

# **production technology of Chilli & Capsicum**



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## CHILLI AND CAPSICUM

*Capsicum annum* L. is the major species commercially grown on large scale. Both chilli and sweet pepper come under the species *C. annum*. Some forms of *C. frutescens* L. are used for their small and very pungent fruits in hot sauces but the species is of relatively minor importance. Generally *C. frutescens* is perennial in nature. The species *C. pubescens* and *C. baccatum* var. *pendulum* are grown on a very small scale. Hot pepper is grown on an area of 0.95 million hectares with the production of 945 thousand tonnes. The major chilli growing states are Andhra Pradesh, Karnataka, Maharashtra, Orissa, Tamil Nadu, Bihar, Uttar Pradesh and Rajasthan. These states account for nearly 80% of area under chillies in India. India is the global leader in the production and export of chillies. Chilli is cultivated for vegetables, spices and pickles. Green fruits are good source of vitamin A and C.

Capsicum or Shimla mirch or bell pepper (*Capsicum annum* L.) is one of the important vegetables grown in India. It bears bell-shaped, non-pungent, mild and thick fleshed fruits. Mid hills of the Himachal Pradesh are the leading suppliers of capsicum during off-season. Green fruits are used as vegetable because they are less pungent. As chilli, it is also rich in vitamin A and C.

The pungency in chillies is due to crystalline volatile alkaloid *capsaicin*, which has good export potentiality. The red colour of chillies is due to the presence of pigment *capsanthin*.

### Varieties of Chilli

Chilli is grown for green fruits, dry fruits, pickles and for export also. The most promising varieties of chilly grown throughout the country are NP46A, Pusa Jwala, Pusa Sadabahar, G-3, G-4, G-5, Pant C-1, Punjab Lal and Kalyanpur Type 1. Among hybrids, the important ones are Agni, HOE-888, HOE-808, BSS-138, BSS-141, CH-1 and ARCH-228. The hybrid CH-1 was developed by utilizing genetic male sterility system at PAU, Ludhiana and has resistance against fruit rot, dieback, CMV and leaf curl virus.

**TABLE 4.6. Important varieties of chilli**

Name of variety	Name of institute	Important characteristics
✓ G-3	Agricultural Research Station, Lam, Guntur	Selection from NP 46A. Fruit 6-7 cm long and 3 cm girth. Immature green and mature red fruit remains smooth after drying. Plant medium with green foliage. Suited for rainfed and irrigated conditions, seed content 14%. Average (dry) yield is 10 q/ha. The leaves are narrow and dark green. Fruits olive green turning dark red on ripening. Seed content 38 to 40%. Fairly tolerant to diseases and insects. Average yield (dry) 11.75 q/ha under rainfed and 50 q/ha under irrigated conditions. Fruit size vary from 7 to 8 cm long and 3-3.5 cm girth.
✓ Bhagyalakshami (G-4)	-do-	A cross of G-2 × Bihar variety. Fruits are short and stout with conical shape. Fruit length is 4 to 5 cm. It is tolerant to thrips.
✓ Andhra Jyoti (G-5)	Agricultural Research Station Lam, Guntur	

Name of variety	Name of institute	Important characteristics
✓ Aparna (CA-1068)	-do-	Plants are tall with more internodal length. Fruits cylindrical and 8.3 cm long and yellow at ripening. High pungency. Average yield (dry) is 21 q/ha.
✓ Sindhur	-do-	Selection from Hot Portoga. Fruits are long (7 to 8 cm) with 4-4.5 cm girth. Pericarp light green turning deep red on maturity. Surface smooth and top is blunt. Seed content 38%, pungency mild. Average fruit yield (dry) 12 q/ha under rainfed condition.
X-235	-do-	Early maturing. Plants spreading with short internodes, leaves small and dark green. Flowers with yellow anthers serve as marker gene. Fruits thin, 5-6 cm long, calyx deeply cup shaped, fruit tip pointed, seed content 45% and highly pungent. Maximum yield (dry) potential upto 75 q/ha.
HC-44	HAU, Hisar	Selection from local material of North Haryana. Plants are medium sized, profusely branched. Fruits are long (8.9 cm), light coloured and turn bright red colour at ripening. Suitable for powder making. High in capsaicin. It can be grown successfully in both high and low temperature conditions. It is tolerant to TMV, CMV and leaf curl diseases. Moderately tolerant to fruit rot, powdery mildew and wilt. Average yield (dry) is 18.5 q/ha.
HC-28	-do-	Plants are medium sized and branched heavily. Fruits borne in clusters. Fruits are medium sized (2-9 cm long), dark green coloured. Black spots are present on the fruits. Fruits are suitable for powder making. It is also tolerant to TMV, CMV, PMV and leaf curl viruses. Average yield (dry) is 17.8 q/ha.
✓ Punjab Surkha	PAU, Ludhiana	Plants are medium tall. Fruits are long (7 cm), green when immature and dark red on maturity. It is suitable for salad and drying. It is tolerant to fruit rot and moderately resistant to mosaic virus.
Punjab Guchhedar	-do-	Plants are medium tall. Fruits are small (5 cm), erect and borne in clusters. It is tolerant to fruit rot, highly resistant to mosaic and tolerant to leaf curl virus.
CH-1	-do-	Plants gain one metre height and have high branching. Plants bear fruits for a long time. Fruits are light green when immature and attain deep colour at maturity. Fruits are medium sized (6.5 cm long). This variety is tolerant to viral and fungal diseases. Fruits are suitable for drying and used as salad.

Name of variety	Name of institute	Important characteristics
✓ Punjab Lal	PAU, Ludhiana	Developed by crossing Perennial × Long Red. Plants dwarf, bushy with dark green foliage. Fruits erect, medium sized (4.25 × 0.79 cm), dark green turning dark red at maturity. Rich in capsaicin (0.7 mg/g), oleoresin, dry matter and red pigment. Resistant to TMV, CMV, leaf curl viruses. Moderately resistant to fruit rot and die back. Average fruit yield (fresh) is 100-120 q/ha.
✓ Solan Yellow	UHF, Solan (HP)	Fruits are 4-5 cm long and borne on the upper side. Fruit colour changes to red ripening. Average yield of green fruits is 75-100 q/ha.
✓ Kalyanpur Type-1	Vegetable Research Station, Kalyanpur (Kanpur)	Fruits are long, top sharp and orange or yellow coloured. Average yield of dry fruits is 12-15 q/ha.
✓ Kalyanpur Type-2	-do-	Fruits are long, sharp top and turn red on maturity. It yields 12-15 q/ha of dry fruits.
✓ Pusa Jwala	IARI, New Delhi	Developed from a cross between NP 46A × Puri Red. Plants dwarf, bushy, light green with broad leaves. Fruit 9 to 10 cm long and thin light green turning light red at maturity. Dry fruit wrinkled and liable to break during packing and transport. Fruit yield (fresh) 75 q/ha. Pungency is high. Fairly tolerant to thrips, mite and aphids.
✓ Pusa Sadabahar	-do-	Plant erect, comparatively tall (60-80 cm). Fruits erect, 6 to 8 cm long and borne in clusters (6 to 14 per cluster). Ripe fruits bright red. Fruit yield (dry) 15-20 q/ha. Resistant to CMV, TMV and leaf curl viruses.
NP 46A	-do-	Plants dwarf, bushy with light green leaves. Fruits 8 to 9 cm long, thin, wrinkled and light green in colour. Turned light red on ripening. Tolerant to thrips and susceptible to viral diseases. Yields 70 to 80 q/ha (fresh).
K-1	Regional Research Station, Kovi (TN)	Selection from Assam type B. Plants tall with long fruits (6.6 cm) with 75 to 80 seeds, red in colour. Smooth surface with pointed tip. Pericarp 0.07 cm thick, capsaicin content is 0.35 mg/g and yields 19 q/ha (dry). More tolerant to thrips and fruit rot than local varieties.
K-2	-do-	Plants tall, semi-spreading type with duration of 210 days. Fruits long (7-8 cm), pericarp thickness 0.19 mm, red in colour, 80-85 seeds with blunt tip. Capsaicin content is 0.49 mg/g and yields (dry) 15 q/ha.
MDU-1	Agricultural College and Research Institute, Madurai (TN)	Developed through mutation utilising gamma rays on seeds of K-1. Plants dwarf, compact, suited for high planting. A closer spacing 30 × 30 cm is recommended. Bear fruits in

<i>Name of variety</i>	<i>Name of institute</i>	<i>Important characteristics</i>
Co-1	TNAU Coimbatore (TN)	cluster (4 to 9 per cluster). Fruits long (8 cm), red coloured, 50 to 60 seed/fruit, crop duration 210 days. High in capsaicin (0.70 mg/g). Yield (dry) on an average is 18 q/ha.
Co-2	-do-	Suited for all three seasons. Duration is 210 days. Fruits 10.7 cm long, bright red in colour.
Pant C-1	GBPUAT, Pantnagar	Selection from Gundu type. Fruits are small (2.4 cm long) with dark red colour. Crop duration is 200 days. Average yield (dry) is 8.7 q/ha.
Pant C-2	-do-	Plants of short duration with more primary branches. Fruits erect, small sized, highly pungent, 6-7 cm long, pericarp thickness 0.09 cm, light green turning light red at maturity. Average yield (dry) 12 q/ha. Tolerant to mosaic and leaf curl virus.
Jawahar 218	JNKV, Jabalpur (MP)	Fruits pendent. Yield (dry) 14 q/ha. Tolerant to mosaic and leaf curl virus.
Jawahar mirch 283	-do-	Plants dwarf, spreading, foliage light green. Fruits erect, good sized (8.5 × 0.92 cm), thin, wrinkled, light green and turned rosy red at maturity. Early and high yielding. Average fruit yield (dry) 18.22 q/ha. Suited for green and red chilli production. Tolerant to leaf curl and fruit rot.
		Developed through selection from local collection. Plants dwarf (40-50 cm), bushy in habit, produce 7-9 primary branches. Fruits straight, firm, medium in length, thin and dark green in colour. Ripe fruits are bright red and pungent. An ideal variety for setting green fruits in summer and improving the storage conditions.

The varieties of chilli suited for different purposes are as follows :

- (i) **Varieties suitable for green chilli production.** Pusa Jwala, NP 46A, Jawahar - 218, X-235.
- (ii) **Varieties suited for salad purpose.** Co-2, Andhra Jyoti (G-5).
- (iii) **Varieties suitable for export as dry chillies.** Punjab Lal, Pant C-1, Co-1, Co-2, Muslabadi, Jawahar 218, Kiran, G-3, G-4, G-5.
- (iv) **Varieties suitable for colouring matter.** Punjab Lal, LCA 206.
- (v) **Varieties suitable for the extraction of capsaicin.** Punjab Lal, Aparna, Kalyanpur Yellow.
- (vi) **Varieties suitable for the preparation of sauce, essence and oleoresin.** Pant C-1, Punjab Lal, X-235, Muslabadi.

### Varieties of Capsicum

Generally California Wonder is grown by the farmers, although Arka Gaurav, Arka Mohini, Arka Basant, Chinese Giant and World Beater have been developed. However, some farmers are growing these varieties also. The promising hybrids produced by private sector are Bharat, Indira, Hira, HOE 801, Early Bonty and Lario. However, farmers are unable to purchase so costly hybrid seed of capsicum.

TABLE 4.7. Important varieties of capsicum

Varieties	Institute	Important characteristics
✓ California Wonder	IARI, New Delhi	Plants vigorous, upright, prolific bearer, fruits 3-4 lobed, medium thick fleshed and dark red coloured.
✓ Yolo Wonder	—	Dwarf, prolific bearer, late, green, blocky, dropping fruited variety. Fruits 3-4 lobed and flesh medium thick.
✓ Bharat	IAHS, Bangalore	Released in 1973. Dark green blocky fruits, 4 lobed and thick fleshed. Average yield 200-250 q/ha. Resistant to TMV.
✓ Chinese Giant	—	Plants vigorous and prolific bearer. Fruits smooth, dark green, 3-4 lobed, thick and sweet fleshed.
World Beater	—	Plants upright. Fruits 4 lobed, thick fleshed, mild and sweet.
✓ Arka Mohini	IIHR, Bangalore	Selection from Titan of USA. Determinate variety with medium to large sized blocky and dropping fruits. Fruits dark green, thick fleshed and 3-4 lobed. Average fruit weight is 80-100 g.
✓ Arka Gaurav	-do-	Selection from Golden Dalwonder of USA. Indeterminate variety. Fruits dark green, blocky, erect, 3-4 lobed and thick fleshed. Fruits are medium sized (70-80 g). It is tolerant to bacterial wilt.
✓ Arka Basant	-do-	Selection from Hungarian variety 'Soroksari'. Fruit creamish white, conical, erect, thick fleshed and prolific bearer. Excellent keeping and cooking qualities. Good export potential. Average fruit yield is 150-200 q/ha.
✓ Pusa Deepti (Kt-1)	IARI Regional Research Station, Katrain (HP)	Hybrid between Yolo Wonder and Russian. High yielding (350-400 q/ha). Fruits are smooth, erect, conical, light green with thick flesh, 9-11 cm long and 3-5 cm in diameter. Early to medium in maturity and becomes ready in 60-75 days after transplanting. It can be grown successfully in spring-summer in hills and Northern plains of India. It is tolerant to bacterial leaf spot and anthracnose.
Punjab-27	PAU, Ludhiana	Plants tall, compact with light green leaves. Fruits pendent, light yellow with conical shape, sweet, medium sized. It is highly suitable for salad, pickles and cooking purposes. Yield 160-180 q/ha.
✓ Solan Hybrid-2	UHF, Solan	Plants tall, prolific bearer, early, fruits 3-4 lobed and resistant to fruit rot and virus.

## Climate

Chillies can be grown both in the Southern and Northern hemispheres from equator to 45° North and South latitude i.e. tropical and sub-tropical regions in areas with over 40°C temperature. It is raised from sea level to 2000 metre above sea level. Chilli is very sensitive to frost. The optimum temperature for fruit set is 24°C. When night temperature goes below 10°C, the fruit set is restricted. Chilli can be grown throughout the year if climate is suitable as this is a day neutral crop. Comparatively milder climatic conditions are preferred for sweet pepper cultivation as compared to hot pepper. Temperature above 23.5°C affects development of fruits adversely. The mild climate favourably affects its yield potential and quality. The climatic conditions of Himachal Pradesh and Southern states are highly favourable for its growth and development.

Fruit weight, length, girth, pericarp thickness and number of seeds per fruit were high at 25°C/18°C day and night temperatures. *Kharif* season is the major season for growing chillies in India. In Northern India, generally two crops i.e. *kharif* and *rabi* are taken. In Southern India, the three crops i.e. *kharif*, *rabi* and *summer* crops are taken. *Kharif* crop is planted in the month of June to July, *rabi* crop in the month of October to November and *summer* crop in the month of January to February.

## Soil and Field Preparation

Chilli can be grown on all types of soils from light sandy to heavy clay. However, light soils are good for an early crop while heavy soils give high yield. The optimum soil pH for chilli is 5.8 to 6.5. Chilli crop is very sensitive to waterlogging. Quality of fruits is better in light soils than in heavy soils.

Thoroughly plough the land 3-4 times to obtain a fine tilth. The last ploughing should be followed by planking to level the field.

## Manure and Fertilizers

Apply 250 q FYM or compost, 150 kg N, 75 kg  $P_2O_5$  and 75 kg  $K_2O$ /ha. Full dose of FYM,  $P_2O_5$  and  $K_2O$  and 1/3 dose of N should be applied at the time of transplanting. The remaining 2/3 N is applied in two equal splits i.e. 5-6 weeks after transplanting at the time of earthing up and 8-10 weeks after transplanting.

## Raising of Nursery

About 10-12 beds of 8 × 1.2 × 0.15 m size are sufficient to raise seedlings for one hectare. Apply 15-20 kg of well rotten farmyard manure and 500 g of 15 : 15 : 15 NPK fertilizer during preparation of nursery bed. Damping off is serious problem in the nursery beds and sometimes it kills completely the young seedlings. Before sowing the nursery soil should be drenched with the Formalin solution (1 part Formaldehyde and 48 parts water) or with the Captan 0.3% @ 5 litre solution/m<sup>2</sup>. After drenching, the beds should be covered with an alkathene sheet for 48 hrs and then open for 43-72 hrs before sowing. About 1-1.5 kg seed is sufficient for one hectare. It would be better if sowing of seed is done 2.5 mm deep in rows 5-7 cm apart. The covering of seed beds with *sarkanda* grass or *puwal* is helpful in maintaining the moisture and temperature of the beds which ultimately improve the germination of seed.

The mulch should be removed after the germination of seeds as it generally takes 10-15 days from sowing. The optimum time of seed sowing for the Northern Indian plains is October-November while February-April is for hills. In the North Indian plains, its seedlings should be protected from cold winds/frost during winters. The small polyhouse made up of polythene sheets and bamboo sticks may be used to protect the seedlings from these abiotic stresses.

## Transplanting

Prepare the land to a fine tilth. Transplanting is done in the evening. The optimum spacing is  $60 \times 45$  cm. Immediate irrigation after transplanting facilitates better plant establishment. Thereafter light and frequent irrigation should be given upto the establishment of the plants.

## Irrigation

Irrigation depends upon the soil type and season. In summers, frequent irrigation is required. Rainy season crop requires less irrigation and it depends upon the intensity of rains. In some areas rainfed crop is also taken. Chilli plants cannot withstand water stagnation and excess moisture, hence, light irrigation and proper drainage is recommended. Water stress restricts fruit set and fruit development, hence, optimum moisture level should be maintained at the time of flowering, fruit set and fruit development. Generally crop is irrigated at an interval of 5-6 days in summers and 9-10 days in winters. Sandy soils require frequent irrigation than clay soils.

## Inter-culture and Weed Control

Gap filling is essential to maintain adequate plant population. It should be done in the evening hours followed by irrigation. Two to three hand-weedings at 20 and 40 days after transplanting are essential. Among the herbicides recommended Fluchloralin, Nitratin, Nitrofen and Alachlor are extensively used for controlling weeds in chilli crop. Pre-plant incorporation (10 days before planting) of Nitratin at 0.5-1.0 kg/ha or Fluchloralin at 0.5-1.0 kg/ha and pre-transplant surface application of Nitrofen at 1-2 kg/ha or Alachlor at 2.5 kg/ha gave good control of weeds in chilli crop.

## Growth Regulators

Unfavourable climatic conditions lead to poor fruit set and fruit drop in chilli. It has been reported by several scientists that fruit set and retention under abiotic stresses may be improved at a great extent by use of different growth hormones. Spray of NAA at 50 ppm at the time of flowering improved fruit set and fruit retention. The use of growth regulators in Solanaceous vegetables has been given in Table 4.8.

TABLE 4.8. Use of growth regulators in Solanaceous vegetables

Plant growth regulators	Concentration (ppm)	Method of application	Crop	Attributes affected
Gibberellic acid	10-20	Foliar spray	Tomato	Higher yield at low temperature.
	40-100	Foliar spray or seed treatment	Tomato, brinjal	Increase seed germination and fruit set.
Cycocel (CCC)	500	Root dipping and foliar spray	Tomato	Control leaf curl virus, increase fruit and yield.
	250	Root dipping	Tomato	Induce salt tolerance.
Ethephon	100-500	Foliar spray	Tomato	Increase flowering, fruiting and yield.
	1000	Pre-harvest spray	Tomato	Accelerate fruit ripening.
PCPA	2000	Post-harvest spray	Chillies	Accelerate fruit ripening.
	50-100	Foliar spray at flowering stage	Tomato	Increase fruit set at low and high temperatures
Planofix	10-20	-do-	Tomato, chillies	Reduce flower and fruit drop.

## Harvesting

Chilli is mainly grown for ripe fruits whereas bell pepper is grown for green fruits. Green fruits are harvested when they are still green in colour at 60 days after transplanting and dry fruits 90 days after transplanting. Generally 5 to 6 pickings are made for green chillies while two to three pickings for red ripe fruits.

## Yield

	<i>Rainfed</i>	<i>Irrigated</i>
Green chillies	50-60 q/ha	200-300 q/ha
Dry chillies	5-6 q/ha	<u>20-30 q/ha</u>

## Physiological Disorders/Production Constraints

✓ **Blossom end rot.** It is characterised by the appearance of water soaked spots on the blossom end of the fruit. They turn light brown and papery as they dry. Application of heavy irrigation after a moisture stress condition and heavy fertilization of nitrogen are the main causes of this disorder.

### Control

1. Supply light irrigation regularly.
2. Locate the soil having good water retention capacity.
3. Avoid heavy application of nitrogenous fertilizers.

✓ **Sun scald.** Soft, light coloured and slightly wrinkled areas appear on the fruit surface. Later these areas become slightly sunken and papery. It is caused when the fruits are exposed to intense sunlight.

### Protection Measures

1. Transplant the seedlings at closer spacing.
2. Grow the varieties having abundant foliage.
3. Raise the crop with high density.
4. Control defoliating insect pests and diseases.

✓ **Flower and fruit drop.** It is a major limiting factor in chilli cultivation. Flower and fruit drop in chilli may be due to the following reasons :

1. High temperature and low humidity at flowering cause excessive transpiration, which results in abscission of buds, flowers and fruits.
2. Low light intensity.
3. Short day and high temperature.

### Control

1. Give light and frequent irrigations at flowering and fruit set stages.
2. Spray the crop either NAA 50 ppm or tricontanol 2 ppm at full bloom stage.

## INSECT PESTS

**Thrips (*Scirtothrips dorsalis*).** The larvae and adults suck the sap of leaves, buds, flowers and cause curling of leaves.

### Control

Spray Dimethoate (0.03%) or Monocrotophos (0.03%) at 15 days interval.

**Aphid (*Aphis gossypii*, *Myzus persicae*).** They suck the cell sap from leaves and tender points.

**Control**

Spray the crop with Methyl Demeton (0.025%) or Monocrotophos (0.03%) or Dimethoate (0.03%).

**White fly** (*Bemisia tabaci*). The insect suck the cell sap of growing leaves and also spread leaf curl disease.

**Control**

Spray malathion (0.1%) or monocrotophos (0.03%) during active period.

**Fruit borer** (*Spodoptera litura*). It is polyphagous in nature and caterpillars feed gregariously on leaves and scrap them.

**Control**

Spray the crop with Cypermethrin (0.05%) or Carbaryl (0.2%) at 15 days interval.

**DISEASES****Fungal Diseases**

**Damping off** (*Phythium aphanidermatum*, *Rhizoctonia solani*, *Fusarium* spp. and *Phytophthora* spp.). Infected seedlings topple down on the ground. Seedlings are killed both at pre- and post-emergence stages.

**Control**

1. Treat the seed with Captan or Thiram @ 2 g/kg seed.
2. Treat the nursery beds with Formalin (1 part : 7 parts water) and cover the treated beds with polythene sheets 15-20 days before sowing.
3. Drench the nursery beds with a mixture of Dithane M-45 (0.25%) and Bavistin (0.1%).
4. Avoid water stagnation in rainy season.

**Ripe fruit rot, dieback and anthracnose** (*Colletotrichum capsici*). Black water soaked spots appear on leaves which gradually turn brown to black in colour. Dieback is usually observed after the rains have stopped and prolonged deposition of dew on the plants.

**Control**

1. Use disease free seed.
2. Seed treatment with Thiram or Dithane M-45 @ 2 g/kg seed.
3. Spray Dithane M-45 (0.25%) or Blitox (0.1%) or Bavistin (0.1%) and repeat at 8-10 days interval.

**Fruit rot** (*Phytophthora capsici*). Water soaked dirty grey spots appear on the fruits which are covered with white layer of fungus and finally rot completely.

**Control**

Same as dieback.

**Powdery mildew** (*Leveillula taurica*). Initially small circular whitish spots are formed on both the surfaces of leaves. Finally the entire leaf is covered by dirty white growth of fungus.

**Control**

Spray the crop with Karathane 0.2% at 15 days interval.

**Leaf spot (*Cercospora capsici*).** The disease is characterised by the formation of small circular and water soaked spots on the leaves, stems and petioles. Leaves turn yellow and finally drop.

#### Control

1. Remove severely affected plants and destroy them.
2. Treat the seeds with Thiram @ 2 g/kg seed.
3. Spray Bordeaux mixture (1%) or Bavistin (0.1%) at 15 days interval.

**Blight (*Alternaria solani*).** Dark and leathery spots appear on the leaves and defoliation occur.

#### Control

Spray the crop with Dithane M-45 (0.2%) and repeat at 10 days interval.

#### Bacterial Disease

**Bacterial leaf spot (*Xanthomonas vesicatoria*).** The important characteristic of the disease is the development of small dark and greasy spots on the leaves, petioles and stems and water soaked spots on the green fruits. Spots remain light brown and slightly sunken towards the centre.

#### Control

1. Use disease free seeds.
2. Seed treatment with hot water at 50°C for 25 minutes.
3. Remove the affected plants.
4. Destroy weed hosts.
5. Spray the crop with Streptomycin 200 ppm + copper oxychloride (0.03%) thrice during October-November at 15 days interval.

#### Viral Diseases

**Mosaic.** It is caused by tobacco mosaic virus (TMV). Chlorosis, mottling, green vein-bending, ring spotting, line pattern, thickening of leaf veins, puckering and clustering of infected leaves. Stunting of plants, flower dropping and fruit deformities are also frequently observed. The virus is transmitted by *Aphis craccivora*, *A. gossypii* and *M. persicae*.

#### Control

1. Grow tolerant varieties like Punjab Lal, Perennial and Gauhati Black.
2. Grow barrier crops like maize or amaranthus to reduce the incidence.
3. Spray Malathion (0.1%) or Methyl Demeton (0.2%) or Phosphamidon (0.05%) at 10 days interval to control vector (aphid).

**Leaf curl.** It is a viral disease and characterised by curling, twisting, crumpling and smalling of leaves. Plants remain stunted and devoid of fruits. White fly (*Bemisia tabaci*) is responsible for the transmission of disease.

#### Control

1. Rogue out infected plants and weeds from the field.
2. Grow nursery in the disease free area.
3. Apply Phorate @ 1.25 kg a.i./ha followed by Carbofuran @ 1.25 kg a.i./ha in the nursery.
4. Spray the crop with Dimethoate (0.05%) or Monocrotophos (0.05%) at 10 days interval.