

Chickpea Seed Production Manual



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Abstract

Although a wide range of improved chickpea cultivars are now available, many farmers still continue to grow old varieties and landraces. Thus, the achievements of chickpea improvement research have not fully translated into increased productivity at the farm level. The productivity of chickpea can be substantially enhanced by adoption of improved cultivars and associated improved production technologies. It is often seen that the farmers who do not adopt improved cultivars are also reluctant to adopt improved crop production technologies. Thus, improved cultivars provide an efficient vehicle for transfer of other improved crop production technologies. Studies show that farmers' lack of access to seed of new varieties is a major cause of non-adoption of new cultivars. There is an urgent need to enhance seed production of improved cultivars to ensure adequate availability of quality seed to the farmers at local level and at affordable price. Because of the minor role of the private sector in seed production of legumes, the informal seed system (seed production by non-government organizations, farmers' groups and individual farmers) plays a significant role in increasing availability of quality seed and adoption of improved cultivars. This manual provides comprehensive information on improved seed production technologies for growing a healthy seed crop of chickpea and storage of chickpea seed. The manual will be useful to all chickpea seed growers involved in formal and informal seed systems.

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Chickpea Seed Production Manual

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Chickpea Seed Production Manual

Chickpea

Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the third largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). Chickpea is grown in more than 50 countries (89.7% area in Asia, 4.3% in Africa, 2.6% in Oceania, 2.9% in Americas and 0.4% in Europe). India is the largest chickpea producing country accounting for 64% of the global chickpea production (Fig. 1). The other major chickpea producing countries include Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico and Iraq. During the triennium 2004-2007, the global chickpea area was about 11.0 m ha with a production of 8.8 m tons and average yield of nearly 800 kg ha⁻¹.

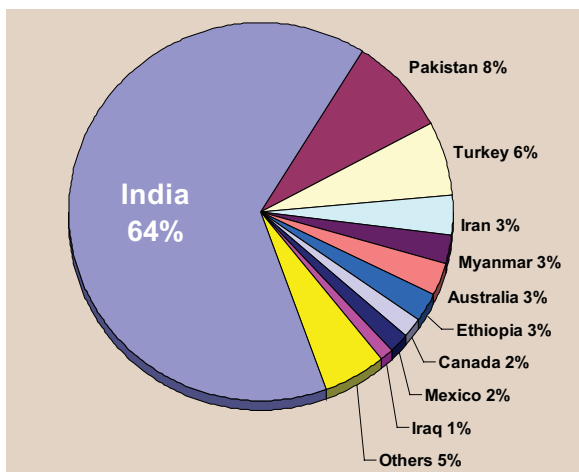


Figure 1. Share of different countries in global chickpea production (2004/05 to 2006/07).

Chickpea is an important source of protein for millions of people in the developing countries, particularly in South Asia, who are largely vegetarian either by choice or because of economic reasons. In addition to having high protein content (20-22%), chickpea is rich in fiber, minerals (phosphorus, calcium, magnesium, iron and zinc) and β -carotene. Its lipid fraction is high in unsaturated fatty acids.

Chickpea plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. Chickpea meets 80% of its nitrogen (N) requirement from symbiotic nitrogen fixation and can fix up to 140 kg N ha⁻¹ from air. It leaves substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improve soil health and fertility. Because of its deep tap root system, chickpea can withstand drought conditions by extracting water from deeper layers in the soil profile.

Types of chickpea

Two distinct types of chickpea are recognized.

Desi chickpea: Chickpeas with colored and thick seed coat are called desi type. The common seed colors include various shades and combinations of brown, yellow, green and black. The seeds are generally small and angular with a rough surface. The flowers are generally pink and the plants show various degrees of anthocyanin pigmentation, although some desi types have white flowers and no anthocyanin pigmentation on the stem. The desi types account for 80-85% of chickpea area. The splits (*dal*) and flour (*besan*) are invariably made from desi type.

Kabuli chickpea: The kabuli type chickpeas are characterized by white or beige-colored seed with ram's head shape, thin seed coat, smooth seed surface, white flowers, and lack of anthocyanin pigmentation on the stem. As compared to desi types, the kabuli types have higher levels of sucrose and lower levels of fiber. The kabuli types generally have large sized seeds and receive higher market price than desi types. The price premium in kabuli types generally increases as the seed size increases.



Figure 2. Desi (left) and kabuli (right) type chickpea.

General plant characteristics

Chickpea is a herbaceous annual and the plant height generally ranges from 30-70 cm. It has tap root system, which is usually deep and strong. The lateral roots develop nodules with the symbiotic *Rhizobium* bacteria, capable of fixing atmospheric nitrogen in plant-usable form. The nodules (slightly flattened, fan-like lobes) are visible about one month after plant emergence, and generally confined to the top 15 cm of the surface.

The leaves are imparipinnate with serrated leaflets and arise alternatively from the third node. The number of leaflets varies from 5 to 17. Some varieties have simple leaves.

The entire surface of the plant shoot, except the corolla, is densely covered with fine hairs known as trichomes. Many are glandular and secrete a highly acidic substance containing malic, oxalic and citric acids. These acids play an important role in protecting the plant against insect-pests.

The plants have primary (generally 1-8), secondary and tertiary branches. Five growth habits, based on angle of branches from the vertical, are classified: erect, semi-erect, semi-spreading, spreading and prostrate. The erect and semi-erect varieties enable mechanical harvesting.

Climatic requirement

Chickpea is a cool season food legume and grown as a winter crop in the tropics and as a summer or spring crop in the temperate environments. It likes cool, dry and bright weather. Temperature, day length and availability of moisture are the three major abiotic factors affecting flowering. In general, flowering is delayed under low temperatures and also under short-days. Genetic variability exists in chickpea germplasm for response to variation in day length (photoperiod sensitivity) and also for response to variation in temperature (thermal sensitivity) and has been exploited in development of short-duration cultivars. Chickpea is sensitive to high (maximum daily temperature $>35^{\circ}\text{C}$) as well as low (mean of maximum and minimum daily temperatures $<15^{\circ}\text{C}$) temperatures at the reproductive stage. Both extremes of temperatures lead to flower drop and reduced pod set.

Plant growth and development

Seedling emergence: Chickpea seedlings have hypogeal emergence, ie, their cotyledons remain underground, while providing energy to the rapidly growing roots and shoots. Emergence occurs in 7-15 days after sowing, depending on soil temperature and sowing depth.

Plant growth: Chickpea has an indeterminate growth habit in which vegetative growth continues even after the start of flowering. Hence, there is often a sequence of leaf, flower bud, flower and pod development along each branch. The duration of vegetative growth before flowering generally ranges from 40 to 80 days depending on the variety, location, availability of soil moisture and weather conditions. A number of pseudo-flowers or false flower buds develop during the changeover from leaf buds to flower buds on the stem. Excessive vegetative growth is a problem of long growing season environments, as in northern and eastern India when soil moisture and temperature conditions remain favorable during the early reproductive growth stages.

Pollination and fertilization: Chickpeas have typical papilionaceous flowers. Most cultivars produce a single flower at each flowering node. A few cultivars with two flowers per node (twin or double flowered) are also found. The flowers are pink, white or blue in color.

Anthesis in chickpea takes place throughout the day. Anther dehiscence occurs inside the bud 24 h before the opening of the flower. Thus, chickpea flowers are truly cleistogamous and self-fertilized. After dehiscence the anthers become shriveled while the standard and wing petals are fully expanded. Under favorable conditions, the time taken from fertilization to the first appearance of pod (pod set) is about 6 days.

Maturity: After pod set, the pod wall grows rapidly for the first 10 to 15 days while seed growth occurs later. Soon after development of pods and seed filling, senescence of subtending leaves begins. If there is plenty of soil moisture, flowering and podding will continue on the upper nodes. Chickpea can tolerate high temperature if there is adequate soil moisture. Chickpea is ready to harvest when 90% of the stems and pods lose their green color and turn light golden yellow.

Seed Systems in India

Good quality genetically pure seed of high-yielding varieties is a critical input in crop production for obtaining high yields. Inadequate availability of seed of improved cultivars in food legumes has been a major bottleneck in adoption of improved cultivars by the farmers.

Government of India (GOI) established the National Seeds Corporation (NSC) in 1963 to improve availability of quality seed to farmers. The Seeds Act was introduced in 1966 and the New Policy on Seeds Development in 1988 to promote the growth of the seed industry. The Seeds Act stipulated that seeds should conform to the minimum prescribed standards of physical and genetic purity, and assured percentage germination either by compulsory labeling or voluntary certification. The National Seed Policy 2002 envisaged a symbiotic relationship between the public and private sector. The establishment of Protection of Plant Varieties and Farmers Rights Authority in 2005 for protection of rights of farmers and plant breeders is expected to promote investment in the development of new varieties.

Seed classes

The following four classes of seed are recognized in India:

1. Nucleus seed: It is produced from the basic seed stock available with the breeder. True to type plants are selected individually from the space-planted basic seed stock. The number of selected plants will depend upon the quantity of nucleus seed to be produced taking into account the seed multiplication ratio. The selected plants are grown as progenies, and the progenies that differ from the cultivar in one or more characters are eliminated and the remaining progenies are harvested as bulk to constitute nucleus seed.

2. Breeder seed: It is produced from nucleus seed under direct supervision of a qualified plant breeder. The breeder seed is labeled with a golden yellow colored tag and serves as the source for the initial and recurring increase of foundation seed. The Indian Council of Agricultural Research (ICAR) institutes and the state agricultural universities (SAUs) have the primary responsibility for the production of breeder seed as per the indents received from different agencies.

The State Governments and the National and the State Seed Corporations are required to submit indent of nationally released varieties to the Seed

Division of the Department of Agriculture and Cooperation (DAC), Ministry of Agriculture, Government of India; and of state released varieties to the respective SAUs by 15 June for the subsequent postrainy season. The private seed companies are required to submit their indent through National Seeds Association of India (NSAI) to the Seeds Division of DAC.

3. Foundation seed: This is the progeny of breeder seed or occasionally of Foundation seed stage I produced under the supervision of the breeder or any designated agency and under the control of a seed quality control agency. Foundation seed produced directly from the breeder seed is designated as foundation seed stage-I, while foundation seed produced from foundation seed stage-I is designated as foundation seed stage-II. Foundation seed stage-II is not used for further increase of foundation seed. The minimum seed certification standards shall be the same for both these classes of foundation seed, unless otherwise prescribed. White color tags are used for both classes of foundation seed.

4. Certified seed: This is the class of seed produced from foundation seed and certified by a seed certification agency notified under section 8 of the GOI Seeds Act, 1966. Certified seed can be used to produce certified seed or can be planted by the farmers for commercial cultivation. Only notified varieties are eligible for entering into formal seed system and production of certified seed. Certified seed production is mainly undertaken by the National and State Seed Corporations. However, state agricultural universities, public and private sector seed enterprises, authorized farmers' organizations and registered seed growers can also produce certified seed from the stock of foundation seed. The color of tag for the certified seed is blue.

Truthfully labeled seed

Progressive seed growers produce the seed of released varieties, maintaining a sufficient level of genetic purity by adopting the recommended package of practices and sell it to the farmers as 'Truthfully labeled (TL) seed'. Similarly, the private seed companies can also breed new high yielding varieties and sell their seed under their own trade name under this category. In case of chickpea and other legumes, where the seed multiplication ratio is low, the informal seed sector plays a significant role in supplying good quality seed to the farmers.

Informal seed system

The informal seed system supplies farmer-saved seeds of local improved cultivars or adapted released varieties, and forms the backbone of seed supply in most of the developing countries. In India, 80 percent of the farmers rely on farm-saved seed. The informal seed system is characterized by lack of functional specialization and quality control. In the informal seed system, the seed is produced by non-governmental organizations (NGOs), community groups and farmers' cooperatives, seed growers associations, and individual farmers.

The success of informal seed systems depends on the assurance of the quality by the producer as no external agency is officially involved in seed certification. Therefore, it is essential that the seed producers follow proper seed production guidelines to avoid contamination. The producer should get fresh source seed after every 3-4 years, as the genetic purity of a cultivar may deteriorate due to mechanical mixtures during seed production, processing and storage.

Minimum standards for foundation and certified seed in chickpea

Each crop has different field and seed standards for production of foundation and certified seed. These variations are mainly because of the variation in extent and the mode of cross pollination. The field and seed standards for chickpea are given in Table 1.

Table 1. Minimum field and seed standards for chickpea seed production in India.

Parameter	Seed class	
	Foundation	Certified
Isolation distance (m)	10	5
Number of field inspections	2	2
Germination (including hard seed) (%)	85	85
Pure Seed (%)	98	98
Inert matter (%)	2	2
Plants affected by seed-borne diseases (%)	0.1	0.2
Off-types (%)	0.1	0.2
Other crop seeds (number kg ⁻¹)	None	5
Other distinguishable variety seeds (number kg ⁻¹)	5	10

Seed Production Technology

A crop grown for seed production requires extra efforts and investments than a crop grown for grain. While taking up seed production, high priority should be given to maintenance of genetic and physical purity of the seed.

Crop season and sowing time: Chickpea is grown in *rabi* (postrainy season) following a *kharif* (rainy season) crop or *kharif* fallow. The sowing is done in the month of October or November. Late sowing (December-January) should be avoided as the late-sown crop may experience moisture stress and high temperatures at the critical stage of pod-filling, leading to reduced yield and seed quality.

Isolation distance: Isolation of a seed crop is done by maintaining a distance from other nearby fields of the same crop and other contaminating crops. Chickpea being a self-fertilized crop has a very low outcrossing percentage (0-1%). In India, an isolation distance of 10 m for foundation seed and 5 m for certified seed is required.

Suitable soil type: Chickpea can be successfully grown in a variety of soil types including coarse-textured sandy to fine-textured deep black soils (vertisols). However, the best suited soils are deep loams or silty clay loams with a pH ranging from 6.0 to 8.0. Saline soil and fields with a high water table are not suitable for chickpea.

Field preparation: Chickpea plants are highly sensitive to poor aeration in the soil. Seedling emergence and plant growth are hindered if field surface is compact. Therefore, the field should have loose tilth and good drainage. The stubble and debris from the previous crop should be removed as these can harbor the pathogens that cause root diseases, such as collar rot.

Sowing: Sowing is usually done on conserved soil moisture. A pre-sowing irrigation may be needed, if the available soil moisture is not adequate for germination. Kabuli chickpea should never be irrigated immediately after sowing, particularly in deep black soils. This is because the kabuli chickpea seeds have thin seed coat and deteriorate faster as compared to desi type and are also more susceptible to seed rot and seedling damping off.

Sowing depth: Seed should be sown deeply enough to make contact with moist soil. A depth of 5-8 cm seems to be ideal for the emergence of chickpea.

Spacing: Line sowing is a must in the crop grown for seed production as it facilitates interculture operations, rouging and field inspection. Row-to-row spacing of 30 cm and plant-to-plant spacing of 10 cm are generally used, which give a plant population of about 33 plants per m² (330,000 plants ha⁻¹). Wider row spacing (45–60 cm) can be used in large seeded kabuli chickpea and irrigated crops (both desi and kabuli types), which are expected to have greater plant width. Broadbed and furrow system or ridge and furrow system are very useful for irrigation, drainage and interculture operations and are widely used at ICRISAT.

Seed rate: It differs from variety to variety, depending on seed size. For initial seed multiplication of a new variety, the multiplication rate (yield per plant) is more important than yield per unit area. The following guidelines may be used for seed rate:

<u>Seed size (100-seed weight)</u>	<u>Seed rate</u>
Small (less than 20 g), eg, JG 315	50 – 60 kg ha ⁻¹
Medium (20 – 30 g), eg, JG 11, JG 130, JAKI 9218	60 – 90 kg ha ⁻¹
Large (30 – 40 g), eg, KAK 2, Vihar, LBeG 7	90 – 120 kg ha ⁻¹
Extra-large (more than 40 g), eg, JGK 3	120 – 150 kg ha ⁻¹

Seed treatment: The seeds should be treated with fungicides (2 g thiram + 1 g carbendazim kg⁻¹ seed) before sowing for reducing seed and soil borne fungal diseases. Phosphorus solubilizing bacteria (PSB) have been identified, which improve availability of phosphorus to plants. Thus, seed treatment with PSB is recommended. If chickpea is being grown for the first time, the seeds should be inoculated with *Rhizobium* culture. The seeds should be treated first with fungicides and then with PSB and *Rhizobium*, following the procedure recommended by suppliers. The culture-treated seeds should be dried in the shade and sown as soon as possible thereafter. If the seed is to be treated with pesticides, always apply insecticides first, followed by fungicides, and finally *Rhizobium* culture/phosphate solubilizing bacteria or follow instructions on the packets.

Fertilizer application: Fertilizer requirements depend on the nutrient status of the field, and thus, vary from field to field. Therefore, the doses of fertilizers should be determined based on the results of soil test.

The generally recommended doses for chickpea include 20–30 kg nitrogen (N) and 40–60 kg phosphorus (P) ha⁻¹. If soils are low in potassium (K), an application of 17 to 25 kg K ha⁻¹ is recommended. There will be no response to application of K in soils with high levels of available K. Total quantities of N, P and K should be given as a basal dose. Foliar spray of 2% urea at flowering has been found beneficial in rainfed crops.

Micronutrients: Intensive cropping without application of micronutrients, limited or no application of organic fertilizers and leaching losses lead to deficiency of one or more micronutrients in the soil. The important micronutrients for chickpea include sulphur (S), zinc (Zn), iron (Fe), boron (B) and molybdenum (Mo). The requirements of these micronutrients vary from field to field and should be determined based on the results of soil analysis.

Sulphur (S): Soil application of 20 kg S ha⁻¹ through single super phosphate (SSP), gypsum or pyrite has given encouraging results in sulphur-deficient soils.

Zinc (Zn): Zinc deficiency generally occurs in soils with a high pH and in areas under rice - chickpea cropping system. It is common in the sandy loam soils of northern India. Zinc application enhances root growth, nodulation and nitrogen content of nodules. The symptoms of zinc deficiency are yellowing and then bronzing and necrosis of middle and lower leaves. Basal application of Zinc Sulfate (ZnSO₄) at 10-25 kg ha⁻¹ has been found to give positive response. Foliar application of 0.5% Zinc Sulfate mixed with 0.25% lime was also effective in correcting zinc deficiency.

Iron (Fe): Iron deficiency is a complex physiological disorder of plants growing on calcareous soils with high pH. Typical symptoms of Fe deficiency are yellowing of young, newly formed leaves that dry and fall off prematurely in case of acute deficiency. Soil application of Fe is usually uneconomical due to reversion to unavailable forms. Foliar spray of 0.5% (w/v) ferrous sulphate has been found effective in correcting iron deficiency.

Boron (B): Boron deficiency has been reported in India in the states of Orissa, Bihar, Uttar Pradesh and Gujarat. Strongly weathered, coarse textured and shallow soils are generally deficient in boron. The critical concentration of

boron in soils is 0.5 ppm. The symptoms of boron deficiency include severe chlorosis and bleaching of leaves followed by tissue necrosis. The leaflets become curled and finally dry up. There is reduction in the number of flowers, which also lack pigmentation. Soil application of 1.0-2.5 kg Borax ha⁻¹ or foliar application of 0.25 kg Borax ha⁻¹ helps in correcting Boron deficiency.

Molybdenum (Mo): The availability of molybdenum is often low in high clay soils (vertisols of Madhya Pradesh and Gujarat in India) and laterites, but it is high in saline and alkaline soils. Thus, both deficiency and toxicity of molybdenum are encountered. Toxicity symptoms appear at an earlier stage (32 DAS) than deficiency symptoms (45 DAS). Molybdenum deficiency causes reduction in the number and size of flowers and many of them fail to mature leading to lower seed yield. Seed treatment with 3.5 g sodium molybdate has been found to have beneficial effect in chickpea. The response to molybdenum was greater when applied along with P and *Rhizobium* inoculation.

Irrigation: Chickpea is generally grown as a rainfed crop, but two irrigations, one each at branching and pod filling stages, are recommended for higher yield. Higher number of irrigations may lead to excessive vegetative growth in heavy soils.

Weed management: Chickpea is a poor competitor with weeds at all stages of growth. Pre-emergence herbicides, such as Fluchloralin @ 1 kg a.i. ha⁻¹ or Pendimethalin @ 1.0 to 1.5 kg a.i. ha⁻¹ were found effective in controlling early flush of weeds. Mechanical and/or manual weeding can be done where wide row spacing is used.

Plant protection: Chickpea being a rich source of protein, is prone to damage by insect-pests and diseases. In general, root diseases (fusarium wilt, collar rot and dry root rot) are more prevalent in central and peninsular India, whereas foliar diseases (ascochyta blight, botrytis gray mold) are important in northern, north-western and eastern India. Among the insect pests, pod borer (*Helicoverpa armigera*). is the most severe yield reducer throughout India in the field, while bruchids (*Callosobruchus chinensis*) cause severe damage in storage.

Management of diseases

Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceri*): It is a vascular disease that causes browning and blackening of xylem. Affected seedlings first show drooping of the leaves, then collapse. The roots look healthy but when split vertically the vascular tissues show brown to black discoloration. The fungus is seed and soil borne and can survive in the soil in the absence of the host.

Management: Use resistant varieties (eg, JG 11, JAKI 9218, JG 130, KAK 2, JGK 1, JGK 2). Deep ploughing during summer and removal of host debris from the field can reduce the level of inoculum. Exclude chickpea from the crop rotations in infested fields for at least 3 years. Seed treatment with *Trichoderma viride* @ 4 g kg⁻¹ seed has been found effective in reducing incidence of wilt.



Figure 3. Symptoms of fusarium wilt.

Collar rot (*Sclerotium rolfsii*): It is becoming a serious problem in central and peninsular India. High soil moisture, the presence of under decomposed organic matter on the soil surface, low soil pH and high temperature (25 to 30°C) favor the disease. The collar region of the chickpea plant is constricted and begins to rot. White mycelial strands with minute mustard seed-sized



Figure 4. Symptoms of collar rot.

sclerotial bodies are seen growing over the affected tissue. The affected seedlings turn yellow and wilt.

Management: Treat seeds with fungicides as suggested above, follow long term crop rotations with cereals such as wheat, sorghum and millets, and remove undecomposed debris from the field before sowing.

Dry root rot (*Rhizoctonia bataticola*): It is a serious disease under moisture stress conditions and when the crop is exposed to temperature above 30°C. The disease generally appears around flowering and podding stage. The whole plant dries up and turns straw-colored. Roots become black and brittle and have only a few lateral roots or none at all.



Figure 5. Symptoms of dry root rot.

Management: Follow crop rotation. Seed treatment with fungicides can reduce initial development of the disease. Timely sowing should be done to avoid post-flowering drought and heat stresses, which aggravate the disease.

Ascochyta blight (*Ascochyta rabiei*): It is a potentially devastating disease in northern and northwestern India where relatively low temperatures along with wet weather prevail during the crop season. Appearance of this disease is not regular and often depends on winter rains. Symptoms of disease usually appear around flowering and podding time as patches of blighted plants in the field. Typical circular spots appear on leaves and pods, elongated lesions on stem, and deep cankerous lesions on seeds.

Management: Use resistant varieties (eg, PBG 1, BG 267, GNG 146). Do not use seed harvested from ascochyta-infested crop. Treat seed with fungicides, practice crop rotation, deep ploughing of chickpea fields to bury infested debris and remove remaining debris from the field. Seed treatment with carbendazim and thiram (1:1) combined with 2-3 sprays of captan, mancozeb or chlorothalonil @ 2-3 g L⁻¹ water can effectively manage the disease.

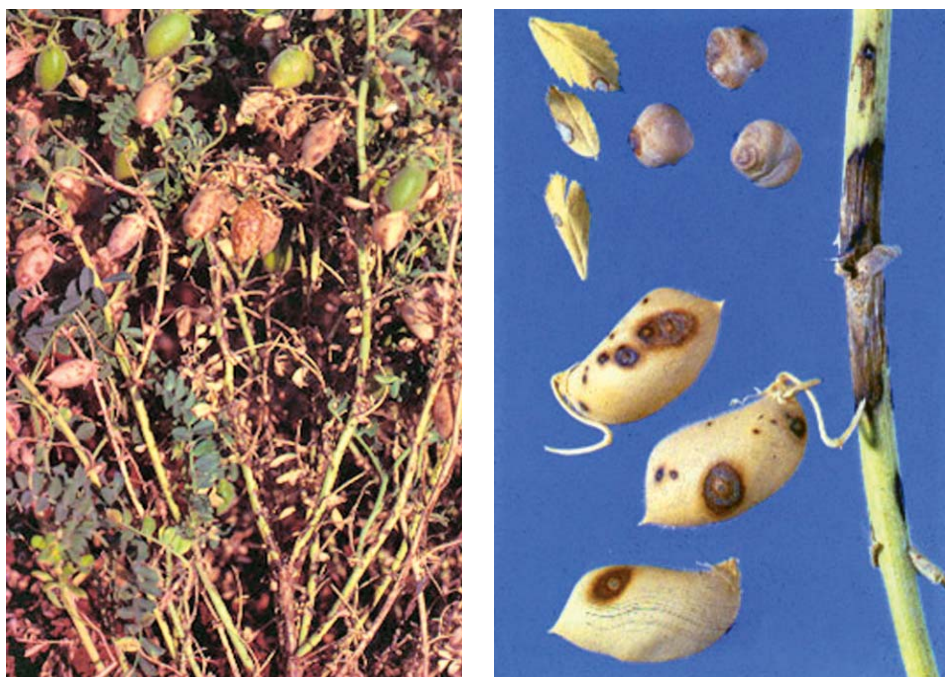


Figure 6. Symptoms of ascochyta blight.

Botrytis grey mold (*Botrytis cinerea*): It is an important disease in north-eastern regions of India. Leaves become yellow followed by defoliation. Water soaked lesions and rotting of terminal buds with moldy growth are the main foliage symptoms. The disease can cause flower drop resulting in poor pod setting, and extension of the crop duration.

Management: Use resistant varieties. Adopt wider spacing (45 to 60 cm) or thin out an infected crop to allow more light to penetrate the canopy. Intercrop with a crop such as linseed, which is resistant to the pathogen. Foliar sprays of captan, carbendazim, chlorothalonil or mancozeb at regular intervals (2-3 times) with first appearance of the disease can control an epidemic and further spread of the disease.

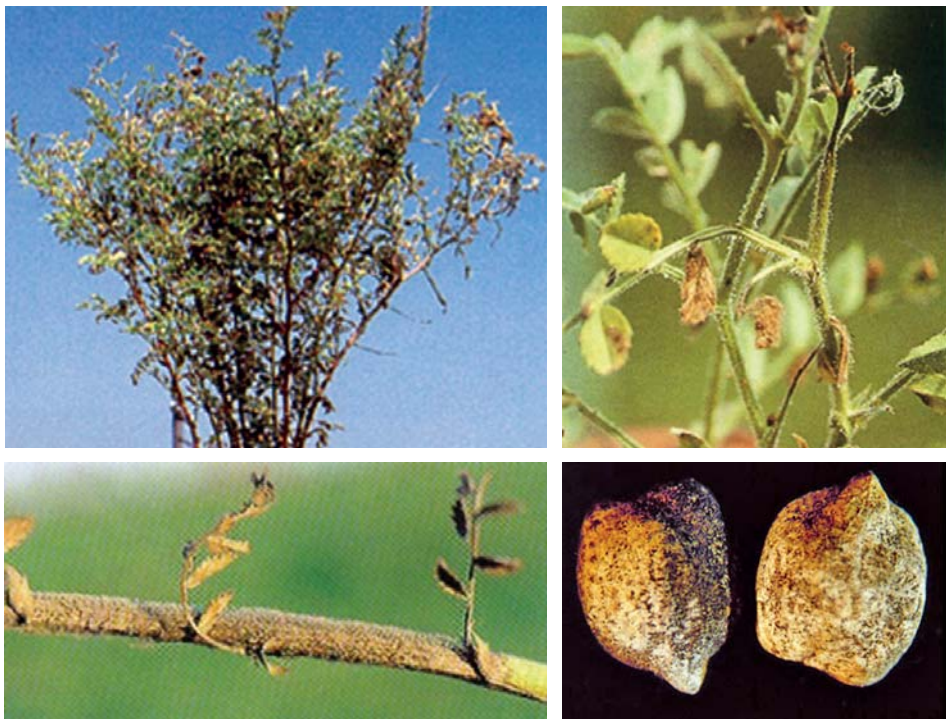


Figure 7. Symptoms of botrytis grey mold.

Management of insect pests

Pod borer (*Helicoverpa armigera*): It is the most important pest of chickpea in all the chickpea growing areas. It damages almost all the pods in case of severe damage, but causes nearly 20-30% annual yield losses in India.

The eggs (1 mm diameter) are laid singly on the leaflets, flowers, immature pods and stem. Larvae can be green, brown, yellow, or pink, but are usually striped, irrespective of their color. Larvae feed on leaves during the vegetative phase and on flowers and pods during the reproductive phase. The third- to fifth-instar larvae feed on the developing seed after making a hole in the pods.

Management of pod borer: Varieties with high levels of resistance to pod borer are not available, but released varieties such as ICCV 10 and Vijay suffer low damage. Though pod borer can be effectively controlled through application of insecticides, an integrated pest management (IPM) strategy is recommended as it is eco-friendly, does not eliminate natural enemies of pod borer, reduces pesticide residues, and the risk of development of resistance to insecticides.

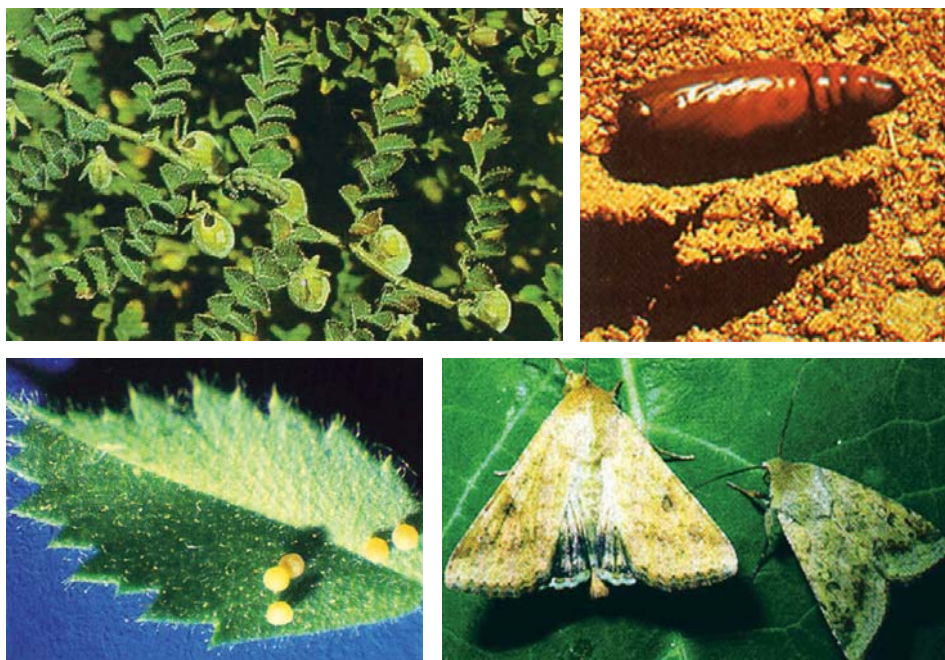


Figure 8. Pod borer (*Helicoverpa armigera*): larva and pods damaged by larva (top left), eggs (bottom left), pupa (top right) and moth (bottom right).

Population monitoring: Monitoring of *H. armigera* population in the field is a prerequisite for successful plant protection. Sex pheromone traps are used to monitor the pest population build-up. Pheromones are specific to individual species. These traps are of different shapes or colors and can be placed at different heights depending upon insect activity and crop architecture. In chickpea, these are placed at 1 m height from the ground level immediately after sowing. The pheromone traps are not useful in controlling the pest directly, but provide an estimate of the pest population, and are an effective tool for timely use of control measures.

Visual observations should regularly be made on the larval population in the field. The action threshold is 1-2 larvae (2nd to 3rd instars) per meter row. To count the larvae, one should observe 10 plants at random at five locations diagonally across the field, and calculate mean larval density to decide on use of control measures to be adopted.

Control measures

- Early sowing, especially of short-duration varieties is helpful in avoiding pod borer damage in northern India.
- Intercropping coriander with chickpea provides nectar sources for adult parasitoids and improves natural control of *H. armigera*.
- Bird perches (10-15 ha⁻¹) can be installed in the field to attract predatory birds.
- Bio-rational pesticides such as *Bacillus thuringiensis* (*Bt*), Nuclear Polyhedrosis Virus (NPV), entomopathogenic fungi (*Metarhizium anisopliae*), etc, are generally safe for human beings and for the environment. These products are commercially available in the market and farmers can even produce them with a minimum cost.
- Application of either NPV @ 250 LE (larval equivalents) ha⁻¹, when the egg/larval population reaches economic threshold level, or 5% neem fruit powder extract (about 15 kg neem fruit powder ha⁻¹) 15 days after seedling emergence provide effective control of *H. armigera*. Methods of NPV production and preparation of neem fruit powder extracts are given in Annexure I and II, respectively.
- Spray of *Bt* formulations @ 1 kg ha⁻¹ helps in management of pod borer.
- If the insect population is not controlled by the above methods, then application of chemical sprays (endosulfan @ 350 g a.i. ml ha⁻¹ indoxacarb @ 70 ml a.i. ha⁻¹ or spinosad @ 45 ml a.i. ha⁻¹) can be applied as and when needed.

Termites (*Microtermes* spp. and *Odontotermes* spp.): Termites may be a problem in some fields, as these can infest chickpea plants at all stages of the crop growth. The initial damage to the seedlings can cause substantial seedling mortality. The roots and stems are tunneled and one can see termites inside. *Odontotermes* spp. cover themselves with earthen galleries under which they feed.

Management: Apply Thimet 10 G or Carbofuran 3 G @ 1 kg a.i. ha⁻¹ at the time of sowing in seed furrows or treat seeds with chlorpyrifos 20 EC @ 12.5 ml kg⁻¹ seed. Seed treatment with chlorpyrifos provides protection up to 30 days after sowing. Chemical control in rainfed crop at later stages is difficult and expensive. However, some cultural practices such as destroying the termite mounds in the vicinity of the field, removal of plant residues and debris from field and timely harvest can help to minimize the damage. The termite nests can be destroyed by drenching with chlorpyrifos (10 ml in one liter of water) after disturbing the mounds.

Cutworm (*Agrotis ipsilon*): This is generally a pest of minor importance, but may reduce plant stand in case of severe infestation. Gray-black larvae hide beneath the soil surface during the day, and become active at night. They cut the seedlings at or below ground level.

Management: Most broad-spectrum insecticides are effective in controlling cutworm.



Figure 9. Cut worm: plant damaged by cutworm (left) and moth of cutworm (right).

Roguing

It refers to systematic examination of seed production fields and removal of undesirable plants that may contaminate the seed crop. Roguing not only maintains varietal purity but also protects the seed crop from seed-borne diseases. The off-type plants, other crop species (with similar seed size), weed plants, parasitic weeds such as *Cuscuta* spp. and plants infected with seed-borne fungal diseases and viruses should be removed from the seed fields from time to time.

Harvesting and threshing

The time of harvesting is crucial in maintaining the quality of seeds. The crop should be harvested when leaves start to senesce and start shedding, pods turn yellow, plants are dry, and seed feels hard and rattles within the pod. After harvest, the plants can be dried in the sun for a few days to ensure that seeds get dried well. Threshing can be done using commercially available power threshers.

Seed processing

The dried seeds are cleaned to remove the undesirable contaminants such as plant parts, soil particles, stones, weed seed, other crop seed, and shriveled, broken, or damaged seed. Cleaning and upgrading is based on physical differences between good seed, poor seed and undesirable contaminants. The cleaning and grading of seeds is first achieved by winnowing and then through a set of mechanical sieves. In addition to air cleaners and aspirators, indented separators, disc separators, gravity separators, spiral separators and drum separators are frequently used.

Seed storage

The seed must be properly dried before storage. The ideal seed moisture level is 10-12% for short-term storage (up to 8 months). After drying, the seed should be either stored in polythene-lined gunny bags or in safe storage structures (metal bins or earthen containers). The bags should be kept in a rodent free room and placed on wooden planks (not more than five in a stack) and away from walls to avoid dampness to the seeds.

Bruchids (*Callosobruchus* spp.) are the most serious storage pests of chickpea and all other food legumes. Bruchids lay white eggs on the seeds and the larvae bore into seeds and adults emerge from the seeds by cutting round holes in the seeds. The infested seeds are unfit for sowing and consumption. Proper control measures should be undertaken to protect chickpea seed from bruchids.

The traditional methods of protecting the seed from bruchid damage by mixing with ash, dried neem leaves, or chickpea or wheat straw are useful for small quantities of seed. In case of large scale storage, the seed store or the seed bins should be fumigated periodically with commercially available fumigants (ethylene dibromide or phosphine) to protect seed from storage pests. The main advantage of fumigation is that all stages of the insect, including eggs, larvae and pupae, are controlled and also affect other storage pests and rodents.



Figure 10. Chickpea seeds damaged by bruchids.

Production of Nuclear Polyhedrosis Virus (NPV)

A good IPM option for effective control of pod borer is the use of NPV, which causes disease in these insects. This virus is very specific and has no deleterious effects on non-target organisms. The availability of NPV is a major constraint in large scale adoption of this technology by the farmers. ICRISAT has developed a simple NPV production technology as given below:

- Collect healthy fourth-instar larvae (1-1.5 cm long) from the field.
- Prepare the inoculum using 5 ml HNPV stock solution on 500 chickpea seeds that have been presoaked for 12 h. Each ml of HNPV stock solution should contain 6×10^9 polyhedral ocular bodies (POB).
- Place 2-3 inoculated chickpea seeds in each container along with a larva.
- Change the food on alternate days.
- Collect the dead larvae starting from fifth day after inoculation and keep them under refrigeration.
- Homogenize dead larvae in a blender with distilled water and filter the mixture through a muslin cloth.
- Centrifuge for about 15 min at 5000 rpm. Discard the supernatant and keep the virus containing sediment.
- Check the quality using a haemocytometer to take the POB count.
- Preserve the viral solution in a refrigerator and use as recommended (@ 250 larval equivalents per hectare).
- Mix UV shield, Robin blue® @1 ml per liter of spray solution, at the time of application.

Note: 100 LE = 6×10^{11} POB and one 5-6th instar infected larva contains 3×10^9 POB.

Preparation of neem fruit extract

A number of neem-based formulations are available, and are being marketed as insecticides. Most of these are made from neem oil containing varying amounts of azadirachtin. But the quality of neem-based insecticides is a matter of concern for farmers. Farmers can procure neem fruits and prepare their own neem extract as given below:

- Collect fresh, good quality neem fruits and dry them under shade.
- Make powder of the dried fruits and soak the required quantity of powder in sufficient quantity of water overnight before use (10-25 kg ha⁻¹).
- Filter the neem fruit extract using a fine cloth, and dilute it based on the spray equipment.
- Add 2-3 g of detergent per liter of spray fluid to help it stick better to the plant and spray the solution on the crop as and when the infestation levels reach economic thresholds.

About ICRISAT



The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT is supported by the Consultative Group on International Agricultural Research (CGIAR).

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