Bora Cultivation and Post Harvest

BORA

INTRODUCTION

Bora (*Vigna sesquipedalis*) also known as long bean or yard long bean is a popular crop and is grown throughout Guyana. The dark green pods can be used raw as in salads or cooked in stews, etc. The plant can be grown in a variety of soils but does best on fertile, well drained, loose soils with high organic matter content.

CULTIVATION VARIETIES

There are a number of bora varieties cultivated in Guyana. These include the Yars Long, Long Green, Cabbage Bora, ect. The typical characteristics of some of the common varieties cultivated in Guyana are shown below:

Bora type

Yard Long	Indeterminate local variety. Pods 120cm long. Plants bushy; pods medium in diameter.
Long Green	Indeterminate local variety. Pods 76cm long. Coarse in diameter.
Cabbage Bora	Indeterminate. Pods are about 30cm, pods fine in diameter.
String Bora	Plant is not bushy. Pods are very fine and long.
Fat Bora	Intermediate pods (50cm long); very fat in diameter.
Thread Bora	Medium sized plant. Pods about 40-50cm long; pods fine.

Land Preparation

Clay soils should be ploughed and harrowed to produce a good tilth. To enhance drainage on these soils, ridges should be made about 60cm apart. Sandy soils should be raked and rows made 60cm apart.

Planting

A seed rate of 10-15 kg/ha should be used. Seeds should be inoculated with the Rhizobium bacteria before planting, especially if bora is produced on the soil for the first time. Inoculation helps the plant to utilize atmospheric nitrogen from the air and reduces the amount of nitrogenous fertilizers necessary.
To apply inoculum, first dampen the seeds with water, mix thoroughly with the inoculum using approximately 14 grams inoculum to 1kg of seeds. On clay soils when ridges are used plant about two seeds for each hole 30cm apart and 2.5cm, deep. On sandy soils sow two seeds per hole 30cm apart and 60cm, between rows.

Staking

Plants should be staked to enable them to make maximum use of the sunlight. There is no hard and fast method for staking and the method most suited to the farmer could be adopted.

Fertilizer Recommendations

It is desirable to have the soil tested before applying fertilizers. A soil test will inform you about the nutrient status of your soil and will help you to use fertilizers wisely. However, where soil test data are not available the following can be used as a guide.

(a) **Clay soil**

Limestone – broadcast approximately 3t/ha evenly over the soil surface and work it into the soil to a depth of 15cm. This should be repeated every 3 years. Alternatively, apply about 100 gram into the soil at each planting hole and mix thoroughly. All the limestone should be applied at least 4 weeks before planting.
About 10-14 days after planting apply

Urea	2.5 kg/ha if seeds are inoculated 2.5 kg/ha if seeds are not inoculated
Triple Super Phosphate	100 kg/ha
Muriate of Potash	100 kg/ha

At flowering apply

Urea	15 kg/ha if seeds are inoculated 25 kg/ha if seeds are not inoculated

(b) On Sandy Soils

Apply limestone at a rate of 1.5 t/ha annually. This is broadcasted over the soil surface and worked to a depth of approximately 15cm. Alternatively, apply about 100 grams into the soil at each planting hole and mix thoroughly. All the limestone should be applied at least 4 weeks before planting.

About 10-14 days after planting apply

Urea	2.5 kg/ha if seeds are inoculated 25 kg/ha if seeds are not inoculated
Triple Super phosphate	100 kg/ha
Muriate of potash	50 kg/ha

At flowering apply

Urea	15 kg/ha if seeds are inoculated 25 kg/ha if seeds are not inoculated
Muriate of potash	50 kg/ha

Insect Pests of Bora in Guyana

Cricket

Gryllotalpa spp. (Orthoptera: Gryllotalpidae) Acheta spp. (Orthoptera: Gryllidae)

Cricket attacks seedlings of all vegetables. Fully grown crickets are brown in colour and are about 2.5 – 3.5 cm long (Figure 1). The various species of these insects usually live either in the soil, bushes and under decaying crop residues and vegetation.

Mole crickets, which have heavily sclerotised front legs that are adapted for digging, are usually common in sandy soils.

All crickets are nocturnal, feeding at night and secluded by day, under the soil. They feed at or slightly below the soil surface, and can cause considerable damage before being discovered. Seedlings may be denuded of leaves or cut below the soil surface without any trace of insect on them.

Fig 1. Adult cricket

CONTROL

Cultural Control

- **Good field sanitation-** rid the field of weeds and plants residues from previous crops.
- The areas where vegetables are grown should receive full sunlight; kept clean of weeds and all crop residues should be removed and burnt.

- Proper land preparation serves to control weeds, diseases, and soil insects, and also helps in the destruction of large soil clods, which act as hiding places for cricket.
- Integrated Pest Management

Chemical Control

- Any approved soil insecticide at the recommended rate may be applied, such as Basudin 60% E.C (Diazinon) or Vydate L 40%E.C at the rate of 10 mls to 4500 mls water, to seed beds and cultivated areas of cropping.

Cut worm

Agrotis spp. (Lepidoptera: Noctuidae)

These are the caterpillars of various species of moth. They have a greasy appearance, are grey to brown in colour with faint seedlings at or slightly above the soil surface. Evidence of cutworm presence will be greenish-black excreta pellets below seedling. Most of its lifecycle is spent below the soil which goes through a period of approximately. 21-28 days.

Fig 2. Larva & adult of cutworm

CONTROL

Cultural Control

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- Proper land preparation serves to control weeds, diseases, and soil insects, and also helps in the destruction of large soil clods, which acts as hiding places for cutworms.
- Integrated Pest Management

Chemical Control

- Any approved soil insecticide at the recommended rate may be applied, such as Basudin 60% E.C (Diazinon) or Vydate L 40%E.C at the rate of 10 mls to 4500 mls water, to seed beds and cultivated areas of cropping.

Aphids

Aphis cracsivora (Homoptera: Aphididae)

This pest attacks all vegetables. They are commonly known as “plant lice” or “nit” and are small, yellow, green or black pinhead-size insects (Figure 3). They are soft bodied, slow moving and multiply rapidly within a short time span. These insects attack plants at all stages of growth and are usually found in dense clusters on the under surface of the young leaves and also on young tender stems and growing point. They suck plant sap and make the plant weak; some also act as vectors of plant diseases. Seedlings are weakened and killed when the infestation is high, and growth of older infested plants is retarded. Infested leaves curl, shrivel and may turn brown and die. Aphids secrete a sweet substance known as “honey dew” while they feed. This substance attracts ants and serves as a substrate for sooty mould (black fungus) thus impairing photosynthesis. Lifecycle ranges between 21-28 days.

CONTROL

Cultural Control

- **Good field sanitation-** rid the field of weeds and plants residues from previous crops.
- Integrated Pest Management

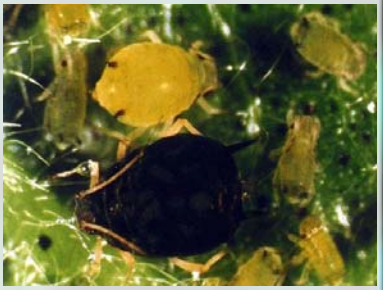

Fig 3. Nymph and adult aphids

Biological Control

- The natural predator lady bird beetles frequently feed on aphids. When aphid population is low and lady bird beetles are presents there is no need for chemical control.

Chemical Control

- This may be applied when the population is high. A contact or stomach insecticide may be used such as: Fastac, Decis or Karate at 6mls to 4500mls water, Sevin 85% W.P. (Carbaryl) at 6g to 4500 mls water, Malathion 57% E.C. at 15 mls to 4500 mls water.

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N.B. Sprays should be directed to underside/surfaces of leaves. When Sevin or Malathion is used do not harvest crops until 7 -10 days after application of chemical. In the case of Fastac, Decis or Karate, crops can be harvested within 3-5 days after chemical application.

White flies

Bemisia tabaci (Homoptera: Aleyrodidae)

These insects are in fact bugs. The adults are white, moth-like insects that fly upwards from plant when disturbed (Figure 4). They are about 2 mm in length and their wings are covered with a white waxy powder.

Fig 4. White flies

The pinhead size nymphs are oval and flattened, and are attached to the leaf surface until maturity. All stages of this pest can be found on the underside of leaves. Nymphs and adults feed by sucking plant sap, resulting in leaves becoming mottled, yellow and brown before dying. Feeding whiteflies excrete honey dew on leaf surface which encourages the growth of sooty mould thus hampering photosynthesis. Ants are also attracted to the honey dew. This pest is also a vector of viral diseases. The life cycle may be completed in about 28-35 days.

Control

Cultural Control

- Do not plant a new crop next to one which is mature: The common practice of having mature crops adjacent to newly planted ones makes management of the pest very difficult since the cycle of the pest is never broken.
- An integrated control strategy is necessary for the effective management of this pest.

Chemical Control

- Several new generation insecticides are now available for the effective control of white flies. Targeting both nymphs and adults with **soap based products**, should be applied very early in the morning or late in the evening. Other chemicals which may be used include Admire, Pegasus and or Basudin/ Vydate L at 10 mls to 4500 mls water.

Mites

Tetranychus spp. (Acarina: Tetranychidae)

Mites are arachnids and are not insects. (Adults have four pairs of legs and two pairs of eyes.) They are extremely tiny and appear as dust- like particles on the underside of leaves (Figure 5). Their colour ranges from red, translucent fawn to green. Eggs are laid on the underside of leaves and hatch beneath a web; which is spun by the adults. Both immature and mature stages suck plant sap resulting in leaves becoming yellow and eventually turning reddish. Fruits may also be affected especially by the rust mite.

Fig 5. Egg and adult of mites

CONTROL

Cultural Control

- Good field sanitation- rid the field of weeds and plant residues from previous crops.
- Integrated Pest Management

Chemical Control

- During severe infestations chemical control may become necessary. Any miticide may be used for their control such as Abamectin, Newmectin, and Vertimec at 5mls to 4500mls water.

Thrips

Frankiniella sp. (Thysanoptera: Thripidae)

Thrips are yellow, tiny, elongated insects about 1mm in length and can be found on the upper and lower surfaces of leaves (Figure 6). Infestations are more severe in the dry season.

Both young and adult suck the sap from leaves and cause them to loose their colour. If attack occurs early the young leaves becomes distorted. Older tissues become blotched and appear silvery or leathery in affected areas thus hindering photosynthesis. Flowers and fruits are also affected thus yields are reduced. Infected fruits are discolored, distorted and hardened. Thrips are also vectors or major virus disease. Lifecycle maybe completed in about 14-21 days.

Fig 6. Thrips and damage caused

CONTROL

Cultural Control

- **Good field sanitation-** rid the field of weeds and residue of all previous crops.
- Crop rotation
- Overhead irrigation will help in reducing population of infestation during the dry season.
- An Integrated Pest Management approach is recommended for the management of thrips

Chemical Control

- Among the insecticides which may be used are Regent (Fipronil), Admire, Abamectin and Vydate L at 5 mls to 4500 mls water, to both surfaces of leaves for effective control.

N.B. Spray should be directed to both surfaces of leaves for effective control.

Pod sucking bugs *Nezara viridula (Hemiptera: Pentatomidae)*
Phthia picta (Hemiptera: Coreidae)

These are various species of plants bugs; they actually do the same type of damage, by puncturing and sucking the sap from leaves; flowers and fruits. Affected fruits become discolored, hardened and deformed; thus the market value of the fruits is reduced.

Nezara commonly known as **"stink bugs"** is green in colour and about 1.5 – 2 cm and are recognized by their shield shape body, and awful protective odors emitted when molested. The Phthia are brownish – black bugs with a red band across the back of the thorax; and are about 2-2.5 cm in length (Figure 7). Both the adult and nymphs of this pest does incur economic losses. Life cycle ranges from 35-70 days.

Fig 7. Adult and nymphs of bug

CONTROL

Cultural Control

- **Good field sanitation-** rid the field of weeds and plant residues from previous crops.

Chemical Control

- Among the insecticides which may be used are Fastac; Decis, Karate; Ambush at 6 mls to 4500 mls water and Sevin at 10 gms to 4500 mls water.
- Integrated Pest Management

Leaf Miner (Chinee writing) *Liriomyza trifolii*
Diptera: Agromyzidae

Leaf miner is the most important insect pest of bora, and may affect the crop from germination through to harvest. Severe infestations lead to premature leaf fall and rapid decline of the crop. The name "leaf miner" is derived from the manner in which the larva feeds, and "Chinee writing" the result of feeding (Figure 8). The larva feeds between the leaf surfaces resulting in serpentine trails (Chinee writing). The pest is prevalent during dry season thus moisture stress may aggravate the infestation and contribute to a faster decline of the crop.

CONTROL

Fig 8. Damage due to leaf miner

Cultural Control

- Field sanitation is an important tool in the management of this pest. The removal and destruction of residue from previous crops will greatly reduce adult populations thus lowering the potential infestation of the next crop.
- The removal of alternate hosts through weed management also helps in lowering adult population.
- Integrated Pest Management

Chemical Control

- Several chemicals are now available for the management of this pest; among them are Trigard, Admire, Pilarking, Vertimec, Abamectin and Newmectin. Use the lower to middle range of the dosage recommended on the labels.

Bean beetle

Cerotoma arcuata Diabrotica sp. Coleoptera: Chrysomelidae

The bean beetle (Figure 9) may affect the plant throughout its life; however, its attack immediately after germination is most important since this can cause the death of plants or retardation of growth. The insect eats leaves causing shot holes; additionally it is a vector of the cowpea mosaic virus.

Fig 9. Bean beetle

CONTROL

Cultural Control

- Field sanitation is an important tool in the management of this pest. The removal and destruction of residue from previous crops will greatly reduce adult population thus lowering the potential infestation of the next crop.
- The removal of alternate hosts through weed management also helps in lowering adult population.
- Integrated Pest Management

Chemical Control

- Any contact insecticide with some residual properties can give effective control of this pest e.g. Malathion, Karate, Fastac or Sevin.

Pod Borer

Maruca testulalis Lepidoptera :Pyralidae

Egg the eggs are laid individually or in small batches on flowers or flower buds, sometimes partly covered with scales, and also on terminal shoots of young plants. The egg period lasts an average of 3 days (Figure 10).

Several first-instar larvae may be found together among flowers, thereafter they disperse singly, moving from one flower to another so that each larva damages 4-6 flowers. Young larvae may feed on any part of the flowers or foliage, but later-instar larvae are more common in the pods. The pupal stage lasts an average of 6-7 days.

Adults are inactive during the day and can be found at rest with outspread wings under the lower leaves of the host plant. They live an average of 6-10 days.

CONTROL

Cultural Control

- Intercropping
- The use of resistant and tolerant cultivars
- Host-Plant Resistance
- Integrated Pest Management

Chemical Control

- For effective level of control of pod borers and a higher yield, Decis, Fastac and Karate, Ambush, Pestac, Abamectin, Newmectin, and Vertimec are recommended.

Non-chemical approaches or the use of chemical insecticides only when necessary are recommended to prevent or delay the development of pest resistance to insecticides.

Fig 10. Larva and adult of pod borer

Major Diseases of Bora *(Vigna sesquipedalis)* And Management Strategies

BACTEIAL COMMON BLIGHT (*Xanthomonas campestris*)

Symptoms

Common blight-infected leaves turn yellow then brown and drop quickly (Figure 11). The organism is seed-borne. Entry into the plant is through the leaf stomata. Rain and damp weather encourage development of these diseases. Common blight is more of a problem in warm weather conditions. The bacteria can live in the soil for two years on plant residue.

Fig 11. Symptoms of bacterial common blight

Cultural Control

- Use an integrated crop management approach.
- Avoid spreading the disease by not entering the field when the foliage is wet.
- Crop rotation.

Chemical Control

- Use appropriate bactericides-Banrot, Mankocide.

CERCOSPORA LEAF SPOT (*Cercospora* spp.)

Symptoms

Lower foliage becomes marked by irregular tan spots (Figure 12). Severe infection causes defoliation and plant stunting. Infection is most severe during periods of extended rainfall and high humidity.

Fig 12. Symptoms of cercospora leaf spot

Cultural Control

- Use an integrated crop ma
nagement approach.
- No resistance exists among varieties.

Chemical Control

- Fungicide sprays should begin at first sign of disease.

TARGET SPOT *(Corynespora cassiicola)*

Symptoms

Survives on leaves and pods Conidia produced on infested leaves cause primary infections (Figure 13). Conidial dispersal can be restricted within the crop during the growing season. This disease is somewhat slower than other common leaf spots and certainly much slower than the epidemics of rusts that are commonly encountered; this may have important implications for disease control.

Fig 13. symptoms of target spot

Cultural Control Fig 13. symptoms of target spot

- Use an integrated crop management approach.

Chemical Control

- Copper based fungicide sprays should begin at first sign of disease.

ROOT ROT (*Rhizoctonia solani*)

Symptoms

Bora seed may rot in soil or the young seedling may become stunted (Figure 14). A reddish-brown canker is formed on the stem. Cankers may completely girdle the stem or may only partially girdle it, causing severe stunting.

Fig 14. Symptoms of root rot

Cultural Control

- Field sanitation;
- Bora should be planted in the dry season;
- Crop rotation bora should follow forage crop; and/ or
- Use an integrated crop management approach

Chemical Control

- Banrot, Manzeb or Dithane M 45 are recommended.

POD BLIGHT (*Diaporthe phaseolorum*)

Pod blight of bora is first observed as brown pustules of irregular shape on the leaves (Figure 15). Lesions grow to one-fourth to three-fourths of an inch in diameter. During the latter part of the growing season, the fungus spreads to nearby pods, where it causes a pale watery spot. The spot enlarges and becomes darker with age. On pods the spot is marked by dark brown to black pustules on the surface arranged in a ring.

Fig 15 Symptoms of pod blight

Cultural Control

- Crop rotation;
- Use disease resistant seeds; or
- Use an integrated crop management approach

Chemical Control

- Follow a fungicide (Kocide, Mankocide) program to control the disease when it occurs consistently.

RUST (*Uromyces phaseoli*)

Symptoms

Small reddish-brown pustules form on lower side of leaves (Figure 16). The fungus lives in crop residue.

Fig 16. Symptoms of rust

Cultural Control

- If rust has been severe, crop rotation should be practiced.
- Disease resistant seeds should be used when past experience indicates rust to be a problem.
- Use an integrated crop management approach

Chemical Control

- Apply approved fungicides (Kocide, Mankocide) at first sign of infection.

POWDERY MILDEW (*Erysiphe polygoni*)

Symptoms

Powdery mildew is characterized by a white powdery growth on the foliage (Figure 17). Infected pods and foliage become malformed. The fungal spores are spread by wind.

Fig 17. Symptoms of powdery mildew

Cultural Control

- Use an integrated crop management approach.

Chemical Control

- Spray with approved fungicides- Kocide or Copper Hydroxide.

SEEDLING DAMPING-OFF *(Pythium sp.)*
This pathogen affects a wide range of plants in the seedling stage.

Fig 18. Symptoms of seedling damping-off

Symptoms:
Pythium sp. occurs in most cultivated soils.
Infected seedlings appear water soaked at the soil level (Figure 18).
This disease is favoured by high humidity and overcrowding.

Results of Infection:
Seedlings topple over, often when the leaves are still green.

Cultural Control

- Use an integrated crop management approach.
- The use of good quality seed and plants.
- Sowing or planting under optimum conditions is essential to reduce infection.
- Avoid overcrowding and over watering.
- Use seeds coated with Captan or Thiram.
- Soil sterilization also reduces infection.

Chemical Control

- Spray with approved fungicides –Dithane M45 or Captan.

ROOT KNOT DISEASE *(Meloidogyne javanica)*
Symptoms:
The nematodes stimulate the formation of root galls, which interfere with the plant's water supply, resulting in stunted and chlorotic growth, poor fruit setting and yellowing (Figure 19). The females lay several hundred eggs which are released into the soil. They enter the plant tissues, such as the root tips and stimulate the formation of galls.

Cultural Control

- Use an integrated crop management approach.
- Resistant cultivars can limit the spread of the infection.
- Crop rotation is sometimes successful.
- Insects can be treated with hot water to kill larvae.
- Bury the residues of infected plants, to reduce the level of infection.

Chemical Control

- Spray with approved nematicide-Nemacur

FUSARIUM WILT *(Fusarium oxysporium)*
This pathogen infects many crops. Acid soils and high temperature encourages this disease to spread. This is a soil-borne disease, often invading plants through roots or wound. The vascular system is infected, toxins are produced and the xylem turns brown (Figure 20). Seedlings may rot, leaves turn yellow and wilt. Plants may eventually die.

Cultural Control

- Use an integrated crop management approach.
- Rotate crops, plant in disease free soil and use clean planting material.
- Burning of crop debris and the planting of resistant cultivars is recommended

Fig 20. Symptoms of

Chemical Control

- Spray with approved fungicides –Cuprasan or Kocide.

ANTHRACNOSE *(Colletotrichum lindemuthianum)*

This is a seed-borne fungus which attacks all above ground portions of the plant. Infected seed are marked by dark, sunken lesions that extend through the seed coat. Stem lesions are oval and sunken. The center of the lesion is dark brown with purplish to red borders (Figure 21). In early stages, the fungus develops along the veins and becomes purplish to red in color. In advanced stages, leaves become ragged. Infection of the pods results in small, reddish, elongated spots. Older spots are sunken and have brown to reddish-brown borders.

Results of Infection

Oods are infected mainly through wounds. Pods that are infected rot. This results in serious crop loss.

Fig 21. Symptoms of anthracose

Cultural Control

- Use an integrated crop management approach.
- Rotate crops and remove and destroy all remnants of crop after final reaping. Seeds from areas where the disease has occurred should not be used for planting, as the agent is seed borne.
- Use clean seeds, rotate crop and remove infected plants to reduce damage.

Chemical Control

- Spray with a fungicide.

Virus Disease

Mosaic Virus: Leaves become puckered and mottled with light and dark-green areas. Infected plants become stunted. The virus is seed-borne and can be spread by aphids (Figure 22).

Curly Top Virus: Infected plants are stunted and have distorted foliage (Figure 22).

Symptoms: Diseased plants are usually stunted and produce little or no crop. Flowers may fall off, but if they produce pods they are usually mottled and ripen unevenly with a mixture of white and green spots on the mature fruits.

Fig 22. Symptoms of viral disease

Cultural Control

- Losses can be reduced by growing resistant varieties and following an approved aphid control program.
- Use resistant varieties.

Chemical Control

- Pesticides can be used to control the vectors of the various viruses.

Harvest Maturity Indices

Bora is harvested at an immature stage, prior to full development of the seeds and pod. The initial harvest maturity can be estimated by counting the number of weeks after planting. Bora requires about 7 weeks from seeding until the start of harvest, depending on cultivar and environmental conditions. The harvest period typically continues over a period of about 6 to 8 weeks. Pod length and pod diameter are the two principal indices of harvest maturity. Pod diameter is more closely related to edible quality than length. Bora is typically harvested when the pods have reached a minimum length of 38 cm (15 inches). However, some markets prefer longer pods of up to 76 cm (30 inches). Pod length is significantly influenced by vigor of the plant and cultivar. Highly vigorous plants may produce pods of 90 cm (35 inches) in length. Highest quality pods are straight, crisp, and uniform in colour (Figure 22). The most popular cultivars have a green colour, although specialty markets may prefer cultivars which produce a reddish-coloured pod (Figure 23).

Figure 22. Long, straight dark green bora ready for harvest.

Figure 23. Purple coloured bora pods for specialty markets.

Pod diameter enlarges with maturity and bora should be harvested when the pods have reached about 1 cm (0.4 inches) in diameter. At this diameter the immature seeds will be slightly protruding or bulging outward (Figure 24). Bora should be harvested before the seeds fill out the pods. Pod diameter should not exceed 1.25 cm (0.5 inches). Overmature pods are tough and unsuitable for eating.

Harvest Methods

Bora should be harvested by pinching the stem with the thumbnail pressed against the index finger. A short section of the stem should remain attached to the pod. If done carefully, twisting of the pod off the plant can be done provided the stem remains attached to the pod. Pickers should be careful not to tear or pull the pods off the plant. The pod should never be severed below the stem, as this creates an open wound in the pod which would be a likely site for decay establishment. Rough handling of the pods during harvest should be avoided as this will result in tissue damage and subsequent decay. In addition, harvested pods should never be packed tightly into the harvest container or allowed to remain in the sun for extended periods. Do not put damaged, diseased, or culled pods in the same harvest container as the marketable pods.

Harvesting should be done during the coolest time of the day, which typically is in the early morning. However, picking should not begin until the moisture on the plants has evaporated. Harvesting after the pods have dried will help prevent the spread of postharvest diseases and will result in less contamination by dirt and debris. Avoid harvesting in the afternoon, as the pods will be the least swollen at this time. Harvest frequency should be every other day or every third day, depending on growth rate of the pod. The harvest container should be well-ventilated and not contain more than about 10 kg (22 lbs) of pods in order to avoid over-heating. Once harvested, bora should be protected from direct sunlight. Heat increases pod respiration rate, which is already relatively high after harvest.

Figure 24. Slightly bulged pods with acceptable diameter for harvest.

Preparation for Market

Bora is highly perishable and must be prepared for market within several hours after picking, particularly if there is no cool storage facility available to temporarily hold the pods. Delayed postharvest cooling and exposure to the sun will soon result in pod shriveling and quality deterioration. Limiting the time between harvesting and cooling to no more than 1 or 2 hours will help maximize potential shelf life (Figure 25). Bora held at ambient temperature for 1 hour before cooling will lose about 2% of its original weight. If the delay in cooling is 5 hours,
bora may lose up to 10% of its original weight. The steps in market preparation involve cleaning, sorting, and packing. The packing area should be shaded, clean, and well ventilated.

Figure 25. Bora should be transported to the packing facility immediately after harvest.

Cleaning

The initial step in market preparation involves cleaning of the harvested product. This is typically done by spreading the pods out in a shallow layer on top of a clean, flat surface (Figure 26). Spreading bora pods out on a flat surface helps to dissipate field heat before packing. Any pod found with a stem longer than 1 cm should be re-trimmed to a shorter length. Bora should be cleaned by removing any leaves, stems, broken pods, blossom remains, insectdamaged, or partially decayed pods.

Figure 26. Harvested bora spread on a flat table for easy inspection and cleaning.

Generally, bora should not be washed because of the likelihood of spreading decay organisms. However, the Barbados export market requires a postharvest wash treatment for phytosanitary reasons (Figure 27). In this case, bora should be submerged in clean water adjusted to a pH of 6.5 and sanitized with 150 ppm hypochlorous acid. Household bleach is the most convenient source of hypochlorous acid and is widely available in a 5.25% solution. Following the washing treatment, the bora pods should be air dried on a clean, flat surface before sorting and grading (Figure 28).

Figure 27. Cleaning of bora in properly sanitized wash water for the Barbados market.

Figure 28. Fan used to speed up air drying of bora prior to grading and packing.

Sorting/Grading

There are no established grade standards for bora, but the pods should be sorted according to length, maturity, and external appearance. The length and thickness of the harvested bora pods is often quite variable. Uniform length and diameter of the bora pods in each bundle and carton is critical for market acceptance. Pod colour should be bright and typical of the cultivar. Each pod should be free of blemishes. Pods displaying rusty brown spots or other blemishes indicate disease, injury, or the possibility of deterioration and should be discarded.

The pods should be well-formed and straight, uniform in colour with a fresh appearance, and tender but firm (Figure 29). They should snap easily when bent. Freshness is indicated by a distinct, audible snap when the pod is broken. Buyers prefer bora with no bulge or only a slight bulge, which indicates the pods are tender with immature seeds. Over-mature bora with bulging pods are tough and fibrous. On the other hand, too immature pods are highly susceptible to wilting.

Figure 29. High quality pods are long and straight with a uniform green colour.

Packing

Bora is typically wrapped in bunches for marketing (Figure 30). Exporters prefer to purchase bora in larger bunches of 350 individual pods, while domestic markets prefer smaller bunches.

Figure 30. Bora wrapped in small bunches (foreground) for domestic marketing.

Several different container types are used for packing bora. Large sacks are often used in the domestic market. However, canvas or polypropylene sacks should not be used because the pods will rapidly heat and wilt due to restricted ventilation. Reed baskets are often used as packaging materials for exporting bora to Canada (Figure 31). However, they do not have an attractive appearance and are not desirable for display on wholesale markets.

Figure 10. Reed baskets used as export packages do not have an attractive visual appeal.

Figure 32. Bunches of bora should be loosely packed inside fiberboard cartons for export.

Well-ventilated fiberboard cartons provide more protection and are recommended, especially for export. Bora should be loosely packed within the carton to allow for adequate heat dissipation (Figure 32).

Temperature Management

Bora has a very high respiration rate and generates large amounts of heat at ambient temperatures. The pods will rapidly lose moisture and crispness and become limp if not cooled immediately after harvest. Bora should be cooled to 5°C (42°F) as soon as possible after harvest to maintain its edible quality and crisp texture. Pods that are not cooled will quickly wilt, lose crispness, and have only a 1 or 2 day market life. Postharvest decay will also quickly begin at ambient temperatures. The most practical way of cooling bora is to loosely stack the pods on a clean surface inside a cold room with high humidity and good air flow. To speed up the rate of cooling, fans should be used to increase the rate of air circulation.

Hydrocooling, the process of bringing chilled water into contact with the pods, is the quickest method of cooling bora. Water is a better heat transfer agent than air. However, if hydrocooling is used, the water must be very clean and properly sanitized to prevent contamination of the bora with postharvest pathogens. Any open wound, cut, or tear in the pod will provide an entry point for bacteria and fungi. It is very important to maintain
a 150 ppm chlorine concentration and keep the water pH at 6.5 for optimal sanitation. Severe postharvest decay will occur if the water is not properly chlorinated or if the pods are allowed to re-warm after hydrocooling. Therefore, although hydrocooling is the most effective method of cooling, it should be used only if adequate sanitation methods are followed and refrigeration facilities are available to maintain a continuous product cool
chain during distribution to market. After cooling, bora should be held at its optimum storage temperature of 5°C (41°F). At this temperature, bora will have a 7 day market life. It is important to maintain the cool

chain during transport and distribution to market. Pods allowed to re-warm will have moisture condensation on their surface, which is a favorable environment for the development of postharvest decay. When efrigeration is not available and the intended market is local, practices such as harvesting during the coolest part of the day, soaking the bora in clean cool water, and keeping the harvested pods in shade will help to extend the market life.

Relative Humidity

Harvested bora is highly susceptible to water loss and wilting. Pod shriveling and loss of crispness will soon occur if the postharvest relative humidity (RH) is low. About 5% weight loss is needed before shriveling and limpiness are observed. After 10% to 12% weight loss, the bora is no longer marketable. The rate of water loss from immature pods is higher than from more mature pods. In order to minimize wilting and quality loss, bora should be held at 95% RH. This may be obtained by the use of a supplemental humidifier or water vaporizer in the cooling and storage area. Packaging materials that allow for the establishment of a high RH microenvironment should also be used.

Principal Postharvest Diseases

Bora is a highly perishable vegetable crop subject to various fungal and bacterial decays. The principal postharvest fungal diseases of bora include cottony leak, rhizopus rot, gray mould, watery soft rot, and anthracnose. The principal postharvest bacterial disease is soft rot.

Cottony Leak

Cottony leak, caused by the soil-borne fungus *Pythium*, is a common postharvest decay of bora. Infection begins in the field and the decay progresses after harvest. The incidence of cottony leak is higher during the rainy season. The first symptoms of cottony leak are dark lesions of irregular shape, which enlarge rapidly at ambient temperatures. Under humid conditions, a white cottony mould may cover the pod and liquid may leak from the rotting tissue (Figure 33). Mould from infected pods will spread to adjacent healthy pods, forming nests of decay in packed cartons. In order to minimize cottonly leak, bora should always be harvested when dry and handled with care to avoid wounding of the pod surface. In addition, the pods should be cooled to 5°C (41°F) immediately after harvest.

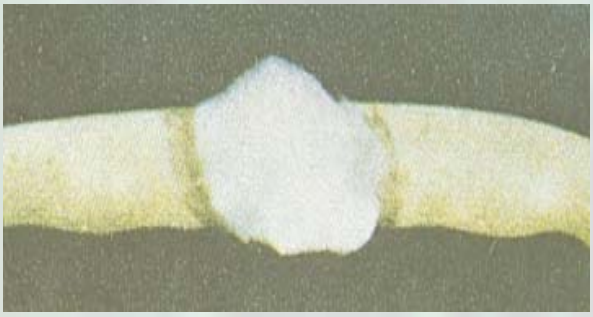

Figure 33. White mould associated with cottony leak.

Rhizopus Rot

Rhizopus rot, caused by the fungus *Rhizopus*, is another common postharvest disease of bora. Injury predisposes the pods to infection, which occurs under warm, moist conditions. Initially, small water-soaked spots form on the pod surface. The decayed tissue becomes soft and watery, with considerable leakage of fluid. Grayish-white masses of mould develop over the infected area (Figure 34). In contrast to cottony leak, Rhizopus rot is characterized by the formation of coarse strands of white mould and round black spore heads. A distinctive sour odour may accompany the decay. Nests of mould and decaying pods form within a carton of packed bora. The main ways to control Rhizopus rot are to harvest when the pods are completely dry, avoid injury to the pods during harvest and handling, and cool the pods to 5°C (41°F) immediately after harvest. Moisture condensation on the pod surface should also be avoided during transport to market.

Gray Mould

Figure 34. Severe infestation of Rhizopus rot forming a nest of mould growth.

Gray mould, caused by the common soil-borne fungus *Botrytis cinerea*, causes dark spotting on the surface of the bora pod (Figure 35). An obvious growth of gray-coloured mould will eventually cover the infected areas of the pod. Control of this disease is obtained by a combination of pre-harvest fungicide sprays, removal of infected crop debris, careful handling practices to avoid damage to the pod surface, and prompt cooling to 5°C (41°F).

Figure 35. Dark spots on pod surface characteristic of gray mould.

Watery Soft Rot

Watery soft rot, caused by the soil-borne fungus *Sclerotinia*, is a common pod disease of bora, especially during periods of prolonged wet weather. This disease is also referred to 0as white mould. Symptoms begin as water-soaked lesions that soon turn brown and become covered with a dense white mould (Figure 36). Pods appearing healthy at harvest may rot during transit or storage. Nests of decay develop most rapidly at around 25°C (77°F). Good aeration of the plant in the field is important in minimizing this disease.

Pre-harvest sprays of systemic fungicides can also be effective in retarding watery soft rot. Holding of the pods at 5°C (41°F) will significantly slow disease development.

Anthracnose

Anthracnose, caused by the fungus *Colletotrichum*, may be severe on bora grown under poor field sanitation or when infected seed is used in planting the field. The disease is more severe during the rainy season and pods may appear healthy at harvest but undergo rotting during transit and marketing. Initial disease symptoms appear as dark specks or blotches on the pod surface. Individual lesions may become sunken and are typically gray or black in the center (Figure 37). They may coalesce and discolour much of the pod. Wounds and skin damage predispose the pod to infection. The optimal temperature for anthracnose development is 25°C (77°F). Cooling the pods to 5°C (41°F) as soon as possible after harvest will arrest the growth of this disease.

Figure 36. Watery soft rot (right) with typical white mould growth.

Figure 37. Anthracnose lesions on pod surface.

Bacterial Soft Rot

Bacterial soft rot, caused by *Erwinia carotovora*, is the main postharvest bacterial disease of bora. The bacteria is a secondary decay organism and attacks tissue weakened by injury, sunscald, chilling injury, or fungal attack. Soft rot rapidly develops in warm, moist storage environments. Pods become soft, slimy, and foul smelling (Figure 38). Control of this disease is obtained by careful harvesting and handling practices to prevent wounding of the tissue, avoiding postharvest fungal growth, and maintenance of the pods at 5°C during transport and distribution to market.

Figure 38. Slimy rot symptoms of bacterial soft rot.

Halo Blight

Halo blight, caused by *Pseudomonas syringae*, is another bacterial disease that may infect bora. The disease is most commonly observed on pods harvested during the rainy season. Symptoms first appear as tiny, water-soaked pinpricks on the surface. These gradually enlarge and appear as small greasy spots scattered on the pod (Figure 39). The spots eventually darken, appear sunken, and sometimes a whitish ooze is emitted from the center. Development of halo blight is rapid under ambient temperatures. Control of this disease is obtained by planting disease-free seed, avoiding harvest when the pods are wet, and holding the bora at 5°C(41°F).

Figure 39. Severe infection of halo blight.

Postharvest Disorders

Chilling Injury

Storage of bora at temperatures less than 4°C (42°F) will result in chilling injury (CI) to the pod. Symptoms appear as surface pitting, brown streaks, a general dullness of the pod colour, and increased susceptibility to decay. Injury may be induced within several days, although cultivars differ in sensitivity. Furthermore, symptoms may not become apparent until the pods have been returned to ambient temperature for a few days. The presence of free moisture on the surface of the pod aggravates the effects of CI.