job is completed in 15-20 days. After identification work is completed, pinch off the already set fruits in male sterile plants. Place two beehives in the one acre seed plot. Harvest the fruits from female parents at maturity. It is possible to produce 30 kg hybrid seed from one acre plot.

Chilli

Female parent for chilli hybrids CH-27, CH-3 and CH-1 is MS-12 (male sterile line) and male parent is S-343, S-2530 and LSS respectively. For transplanting in the seed production plot,

the ratio of rows of female to male parents is 2 : 1. Ridges are 60 cm apart and hills are 22.5 cm apart. Identification of male sterile plants is done at flowering. The sterile plants have blue coloured anthers and has no pollens while fertile plants have green colour anthers and have plenty of pollens during day time. The sterile plants are retained and fertile plants are uprooted. This process should be completed in 8-10 days. After completing identification operation, all fruits from female parent are removed. Isolation distance is 400 m. The roguing of off-type plants from the rows of parental lines is necessary. Three to four beehives are required for one acre seed production plot. Fruits from female parent are harvested at red ripe stage and 30 kg hybrid seed is produced in one acre plot.

Tomato

Female and male parents are planted in the ratio of 4-6 : 1. Hybrid seed production involves emasculation and pollination. Flower buds that are expected to open in the next morning (yellow colour) are emasculated in the evening and covered with butter paper bags. Emasculation is done with forceps. Next morning freshly opened flowers are collected from the male parent. Bags from the emasculated flower are removed and pollen from the anther of male flower are extracted with needle and placed in the tip of the stigma of emasculated flowers. A tag is put around the neck of the pollinated bud or 2-3 sepals are removed to keep identity of the crossed fruits from the selfed ones. Two to three buds are pollinated in each flower cluster. Seed is extracted from the red ripe fruits.

Brinjal

Hybrids BH-2 is recommended for cultivation and the female parent of this hybrid is Punjab Neelam and male parent is Punjab Barsati whereas, female parent of PBH-3 is P-67 and male is P-47. Use female line BR-104 and male line MR-319 for hybrid PBHR-41. Female parent of PBHR-42 is BR-109 and male is MR-319. Seed required for female parent is 160 g and of male parent is 40 g for an acre hybrid seed production. The plant population ratio of female to male parent is 4:1. Hybrid seed is produced by emasculation and hand pollination. For emasculation, the buds of

long and medium styled flowers which are expected to open in the next morning are selected and anthers are removed with forceps. Emasculated buds are covered with paper bags. Buds on male parent that are expected to open to next morning are also covered with paper bags. In the following morning emasculated flowers of female plants are cross-pollinated with the pollen collected from anthers of the male parent. The pollinated flowers are covered for 2-3 days with paper bags. The calyx crossed fruits are clipped for keeping identification mark. The fruits are harvested for seed extraction when one third of fruits turns yellow.

Pumpkin

For hybrid seed production, cover the pistillate flowers of male line and staminate flowers of male line one day before opening with paper bags. On next morning, pollinate the pistillate flower of female line with the pollen from staminate flower of male line and cover with the paper bag again. Harvest the fruits having hybrid seed from the female line upon attaining maturity.

Onion

For producing hybrid seed of onion, previous year bulbs of both male and female parents are required. Bulbs of female and male parents are planted in 6:2 row ratios. Graded seed bulbs of female parent should be 7-8 quintals and male parent 1.5-2.0 quintals for an acre. The bulbs are planted at 60 cm × 45 cm in first fortnight of November. The isolation distance from other varieties of onion should be 1000 metre. Extra early and late bolters should be removed. A minimum of three field inspections should be conducted to produce true to type seed. The first inspection before flowering, second at flowering and third at harvesting should be done. The off type and diseased plants should be rogued off. Upon completion of pollination process, uproot the male parent. The seed harvested from female line would be the hybrid seed. All the flowering stalks do not mature at one time. The primary head generally matures first, followed by secondary and tertiary umbels. Therefore, when the seed showed black appearance, the umbel should be harvested. It takes at-least three rounds to complete the harvesting process.

38. PROTECTED CULTIVATION

In the present scenario of perpetual demand for better quality vegetables and continuously shrinking land holdings, protected cultivation is the best choice for quality produce and efficient use of land and other resources. Protected cultivation means some level of control over plant microclimate to alleviate one or more of abiotic stresses for optimum plant growth which can be achieved in naturally ventilated poly-house or net-/polynethouse. Crop yields can be several times higher than those under open field conditions, quality of produce is superior, higher input use efficiencies are achieved and vegetable export can be enhanced. In Punjab, extreme weather conditions under the open field conditions are the major limiting factors for achieving higher yield and better quality of vegetables. Under such circumstances, protected cultivation is best option. Keeping these points in view, net-house and naturally ventilated poly-house technology has been recommended for the cultivation of different vegetables.

1. Modified design of nethouse - polynethouse

Polynethouse is a framed structure consisting of GI pipes covered with ultra violet (UV) stabilized plastic film of 200-micron thickness at the top and UV stabilized net of 40-mesh size on the sides. A relatively cost effective and stable structure of poly net house has been designed and different pipe sizes to be used for its construction are given Fig 1 and Fig 2.

Selection of site

1. The site for the net house should be well drained & fairly shadow free.
2. It should be away from the obstruction at least three times the height of the obstruction.
3. Windbreaks are desirable and at least 30 m away on all sides to minimize the adverse affect of wind.

Orientation

Polynethouse should be constructed in the East-West direction to get the maximum benefit of the sunlight throughout

the year and to minimize the adverse affect of wind. The detailed dimensions for its construction are given in Table 1

Table 1. Detailed dimensions of polynet-house

S. No.	Particulars	Dimensions
1	Area	500 m ²
2	Length	62.5 m
3	Width	8.0 m
4	Height at the center	3.0 m
5	Height at the side	2.0 m
6	Depth of the foundation	0.90 m
7	Distance between two side poles	2.0 m
8	Door size	2.0 × 1.0 m
9	GI pipes for foundation post	25.0 mm dia
10	GI pipes for hoops, perlins and other support	19.0 mm dia
11	GI pipes for making hoops and truss	12.5 mm dia

Salient features of the polynet-house

1. Stability has been increased by making the hoop as a truss and by increasing the depth of foundation.
2. The modified design of net-house can withstand to wind speed of up to 100 km/hr.
3. Modified net-house has been installed using various types of assemblies so that it can be dismantle and can be put up at another place (every 3-4 years) to prevent the build up of inoculum of soil borne diseases (soil sickness, nematode etc).
4. Poly grip assembly is used to fix the poly sheet at the top and net at the sides of the structure so that it is not blown away by the strong wind.
5. The same assembly can be used for fixing of shade net during the summer period.
6. Side height is about 7 ft and center height is about 10 ft. It can accommodate all crops.

7. Vertical stitching of the net is recommended instead of horizontal one. This reduces extra pressure on stitched section & avoids tearing of net.
8. The average life of structure and net is 25 and 3 years, respectively.

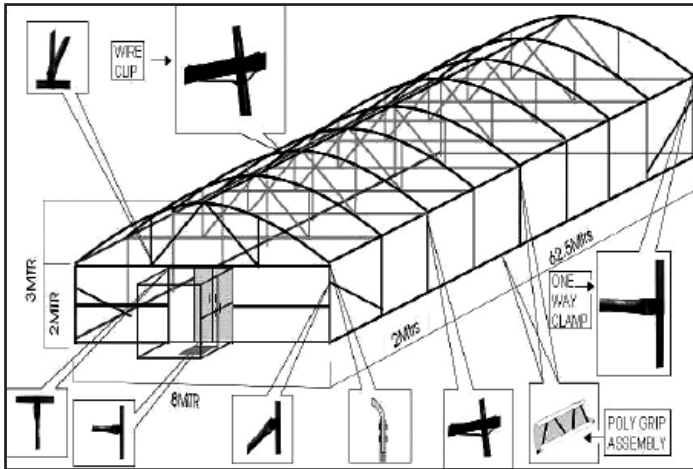


Fig. 1 : Details of assemblies used in polynet-house (62.5m × 8.0m)

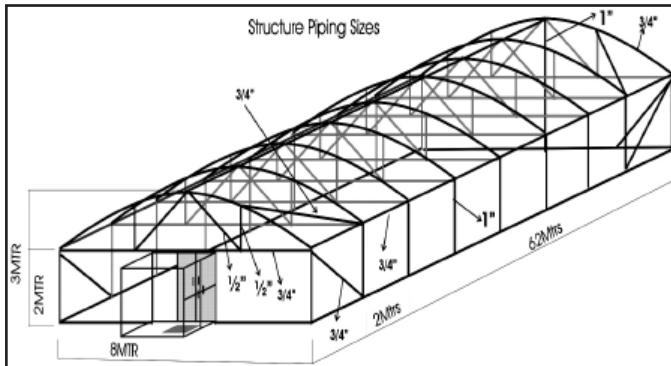
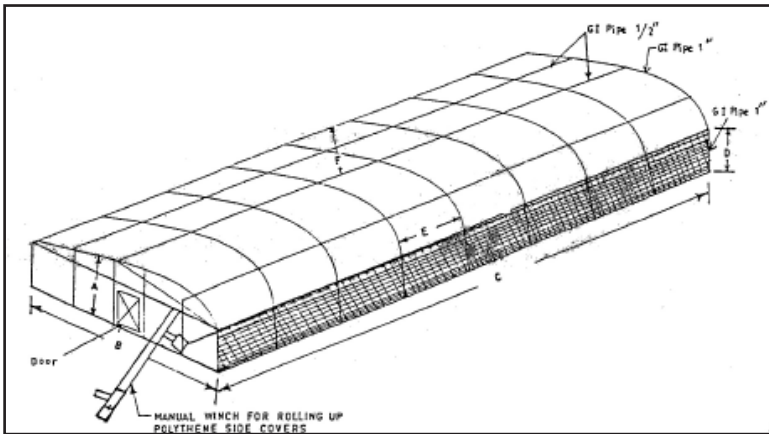


Fig. 2 : Details of pipes used in polynet-house (62.5m × 8.0m)

2. Naturally ventilated poly-house technology

Poly-house (Fig-3) is a framed structure consisting of GI pipes covered with transparent UV stabilized polyethylene film

and large enough to grow crops under protective cover. In a poly-house, environment is partially controlled by opening and closing of roof and sidewall ventilation. Although, poly-house is costlier than net house but it provides a controlled and favourable environment, which results in early harvest of superior quality fruits than that of the net-house. In poly-house, carbon di-oxide released by the plants during the night is consumed by the plants itself in the morning which increases the photosynthesis rate by nearly 15 times that helps in higher yield in comparison to net-house and open field conditions. It also gives additional protection to the crop from high or uneven rainfall and frost especially in winter. The poly-house can also be used for raising nursery during adverse weather conditions.



A=3m; B=6.25m; C=16m; D=2m; E=2m

Fig. 3: Details of the naturally ventilated poly-house (100sq.m.)

39. CULTIVATION OF VEGETABLES IN NET HOUSE/POLYNET HOUSE

1. *CAPSICUM*

Capsicum can be cultivated in 3.0 and 6.5 m height polynet house and naturally ventilated polyhouse with following method:

Selection of Hybrid : Green colored *Capsicum* hybrids “Bharat and Indra” are recommended for cultivation under both nethouse/polynethouse and naturally ventilated poly-houses. Yellow colored “Orobelle” and red colored “Bomby” *Capsicum* hybrids are recommended for cultivation under naturally ventilated poly-houses only.

Based on the method of irrigation, cultivation of *Capsicum* in net-house/polynet-house and naturally ventilated poly-house is given as under :

(A) *Capsicum* crop under drip irrigation

Seed rate and nursery raising – For an area of 1 acre, 12,000 seedlings are required. Sow capsicum nursery in the first week of August in pro-trays. Treat the seed with 3g of Captan per kg of seed before sowing. Before transplanting, drench pro-trays with Bavistin @ 2g/l of water.

Land preparation and fertilizer application : Add 80 tonnes of well-decomposed farmyard manure per acre in the first year and 20 tonnes per acre in the subsequent years. Add DAP @ 100 kg and CaNO_3 @ 25 kg per acre every year and then prepare the land to a fine tilth.

Bed Size : Mark the plot in nethouse/polynethouse and naturally ventilated poly-houses with rope at 1.5 m spacing, leaving at least 30 cm (1 foot) from all side walls. Then make beds of 1m width and 15 cm (1/2 foot) height with 50 cm row/path and slant from center of bed to both sides, rather than flat bed.

Transplanting : Use 35-40 days old seedlings for transplanting in 2nd-3rd week of September. Transplant in early morning/ late evening. Plant at shallow depth of 2-2.5 cm. (In case of absence of provision for polysheet on the roof of net-houses in rains and shade-net in both net-house/poly-house in summer, sowing and

transplanting can be delayed but it will have direct effect on the yield of capsicum)

Spacing : Seedlings should be transplanted in a paired row pattern with row to row and plant to plant @ 45 cm×45 cm (1.5 ×1.5 foot) from the centre of bed, with zigzag transplanting i.e. in a triangle shape (means plants of second row should be placed in the centre and parallel of the plants of the first row) and the spacing between the paired rows should be 105 cm.

Irrigation : If possible, it is advisable to install the drip irrigation system in the net-/poly-house. One lateral per bed with drippers spaced at 30 cm having discharge of 2.25 l/hr should be used. Water the beds to field capacity up-to 15 days after transplanting and then operate drip daily as per the timings given below:

Daily drip timings (in minutes)

Month	Net-house/Polynet-house	Poly-house
September	16	21
October	16	19
November	11	11
December	8	8
January	8	8
February	11	13
March	11	21
April	37	43
May	53	53
June	35	48

Fertigation: Start fertigation 15 days after transplanting and stop one month before crop end. Give fertigation daily through drip as given below:

Daily fertigation schedule

S.No.	Time of application	* Liquid Fertilizer (N:P:K)	Daily dose (litre/acre)
A	Initial 15 days	12:61:0	2
		19:19:19	2
B	Next 30 days	13:40:13	1
		19:19:19	1
C	Next 30 days (flowering & fruiting)	13:5:26	4
D	Next 90 or 180 days (fruit development & picking)	13:5:26	2
		0:0:50	1
		CaNO ₃	1
		MgNO ₃	0.5

Different ratios of liquid fertilizers required can be made on-farm as per given below:

How to make 1 litre of required ratio of fertilizer (rounded-off figures)

Fertilizer	Urea (46%N)	Phosphoric acid (80% P)	* SOP (50%K)	*KNO ₃ (38%K)	Water
12:61:0	260 g	760 ml	-	-	240ml
19:19:19	412g	238 ml	380 g	500g	762 ml
13:40:13	282 g	500 ml	260g	341g	500 ml
13:5:26	282 g	63 ml	520 g	639 g	937 ml
0:0:50	-	-	1000 g	1315 g	1000ml

* Use either SOP or KNO₃, not both

Production Measures

Pruning and number of branches : Do pinching after 5-6 pairs of leaves. It will give 5-6 branches after few days. Select 4 best branches, preferably in opposite direction. Remove all flowers for 1 month. Remove side shoots at weekly interval. Pruning starts 15-20 days after transplanting. Two steel strings per bed should be overhung at the gutter level of net-/poly-house, running parallel alongside the length of the bed. Twining (tying) of 4 branches

should be done 30 days after transplanting with blue or green colored plastic twines, not gunny threads. Two branches of a plant should be tied to one steel string and the other two branches of a plant to the other string running parallel overhead. This will open up the plant and help in ventilation.

Removal of lower older leaves : As the plants grow up and fruit is harvested, remove lower and older leaves at least 1 feet or more from the ground.

Micronutrient and Growth regulator foliar sprays (Under 6.5 m structure height) : Give foliar spray of Microsol B (micronutrient) @ 0.5 g/l water + Spic Cytozyme (growth regulator) @ 2 ml/l water at fortnightly intervals after transplanting. Spray growth regulators Lihocin/ Cycocel (chlormequat chloride) @ 300 ppm (3g/l of water) + NAA (Planofix) @ 25 ppm (0.25g/l of water) 2.5 months after transplanting, along with Microsol and Spic Cytozyme, at fortnightly interval.

But under 3 m structure height, start spraying Lihocin/ Cycocel along with Microsol and Spic Cytozyme, while spray of NAA should be started 2.5 months after transplanting.

Shade net : Use 50% white or red colored shade net placed at gutter level from September to mid-October and then April onwards till the end to protect the crop during hot months. Putting shade net over the roof from outside will give less reduction in heat.

Ventilators opening/ closing : In winter, all ventilators of poly-house should be closed at night to obtain maximum yield. Always open ventilators for at least 2-3 hours each day even in severe winters for exchange of air.

(* Net-house should have provision of poly-sheet during rains and winter months. During summer, provide roof-top ventilation in case of polynet-house. Roof should not be fully closed with poly-sheet)

Harvesting : >60 g green colored fruits and >100 g yellow and red colored fruits are preferred in the market. In case of September transplanted crop, the green colored fruits are ready for harvest in mid-November and yellow and red colored fruits

in mid-December. September transplanted crop gives 11 and 31 percent more and early yield advantage over October and November transplanted crop, respectively.

Yield : Yield of capsicum hybrids depend on the height of protected structure, time of transplanting, type of irrigation system and use of shade-net and poly-sheet.

September transplanted green colored Indra gives yield of 580 and 443 q/acre under 6.5m and 3m structure height, respectively, while Orobelle (yellow colored) give yield of 315 and 162 q/acre and Bomby (red colored) give yield of 322 and 167 q/acre under 6.5m and 3m structure height, respectively.

(B) Capsicum crop under furrow irrigation

Sowing and transplanting time should be as given under drip irrigation. Seedlings should be transplanted on 15 cm high raised beds with a spacing of 90 cm×30 cm, accommodating 15,000 plants/acre. The fertilizer should be applied as per the recommendation mentioned in the package of practices for open field cultivation of capsicum. Cover the beds with a black polythene mulch of 25 micron thickness. Mulching increases early and total fruit yield, extends shelf life of fruits and improves fruit quality, especially colour of the fruits. The mulched crop produces maximum early and total fruit yield when seed is sown around 1st of October and seedlings are transplanted about a month later. Yield of November transplanted Bharat and Indra is 225 and 255 q/acre respectively, when white/red colored shade net is used from April onwards and 160 and 180 q/acre respectively without the use of shade net. If the net-house has the provision of both poly-sheet and shade-net, then September transplanted Indra gives yield of 310 q/acre.

2. Tomato

(A) Cultivation of Tomato in Net house

The Cultivation of tomato varieties, Punjab Swarna, Punjab Gaurav, Punjab Sartaj, Punjab Sona Cherry, Punjab Red Cherry and Punjab Kesar Cherry are recommended in net house and poly house cultivation.

Only indeterminate varieties/hybrids by virtue of their having long fruiting span can be grown successfully in net-house where

fruit maturity is advanced by 20-25 days as compared to open field conditions. Cover the beds with a black polythene mulch of 25 micron thickness. Mulching increases early and total fruit yield, extends shelf life of fruits and improves fruit quality especially colour of the fruits. The mulched crop produces maximum early and total fruit yield when seed is sown around 25th of September and seedlings are transplanted about a month later. Seedlings should be transplanted on 15 cm high raised beds keeping a spacing of 1.25 m×30 cm. Plants should be trained upright with the support of bamboos with nylon ropes. All cultural practices should be followed as mentioned in the package of practices for open field cultivation of tomato crop.

(B) Cultivation of Tomato in Naturally Ventilated Poly house

Seed rate and nursery raising : For an area of 100 m², 1.5 g of seed is sufficient. Sow tomato nursery in the last week of September, which will be ready for transplanting in 25-30 days after sowing. Treat the seed with 3g Captan or Thiram per kg of seed before sowing. Nursery should be raised in the same polynet-house in which crop is to be grown to protect the seedling from white fly, a vector for viruses and other insect- pests.

Land preparation and fertilizer application : Prepare the land to a fine tilth and apply well-decomposed farmyard manure @ 2.5 q/100 m² 15 days before transplanting. Apply urea 3.0 kg/100 m² in 4 equal splits (1/4, 3-4 days prior to transplanting, 1/4, 25 days after transplanting, 1/4, 45 days after transplanting and the remaining 1/4, 90 days after transplanting). For P and K, apply Single Super phosphate 4.0 kg/100 m² and 1.1 kg Muriate of Potash/100 m² as basal dose with first split dose of urea. If the crop is drip irrigated, than apply 3.0kg/100 m² of urea in 15 equal splits at 10 days interval along with irrigation.

Spacing : To utilize the space efficiently, seedlings should be transplanted in the polynet-house in a paired rows pattern with plant-to-plant spacing of 30 cm. The spacing between two paired rows should be 90 cm and row-to-row spacing within the paired line should be 60 cm.

Irrigation : If possible., it is advisable to install the drip irrigation system in the polynet-house as it reduces the humidity build up and weed problem. First irrigation for surface irrigation is to be given just after transplanting. Initially for a few days, regular irrigation is to be applied for the establishment of the crop. Subsequent irrigation should be applied at 4 to 5 days interval depending upon the soil and climatic conditions. If the crop is drip irrigated then irrigation should be applied at 4-5 days interval in the month of November-February, 2-3 days interval in the month of March and 1-2 days interval in the month of April-May depending upon the climatic conditions. Application of urea along with irrigation (fertigation) helps in saving the quantity of fertilizer and labour besides improving the yield and quality of produce. The drip irrigation results in 48% saving of water as compared to surface irrigation. Don't allow the plants to wilt at any time. Fruit will be damaged if the plants do not get appropriate amount of water and fertilizer regularly.

Earthing up and pruning : After 20-25 days of transplanting, earthing up is to be done. Prune the plants in a polynet-house to a single stem for better growth of fruits. All lateral branches must be removed when they are one to three inches long. This allows for maximum air circulation and reduces pest control problems. Pruning must be done regularly and plants should be checked at least once a week. Because of indeterminate nature of polynet-house tomato, the crop should be staked properly to get higher yields. The staking method involves the use of wooden stakes placed within the row of plants and running a number of parallel pieces of string or wire from stake to stake and trapping the new growth of plant between the strings. This keeps the plants in an upright position preventing the fruit from touching the ground.

Harvesting : The fruits will be ready for harvesting in the last week of February, which will continue up to first fortnight of May. The average yield under naturally ventilated polynet-house condition is about 264 q/acre with surface irrigation and about 384 q/acre with drip irrigation and fertigation.

(C) Cultivation of Tomato in soilless media

Tomato hybrids, NS-4266, Himshekhar and Punjab Sartaj can be grown in soilless medium under naturally ventilated polyhouse.

3. Cultivation of Cucumber in soilless media under naturally ventilated polyhouse

Selection of Cultivar

Parthenocarpic cucumber cultivars like hybrid Multistar or Kafka and PAU variety Punjab Kheera 1 are recommended for growing under naturally ventilated polyhouse /poly net house.

Seed rate and nursery raising

For an area of 500 m², 1500 seeds (15 g) are sufficient. Sow, the cucumber seed in mid of September and it will be ready for transplanting in 15-20 days after sowing. Transplant the nursery in first week of October. The second crop can be taken by sowing the nursery in January, which will become ready for transplanting in 30-35 days after sowing. Transplant the nursery in first fortnight of February. The nursery raising is done in trays, each having 50 conical shaped cells (**Plate-1a**). The cells are filled with coco-peat saturated with nutrient solution. Before the placement of the seed in growing media in the cells, impressions of 1.0-1.5 cm deep are made. One seed per cell is placed in horizontal position at 1.0-1.5 cm depth from the surface. After placing the seed in all the cells, the seed is covered with more growing media and the excess was removed by striking off a ruler. During nursery stages the seedlings should also be fed with nutrient solution for getting healthy nursery/seedlings.

Seed Bed Preparation while shifting from soil to soilless media cultivation:

Shifting from soil cultivation to soilless (coco peat) media based cultivation involves the following steps. The first step involves levelling the greenhouse with a proper slope. A -slope of 1-1.5 % is provided to soil in polyhouse from north to south direction for the collection of the leachate. The entire surface area of the greenhouse floor should be covered with weed mat for

avoidance of weed emergence and to eliminate contact between soil and growing media.

Plastic troughs, each of thickness 500 μ and dimensions of 20.0 m length \times 0.60 m width are laid on the weed mat at 90 cm between two adjacent troughs. The spacing trays each having dimensions of 50.0 cm \times 60 cm are laid on the plastic troughs to facilitate drainage of leachate. The next step is the placement of coco-peat slabs and the installation of subsequent drip lines for the supply of nutrient solution to the plants. Once the system is operated, there would be a need for a collection unit for collecting the drained leachate from the system. Therefore, setting of the leachate unit is a pre-requisite for soilless cultivation.

Setting up of fertigation system

The crop should be supplied with fertigation of single strength solution in plastic tank of 1000 litre capacity containing all macro and micro nutrients. All macro and micro nutrients are weighed in required quantity and mixed in one packet and dissolved in 4-5 litres water in a bucket and dissolved and filtered by passing through a muslin cloth. Filtered solution is put into 1000 litre of water in fertigation tank. The desired EC is 2.0 –3.0 dS/m and pH between 5.8-6.5 should be kept. Acidification is done using phosphoric acid to adjust pH of the fertigation solution. For example 0.26 ml phosphoric acid (85 %) per 1 liter of nutrient solution is added to lower pH from 7.2 to 6.2. The prepared nutrient solution was monitored on regular basis for EC and pH value. The frequency of fertigation varies from 3-5 times per day, however duration (4-13 minute) of fertigation is governed by the crop growth stage and prevailing weather conditions.

The main components include a filter, pressure gauge and timers. For preventing the clogging of emitters, the nutrient solution from the tank is passed through filter before its delivery to the plant root system. The system include timer for operating the fertigation automatically. The time to operate the fertigation system is set in the timer for a pre-determined time. The timers allowed the application of nutrient solution for a pre-determined time and stopped automatically after the completion of pre-set time. To deliver the nutrient solution safely and at desired rate

to the root zone of the plants, the operating pressure of emitters is regulated using pressure gauge. The system is operated at a pressure of 1.5 kg/cm².

Nutrient requirements (ppm) for raising nursery and cucumber in soilless media under polyhouse

Crop Stage	N	NH ₄	P	K	Ca	Mg	Fe	Mn	Zn	B	Cu	Mo	S*
Nursery raising	200	10	50	253	247	75	0.8	0.55	0.33	0.5	0.05	0.05	120
Normal Feed	210	22	50	370	190	75	0.8	0.55	0.33	0.5	0.05	0.05	120

4. Transplantation

On each coco-peat slab, three square holes of are cut, keeping a 30.0 cm spacing between any two adjacent holes. The slabs are kept under saturation for at least 24 hour before transplanting. The seedlings become ready for planting after attaining 3-4 true leaf stage. The seedlings planted with 3-4 true leaves, give first picking about 30 days after transplanting.

Different water soluble fertilizers and their quantity required for making 1000 litre fertigation solution

Sr. No.	Major and secondary nutrient containing fertilizers	Nursery stage (g)	Normal feed (g)
1	Calcium Nitrate (18.8 % Ca +15.5 % N)	1121.0	1010.0
2	Potassium Nitrate (13:0:45)	257.0	410.0
3	Monopotassium Phosphate (0:52:34)	227.0	220.0
4	Potassium Sulphate (0:0:50) +17 % S	225.0	493.0
5	Magnesium Sulphate (9.6 % Mg +13 % S)	700.0	780.0
Micronutrient containing fertilizers			
1	Iron Chelate (12 % Fe)	6.667	6.667
2	Manganese sulphate MnSO ₄ (30.5 % Mn)+17 % S	1.803	1.803
3	Zinc EDTA (12 % Zn)	1.000	1.000
4	Borax (20 % B)	2.500	2.500
5	Copper sulphate CuSO ₄ (24% Cu+12 % S)	0.208	0.208
6	Ammonium Molybdate (52% Mo)	0.096	0.096

Training and pruning

After one week of transplanting plants should be trained using plastic clips and nylon rope. The lower end of nylon rope is tied

to the coco peat slab and upper end rolled on a roller hook hanged on GI wire string placed at a height of 2 m above the ground level. As the vine grows in length stem is attached to nylon rope using plastic clips, till it touches the roller hook, thereafter when fruits are picked from lower end, the leaves are also removed and plant is lowered. The plants are turned in clock wise direction while lowering is done. After each picking of fruit, the leaves are removed. This allows maximum air circulation and reduces pest control problems.

Harvesting

When fruits attain 100-120 g weight become ready for harvesting (**Plate-1b**). In October first week transplanted crop, fruits are ready for harvesting by the end of October or first week of November under naturally ventilated polyhouse and harvesting continues on alternate days by last week of December or early January. In February transplanted crop, the picking will be ready in first week of March and picking continues up to end of May. The fruits are harvested in 20-22 pickings.

5. Cultivation of Brinjal in Net-house

Hybrid BH-2 has been recommended for net-house cultivation of brinjal. It gives 325, 270 and 132 q/acre yield by transplanting in 4th week of July, 1st week of Nov. and 4th week of Feb, respectively. Seedlings of 4 to 5 leaf stage are ideal for transplanting. For July transplanting, seed should be sown in mid June, for Nov. in mid Sept and for Feb. in end of Nov. November sown nursery should be protected from low temperature with poly-thene sheet. Seedlings should be transplanted on raised beds at spacing of 90 cm between rows and 30 cm between plants. The fertilizer should be applied as per the recommendation mentioned in the package of practices for open field cultivation of brinjal. To get early and high yield from autumn transplanted crop mulching should be done with black polythene (25 micron thickness) from last week of Nov. to first week of March.

In net-house brinjal, supplementary pollination by tapping main stem with stick significantly increased the yield. This practice should be done during noon hours (12.00-3.00 P.M.) upon dehiscence of pollen from the flowers.

The rainy season crop of brinjal in net-house should be trained by keeping two main shoots. This practice helps in utilizing vertical space, avoid overshadowing of plants and facilitate in supplementary pollination.

PLANT PROTECTION

1. Soil-borne pathogens in net-house/polynet-house or naturally ventilated poly-house

Among the soil-borne pathogens, fungal pathogens (*Sclerotinia sclerotiorum* and *Fusarium solani*) and root-knot nematode cause maximum damage. Population of these pathogens build-up over a period of cultivation in net-/poly-houses. Straw colored symptoms seen externally and black colored sclerotia along with white colored cottony growth formed inside stem and branches are the typical symptoms of plants infected with *Sclerotinia*. Dark brown discoloration is seen externally on plants infected with *Fusarium*. *Sclerotinia* and *Fusarium* cause maximum damage near harvesting stage and result in complete loss of a plant. In root-knot nematode infected plants, above ground symptoms include reduced growth, pale green or yellow foliage. Underground symptoms are most characteristic for the disease with root galls two to three times the diameter of healthy roots which give the root system a knobby appearance.

Management of soil-borne pathogens

Sick soils in net-/poly-houses need to be managed by green manuring and soil solarization.

i) Green Manuring : In root knot nematode infested soils green manuring with 50 days old sunhemp crop or 60 days old marigold crop helps to check the build up nematode population. In such soils green manuring with daincha should be avoided.

ii) Soil Solarization : First rotavate the soil (along with any recommended organic amendment) to fine tilth followed by levelling and flooding. After 24 hours, cover the ground soil with 200 gauge (50 micron) clear or transparent poly-sheet, leaving no gaps between sheets followed by covering the whole above ground structure also with 200 gauge clear poly-sheet in case of net-house or simply closing all vents of polynet-house and taping them for

4 weeks or 1 month. This will give effective soil solarization of protected structure against soil-borne fungal pathogens and nematodes. Period can be anywhere between 15 May to 30 June; but keeping in view the crop rotation in protected cultivation in Punjab, June is the most practical period.

To prolong the benefits of soil solarization for 3 or more years, following disease management practices are necessary to be followed :

1. Proper site selection

Prefer Net-/Poly-house construction in rice fields. Avoid low lying and high clay fields.

2. Pre-plant sanitation for disease control

(a) Previous crop debris removal – helps in reducing nematode population.

3. Nursery raising

(a) Seed treatment as per recommendations

(b) To prevent insect-pest infestations, grow nursery under net of 40-mesh size.

4. Production (crop raising) sanitation for pests, diseases and algae control

(a) Prefer raised beds and suitable planting time.

(b) Proper sunlight, ventilation and relative humidity in Net-/Poly-house can be ensured by selecting right combination of plant density (12,000 plants/acre under drip irrigation and 15,000 plants/acre with single row on a bed under furrow irrigation in case of *Capsicum*), canopy management (pruning and tying of branches), enhance soil drying and aeration by using only required quantity of water through drip irrigation (follow given timing schedule), removing lower and older leaves by at least 1 feet, avoid growing crop all along borders/ walls inside net-/poly-house and prevent rain water entry from roof by having poly-sheet on roof in case of net-house and on lower one feet of side walls and proper spacing between two Net-/Poly-houses.

(c) **Control of weeds** : Destroy weeds in and around the production area for managing diseases and proper crop growth.

- (d) Regular monitoring and correct diagnosis of disease symptoms, removal and disposing of diseased plant parts and timely and correct fungicidal sprays with proper spray technology – spray the plants in a row from both sides moving the lance up and down.
- (e) Use double door system in the Net-/Polynet-house. Always close the doors properly while entering.
- (f) Give preference to drip irrigation. Use under-ground water pipes for furrow irrigation.
- (g) Monitor the crop on alternate days to check the incidental entry of insect-pests. In case of infestation of brinjal shoot and fruit borer, tobacco caterpillar, hadda beetle or leaf miner, remove and destroy the infested leaves, shoots or fruits immediately. Destroy egg masses and tobacco caterpillars manually.
- (h) Remove dry and fallen leaves at frequent intervals to check insect-pests carry over.
- (i) All machinery and tools should be cleaned and disinfected before entering in the protected structures.
- (j) In winter, all ventilators should be closed at night to obtain maximum yield.
- (k) Always open the ventilator for sometime in each day for exchange of air/heat.
- (l) All ventilations must be provided with insect proof mesh/rambonet.
- (m) Inspect the Net-/Polynet-house regularly for wear and tear, plug all holes in doors and wall and fix the net or polysheet in the soil properly to prevent insect entry.
- (n) The entry door should be outside the main structure and preferably on the southern side covered fully with poly-sheet, so that it remains solarized throughout the year.
- (o) Provision of foot pond for potassium permanganate inside door the enclosure.

40. LOW TUNNEL CULTIVATION OF VEGETABLE CROPS

In this technologies, low tunnel are made of flexible transparent materials and are used to enclose one or more rows of plants in order to promote the crop growth by warming the air around the plants during winter season. This low cost technology is suitable for early cultivation of summer vegetables. It can protect the plants from cold injury and advance the crop by about one month than the normal season.

The low tunnels are simple structures, easy to construct and require limited skills to maintain. Another advantage of such technology is that poly-tunnels can be easily dismantled and utilized in the subsequent years. This technology is affordable for small and marginal farmers. In this technique, less irrigation required since water collects as condensation on the inside of the cover and returns to the soil.

Cucumber

To get early yield of cucumber, practice of low tunnel is helpful in raising crop in early summer. It helps to protect plants against cold from December to February. The beds of 2.5 metre width are prepared in the month of December. The sowing is done on both sides of beds at a distance of 45 cm.

After sowing the seeds, flexible iron rods of 2 metre length shaped into arches/hoops are fixed manually at the distance of 2 metre so as to have the height of 45-60 cm. It will cover the paired rows on the beds. Cover the hoops with transparent plastic sheet of 100 gauge thickness. Burry these sheets on both sides of the beds. Remove these sheets when temperature rises outside in the month of February.

Brinjal

Brinjal is also sensitive to low temperature, therefore, low plastic tunnel technology is recommended to protect the plants during winter. The seedlings of brinjal plants are transplanted

in first fortnight of November on raised beds at a spacing of 90 cm between rows and 30 cm between plants. In first week of December, iron arches are fixed and covered with transparent non-perforated plastic sheet 50 micron thickness. When the temperature starts warming up remove the polythene sheet, usually in second fortnight of February. Compared to open field cultivation this practice gives higher yield and make possible to harvest fruits during the lean period in March-April.

Capsicum

To get early yield of sweet pepper the low tunnel technology can be practised. It helps to protect the plants against extreme low temperature from December to mid February. Nursery of the PSM-1 variety of *Capsicum* is sown in the first fortnight of October. Protect the seedlings against whitefly to check the spread of viruses by covering them with net in the area of nursery itself. Four to five week old seedling are planted on both sides of the raised beds maintaining a distance of 130 cm and 30 cm between rows and plants respectively.

In beginning of December, fix the iron arches manually at a distance of 2 meter so as to cover the paired rows and support the plastic tunnels. To prepare these arches, flexible iron rods of 2 meter length are shaped into hoops and fixed in a way so as to have the height of 45-60 cm above the bed level. Transparent non-perforated plastic sheet of 100 gauge thickness should be used to cover the plants. It helps to keep the temperature of low tunnel higher than outside. The sides of the sheet should be buried in to the soil on both sides. When the temperature rises in the month of February, remove the plastic sheet.

Weed Control

The covers not only enhance crop development but also weed growth. Weeding can be done on a sunny day by removing polythene partially. Low tunnels create a greenhouse effect and provide near optimum conditions for plant growth in the field. Therefore, seedlings inside the low tunnels are tender. If the low tunnels are removed at once, the plants may face a stress. Thus it is preferred partial cover for few days before those are completely removed.

41. VEGETABLE NUTRITION GARDEN

1. Model for growing vegetable in soil

Most of the vegetables reaching the market contain high amount of pesticide residues, it is of special interest of the consumers to grow vegetables themselves for their own use with minimum or no use of pesticides. In addition, micro-nutrient deficiencies affect the lives and health of a large number of people and three nutritional problems having serious consequences include deficiencies of iron, vitamin A and iodine. Vegetables help to combat malnutrition and diversify diets. Dietary diversification balances the diet by enhancing the supply of essential micro-nutrients leading to improved health, enhanced thinking ability and increased efficiency. The improved model has been developed by PAU which involves many annual crops that can be repeatedly harvested to meet a family's vegetable needs throughout the year (**Plate-2**). The crops and their varieties are scientifically selected to be highly nutritious with few pest and disease problems. The suggested model can produce 300 kg of vegetables each year from 6m × 6m land by growing 27 different vegetables. This will be sufficient to meet vitamins, minerals and protein requirement of a family comprising two adults and two children.

Important points to be kept in mind

The cucurbitaceous vegetables like bottle gourd, sponge gourd, long melon, cucumber; and tomato are weak stemmed and should be staked vertically with the help of nylon ropes tied to bamboo at a height of eight feet for production of good quality fruits.

Staggered sowing of coriander, carrot, radish, methi and okra at fortnightly intervals is recommended for continuous supply of these vegetables.

2. Model for growing vegetable on rooftop/terrace

Vegetables are said to be the best food for our health as they are rich in vitamins, minerals, fibers and phytochemicals/ antioxidants

that build natural resistance against diseases. Unfortunately, we fail to add these healthy vegetables in our daily meals. In urban and semi-urban areas due to the shortage/ higher land prices, people cannot produce vegetables for themselves even if they wish to do so. A solution to this is the Rooftop/ Terrace Vegetable Nutrition Garden. A rooftop vegetable garden ensures regular and handy supply of fresh vegetables which are basic to nutrition. Rooftop/ terrace Vegetable Nutrition Garden uses soilless media like coco peat as a medium for growing vegetables on rooftop/terrace/front yard/ back yard depending upon the space available.

Coco peat grow bags technique

Coco peat retains moisture, stores and releases nutrients to roots over extended period of time enhancing plant growth. It is ideal growing media for plants used for horticultural plants and other agricultural applications. Weight of dry coco peat slab is around 1.5 to 2 Kg. The slab type grow bags are environmental friendly. The E.C of slab is < 0.5 and pH is around 6-7. The expected life is around three growing seasons or years.

Design of five row model

The structure of Rooftop vegetable nutrition garden model is designed to withstand the load of covering material, rainfall and specific cropping activity. The site for the Rooftop vegetable nutrition garden should be fairly shadow free. The developed model is user friendly, easy to operate and maintain. The detailed dimension and material used for its construction are given below.

Height of the Structure	2.2 m
Front Width of the Structure	4.2 m
Length of each bench	3 m
Width of each bench	0.4 m
Spacing of benches	0.5 m
Slope of benches	1-1.5 %
Net area	12.6 m ²

Salient Features of the Rooftop vegetable nutrition garden model:

- The model has been designed as per urban needs and space constraints (**Plate-3a & 3b**).
- A 5 row Rooftop vegetable nutrition garden model requires a net area of 12.6 m² (4.2 m × 3.0 m) and a gross area of 20 m² (5.5 m × 3.6 m), whereas a 3 row Rooftop vegetable garden model requires an area of 6.90 m² (Net area= 2.3 m × 3.0 m) and a Gross area of 12.96 m² (3.6 m × 3.6 m).
- A timer has been integrated into the system to automate the daily nutrients solution supply which would be useful for those that lead busy lives and are away from home during daytime. Leachate from the Garden can be recycled into the system after filtration.
- It can also be used for raising ornamental/ medicinal plants.
- The vegetables produced are safe to eat and will be sufficient for a family of 2-4 persons.
- With staggered sowing/transplanting or staggered cutting in case of multi cut leafy vegetables, the vegetables would be available throughout the season.
- The vegetable nutrition garden has a provision of fixing shade over the UV stabilized sheet.
- The cucurbitaceous vegetables like bottle gourd, sponge gourd, long melon, cucumber and tomato are weak stemmed and staked vertically with the help of nylon ropes tied to roller hooks hanged on galvanized iron wire for production of good quality fruits.

42. MULTIPLE CROPPING

Most of the vegetable crops are of short duration and fit well in a number of sequences which result in greater production per unit area and time. The success of these vegetable rotations depends upon the selection of proper varieties, the adjustment of sowing time, adequate application of organic manures, fertilizers and irrigation, control of weeds, insect-pests and diseases and timely harvesting of the crops. The timeliness of these cultural operations becomes a highly critical factor in a successful multiple cropping programme in case of vegetables.

The following rotations may be practised :

a) Vegetable farms located away from the main markets

- i) Potato-Onion - Green manuring
(September-December)-(December-May)-(June-July)
- ii) Potato-Late Cauliflower-Chilli
(October-December)-(December-March)-(March-October)
- iii) Potato-Okra-Early Cauliflower
(November-February)-(March-July)-(July-October)
- iv) Potato (seed) - Carrot / Radish-(seed)-Okra (seed)
(October-January)-(January-May)-(June-October)
- v) Pea-Chilli (October-February)-(March-September)

b) Vegetable farms located near the main markets

- i) Brinjal (long) - Late Cauliflower - Bottle gourd
(June-October)-(November-February)-(February-June)
- ii) Cauliflower - Tomato- Okra
(September-November)-(December-May)-(May-September)
- iii) In root knot nematode infested fields, follow
Cauliflower-Onion-Okra.
- iv) Potato - Muskmelon - Radish
(October-January)-(February-May)-(June-August)
- v) Spinach - Knolkhol - Chilli
(August-October)-(October-February)-(February-August)

43. ORGANIC FARMING OF VEGETABLES

Organic farming prohibits the use of synthetic agro-chemicals and relies on crop rotations, crop residues, animal manures, composts, legumes, green manures and on-farm wastes to maintain the soil productivity and to supply plant nutrients to the crops. Disease and insect-pest management is done by using biopesticides.

Basic organic standards

- Conversion from chemical to organic farming requires a three year conversion period during which all the practices should be organic.
- A buffer zone must be created around the organic field to avoid any contamination or run off from the adjoining chemical fields.
- Seed should be from the organic produce and should not be treated with any chemical. Genetically modified (GM) crops are not allowed. The cultural practices of organic crops like seed rate, sowing time and spacing may be same as that of conventional crops, if otherwise not mentioned.
- Herbicides should not be used for weed control and weeds should be managed by cultural practices/methods and need based weedings.
- Chemical fertilizers, pesticides and growth regulators are prohibited.

Organic crop production

The best fields should be preferred for organic farming. The yields of organic crops are less than the inorganically grown crops during initial 3-4 years but later on they become equal. Organic farming can be practiced in the following cropping systems:

Maize-Potato-Onion

The maize-potato-onion cropping system enables to harvest the comparable yield with the chemical farming even in the first year when potato is intercropped with radish and onion with coriander. The quantity of organic manures to be applied to organic maize for getting 50 kg N/acre is 1.7 tons FYM (1% N); 1.1

tons vermicompost (1.5% N) and 0.7 tons non-edible cake (2.5% N)/acre. For potato (75 kg N/acre) the corresponding quantity of FYM, vermicompost and non-edible cake is 2.5, 1.7 and 1.0 tons/acre; and for onion (40 kg N/acre) is 1.3, 0.9 and 0.5 tons/acre, respectively. Application of *Consortium* biofertilizer @ 4 kg/acre as soil application at the time of planting of potato/transplanting of onion would be helpful in increasing economic yield of potato and onion and improving the soil health. The *Consortium* culture is available with the department of Microbiology, Punjab Agricultural University, Ludhiana. The maize crop should be sown during the first fortnight of June, potato in the first fortnight of October and onion in first fortnight of January. Similarly, sow radish in first fortnight of October on the southern side of each potato ridge and dugout radish 2-3 times after 50-70 days after sowing in December. Sow one row of coriander (after five rows of onion) after applying first irrigation to onion after transplanting in the first fortnight of January and harvest green coriander 40 days after sowing and seed coriander in the second week of May.

Maize-Potato-Summer Moong

Maize

Nutrition : The nutritional requirement of 50 kg nitrogen per acre of maize can be met through 5.0 tons dry FYM (1% N) or 3.3 tons dry FYM and 1.1 tons vermicompost (1.5% N).

Potato

Nutrition : The nutritional requirement of 75 kg nitrogen per acre of potato can be met through 7.5 tons dry FYM (1% N) or 5.0 tons dry FYM and 1.7 tons vermicompost (1.5% N).

Summer moong

Nutrition : The nutritional requirement of 5 kg nitrogen per acre of summer moong can be met through 0.5 tons dry FYM (1% N) or 0.3 tons dry FYM and 0.1 t vermicompost (1.5% N).

Turmeric-Onion

Turmeric

Nutrition : The nutrition requirement of organic turmeric can be met by applying 6 trolleys of farmyard manure (6 tons of fully dried farmyard manure having 1% N). In case of non-availability

of required farmyard manure, apply 4 trolleys of farmyard manure (4 tons of fully dried farmyard manure) supplemented with 1.3 tons of vermicompost (1.5% N).

Weed Management : To manage weeds apply 40 q/acre paddy straw mulch at the time of planting and if needed, give one hand weeding at 3 months after planting. If straw mulch is not applied then give three hand weedings at 1, 2 and 3 months after planting the crop.

Onion

Nutrition : The nutritional requirement of organic onion can be met by applying 4 trolleys of farmyard manure (4 tons of fully dried farmyard manure having 1% N). In case of non availability of required farmyard manure, apply 3 trolleys of farmyard manure (2.7 tons of fully dried farmyard) supplemented with 0.9 t vermicompost (1.5% N).

Weed Management: Weeds should be controlled by manual hoeing.

Method of Preparing Phospho-compost

Collect rice-straw from fields and bring it to the composting site near the tubewell on the farm to have easy water availability. It can be made into bundles of convenient size (about 10-15 kilograms).

Prepare large quantity of a “soaking solution” by thoroughly mixing one kg cow dung for every 1000 litre of water in a big tank. The volume of the tank can be calculated by measuring Length \times Breadth \times Height of the tank in metres. One cubic metre is equal to 1000 Litres of water. Dip the bundles one by one into the “soaking solution” for 2-3 minutes.

Drain the excess solution by placing the bundles on a slope lined with a plastic sheet. The drip should be collected and recycled into the tank again. Make 15 cm raised beds 5 metre long and 1.5 metre wide on the ground. This will help in assessing the exact watering of the heap later. Draining of water out of bed is a visual indication of excess watering.

Take the wet rice-straw to the location of the compost heap. Line the bed with 2-6 centimetre diameter tree branches/sticks.

This helps in aeration in the heaped rice-straw. The wet rice straw will generally have 70 per cent moisture. Place the wet rice straw on the beds uniformly until 500 kilograms has been stacked. Powdered low-grade rock phosphate (low grade rock phosphate can be had from Rajasthan State Mines and Minerals Ltd 4, Meera Marg, Udaipur 313004) should be mixed @ 6 per cent on dry weight basis of the rice straw approximately. For 500 kilogram of the rice straw, 30 kg of the rock phosphate should be sprinkled uniformly while making the heap after wetting. This will give approximately 1% phosphorus in the final decomposed product. The height of 500 kg rice-straw stack is 1.5 metre approximately. Any quantity of rice-straw can be composted in multiple heaps of 500 kg at one time leaving a passage of 1 metre between the beds.

Cover the heap with a 20-30 centimetre thick layer of unsoaked rice-straw. This will minimize water loss while providing the necessary aeration. The major key to success is the ability to maintain about 70 per cent moisture in the heap. Any major error in this step will delay composting. Water the heaps using watering lance with the help of Tullu Pump. (Note : watering heaps with sprinklers does not work because water generally runs down the sides, instead of going inside the heap. Ensure that the water penetrates the heap by using a lance with a sharp point to pierce the heap of rice-straw. Pierce the lance deepest possible with an aim to water uniformly). Composting can be terminated after 80-90 days by which time it is ready for processing or for field application. By this time its carbon and nitrogen ratio changes to 15:1. At this stage, strands of the rice straw are weak and twisting can readily break a hand-full of it.

Certification of Organic Produce

The government of India has formulated certain organic standards for certified organic production and accredited certain inspection and certification agencies to certify organic farms based on these organic standards. The farmers who want to get their farms certified as organic can contact these agencies. The addresses of these inspection and certification agencies can be obtained/downloaded from the APEDA website www.apeda.gov.in

44. BEEKEEPING

Honey bees apart from providing various valuable hive products increase yield of several vegetable crops through their pollination services. A normal colony of the honey bees (*Apis mellifera*) has a laying queen, thousands of worker bees and occasionally hundreds of drones. Besides, all stages of brood, honey and pollen are also present. Honey bees, apart from providing various valuable hive products, increased fruit setting in soft pear, plum, citrus, etc.

1. Starting Beekeeping

Keep following points in consideration for starting beekeeping:

- **Training:** Acquire training from the PAU Ludhiana or from KVKs located in various districts heads of Punjab.
- **Bee flora:** Bee flora is basic requirement for beekeeping. Major utility bee flora in the Punjab includes *Brassica* spp., *Eucalyptus*, Egyptian clover, sunflower, cotton, pigeon pea, wild forest multiflora, etc. Among the vegetable crops, cucurbits, broccoli, radish, turnip, coriander, etc. constitute important bee flora.
- **Bee equipment:** Main equipment required in beekeeping include ten frame wooden Langstroth hives, bee veil, hive tool, smoker, uncapping knife, drip tray, comb foundations, queen excluders and honey extractor.
- **Season for starting beekeeping:** February-March and October-November are suitable periods for starting beekeeping in the Punjab.
- **Apiary siting:** Apiary should be established on an up-land and away from the main roads and railways. Hives should be placed under shade during summer and in sunny places during winter. The entrances of hives should preferably be towards south-east direction. Row-row distance between colonies must be at least 10 feet and colony-colony distance in a row must be at least 3 feet.

2. Seasonal Bee Management

A) Spring season (mid February - mid April)

- With warming of the season, unpack honey bee colonies.

- In the beginning of season following winter, examine the colonies on a clear sunny day at noon time, clean the bottom board and burn or bury the collected debris.
- Provide more space as raised combs or frames with foundations or super chamber to cope up with increased brood rearing and food storage.
- Provide stimulative feeding (sugar: water = 1:2, w/w) in colonies to boost foraging.
- Populous and congested colonies may issue swarms. To check swarming, keep destroying gyne cells raised under swarming impulse, provide more space, clip half of one side wings of the queen or fix queen guard at hive entrance. Divide the colonies with persistent urge for swarming.
- Replace combs older than three years and also queen older than one and a half years of age.
- Be vigilant brood mites and diseases and in case of their occurrence, undertake appropriate management measures.
- This period is the best for colony multiplication, mass queen bee rearing, royal jelly production and pollen collection.
- Extract ripe honey as and when available in the supers.

B) Summer season (mid April - June)

- Shift colonies to shady places, preferably under thick canopy.
- Ensure provision of fresh water in/ near apiary for the honey bees by placing water bowls under legs of hive stand, or throwing some sticks in the water reservoir of tubewell.
- Be vigilant brood mites and diseases and in case of their occurrence, undertake appropriate management measures.
- Extract ripe honey as and when available in the supers.

C) Monsoon season (July - mid September)

Stronger colonies start robbing weaker ones because of scarcity of bee flora and food reserves in the colonies. Weak colonies are also more prone to the attack of bee enemies and diseases. High humidity and incessant rains impair foraging and stagnating rain water cause drowning of colonies. To overcome these problems, following operations are advised:

- Examine the bee colonies very quickly lest robbing starts.

- Clean the hive debris and burn it to get rid of harbouring wax moth inoculum.
- Keep the colonies at raised place and clear the vegetation growing around the colonies to improve ventilation in colonies.
- Keep the colonies tilted a bit down anteriorly and properly covered with top covers lined with metal sheet on the top.
- Remove extra empty combs from the colonies and store them under air-tight condition with fumigation.
- Depending upon the colony strength and the need, provide sugar syrup feeding (sugar: water 1:1, w/w) inside the hives.
- If honey bee colonies are short of pollen, bee collected pollen or pollen substitute patty (mixture of 42 g brewer's yeast + 4 g parched gram flour + 4 g skimmed milk powder kneaded with 50 g of 50 per cent aqueous sugar solution) or pollen supplement patty prepared by adding 10 per cent pollen in the pollen substitute should be provided to the colonies.
- To prevent robbing, provide sugar feeding to all the colonies very late in the evening, make colonies bee proof, except hive entrance, by plugging cracks and cervices and reducing the entrance to one-bee wide before feeding and prevent spillage of feed in the apiary or outside the colonies.
- To check robbing, place grass soaked with one per cent carbolic acid or kerosene oil at the hive entrance of colony being robbed and make a long and one-bee narrow tunnel with mud to the colony entrance or close entrance of the colony being robbed in the case of heavy robbing; spot out and shift the robber colony 3 km away.
- Laying worker/weak colonies should be united with the stronger colonies using newspaper method.
- Protect honey bee colonies against predatory wasps, ants and birds.

D) Autumn season (mid September - November)

Autumn season is the second best season for colonies growth and multiplication. During this season, colonies can be migrated to pigeon pea, ber, guava and toria growing belts. The State beekeepers may also migrate their colonies outside Punjab on

Brassica and ajwain. Almost all the operations that are followed during spring season hold good during autumn season too. By the end-November (before chilling winter), extract surplus ripe honey. Towards the end of the season, shift colonies gradually to sunny places.

E) Winter season (December - mid February)

To sustain bee activities and brood rearing, following operations should be followed:

- Shift colonies to *raya* and *gobhisarson*) growing area of the Punjab, Haryana or Rajasthan. And towards the end of the season the colonies may be migrated to the coriander growing belt in Rajasthan.
- Place/ move the colonies to sunny places.
- Examine colonies only on some calm and sunny day during noon time in the beginning of the season.
- Unite weaker colonies with stronger ones, using newspaper method, at the onset of winter. Very weak colonies can be united into single chamber using vertical queen excluder.
- Provide supplementary sugar: water (2: 1, w/w) feeding, if required, before winter packing. This feed preferably be provided in drawn combs or in division board feeder.
- Plug cracks and crevices, narrow down the hive entrance and place colonies with entrance facing south - east to protect bees from chilly winds.
- Don't keep colonies in the open area all around; keeping them near some walls serving as wind breaks helps.
- Provide inner packing to weak colonies with dry paddy straw (*prali*) wrapped in newspaper or polythene sheets. Give outer packing with polythene sheet.

3. Maximizing Honey Production: For maximizing nectar collection, follow the under-mentioned practices:

- Colonies should be headed by freshly mated, prolific queen bees in the beginning of spring to get the colonies strengthened about 45 days in advance of nectar flow and not on the honey flow.

- Ensure to provide required space in the form of raised combs or comb foundations at the initiation and during the nectar flow.
- Curb drone population, if and when not required, by removing combs with drone brood cells, destroying drone brood, excluding drones using drone traps, requeening the older drone layer queen bees by freshly mated one and by using only worker brood cell combs or CFs in the brood chamber.
- In view of the weather, provide ventilation to colonies to hasten honey ripening by providing more space/ chambers, staggering the chambers, increasing hive entrance size, by providing extra gate in supers and using screened inner covers.
- Maintain colonies strength, at least on single super, during the nectar flow.
- Increase colony strength by uniting weaker colonies with stronger ones and following double queen management system.
- Use queen excluder between brood chamber and honey chamber during honey flow.
- Extract ripe honey from the supers by the end of nectar flow.

4. Bee Diseases and Enemies

A. Diseases

- **European Foulbrood (EFB):** It is a bacterial disease in which infected larvae (in open brood cells), first turn dull white to yellowish white, later brownish yellow and then brownish; body segmentation becomes faint, and the larvae turn soft and pasty. The dead larvae can mostly be attached to the cell walls in upright condition. Dried scales of the larvae are rubbery and easily removable.
- **Sacbrood:** It is a viral disease affecting very late larval or prepupal stages. The infected sealed brood depicts holes in the cappings. The head of dead larva/prepupa is predominantly raised and becomes pointed and darker, the affected larva/prepupa turns greyish, then straw coloured and finally to dark colour. Dead brood, upon taking out with forceps, comes out

like a water filled sac with body margins showing greenish yellow fluid in the body. Dried dead brood scale is boat/slipper shaped.

Management of Bee Diseases: Maintaining stronger and nutritionally adequate colonies headed by young queen bees provide bees tolerance against bees. Isolation of diseased colonies, maintaining hygienic conditions, checking robbing and drifting and avoiding transfer of hive parts from diseased to healthy colonies, requeening, shook swarm and destruction of the severely infected colony help in checking incidence and further spread of the bee diseases to healthy colonies. Maintaining hygienic colonies through their screening using pin-prick method would facilitate in imparting resistance against disease incidence.

B. Enemies

a) Wax Moths: Wax moths attack live colonies as well as stored combs. Larvae of wax moths eat away the combs by making silken tunnels in the combs and presence of uncapped bee pupae with fine black elongated faecal pellets on their abdomen is another symptom.

Management

- **Apiary management:** Maintain bee colonies stronger, keep bottom boards clean, burry or burn the collected debris, keep cracks and crevices in the hives plugged, and remove extra empty combs from the colonies and store them properly with fumigation. Keeping the infested combs in sun during noon hours for a short period also helps in killing the wax moth larvae.
- **Management of stored combs:** Keep surplus combs in chambers arranged in stacks and fumigate them with burning sulphur @ 250 g per m³ of chamber space under air-tight condition and repeat the treatment after 15 days.

b) Ectoparasitic Mites

- **Brood mite (*Tropilaelaps clareae*):** The cappings of affected brood cells are sunken and sometimes punctured. The infested pupae are sometimes without cappings (bald). Infested bees with shortened and twisted wings and dead pupae may be seen lying on the ground in front of the hive.

- **Management:** Dust powdered sulphur on top bars of combs @ 1 g per comb for the management of this mite. Alternatively, formic acid (85%) @ 5 ml per day for 14 days, taken in a vial with a thick cotton wick with one end dipped in acid below and the other out side the vial to facilitate evaporation of the acid, placed on bottom board, can also be used. Avoid the use of formic acid during honey flow.
- **Varroa mite:** Adult *Varroa* female is dorso-ventrally flattened, brown to dark brown and shiny, shaped like a tiny crab - more in width than length. Heavily infested colonies usually show patches of bald brood cells. Pupal anterior appear eaten with grey markings/specs on head side. Dead or dying newly emerged smaller bees, with malformed wings, legs, thorax and shortened abdomen, may be found on the ground in front of hive.

Management

i) Non-Chemical

- **Trapping *Varroa* on drone brood:** *Varroa* mite is more attracted to drone brood. During breeding season, put one or two empty drone brood combs in the centre of the brood nest to trap the mite population. The sealed drone brood comb part is cut and destroyed. Destruction of existing drone brood comb part in infested colony also reduces its carry over.
- **Sticky paper:** The placement of a sticky paper covered with 8 mesh screen on the bottom board or use of *Varroa* bottom board make the fallen mites stuck to it and prevents their return to the brood combs.
- **Dusting icing sugar:** Dusting finely ground sugar @ 20 grams per 10 bee frame strength colony, uniformly between the inter-comb spaces in the late evening time, reduces infestation of the mite.

ii) Chemical

- **Use of formic acid:** Treat colonies with formic acid (85%) @ 5 ml per day continuously for two weeks as detailed under brood mite. It should not be used during honey flow.
- **Use of oxalic acid:** Trickle 5ml of 4.2 per cent solution (w/v) of oxalic acid prepared in 60 per cent sugar solution in water

(w/v) in between every two combs of bees, three times at weekly interval, in the late evening in the infested colony.

c) Wasps : Yellow spotted brown wasp causes damage to honey bee colonies by catching the bees during monsoon and post monsoon period (July-November) with peak activity in September in the Punjab plains.

Management: Kill the fecundated female wasps during early spring by flapping, and destroy newly developed wasp nests either by burning or pesticidal application. Placing obstructions at the entrance or fixing queen guard at hive entrance checks entering of wasps inside the colony or their approaching near hive entrance to catch bees. Placing wasp traps in apiary and use of large mesh nylon nets around the colonies, is also helpful.

d) Black Ants : Serious attack of black ants may lead to death of the colony or its absconding. The ant nests in the apiary should be destroyed by drenching with pesticidal applications and then covering it with dry soil. Place the hives on the iron stands with legs in water/used engine oil filled bowls.

e) Bee Eating Birds : Green bee eater and king crow catch the flying bees/queen bees. Green bee eater is more serious as it attacks the apiary in flocks. These birds should be scared away by the use of tinsel tapes, bird scarer or use of nets around the colonies.

5. Diversification in Beekeeping

Diversify beekeeping by producing hive products other than honey by following technologies developed by PAU for production of beeswax, pollen, propolis, royal jelly and mass queen bee rearing. Renting out honey bee colonies as an input for augmenting pollination of crops is another option of increasing income from apiary. Use *Apis mellifera* colonies (each of 10 bee-frames) @ 10, 2 and 1 colonies per 5 acres for enhancing seed production in radish, broccoli and turnip, respectively.

6. Safer window for insecticide spray

Insecticide spray on sponge gourd and muskmelon should be undertaken after 5 PM, and on bitter gourd, only after 1 PM, when pollinators are not visiting flowers of these vegetable crops.

45. MANAGEMENT OF RODENTS AND BIRDS

1. RATS AND MICE

Rats and mice usually live in burrows on the ground, possess acute senses of smell and taste, and are very selective in food choice. They are prolific breeders, extremely adaptable and intelligent pests and thus their control poses difficulties. Out of 8 species of rodents in fields, the lesser bandicoot rat, *Bandicota bengalensis* is most predominant under irrigated conditions and Indian *Gerbil Tatera indica* in dry and sandy soils.

The rats and mice attack seeds and seedlings of vegetable crops at growth stage and fruits at ripening stages. Seedlings are also destroyed under heaps of soil made by rats. The lesser bandicoot rat during burrowing, loosens the soil resulting in the drying of plants.

Methods of Control

The performance of different control methods vary in different situations and at different stages of the crop. Therefore, best control can only be achieved if these methods are adopted properly at appropriate timings.

A. Mechanical Control

- i) During irrigation of vacant harvested fields, rats coming out of flooded burrows should be killed with sticks.
- ii) Traps can be used to control rodents. Place 16 traps per acre at damage and activity sites of rodents. Kill the trapped rats by drowning in water and the interval between two trapping at the same location should not be less than 30 days.

B. Environmental Control

Weeds, grasses and bushes should be removed as these provide shelter and food to rodents. Highly infested bunds, water channels and field pavements should be periodically rebuilt to destroy permanent rat burrows. Keep the height and width of bunds to the minimum.

Waste lands along roads, canals, railway lines, other uncultivated areas and forest strip serve as hiding places for

rodents. So, to protect the adjoining crops, rat control operations must be carried out in these areas also.

C. Biological Control

Owls, kites, eagles, falcons, cats, mongoose, jackals, snakes and lizards are the natural predators for rats and mice. These should be protected.

D. Chemical Control

Baiting Technique

Poison bait preparations: The acceptance of poison baits by rodents depends upon the quality, texture, taste, odour etc. of the baiting materials. Therefore, the recommended baiting materials should be used for preparation of poison baits.

- (i) 2% Zinc phosphide bait: Smear 1 kg of bajra or sorghum or cracked wheat or their mixture with 20 g of edible refined oil and mix it thoroughly with 25 g of 80% zinc phosphide powder.

Caution: Never add water in zinc phosphide bait and always use freshly prepared bait.

- (ii) 0.005% Bromadiolone bait: Mix 20 g of 0.25% bromadiolone powder, 20 g of edible refined oil and 20 g of powdered sugar in 1 kg of any cereal flour or bajra, sorghum or cracked wheat.

Poison Bait Placement and Timings

Burrow baiting: Rat burrows can be easily located in the fields, on bunds, water channels and surrounding waste lands. Close all the burrows in the evening and in the re-opened burrows on the next day, insert a paper boat containing about 10 g of poison bait about 6 inches deep in each burrow. In case of burrows of the lesser bandicoot rat, gently remove the fresh soil from the burrow opening to locate the tunnel and then put the poison bait deep inside it.

Crop baiting : Place about 10g of zinc phosphate or bromadiolone bait at 40 bait points per acre on dry sites and inside the crop throughout the field covering runways and activity sites of rats.

Pre-baiting : To increase the efficacy of zinc phosphide bait do pre baiting. Place bajra & sorghum or cracked wheat or their mixture smeared with oil on pieces of paper, 10g each at 40 bait points per acre for 2-3 days.

Safety Measures

Since the rodenticides are very toxic to humans, domestic animals, pets and birds, the following safety measures must be adopted.

1. Keep the rodenticides and poison baits away from the reach of children, domestic animals, pets and birds.
2. Mixing of rodenticide in the baiting material should be done with a stick, spade or by wearing gloves. Avoid the contact of poison with mouth. Wash exposed skin and hands after mixing.
3. House hold utensils should never be used for preparation of the rodenticide baits.
4. Polythene bags used for storage and carrying the rodenticide bait should be buried after use.
5. Collect and bury left over rodenticide bait and dead rats from the orchard.
6. Zinc phosphide is toxic and there is no antidote for it. In case of its accidental ingestion, induce vomiting by inserting fingers in the throat and rush to doctor. Vitamin K is antidote for bromadiolone, it can be given to the patient under medical advice.

Integrated approach

No single method is 100% effective in controlling rats and mice. Left over population reproduce reaching the original size in short time. Therefore, adopt an integrated approach by using different methods at different stages of the crop.

Rodent Management in Pea Crop

For managing rodents in pea crop, regularly remove weeds from within the field along with manual killing of rats coming out of flooded burrows during irrigation. If the rodent burrows are

more than five/acre, then do single burrow bating with 0.005% bromadiolone bait as per the method given above.

Village level campaign

Control of rats and mice in smaller area usually become ineffective due to their migration from the surrounding untreated fields. Therefore, for better results, village level anti-rat campaign to cover maximum possible area, both cultivated and uncultivated, should be organized.

2. BIRDS

Birds, in general, are both useful and harmful to fruit crops. Even the same species may be beneficial or problematic in different situations. Only a few of about 304 species of birds of Punjab cause problems in orchards. The rose-ringed parakeet is the only bird that seems to be exclusively harmful to farmers' interests.

Harmful Birds

Several fruits are damaged by birds at the bud stage and ripening stage. Parakeet is the major bird pest causing serious damage to guava, peach, pear, almond, grapes, mango and ber. House crows damage peach, plum and grapes. The major damage to grape is caused by mynas, especially the bank mynas.

MANAGEMENT OF BIRD DAMAGE

A. Mechanical Control

1. Make false gun-shots at different intervals to scare the birds.
2. Frequent beating of drums and use of Gopia at different points in the orchard is very effective against the birds.
3. Covering the vines of grapes and isolated fruit trees with nylon nets prevents the bird damage.
4. Fixing of scare crows i.e. a discarded earthen pot painted to stimulate human like head supported with wooden sticks and clothed in human dress to give a human like appearance is one of the most effective traditional techniques to keep the birds away. Position, direction and the dress of the scare crow should be changed atleast at 10 days interval. The height of the scare crow should be 1 metre above the plant height.

5. Use automatic bird scarer by shifting their position periodically and supplementing their noise with actual gunfire's. The other simplest method is the use of rope-crackers. It involves tying of sets of small fire crackers at a distance of 6-8 inches apart on a rope and igniting it from the lower end. The explosions caused by fire crackers on catching fire at different intervals scare the birds feeding on fruits. Fix the rope-crackers in the centre of the orchard.

B. Cultural Practices

As far as possible sowing of maize and sunflower crops should be avoided in and around the orchards.

C. Alarming Calls

Playing of cassettes (available at Communication Centre, PAU) of distress or flock calls of parakeets and crows respectively in a tape-recorder at peak volume for 1/2 hr. twice each in the morning between 7.00 to 9.00 a.m. and in the evening at 5.00 to 7.00 p.m. respectively, with a pause of 1 hour, scare the birds or halt their activities in orchards. Use of distress or flock calls remain effective for 15-20 days. Better results can be obtained by using this technique in sequence or in combination with other methods as an integrated pest management. For covering larger area use of amplifier or additional speakers (as per requirements) can be done.

Conservation of Useful Birds

Predatory birds like owls, falcons, hawks, eagles, kites, etc. eat a large number of rats and mice. A single owl normally eats 4-5 rats a day. Insect eating birds like drongos, babblers, shrikes, lapwings, mynas, and many other small birds like sparrows and weaver birds feed a large number of insects to their young. A single pair of house sparrows feeds insects to their young about 250 times a day. Therefore, the useful birds should not be killed.

46. DOMESTIC SOLAR DRYER

Advanced Domestic Solar Dryer is a small sized dryer in which only solar energy is required for drying (**Plate-4**). It can be used for drying of vegetables, spices and other household products such as chilly, turmeric, ginger, garlic, methi, papad, amla, wadian, vegetables for pickle making, etc. In one batch, upto 3 kg of product can be dried. The drying is done under hygienic conditions. It does not require any attention during off-sunshine hours and in case of inclement weather. The dryer has separate solar air heater and drying chamber. The drying chamber is openable at the top and has two trays placed one above the other. The product to be dried is placed in these trays. For drying, the dryer is placed facing south, at a location where sunshine remain available throughout the day. It is mounted by wheels for movement.

The drying time in solar dryer depends on drying product and season. Generally the product gets dried in 1-4 days. In comparison to open sun, the drying time in solar dryer reduces to 25-35%. The quality of product dried in the dryer is superior as compared to open sun drying. The product dried is free from any adulteration. In comparison, the traditional practice of open sun drying is slow, open to loss by birds, rodents etc. and the quality of open sun dried product is adversely affected due to discolouration and contamination by dust, insects, etc.

47. VERTICAL CUP TYPE VEGETABLE TRANSPLANTER FOR CELL FEED NURSERY

It is a two-row semi-automatic vegetable transplanter having cup type metering mechanism for transplanting cell type nursery have been developed by the University. The vegetable transplanter can be used to transplant nursery of different vegetable crops like brinjal, tomato, chilli etc. It consists of three ridge bottoms, two vertical cup type metering units, two seats for operators, two seedling tray stands and two ground wheels (**Plate-5**). The machine can be operated by tractor having 50 hp or above. The field capacity of the machine for transplanting nursery of tomato, brinjal and chilli varies between 0.11-0.15 ha/h at forward speed of 1.0-1.5 km/h. The gear ratio between ground wheel and metering wheel can be changed to vary plant to plant spacing. The plant missing is below 4 %. The saving in labour with machine over manual method is about 85%.

48. MANUALLY OPERATED GARLIC PLANTER

Machine is recommended for sowing garlic (**Plate-6**). The machine has a single row and it consists of a wheel hand hoe on which a planting mechanism is mounted. The seed metering mechanism consists of vertical disc with spoons. The spoons are fixed on the circular ring and this ring is mounted on the circular vertical plate in the planting hopper by means of three nuts and bolts. The capacity of hopper is about 3 kg and machine is operated by two persons. One person on the front pulls the machine with the help of a rope and another person steers it. Also, some time, third person is engaged for gap filling. It has also been provided with two depth adjusting wheels and markers to maintain the row spacing. Plant spacing can be varied by varying the number of spoons on the disc or by changing the sprockets. Also planting plates for different crops have been developed for sowing different crops like peas, moong/maize etc. Machine is operated in a prepared field and depth of sowing is maintained at about one inch. Since, the machine is light in weight about 12 kg thus operation of machine is very easy. At shallow depth of sowing, the germination after 20 days of sowing is about 95 percent which is close to manual planting. Also, it was observed that there was not much effect of position of garlic cloves on germination and yield. It can plant about 0.5 acres/day. Cost of planting with machine is only Rs. 350 per acre as compared to Rs. 2000 per acre manually.

49. CARROT SOWING MACHINE

The sowing of carrot is earlier carried out on ridges made by the labourers in the field but now it can be mechanized. Punjab Agricultural University has recommended tractor drawn inclined plates carrot planter. With the help of this machine, sowing of carrot seeds can be done on seed beds. The machine uses the pores situated in inclined plates to further transfer them to seed tubes. The machine can make three beds with width of 67.5 cm at a time. Tractor drawn inclined plate planter can help in direct sowing of carrot (**Plate-7**). This machine can sow four rows on a bed with row spacing of 10 cm and plant to plant spacing of 8 cm. A flat plate is attached after each row to cover the seed with soil.

This machine has sowing capacity of 1-1.5 acre/hour and requires 2.5-3.0 kg seed/acre. Germination capacity is much higher in machine sown carrot as compared to traditional methods. There is 50-60% of labour saving by sowing the carrot with machine. Machine sown carrot can save 70% of labour and increase 40% of yield.

50. TRACTOR DRAWN BED FORMER-CUM-PLASTIC MULCHING MACHINE

Plastic mulches have various beneficial effects on crop production, including an increase in soil temperature; the conservation of soil moisture, texture and fertility; and the control of weeds, pests and diseases. Besides, the volume of plastics material to be used per unit area is much lesser than that of traditional mulch material and, hence, plastic films are easy to handle, transport and lay in the field. Manual laying of plastic mulch is a laborious as well as time consuming process. A long time need was felt to mechanise this process.

Machine is being manufactured by Agribiz Corporation Gujarat. Machine's length is 2.2 meter, width 1.85 meter, height 2.2 meter (**Plate-8**). The tractor drawn bed former-cum-plastic mulch laying machine does four operations at a time i.e. bed forming, drip pipe laying, mulch laying and punching at the desired spacing. Tractor drawn bed former-cum-plastic mulching machine lays 75 cm, 90 cm, 105 cm, 120 cm, 135 cm wide plastic mulch and requires a minimum of 30 hp tractor to operate. The height of the bed can also be adjusted from 15cm to 20 cm. This machine is very easy to operate and maintain and reduces the labour requirement by 92.5% and saves 30 man days per hectare per season.

51. VEGETABLE DIGGER FOR MECHANICAL DIGGING OF ONION, GARLIC, CARROT AND POTATO

A vegetable digger has been developed by the Department of Farm Machinery and Power Engineering, PAU, Ludhiana after modifying the existing potato digger. It is used for mechanical digging of different crops like onion and garlic grown on single bed of 1.1m width; carrot and potato on ridges at 67.5 cm ridge spacing. The machine consists of a digger blade having width of 1144 mm and thickness of 16 mm (**Plate-9**). The blade is mounted on the machine at an angle of 20° with the horizontal. An elevator chain conveyor is attached behind the blade. The spacing between the MS rods used for the fabrication of the elevator conveyor is 20 mm. Two oval agitators are provided in the conveying system for separation of soil particles from the bulbs. The power to the elevator conveyor is provided through a gear box. Two coulter discs are provided in front of the blade at the outer ends which helps in easy slicing and lifting of soil by the blade. Extension at the rear was also provided to increase the time for separation of soil.

The field capacity of the machine is 0.20, 0.25 and 0.23 and 0.24 ha/h for digging onion, carrot, garlic and potato crop, respectively. Per cent exposed bulbs/roots were 99.0, 96.3, 98.6 and 96.4 per cent for onion, carrot, garlic and potato, respectively whereas respective damage to the crop was less than 1.0, 2.8, 1.1 and 1.92 per cent respectively for these crops. The performance of the machine was found satisfactory for digging these crops. Saving in labour was 69.0, 59.2 and 61.41 per cent respectively for onion, carrot and garlic as compared to manual harvesting and collection.

52. HORTICULTURAL PRODUCE WASHING MACHINE

A stainless steel, portable, 1 hp, electric power operated rotary drum type washing machine has been developed to wash a wide range of horticultural produce viz. carrot, potato, raddish, turnip, ginger, turmeric, okra, tomato, spinach, kinnow and pear (**Plate-10**). The inner rotary drum of the washer is made of stainless steel of 1.5 mm thickness, 760 mm long and 620 mm in diameter. Proper arrangements for feeding water into machine and draining out dirty water and silt are provided. Pressurized sprays of water with a water injection pump through the central, perforated inner shaft is provided for extensive washing. The machine when operated at optimum rotational speed for optimized time can wash 1-6 q/h of horticulture produce depending upon the crop as depicted in the following table. At optimum performance parameters, it does not cause any mechanical damage to the produce and gives a microbiological washing efficiency of 90.2 - 95.5%. An electronic timer and a regulator has been provided in the machine to achieve optimum washing time and speed for various crops. Rotating parts and moving belts are covered with guard for operational safety.

Table. Optimum performance parameters of the washing machine.

Horticultural Produce	Capacity (qph)	Optimum Speed (rpm)	Optimum Washing Time (min)	Microbiological Washing Efficiency (%)
Carrot	3.5-4.0	40	8	95.5
Radish	1.5-2.0	50	5	94.0
Spinach	1.0-1.5	5	3	90.8
Ginger	3.5	40	6	90.2
Tomato	4.0	5	3	92.5
Potato	3.5-5.5	25	3	91.0
Turmeric	2.5-3.0	40	5	91.0
Okra	2.0-3.0	35	4	90.5
Turnip	2.5-3.5	25	4	92.2

53. SEED EXTRACTION

“PAU” Axial-Flow Vegetable Seed Extracting Machine

Machine is recommended for extracting the seeds of tomato, brinjal, chillies, cucumber, watermelon, ashgourd and squashmelon (**Plate-11**). Freshly harvested ripe fruits of different crops are used for extracting the seed. Sufficient water should be available at the site of the machine and the machine preferably be installed near a tubewell/water source. Three persons are required to operate the machine. The efficiency of machine as compared to manual extraction is the highest in brinjal (12 times), cucumber (7 times) and tomato (5 times) whereas the efficiency is 3 times in watermelon and 2 times in chillies, ashgourd and squash melon. The cost of the machine excluding the cost of electric motor (2HP) is about Rs.20,000/-. Above all, the mechanical seed extraction is hygienic and the injury to the seed from traditional methods of seed extraction could be avoided.

Separation of the Seed

Separation of the seed from the finally crushed seed material collected at the seed outlet is done by putting in a trough containing water. The seed being heavier settle down at the bottom of water and the fruit material floating over the water surface is easily removed by tilting of container. This process is repeated 2-3 times to obtain clear seed. The seed thus obtained should be sun dried in thin layers. However, since the tomato seed is surrounded by mucilaginous layer, the extracted seed should be treated with concentrated hydrochloric acid (commercial grade) at the rate of 8 to 10 ml per kg of seed material for 15 to 20 minutes. The mixture should be continuously stirred and thereafter the seed should be thoroughly washed with water and dried in thin layers under the sun.

Vegetable Seed Thresher

The vegetable seed thresher is used to thrash crops like radish, carrot and turnip. This thresher is of chaff-cutter type commonly used for wheat threshing, but differs from the conventional wheat thresher in the arrangement of separation and cleaning systems

namely; location of the blower and size of sieve openings. The material after threshing passes through the concave and is allowed to flow on the sieves where the seeds are separated. The blower performs the winnowing action and it is located towards the rear end of the sieve. The blower is mounted on separate shaft from the threshing drum. The machine can be operated with an electric motor of 5 HP. Two persons are required to work on the machine. The machine can also thrash crop like soybean, arhar, moong, rapeseed and mustard etc. The output capacity per hour of this machine is 37 kg. for radish and 45 kg. for turnip.

1. Crashing chamber	8. Primary cutting unit lever
2. Water spraying pipes	9. Feed regulator
3. Rotor Shaft	10. Seed outlet
4. Driving belt	11. Electric motor
5. Pulp outlet	12. Water pump
6. Frame	13. Seed collecting chamber
7. Feeding through (chute)	14. Pulp size regulator

54. EVAPORATIVELY COOLED STORE

It is a simple, low cost and zero energy store which can be used to extend the shelf life of fresh vegetables and fruits for short duration. The recommended store is a double walled structure with a cavity of 0.115 m (4.5") in between the walls which is filled with sand. Each wall is un-plastered single brick i.e. 0.115 m (4.5") thick. The outer dimensions of the store are 2.05×2.05×0.75 m and internal dimensions 1.36×1.36×0.75 m. A PVC pipe of 0.0125 m (0.5") diameter with 1 mm diameter holes at 0.150 m (6") interval, is placed above the sand filled cavity and is connected to a water tank placed at a height of 2.5 m from the ground for wetting the sand. The cover of the store should be made from wire mesh or bamboo sticks and should be covered with wet jute bags. To operate the store for storing fruits and vegetables, sand between the cavity of the walls and jute bags are kept wet thus reducing temperature and increasing relative humidity in the store which results in extension of shelf life of fruits and vegetables placed in plastic crates inside the store. Relative humidity inside the store remains more than 90% throughout the year whereas the average temperature drop inside the store is 12-18°C during April to June followed by 6-8°C drop in the months of September, October, February and March. Thus the store is suitable for extending shelf life of fruits and vegetables in general and particularly in hot and dry months (April to June). The store can be safely used to store a number of commodities such as pears, cabbage, tomatoes, ber for 15 days, kinnows for 20 days and lemons and potatoes for 30 days. The store should preferably be constructed at a shady and airy location on the field or backyard of the farm house. For further details, the information can be had from the Department of Processing and Food Engineering, Punjab Agricultural University, Ludhiana.

APPENDIX - I
Botanical Names of Vegetables

Sr. No.	English name	Botanical name
1.	Muskmelon	<i>Cucumis melo</i>
2.	Watermelon	<i>Citrullus lanatus</i>
3.	Summer squash	<i>Cucurbita pepo</i>
4.	Bottle gourd	<i>Lagenaria siceraria</i>
5.	Bitter gourd	<i>Momordica charantia</i>
6.	Sponge gourd	<i>Luffa cylindrica</i>
7.	Pumpkin	<i>Cucurbita moschata</i>
8.	Ash gourd	<i>Benincasa hispida</i>
9.	Cucumber	<i>Cucumis sativus</i>
10.	Long melon	<i>Cucumis melo var. utilissimus</i>
11.	Squash melon	<i>Citrullus vulgaris var. fistulosus</i>
12.	Wanga	<i>Cucumis melo sub sp melo</i>
13.	Tomato	<i>Solanum lycopersicon</i>
14.	Brinjal	<i>Solanum melongena</i>
15.	Chilli	<i>Capsicum annuum</i>
16.	Sweet pepper	<i>Capsicum annuum var. grossum</i>
17.	Okra	<i>Abelmoschus esculentus</i>
18.	Cowpea	<i>Vigna sinensis</i>
19.	Onion	<i>Allium cepa</i>
20.	Garlic	<i>Allium sativum</i>
21.	Pea	<i>Pisum sativum</i>

22.	Cauliflower	<i>Brassica oleracea var. botrytis</i>
23.	Cabbage	<i>Brassica oleracea var. capitata</i>
24.	Broccoli	<i>Brassica oleracea var. italica</i>
25.	Chinese Cabbage	<i>Brassica Oleracea var. pekinensis</i>
26.	Carrot	<i>Daucus carota</i>
27.	Radish	<i>Raphanus sativus</i>
28.	Turnip	<i>Brassica campestris var. rapa</i>
29.	Palak	<i>Beta vulgaris var bengalensis</i>
30.	Lettuce	<i>Lactuca sativa</i>
31.	Coriander	<i>Coriandrum sativum</i>
32.	Potato	<i>Solanum tuberosum</i>
33.	Arum	<i>Colocasia esculentum</i>
34.	Turmeric	<i>Curcuma longa</i>
35.	Sweet potato	<i>Ipomea batatas</i>

APPENDIX - II

Waiting Periods of Different Pesticides in Vegetables and Fruit crops

Recommended Pesticide	Crop	Waiting Period (Days)
Malathion	Brinjal, Okra, Cabbage, Grapes	1
Quinalphos	Brinjal, Cabbage (Autumn)	4
	Cabbage, Cauliflower (Winter)	7
	Kinnow	7
	Grapes	10
Chlorpyrifos	Peas, Chilli	7
Cypermethrin Fenvalerate Deltamethrin	Tomato, Cabbage, Okra	1
	Cabbage, Brinjal, Cauliflower	1
	Kinnow	1
Dicofol	Brinjal, Cucumber	1
Ethion	Brinjal,	5
	Cucumber	7
	Pear	1
Fenvalerate	Pear, peach, Guava	2
Spinosad	Cauliflower	7
	Cabbage	5
Indoxacarb	Cauliflower, Cabbage	3
Propargite	Brinjal	1
Cypermethrin	Kinnow	3
Profenofos	Tomato	5
Flubendiamide	Tomato	3
Emamectin Benzoate	Okra, Cabbage, Brinjal	3
	Cauliflower	5
Chlorantraniliprole	Tomato	1
	Brinjal	7
	Okra	1
Imidacloprid	Okra	1
Thiamethoxam	Okra	1
Diafenthiuron	Brinjal	1
Pyridalyl	Okra	1

APPENDIX - III
**Fertilizer Sources for the Supply of Nitrogen,
Phosphorus and Potassium**

(A) Nutrient contents of different fertilizers

Fertilizer	N (%)	P₂O₅ (%)	K₂O (%)	Other
Ammonium sulphate	20.5	-	-	
Ammonium chloride	25.0	-	-	
Calcium ammonium nitrate	25.0	-	-	
Urea	46.0	-	-	
Superphosphate (single)	-	16.0	-	
Diammonium phosphate	18.0	46.0	-	
Sulphated phosphate	13.0	33.0	-	15(s)
Urea-ammonium phosphate	28.0	28.0	-	-
Nitrophosphate	20.0	20.0	-	-
Sulphate of potash	-	-	48.0	
Muriate of potash	-	-	60.0	
Manganese sulphate	-	-	-	30 (Mn)
Zinc sulphate (Heptahydrate)	-	-	-	21 (Zn)
Zinc sulphate (Monohydrate)	-	-	-	33 (Zn)
Ferrous sulphate	-	-	-	19 (Fe)
Copper sulphate	-	-	-	24 (Cu)
Gypsum	-	-	-	16 (s)
FYM/Vermicompost (Dry)	0.5-1.5	1.2-1.8	1.2-2.0	Sufficient

(B) Quantity of the fertilizer to give 1 kg of nutrient				
For 1 kg of N				
Calcium ammonium nitrate	4 kg			
Ammonium chloride	4 kg			
Ammonium sulphate	5 kg			
Urea	2.2 kg			
For 1 kg of P₂O₅				
Superphosphate	6.2 kg			
Diammonium phosphate	2.2 kg			
Urea-ammonium phosphate	3.6 kg			
Nitrophosphate	5.0 kg			
For 1 kg of K₂O				
Muriate of potash	1.7 kg			

Note: Urea-ammonium phosphate (28-28), and diammonium phosphate (18-46) contain both nitrogen and phosphorus. By adding one kg of phosphorus (P₂O₅) through these fertilizers, one kg nitrogen (N) from urea ammonium phosphate and 400 g of N from ammonium phosphate is also added. This point must be taken into account while using two fertilizers.

APPENDIX - IV

General Recommendations Regarding Safe Use of Pesticides

1. Read the label carefully and follow the manufacturer's instructions.
2. Keep pesticides in labelled containers only.
3. Store pesticides in a safe and locked place, out of reach of children, irresponsible persons and pets.
4. Never store pesticides near foodstuffs or medicines.
5. In the handling of dangerous pesticides, the necessary protective clothing and devices must be used.
6. Do not tear open the pesticides bags, but cut them with a knife.
7. The preparations of spray solutions from concentrated dangerous pesticides should be done in drums using long sticks to protect the operator from splashing and to permit stirring from a standing position.
8. Wash hands thoroughly with soda and water (i) every time the sprayer/duster is filled with pesticides, (ii) before eating, drinking or smoking and (iii) at the end of the day's work.
9. Water contaminated, as a result of washing the equipment and drums, must be disposed off by scattering it over barren land.
10. Do not blow, suck or apply your mouth to any sprinkler, nozzle or other spraying equipment.
11. Operators should not work for more than 8 hours a day. Those engaged in handling dangerous pesticides should be checked by a physician periodically.
12. Separate working clothes should be used. They should be washed and changed as frequently as possible.
13. Do not use the empty containers of pesticides for any purpose. Destroy them by making holes and bury them afterwards.
14. Do not burn weedicide cartons, but bury them deep.
15. The worker should not smoke, chew, eat or drink in the spraying area or while spraying
16. A worker suffering from cold or cough should not be engaged for spraying.

17. Spray should always be done in direction of the blowing wind to avoid skin exposure and inhalation.

FIRST AID PRECAUTIONS

In case of pesticide poisoning, call a physician immediately. Awaiting the physician's arrival, apply the FIRST AID.

1. Swallowed Poisons

- a) Remove poison from the patient's stomach immediately by inducing vomiting. Give common salt one tea-spoonful (15 g) in a glass of warm water (emetic) and repeat until the vomit fluid is clear. Gentle stroking or touching the throat with a finger or placing the blunt end of a spoon will help induce vomiting when the stomach is full of fluid.
- b) If the patient is already vomiting, do not give common salt in warm water and follow the specific directions as suggested.

2. Inhaled Poisons

- a) Carry the patient (do not let him walk) to fresh air immediately.
- b) Open all doors and windows.
- c) Loosen all tight clothing.
- d) Apply artificial respiration if breathing has stopped or is irregular. Avoid a vigorous application of pressure to the chest.
- e) Cover the patient with a blanket.
- f) Keep the patient as quiet as possible.
- g) If the patient is convulsing, keep him in bed in some dark room.
- h) Avoid any jarring noise.

3. Skin Contamination

- a) Drench the skin with water (giving a shower with a hose or pump).
- b) Apply a stream of water to the skin while removing the clothing.
- c) Clean the skin thoroughly with water.
- d) Rapid washing is most important for reducing the extent of injury.

4. Prevention of Collapse

- a) Cover the patient with a light blanket.
- b) Do not use a hot-water bottle.
- c) Raise the feet of the patient on the bed.
- d) Apply elastic bands to arms and legs.
- e) Give strong tea or coffee.
- f) Give hypodermic injection of stimulants, such as caffeine and epinephrine.
- g) Give fluid administration of dextrose 5% intravenously.
- h) Give blood or plasma transfusion.
- i) Do not exhaust the patient by too much or too vigorous treatment.

5. Eye Contamination

- a) Hold eyelids open.
- b) Wash the eyes gently with stream of running water immediately. A delay of even a few seconds greatly increases the extent of injury.
- c) Continue washing until the physician arrives.
- d) Do not use chemicals. They may increase the injury.

SOME OTHER FIRST AID MEASURES

1. Cut Injury

- a) The first aid treatment of cut injury depends upon the date and extent of injury.
- b) But in first aid one should clean the wound with antiseptic lotion.
- c) If it is bleeding profusely tight bandage without ointment is to be given.
- d) The injured part should be kept raised or elevated.
- e) If there is any associated fracture, a proper splint or support should be given. But the patient, should be brought to the hospital at the earliest possible.

2. Snake Bite – Preventions

- a) In snake infested regions long trousers, high shoes or leggings and gloves should be worn. Most important is to look where to step while walking.

First Aid

- a) Re-assure the complete rest to the victim to retard the absorption of venom. A wide tournaquet or any piece of cloth should be placed a few centimeters proxymal or above the site of bite. It should be tight to an extent that a finger should pass below it with difficulty.

Suction of venom should be done by giving 1 cm linear and 1/2 cm deep incision at the mark of the fangs after applying an antiseptic lotion. Suction should preferably be done with rubber bulb, breast pump or with moth after ensuring that there is no oral lesion. It should continue for about an hour. If done promptly 50% of the venom can be removed.

3. Electric Injuries – Preventions

- a) Educate the electric hazards to everybody.
- b) Proper installation of electric appliances, grounding of telephone lines, radio and television arials, use of rubber gloves and dry shoes when working with electric circuit.

First Aid

- a) Prompt switching off the current, if possible.
- b) Immediate removal of the victim from the contact with the current without directly touching him. Rescuer should use a rubber sheet, a leather belt, a wooden pole or any other non-conductive material to detach him.
- c) If the victim is not breathing, mouth respiration should be given.
- d) If no pulse is felt cardiac massage (pressure on left side chest) should be given.
- e) In mild cases local treatment of burnt part is required.

4. Honey bee Bite

- a) Cooling of the part with ice pads.
- b) Removal of stings.
- c) Cleaning with soap and water.
- d) Local and systematic anti allergies to be given.
- e) Perfumes and bright colours attract these insects and should be avoided.
- f) Sensitive person can have serve anaphyllatic shock with even a single bite.
- g) Every such patient must get the medical aid from a doctor.

LIST OF PESTICIDES RESTRICTED OR BANNED IN THE COUNTRY

a. Pesticides restricted for use

Aluminium phosphide	It is to be sold only to government undertakings/ organisations and to be used under strict supervision of government experts or pest control operators.
DDT	Restricted for use in public health only.
Fenthion	Banned for use in agriculture except for locust control.
Lindane	Use of Lindane formulations generating smoke for indoor use is prohibited in India. It can be used for control of insect pests of field crops.
Methyl bromide	Restriction for its sale and use is similar to that of aluminium phosphide.
MEMC (methoxyethyl mercuric chloride)	--
Methyl parathion	Use is permitted only on those crops where honey bees are not acting as pollinators.
Monocrotophos	Banned for use in vegetables
Sodium cyanide	Use of sodium cyanide shall be restricted for fumigation of cotton bales by Plant Protection Advisor, Govt. of India.

b. Pesticides banned for use in agriculture in India

S. No.	Name of pesticide
1.	Aldicarb
2.	Aldrin
3.	BHC (HCH)
4.	Calcium cyanide
5.	Captafol
6.	Chlorobenzilate
7.	Chlordane

8.	Chlorofenvinphos
9.	Copper acetoarsenite
10.	Dibromochloropropane (DBCP)
11.	DDT
12.	Dieldrin
13.	Endrin
14.	Ethylene dibromide
15.	Ethyl mercury chloride
16.	Ethyl parathion
17.	Heptachlor
18.	Maleic Hydrazide
19.	Menazon
20.	Metoxuron
21.	Nichotine sulphate
22.	Nitrofen
23.	Paraquat-di-methyl sulphate
24.	Pentachloro Nitrobenzene (PCNB)
25.	Pentachlorophenol (PCP)
26.	Phenyl mercury acetate (PMA)
27.	Sodium methane arsonate
28.	Trichloro acetic acid (TCA)
29.	Tetradifon
30.	Toxaphene

c. Pesticide formulations banned for use

1.	Carbofuran	50% SP
2.	Methomyl	24% L
3.	Methomyl	12.5% L
4.	Phosphamidan	85% L

APPENDIX - V

Pesticide Antidotes for Human Beings

Signs and symptoms of toxicity:

Inhalation	Usually appear within 1/2 hour of exposure, maximum after 6 hours. Nausea and vomiting, running nose, feeling of chest tightness, excessive salivation, difficulty in respiration, frothing from mouth, headache, giddiness, vertigo
Oral intake	Nausea and vomiting, abdominal cramps, diarrhoea, muscle twitching, confusion and disorientation, salivation and frothing, profused sweating, diminished vision, pin-point pupils, respiratory difficulty, convulsions, coma, death
I. INSECTICIDES	
Organochlorines (lindane etc)	No specific antidote. For convulsions : Diazepam 10 mg intravenous (I/V). Could be repeated upto 30-40 mg. After that it should be mixed with drip. Phenobarbitone 100-300 mg in drip.
Organophosphates (monocrotophos, chlorpyrifos, methyl parathion acephate, triazophos malathion, quinlphos, dimethoate etc)	Atropine : 2-4 mg intravenous as a test dose. If no effect double dose may be given every 10 minutes till atropinization. Maintain upto 24-48 hours. 2-PAM: 1-2 g I/V as 5% solution in dextrose to be given in 5-7 minutes or 150 ml of saline drip every 30 minute. If required it may be repeated every hour if the muscle weakness and fasciculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2 g/hr. 2-PAMCL : dose same as above. Atropine+2PAM : should be given together as 2 PAM acts as synergist to atropine
Carbamates (Carbaryl carbofuran etc.)	Atropine : 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours. Warning: Do not use oxime or morphine.
Pyrethroids (cypermethrin, fenvalerate, deltamethrin etc).	Only symptomatic treatment, antihistamine are of value, if large amounts are ingested to cause nervous infestation, pentobarbitone (0.7g/day) should be used. For diarrhoea treat by atropine.
Cartap hydrochloride (Padan, Caldan etc)	Dimercaprol (BAL) 3-4 mg/kg body weight. (Comes as 3 ml, 10% solution alongwith benzyl benzoate in arachis oil). Given deep intramuscular every 4 hours for 2 days and then twice for another 10 days.

Aluminium phosphide (celphos. phostoxin etc)	No specific antidote, induce vomiting with 5% sodium bicarbonate. Give activated charcoal slurry with sorbitol 50-100 g orally, diazepam 5-10 mg I/V slowly over 2-3 minutes. Phenobarbitone 600-1200 mg, diluted in 60 ml normal saline. Maximum dose 1-2 g. Dimercaprol (BAL) . Dopamine 4-6 ug/kg/min I/V. Magnesium sulphate 3g I/V bolus followed by 6 g in 12 hours for 5-7 days. Administering 5% glucose I/V can minimize liver and kidney damage. Warning : Do not give water or water based drinks
Naturalyte (Spinosad)	No specific antidote. Treat symptomatically
Oxadiazine (Indoxacarb)	No specific antidote. Treat symptomatically
Phenyl Parazole (fipronil)	No specific antidote. Treat symptomatically
II. FUNGICIDES	
Carbendazim (Bavistin, Agrozim, Parazim, Derosal etc.)	Atropine: 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours.
Streptocycline	Injection of adrenalin , antihistamine and cartisone in case of acute anaphylactic shock, high or low blood pressure, profuse respiration and urticaria.
Copper oxchloride, Copper sulphate (Blitox etc.)	Dimercaprol (BAL) 3-4 mg/kg body weight. Comes as 3 ml, given deep intramuscular every 4 hours for 2 days and then twice for another 10 days.
Edifenphos (Hinosan)	Atropine: 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minutes till atropinization.
Iprobenphos (Kitazin)	Maintain upto 24-48 hours. 2-PAM : 1-2g I/V as 5% solution in dextrose to be given in 5-7 minutes or 150 ml of saline drip every 30 minutes. If required it may be repeated every hour if the muscle weakness and fasciculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2g/hr.
Methoxy ethyl mercuric chloride (MEMC), Agallol, Ceresan etc.	Activated charcoal, egg white or 5% sodium bicarbonate solution (gastric lavage). High colonic irritation : 5% sodium formaldehyde sulfoxylate (fresh 100-200 ml) intravenous. For faster treatment sodium citrate, oral 1-4 g every 4 hours. For spasms 100 ml (10%) calcium gluconate intravenous.

Mancozeb, Thiram, Zineb	Ascorbic acid (vitamin C) intravenous @ 0.2 g/min.
Ridomil MZ (8% metalaxyl+64% mancozeb)	No specific antidote for metalaxyl. Antidote for mancozeb as given above may be recommended as this combination contains 64% mancozeb)
Triadimifon (Bayleton)	No specific antidote, gastric lavage with 5% sodium bicarbonate.
Dinocap (Karathane)	No specific antidote. Gastric lavage with 5% sodium bicarbonate and medicinal charcoal suspension. Then give 15-30 g sodium sulphate in half litre of water.
Carboxin (Vitavax)	Treat symptomatically
Captan (Captaf)	If ingested, induce vomiting by administering a spoonful of salt in hot water.
Chlorothalonil (Kavach)	Treat symptomatically
Propiconazole (Tilt)	Treat symptomatically
Wettable sulphur (Sultaf)	If chemical has gotten into the victim's eyes, flush eyes with plenty of water for atleast 5 minutes
III. HERBICIDES	
Anilophos (Arozin, Libra, Anilguard, Anilfos Padigard etc.)	Atropine : 2-4 mg I/V as a test dose. If no effect double dose may be given every 10 minute till atropinization. Maintain upto 24-48 hours. 2-PAM : 1-2 g intravenous as 5% solution in dextrose to be given in 5-7 minutes or 150 ml of saline drip every 30 minutes. If required it may be repeated every hour if the muscle weakness and fasciculation persists. To be continued every 6-8 hours for 1-2 days or 5% solution as infusion @ 1/2g/hr. 2-PAMCL: dose same as above. Gastric lavage with 5% sodium bicarbonate.
2,4-D	Ingestion: Gastric lavage with activated charcoal slurry. For muscle and cardiac irritability give Lidocaine 50-100 mg intravenous, followed by 1-4 mg/min as needed. Alkalize urine by sodium bicarbonate 10-15 g daily intravenously.
Glyphosate (Roundup)	Ingestion : immediately dilute by swallowing milk or water.
Isoproturon (Arelon, Delron Milron etc.)	Flush eyes with soap. Wash skin with soap and water.
Paraquat (Grammoxone)	Induce vomiting unless unconscious. Give gastric lavage with one litre of 30% aqueous suspension with Fuller's earth together with sodium sulphate. Repeat administration until Fuller's earth is seen in stool.

IV. RODENTICIDES	
Zinc phosphide (Ratol, Zinc-Tox etc.)	As under aluminium phosphide
Coumatetralyl (Racumin)	Vitamin 'K' under medical supervision
Bromadiolone	Vitamin 'K' under medical supervision

Some Common Trade Names of Antidotes

Diazepam :	Calmose, Lori, Paciquil, Tenil, Valium
Phenobarbitone :	Gardenal
Dimercaprol :	Inj. BAL (Knoll Pharma)
PAM :	Neopam, Pam, Pamplus, Pam-A-Korea

Atropinisation includes :

1. Drying up of secretions i.e. dry mouth, no frothing, loss of sweating.
2. Tachycardia : Pulse should be maintained at about 110/minute
3. Dilated pupils
4. Hyperthermia

Sources of Information

- (a) Farm Chemicals Handbook, 1994
- (b) Health hazards of Pesticides and its management (1996)
Voluntary Health Association of India
- (c) Essentials of Forensic Medicine and Toxicology (1999) by Narayan Reddy
- (d) National Poison Information Centre, AIIMS, New Delhi

Caution : Antidotes are to be used in case of poisoning only, for which a physician must be consulted immediately.

Disclaimer : The information given is only advisory. Actual selection of antidote, dose and manner of administration is to be decided by the qualified physician. Punjab Agricultural University, Ludhiana accepts no legal responsibility.

Appendix - VI

Performa for Referring Sample to Plant Clinic, PAU, Ludhiana for Diagnosis of Disorders

Name and address of the farmer	
Crop	Variety..... Age of the crop.....
Problem noticed (Approx. date)	
Sowing date	
Area (under the crop)(acres)
Source of seed	
Is this problem related to weather ?	Yes/No
If yes, type of Weather	Rain/High temp./Storm/Frost/Hot dry Spell/Wet condition/Hail/Any other (Specify)
Suspected disorder	Insect damage/Disease/Nutritional/Input Phytotoxicity/Any other
Symptoms	Holes/Excreta/Rotting/Blight/Yellowing/Wilting/Mottling/Mosaic/Root swelling/Distortion/Any other
Extent of spread	Less than 25%/25-50%/50-75%/More than 75%
Spread pattern	Whole Crop/Patches/Isolated plants
Crop rotation	Wheat-Rice/Wheat-Cotton/Any other (Specify)
Soil type	Sandy/Loamy sand/Clay/Loam
Soil/Water analysis report	Copy attached/Not attached
Drainage system	Good/Moderate/Poor
Source of irrigation	Canal/Tubewell/Rainfed
Irrigation applied	1/2/3/4/5/More than 5
Industrial plant in adjoining area	Yes/No
If yes,	Distance in Mts.....
Name the Inputs used Dose..... Timing.....
Diagnosis by field functionary (Extension Scientist)	
(Signature and Address of Extension Scientist)	
To be sent to	Director, Extension Education Punjab Agricultural University, Ludhiana.

Appendix - VII

Important Telephone Numbers of Punjab Agricultural University, Ludhiana for the Convenience of the Farmers 0161-2401960 to 2401979

Name/Designation	Telephone Number	
	Office	Mobile
Dr. Jaskarn Singh Mahal Director Extension Education	0161-2401644	----
Dr. Gurmeet Singh Buttar Additional Director Extension Education	0161-2401074	94176-48885
Dr. Gurjinderpal Singh Sodhi Additional Director Extension Education	--	94176-26843
Dr. Tejinder Singh Riar Additional Director Communication	0161-2405731	98142-10269

Help Line Numbers for the Farmers

Kisan Call Centre, Chandigarh		1800-180-1551 (Toll Free)
Seed Shop	419 (Ext. No.)	---
Dr. Surinder Kumar Thind Plant Clinic	417	94630-48181
Dr. Khuswinder Singh Brar Plant Breeding & Genetics	435	94175-77458
Dr. Amarjit Singh Plant Pathology	505	94637-47280
Dr Yuvraj Singh Pandha Entomology	504	98727-44194
Dr. Amit Kaul Agronomy	401	81464-00233
Dr. Rajiv Gupta Soil Science	506	81462-00940
Dr. Dilpreet Talwar Vegetable Science	452	83608-35919
Dr. Jaswinder Singh Brar Fruit Science	303	99158-33793
Dr. Mahesh Kumar Narang FP&PE	446	94173-83464

Dr. Arshdeep Singh Food, Vegetable & Fruit Processing	305	98762-35555
Dr. Rakesh Sharda Soil & Water Engineering	284	98555-45189
Dr. Raj Kumar Economics & Sociology	461	81460-96600
Dr. Tarsem Chand Processing & Food Engineering	384	97790-00640
Dr. Ranjit Singh Landscaping & Floriculture	440	94631-46872
Dr. Dharminder Singh Extension Education	321	98726-12124
Dr. (Mrs.) Neena Singla Rat Management	382	93573-25446
Dr. (Mrs.) Tejdeep Kaur Kaler Bird Management	382	98559-65904
Biocontrol Lab, Ludhiana	320	---
Biocontrol Lab, Abohar	01634-225326	---
Biocontrol Lab, Gurdaspur	01874-220825	---
Biocontrol Lab, Bathinda	0164-212159	---

Phone Number of Heads of Various Departments

Plant Breeding & Genetics	224
Wheat Section	250
Cotton Section	334
Maize Section	437
Oilseed Section	433
Pulses Section	413
Fodder Section	443
Entomology	320
Plant Pathology	319
Agronomy	308
Soil Science	317
Vegetable Science	370
Fruit Science	303
Landscaping & Floriculture	440
Extension Education	321

Farm Machinery & Power Engineering	257
Economics & Sociology	301/461
Microbiology	330
Rats & Birds Control	429

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