

GROWING

SCOTCH BONNET PEPPER

(*Capsicum chinense Jacq.*) IN JAMAICA

Don McGlashan

Handbook

Sponsored by

The Food and Agriculture Organization of the United Nations
Ministry of Agriculture, Jamaica



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FOREWORD

Scotch Bonnet pepper remains one of our competitive non-traditional export crops, providing significant foreign exchange. Knowledgeable farmers, using modern crop production practices, are needed for the industry to remain viable.

This handbook, **Growing Scotch Bonnet pepper in Jamaica** was prepared to provide the technical information necessary to successfully grow Scotch Bonnet pepper. It focuses on the practice of integrated crop management techniques, highlighting information obtained from research done by the Research and Development Division of the Ministry of Agriculture over a number of years and a joint project between the Ministry and the Food and Agriculture Organization of the United Nations (FAO) - **Increasing Production and Quality of Hot Pepper Seeds in Jamaica (May 2000 - December 2001)**. This publication was made possible through the project.

While primarily geared towards the Jamaican farmer, it is expected that research and extension officers, exporters and students will find this handbook useful.

I welcome the publication, which I am confident will contribute to a successful pepper industry.

Aaron Parke

Permanent Secretary
Ministry of Agriculture

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INTRODUCTION

There are seven vital steps to hot pepper production. Unless growers become fully acquainted with these and put them into practice, optimum fruit quality and yields will not be realized.

These are the steps.

1. Growers must at all times use high quality seeds.
2. Seedlings must be grown in nurseries where good management practices are always observed.
3. Seedlings must be transplanted only at the correct stage of growth.
4. There must be proper site selection and land preparation.
5. There must be timely application of fertilizer and irrigation water.
6. Appropriate pest and disease control techniques must be used, including chemical and non-chemical methods.
7. Finally, proper harvest and post-harvest techniques should be applied to ensure that fruits are of exportable standard.

HIGH QUALITY SEEDS

Seed quality

Without good quality seeds, Scotch Bonnet pepper yields will be inadequate, no matter what else a grower might do. Good quality seeds should have; over 85% germination and be at least 96% pure. (i.e. free of dirt, weeds and other crop seeds).

Seed selection

Farmers can sometimes obtain good quality seeds on their own if they have good plants to begin with and if they take the best fruits from the first four reaping only. It is, however, strongly recommended that farmers buy high quality seeds from a reliable source in order to get the best results.

Purchasing of seeds

Seeds bought from farm stores, are not always guaranteed to be of good quality. Farmers should only buy seed packages which are clearly labeled, detailing species, variety, date of harvesting, percentage germination, percentage purity, seed treatment, net weight and producer's name.



Plate 1.
Properly labeled seed package



Plate 2. *An insect-proof screen house*

Nursery Establishment

Good fruit will only come from vigorous, healthy plants. The only way to ensure healthy plants is to obtain seedlings from a reputable source, or to build one's own nursery to produce them.

Nursery Site Selection

The nursery location is critical. It should not be located in areas where other varieties of pepper, tomato, tobacco or irish potatoes are growing. These crops are related and may be affected by similar pests and diseases, which can spread to the seedlings in the nursery. Nurseries should, therefore, be located in a place that is at least **200 m** (220 yd) from any other pepper, tomato, tobacco and irish potato field.

Knowledge of wind direction is also important. Build nurseries so that fields which may have aphids and other insects are kept downwind from the site. Wind movement will help to keep these insects away from the nursery.

Constructing an insect-proof nursery

An insect-proof nursery can be expensive but is a necessary investment that will bring the farmer increased profit over the years, and is therefore strongly recommended by the Ministry of Agriculture (MINAG) and the Food and Agriculture Organization (FAO).

Building an insect-proof nursery, requires lumber, gravel, concrete blocks, cement, insect-proof mesh and corrugated or plastic translucent roofing material. The most essential element is the insect-proof meshing.

NURSERY MANAGEMENT

Once the nursery is constructed, other requirements will be:

- **good quality seeds;**
- **seedling trays;**
- **good potting soil and**
- **foliar fertilizer(s).**

Seedling trays

There are two main types - the black polythene and white styrofoam trays. The styrofoam trays last much longer and are easier to carry. Trays should have between **60 - 80 cells**. **Fifty to 60** such trays are needed to produce seedlings for a **0.4 hectare (one acre)** field.

Trays must be sterilized each time seeds are sown. Sterilize trays by soaking them for five (5) minutes in nine (9) parts water, to one part household bleach. One hundred and seventy(170 L) litres (**45 gallons**) of this solution is enough to sterilize 60 trays.

Potting soil

The soil used should be free-draining and free of pests and disease organisms. Commercial, ready-made potting soil is available, but one can make one's own potting soil by using manure, mulches and composts with soil or sand and then sterilizing the mixture.

Approximately **450 g (1 lb.)** potting soil is needed per seedling tray. Good potting soil is loose, allowing for good drainage, aeration and good root growth, and may also provide some plant food.



Plate 3.
Filling trays with potting soil

Soil Sterilization

Sterilized potting soil will destroy any harmful pests and disease organisms. Sterilizing can be done in two ways.

- Place soil on a corrugated zinc sheet, wet and place over a moderate fire for 30 minutes. The steam will kill pests, weed seeds and disease organisms, without damaging the soil. At least one week must pass before using the sterilized soil. Unsterilized soil and tools should not be allowed to contaminate the sterilized soil.
- Soil may also be sterilized by wetting, covering it with clear plastic sheeting and leaving it for six to eight (6 - 8) weeks. This process is called "soil solarization" and results in the death of pests, disease organisms and some weed seeds.

Notice that in each case, no harmful chemicals are used!

Sowing of seeds

Fourteen to 28 g (1/2 - 1 oz) of seeds are required to plant out a 0.4 ha (1 acre) field. Twenty-eight grams (1oz) of seeds contain approximately 5500 - 6000 seeds. Place soil into cells with one seed in each cell, 0.5 cm (roughly 1/4 in.) deep. Use more soil to cover the seeds lightly. Trays should then be watered and allowed to drain.



Plate 4. Good quality packaged Scotch Bonnet pepper seeds

Seedlings will emerge in seven to twelve (7-12 days) and should be watered lightly and frequently (usually twice daily) until they are ready to be transplanted. Seedlings should not be over-watered.

Applying fertilizer to seedlings

Seedlings should be fertilized regularly with a foliar fertilizer. Mix the fertilizer in water (following manufacturer's recommendations) and spray or water the seedlings. The nutrients are absorbed directly by the leaves. Some are also taken up through the roots.

Several commercial foliar fertilizer mixes are available, but a 20-20-20 mix is best. This contains the three main plant foods, nitrogen (N), phosphorus (P) and potassium (K), in equal portions.

Plate 5.
*Applying
foliar fertilizer*



Preparing seedlings for transplanting

The seedlings should be ready for transplanting after five to six (5 - 6) weeks, when they should be about 12 - 15 cm (5 - 6 in) in height .



Plate 6. *Seedlings ready for transplanting*

To prepare the plants for the shock of transplanting, they should be "hardened off" for five to seven (5 - 7 days). This is done by reducing their water supply, watering once daily, or every other day and exposing them to outdoor conditions. This will make them able to withstand the transplanting process and they will be less likely to wilt when put in field.

CHAPTER 4.

FIELD SITE SELECTION AND LAND PREPARATION

Field site selection

- The field site for growing the crop should have full sunlight all day, and not be shaded; with fairly deep, well-drained soil. Peppers are susceptible to waterlogging.
- The field site should not be located within **200 m (220 yd)** of any other pepper, tomato, irish potato or tobacco field, as diseases already in those fields could be spread to the pepper crop.
- Peppers grow best in soils with a pH level of between **5.5 and 7.0**. It is, therefore, best to test soil pH levels before planting. Soil **N.P. K.** levels should also be checked.
- Crop rotation should be practiced. Pepper should not be planted repeatedly in the same area. Crop rotation prevents the build-up of pests and disease organisms.

Land preparation

Soil in the field must be properly tilled and weathered before planting. Fields should be ploughed before, or at the same time the seeds are sown.

Allow enough time between ploughing and transplanting, so as to expose the soil to sunlight and to birds, wasps and what are known as friendly insects, which will feed on pests and help to eradicate weed seeds.

After ploughing the field, it should be harrowed, and then the beds shaped. Where soils have a heavy clay content, or are poorly drained, make mounds or raised beds. The beds should be at least **100 cm (40 in.)** wide and **30 - 40 cm (12 - 15 in.)** high.

Weeds may begin to emerge before one is ready to transplant, in which case a non-persistent chemical herbicide, or hand weeding is recommended; this will provide the cleanest possible field.

On sloping lands(20° or more), follow proper land husbandry techniques in setting the contours for the beds and the drains. Slant each bed and drain to allow water to run off without eroding (eating away) the soil. Protect drains by allowing grass to grow in them.



Plate 7. Land with heavy clay prepared for receiving Scotch Bonnet transplants.

Plant a barrier crop at this time (see section on aphids control). Once the barrier crop is 45 - 60 cm (18 - 24 in.) high, seedlings may be transplanted. If grass or plastic mulch is used, place in the field before seedlings are transplanted.

CHAPTER 5.

TRANSPLANTING

Transplanting the seedlings

The best time to transplant the seedlings is in the afternoon or evening, and ideally, after rain or irrigation water has been applied.

Selection of seedlings

Select only the healthiest seedlings. Pick those that are at least 12 - 15 cm (5 - 6 in) high. Plants that look weak or diseased should not be used. If seedlings are diseased, the entire crop could be affected. Remove plant waste promptly from the field and destroy by burying at least 60 cm (2 ft) deep or by burning.

How to transplant

Water seedlings before they are removed from the trays. This makes it easier to take out each plant without damaging it.



Plate 8. *Healthy seedling showing a good "root ball"*



Plate 9. *Well established Scotch Bonnet pepper field after transplanting*

Carefully remove seedlings from the tray with the "root ball" intact. Seedlings with bare roots will grow more slowly after being transplanted and their roots may be more easily damaged. By keeping the soil around the roots, the shock of transplanting will be reduced. Transplant seedlings immediately after removing them from the trays, so that they do not dry out.

Dig holes large enough so that each seedling will hold easily. Pat down the soil around the "root ball" so that good contact is made with the soil. Cover the seedling to the same depth as it was when it was in the tray. As soon as the seedling is transplanted, ensure that it gets water immediately.

Spacing

Spacing is very important to Scotch Bonnet pepper growth. Proper spacing will ensure maximum use of the land without overcrowding. Rows may be spaced 90 – 150 cm (3 - 5 ft) apart, with plants along the row at 90 cm (3 ft). For high density planting, rows 90 cm (3 ft) apart with plants 90 cm (3 ft) apart, is recommended, but only at low elevations.



Plate 10. Recommended planting distance

It is necessary to identify the best type of fertilizer. Fertilizers must be applied at the right time during the plant's growth and in the correct way.

These are the best times to fertilize plants.

- **When transplanting** - A fertilizer such as N.P.K. (15-5-35 or 8-4-32) is suitable. Apply at the rate of 28 g (1 oz) per plant.
- **When flowering** - The plants will flower about 40 days after they have been transplanted. At this time, apply 28 g (1 oz) of sulphate of ammonia or 14 g (½ oz) urea per plant.
- **Twenty-five to thirty (25 - 30) days after start of flowering**- apply 28 g (1oz) muriate of potash and 56 g (2 oz) sulphate of ammonia per plant.
- **After two or three harvests**, apply muriate of potash and sulphate of ammonia in equal amounts of 28 g (1oz) per plant. Thereafter, apply every four to six(4- 6) weeks, depending on soil type – six (6) weeks for clay soils and four (4) weeks for sandy soils.

Fertilizer may be applied in a number of ways to ensure maximum benefit and reduce wastage:

- in a circular band around the plant. The circle should be at least 10 - 12 cm (4 - 5 in.) away from the stem. It is very important to cover it with soil.
- Place in holes that are seven to ten (7 - 10 cm), three to four (3 - 4 in.) away from the plant stem.
- A single band can also be used; 3 - 5 cm (1 - 2 in.) deep between double rows of plants, once this is completely covered with soil.
- For large acreages, apply soluble fertilizers through drip irrigation systems.
- Foliar fertilizers can be sprayed on where plants show signs of nutrient deficiency.



Plate 11. *Circular banding of fertilizer*



Plate 12. *Covering fertilizer*

For best growth and production, peppers need to be well irrigated. Without adequate water, plants will grow poorly, or wilt and will not yield their best.

If peppers are not getting enough water, signs of water stress will begin to show. These are:

- wilting - the plant becomes droopy;
- flowers shed and fall off; and
- fruits become soft and may also fall.

Irrigation is necessary to produce a good crop. The main types of irrigation are sprinkler, drip and furrow.



Plate 13. *Drip irrigation*

When using drip irrigation, apply 4500 - 6750 litres (1000 – 1500 gallons) of water each day, for a 0.4 ha (1 acre) field during the life of the crop. For the first four weeks after transplanting, irrigate daily. Thereafter, depending on rainfall, irrigate every other day. If mulch is used, water requirements will be reduced. However, do not allow plants to suffer water stress.



For Scotch Bonnet peppers, drip irrigation is the best as it allows for:

- more efficient use of water;
- less leaching;
- less weed growth;
- less foliage diseases, as irrigation water is not splashed onto leaves;
- more efficient use of fertilizer when used through the drip method; and
- more uniform crop growth.

WEED CONTROL

Proper weed control is important. Weeds compete with crops for soil nutrients and water. Weeds such as white top (*Parthenium hysterophorus L.*), cow pops (*Physalis angulata L.*), jimson weed (*Datura stramonium*), black nightshade (*Solanum americanum*) and velvet burr (*Priva lappulacea*) must, therefore, be removed from and around Scotch Bonnet pepper fields, as they may harbor viruses and aphids that are detrimental to pepper production. The most critical period for weed control in peppers is the first 40 - 70 days after transplanting.

If there are many weeds, chemical herbicides may be used. Paraquat will quickly kill the tops of most weeds, which will grow again after a few weeks. For best results, apply herbicides in the evening. Fusilade and Agil, which kill only grasses and Glyphosate, which kills most weeds, are other herbicides which may be used. When spraying between rows of pepper plants, a spray shield should be attached to the nozzle to prevent spray drift and crop burn. (See **Appendix 1** for recommended herbicides and their application rate).

It is important to use non-chemical weed control methods where possible, as chemical herbicides should never be used as the only form of weed control. They are costly and may be harmful to the crops and the environment, if not properly applied.

Mulch, using grass or plastic, is strongly recommended to reduce weeds and should be laid in the field after land preparation and prior to transplanting.

Mulching has the following added benefits:

- mulch helps to maintain soil moisture;
- it protects the soil during heavy rains;
- organic mulch improves the soil quality and soil nutrient levels after it decomposes
- mulch can help to prevent soil-borne diseases from splashing onto/reaching the leaves of pepper plants; and
- it repels aphids, which can cause viral diseases.



Plate 14. *Scotch Bonnet pepper on Grass mulch*

Hand weeding may still be necessary, especially between the pepper rows. Carefully remove these weeds with a machete or hoe.

When the plant is big enough to cover much of the ground, this too will help to reduce weed growth.

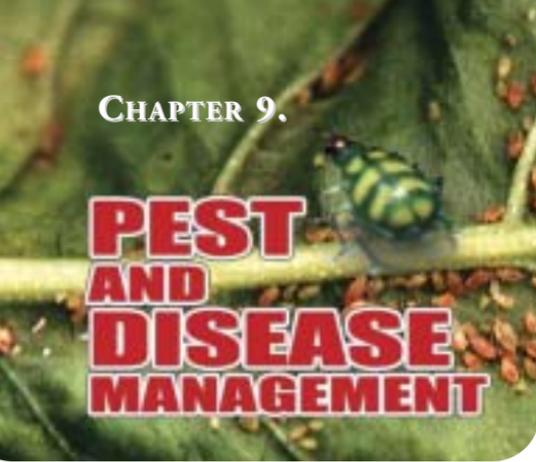
"Cover crops" should be grown between pepper crops. Crops such as beans, not only help to suppress weed growth, but can also provide an additional source of income for the farmer. Pumpkin is also a good cover crop. After reaping cover crops, the plant trash can be forked into the ground to form mulch to help to build up the soil.



Plate 15. **A.** *Black nightshade* **B.** *Jimson weed*

CHAPTER 9.

PEST AND DISEASE MANAGEMENT



Pests and diseases affecting Scotch Bonnet pepper

Several pests and diseases affect Scotch Bonnet peppers plants. These include:

- insects;
- mites;
- fungi;
- bacteria; and
- viruses.

The pests which are particularly damaging to Scotch Bonnet pepper are aphids, broad mite, gall midge, crickets, the cucumber beetle, pepper budworm and hornworm.

Viral diseases are the most limiting factor to Scotch Bonnet pepper production. Other diseases are Fusarium wilt, Southern blight Sclerotium wilt, Anthracnose, Bacterial spot and Cercospora leaf spot.

With the application of the measures outlined below, a good crop can be produced.

- High quality seed is important to avoid plant diseases at the outset.
- Good nursery preparation is critical to give the plants the best chance from the beginning.
- Crop rotation can help to prevent the conditions for most of the diseases and pests that are likely to affect Scotch Bonnet plants.
- Proper land preparation also reduces the likelihood of soil-borne diseases.
- Live barriers help to reduce aphid infestation.
- Many insect pests can be fought by using non-chemical means of control.
- "Natural enemies", such as the ladybird and certain wasps destroy some pests and these should be encouraged.
- As far as possible, manage fields without the use of pesticides.

See **Appendix 2** for the list of recommended chemicals and application rates for control of pests).

Aphids

Aphids (commonly called plant lice) are small insects that are readily seen. They vary in colour from yellowish green to dark green, and are mostly found feeding on the underside of pepper leaves. Aphids pierce plant tissue and suck the sap. This weakens the plant and may cause leaves and twigs to become deformed.



Plate16. *Aphids on pepper leaf*

As the aphids feed, they pass out a sweet liquid called honeydew. Ants and other insects are attracted to this substance, and feed on it. The ants transport aphids from plant to plant and drive away natural enemies, causing the aphids to spread.

A black fungus called "sooty mould" sometimes grows on the honeydew and reduces the plant's capacity to make food. Aphids also transmit viral plant diseases. These can be very damaging to hot pepper production. Two major viruses spread by aphids in Jamaica are the Potato Virus Y (PVY) and the Tobacco Etch Virus (TEV).

Control

Aphids may be prevented from spreading viruses into fields by planting a "barrier crop," which is not a host of the virus, around the field. As the aphids feed on the barrier, the viruses become dislodged from their mouths, and they can no longer transfer them to the field. This gives the pepper field a longer productive life. Grass and plastic mulches also help in the control of aphids.

The barrier crop which should be a minimum of 1.8 m (6 ft) wide, should be planted around the boundary of the pepper field. It should not be planted at the normal spacing, but very close. If corn is used, plant at 15 cm x 15 cm (6 in. x 6 in.) spacing. A narrow opening of 60cm (2 ft) should be left in the barrier to enter and leave the field. Once the barrier crop height is at least 45 - 60 cm (18 - 24 in.) transplant your seedlings.

Where it becomes necessary to use insecticides, Dimethoate, or Admire may be applied before fruit development. During fruiting, Safer Soap or Malathion may be sprayed. In cases where peppers are being exported, other chemicals allowed by the importing country may be used. Chemicals such as Abamectin and Pegasus used for broad mite, also control the spread of aphids (see **Appendix 2**).

Broad mite

The broad mite is a very small insect-like pest, but it is not actually an insect. It is of the spider and tick family. The fully-grown broad mite resembles very small ticks, or grass lice when viewed with a microscope; as it cannot usually be seen with the naked eye. The adult

broad mite has eight legs, while insects have six. The mite may be carried from one plant to another, or from field to field by the wind, by insects, or even by people and animals. You can tell when the broad mite is present in the field, by the damage it does to the plants.



Plate 17.
Broad mite damage



Plate 18. *Broad mite damage on fruits*

Mites will cause leaf deformation and curling. Affected leaves may appear rusty (bronze/brownish), especially on their lower surface. These will be smaller in size and will eventually fall off. If there is severe broad mite infestation, the entire plant will become stunted; flowers will fall off and fruits will be small, deformed and discoloured (rusty). Broad mite leaf damage is sometimes mistaken for virus damage. If in doubt, seek the assistance of your extension officer or plant protection specialist.

Control

Like insects, the broad mite can become resistant to chemicals after continuous exposure to them. The best way to control this pest is, therefore, to apply good field sanitation and farm husbandry practices from the beginning.

Broad mite can attack pepper plants from the seedling stage to maturity. Check for symptoms when pepper plants are in the nursery, as it is important to have clean, healthy seedlings for transplanting. Infested seedlings will lead to infested pepper fields. Where only a small number of seedlings are affected, they should be removed and destroyed by placing them in a sealed plastic bag, or in soapy water for five minutes. If the problem is severe, seedlings may be treated with Pegasus, Vertimec, or Top Cop before transplanting.

It is important to note that the broad mite has many host crops, including sweet potato, Irish potato, tomato, cowpeas, beans, mango, citrus, avocado, coffee, papaya and guava. Where possible, peppers should be grown away from these crops, otherwise care should be taken to ensure that mites are not present on these hosts to provide a ready source of infestation.

A non-host crop such as corn, may be planted to reduce broad mite infestation by using it as a barrier around the field, as an intercrop, or in a rotation cycle.

Where only few plants or portions of plants are badly infested, the affected portions may be pruned and burnt, or packaged and sealed in plastic bags to prevent the spread of the infestation.

Spraying should begin when young leaves appear bronze in colour. Vertimec, Pegasus and Top Cop have proven effective against broad mite, but these should not be used routinely, only when necessary. Top Cop should be rotated with Vertimec or Pegasus. Vertimec is less harmful to beneficial mites than Pegasus (See Appendix 2).

Gall midge

The gall midge is a small fly resembling a mosquito. It is difficult to see it in the field, but its damage is obvious in bearing pepper fields. These tiny insects lay their eggs in the stems of maturing pepper fruits. The eggs hatch and the young gall midge (called a maggot), feeds under the skin of the stem, causing the tissue to dry out and to develop irregular brown patches on the stems. Damage is greatest on mature, green and ripening fruits.

It is important to note that although the gall midge does not affect the farmer's hot pepper yield, peppers cannot be exported to the lucrative U.S. market, unless they are fumigated. Fumigation is an added expense to exporters, and causes fruits to breakdown much sooner than normal.



Plate 19. *Gall midge damage on ripe Scotch Bonnet*

Control

The gall midge population and the damage it causes in the field can be reduced by using the following good farming practices:

- destroy all plants at the end of each crop;
- ploughing soil and ensuring that it is fully turned, so that the insects are either buried, or exposed;
- where possible, planting new pepper fields some distance upwind from old existing fields;
- practicing clean harvesting by removing all mature fruits (ripe & green) from bearing trees;
- while pepper plants are in the field, weeds should be promptly removed;
- rejected and fallen fruits should be collected and buried or burnt to kill pests; and
- crop rotation should be practiced using corn and legumes.

See **Appendix 2.** for chemical control.

Crickets

These insects damage pepper plants mainly at the seedling stage and soon after transplanting. Field crickets, or "pull-pull", as they are commonly called, resemble small grasshoppers, but are dark, fairly large and primarily do damage at nights. During the daytime, they live in holes (nests) in the ground near to the young plants, which they prey on at nights and store underground.



Plate 20. *Field cricket*

Control

To reduce cricket damage, prepare land well ahead of time, by bushing and ploughing. This will expose and destroy cricket nests and allow natural enemies such as birds and lizards to devour them. When necessary, fields should be sprayed immediately after transplanting with an insecticide such as Sevin or Basudin.

Cricket damage can greatly reduce the plant population, making it necessary to supply or replant the field. This results in increased labour and material costs, as well as delayed harvests.



Plate 21.

Seedling damaged by cricket, note portion of shoot on the ground at base of stem. Cricket damage is usually in this region



Plate 22.

multiple side shoots of seedling due to cricket damage

Cucumber beetle

The green, yellow-banded cucumber beetle can be a serious problem in the early stages of the pepper crop. These small beetles cut holes in the leaves (like bullet holes). Where large numbers develop and feed on plants, growth is retarded.



Plate 23. *Yellow-banded cucumber beetle*



Plate 24. *Cucumber beetle damage on plant*

Control

The cucumber beetle is best controlled by poisons such as Actellic, Sevin, or Diazinon (See Appendix 2). Keeping borders of fields free from host weeds also helps to reduce this beetle's breeding sites.

Pepper hornworm

The pepper hornworm can at times be a serious pest, which destroys the leaves and young shoots of pepper plants. When fully developed, the pepper



Plate 25 *Hornworm*

hornworm is a large caterpillar of about 9 - 10 cm (3 - 4 in.) long and 1.3 cm (1/2 in.) wide. It is green in colour, with slanted white bands along its sides. There is a spiny structure resembling a horn at its rear - hence the name hornworm. The pepper hornworm hides during daylight on the underside of leaves and blends in with the green leaf colour. Its feeding activity is readily detected by the presence of eaten leaves on branches and twigs of the plants. Fresh green droppings are also a sign of hornworm presence.

Control

Hornworms are usually kept in check by several natural enemies, such as predators and parasites for example birds, wasps, flies and bugs. They are also easily removed by hand and killed. Examine fields regularly for early detection of hornworm outbreaks to reduce damage. Where spraying is necessary, a bacterial formulation such as Dipel, Agree, or Xentari may be used when the caterpillars are in their younger stages. (See Appendix 2)

Pepper budworm

The pepper budworm is the caterpillar stage of the bud moth. This is a very small moth, which lays its eggs on the leaves of pepper plants during flowering. When the eggs hatch, the young budworm crawls into the unopened flower and feeds on the inside, causing it to fall off. Although some flowers fall off naturally, the budworm causes greater flower loss. Fewer flowers on the tree, cause less fruits to develop, and result in reduced yields and income for the farmer.



Plate 26. *Natural enemy, the paper wasp*

Control by natural enemies

In addition to predatory insect pests attacking the pepper crop, there are a number of other insects and mites, which cause no damage. These are "friendly", and are regarded as "natural enemies" and should, therefore, be encouraged and protected where possible. The paper wasps "brown gal", feed their young with small caterpillars; some very small wasps lay their eggs and develop inside caterpillars; spiders feed on various insects; "assassin" bugs suck the juice of caterpillars and other bugs such as ladybird beetles and lacewing. Some fly maggots also feed on aphids and small soft-bodied insects; while predatory mites feed on plant mites.



Plate 27. *Natural enemy, young ladybird beetle*

Non-chemical pest control methods are strongly recommended. Chemical methods cannot always be specifically targeted, that is, they usually kill all the insects ("friendly" and predatory alike). However, safer chemical and non-chemical methods will allow natural enemies to live, while helping the farmer to kill pests that damage his pepper crop.

DISEASES AND CONTROL METHODS

Viruses (TEV and PVY)

A number of viruses infect Scotch Bonnet pepper, however, those of major concern are the Tobacco Etch Virus (TEV) and the Potato Virus Y (PVY). Of the two, TEV is the more severe. The viruses cause yellowing and mottling of leaves, upward leaf curl and small, deformed leaves, with vein puckering. Where plants are infected at an early stage, growth is stunted, and their production is low.

As was outlined earlier, aphids spread these viruses.



Plate 28. *Plant infected with TEV*

Control

Control should be aimed at maintaining the aphid population at low levels. This can be done in the following ways:

- by growing seedlings under insect-proof conditions;
- using a trap, or barrier crop, in conjunction with insecticides such as Dimethoate* and Admire;
- using plastic or grass mulch to deter aphids; and
- by the prompt removal of weed hosts, such as cow pops, black nightshade, white top, velvet burr and jimson weed.

**Dimethoate should not be used within two (2) weeks of harvesting.*



Plate 29. *Scotch Bonnet pepper with corn as barrier crop*

Fusarium wilt

Fusarium wilt is caused by a fungus, which is present in the soil. Where the soil is allowed to dry out or is overwatered, the fungus develops rapidly. When plants suffer from water stress they are more readily affected by the disease.



Plate 30. *Fusarium wilt - showing yellowing of leaves*



Plate 31. *Fusarium wilt, root damage*

The disease can be carried from the nursery into the field on the roots of seedlings. diseased plants in the field become yellow, weak and die slowly. *Fusarium wilt* is confirmed when the tissue under the bark of the stem appears reddish-brown in colour. This indicates the presence of the fungus blocking the vessels (tubes) in the plant that carry water upwards to the leaves.

Control

Fusarium wilt is a disease that the farmer cannot “spray away”. Some farming methods that may be used to reduce the disease include:

- crop rotation with the use of resistant crops;
- deep ploughing the soil and leaving it exposed to the sun for several months;
- planting on soils that drain freely and are not too acid;
- maintaining adequate soil moisture throughout the life of the crop;
- harvesting mature peppers promptly, to reduce stress on the plants;
- when establishing new pepper fields, use disease free seedlings;
- as soon as plants show signs of Fusarium wilt, they should be removed from the field and burnt; and
- every effort should be made to fertilize plants adequately at the appropriate times, to ensure healthy growth. This will help them to bear well and resist diseases.(see **Appendix 2**)

Southern blight or Sclerotium wilt

This disease is caused by a fungus that lives in the soil., and affects a wide range of vegetables and other crops. The fungus can remain dormant in the soil for many years. It affects plants at ground level, producing a white fungal growth with small brown, seed-like bodies on the plant stem, as well as on the soil surface.

Infected plants wilt and die suddenly with the section nearest to the ground becoming brown; while the stem tissue above this area appears normal. This is not so with Fusarium wilt.

Blight is more likely to be a problem in hot weather that is followed by heavy rain. It is also more likely to attack plants that are suffering from an excess of, or too little moisture.

Like Fusarium wilt, Southern blight cannot be controlled by spraying. (See **Appendix 2**). Although it develops very rapidly, it usually only affects a few plants in a field.

When plants die from Sclerotium wilt, the whole plant and the soil around the root area should be carefully removed and burned outside of the field. Deep ploughing will also bury the fungus below the surface layer, away from the plant root. (see Appendix 2)



Plate 32. *Anthracnose - fruit*

Anthracnose

This fungal disease is common wherever peppers are grown. It first appears on the fruit as small, water-soaked, dark and sunken areas, which increase in size rapidly. After a while, a black layer appears over the affected sections of the plant. Sometimes waxy pink patches appear on the fruit. These are the fruits, or spores of the fungus. Eventually, the affected fruits rot.

Control

The fungus is carried from one crop to another on diseased plants. This makes it necessary to remove and burn all plants and fruits from old fields. Where possible, rotation should be practiced with resistant crops. The fungus also affects the seeds, so farmers should obtain clean, good quality seeds when establishing new nurseries, instead of using seeds from their old crops. Prompt and thorough harvesting of mature fruits also reduces the build up of the disease in the crop.



Plate 33. *Bacterial spot - leaf and fruit*

Bacterial Spot

This disease can become serious when conditions are favourable. When the weather is hot and moisture is abundant, it can develop and spread rapidly. Bacterial spot shows up as raised brown spots on the underside of leaves and brown spots on fruits. The disease can enter the fruit and cause rotting. It also affects the seeds.

Control

Farmers should avoid selecting seeds from affected fields to be sown in nurseries. Where fields are badly affected, spraying can be done fortnightly, using Mankocide up to two weeks before harvesting begins.

Cercospora leaf spot (Frogeye)

A fungus causes this disease. It produces spots that are round, whitish, grey or brown, often with brown or reddish brown borders. Infected leaves fall off early. The fungus also attacks the stem. The severity of the attack sometimes varies. Where conditions are suitable, crop damage may be serious. The fungus is carried on seeds; hence, care should be taken to select clean seeds for plant



Plate 34. *Frogeye spot - leaf*



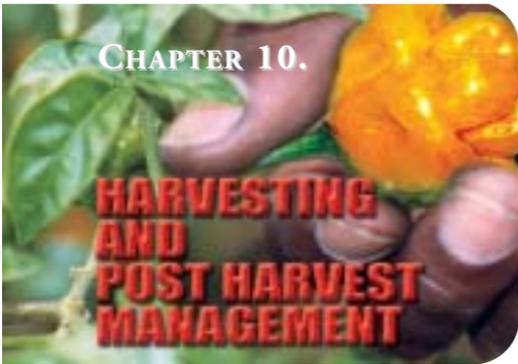
Plate 35. *Frogeye spot - stem*

Control

Select good quality seeds for planting. When outbreaks occur control can be effected by sanitizing and the application of Mankocide*, Dithane, Topsin M** or Daconil.

* *Mankocide may be used before and after flowering.*

** *Topsin M should be used before fruit is set.*



CHAPTER 10.

HARVESTING AND POST HARVEST MANAGEMENT

Yield

Using drip irrigation with a plant population of 3000 plants per 0.4 ha (1 acre), an average yield of 360kg (800 lb) of fruits per week is expected for at least four to five (4-5) months. Higher yields may be obtained with more plants per unit area, but the plant population should not exceed 5000 plants per 0.4 ha (1 acre).

The length of the harvesting period is dependent on the health and general condition of the plants.

Signs of fruit maturity

Harvesting usually starts about 12 weeks after transplanting. The fruits must be harvested when they are a full green colour, or with a blush of yellow/orange. The pedicel (stalk) and calyx (stalk base) should be green and overall, fruits should look fresh and firm. Immature fruits are dull in colour, as they do not have the protective waxy layer on the outside and these will shrivel if harvested. Immature fruits also weigh less than mature green fruits, so that selling them will mean loss of earnings for the farmer.

How to harvest

A close look at the fruit will show a distinct line where the pedicel is attached to the plant. Hold the pedicel between two fingers and snap the fruit off, upwards towards the back of the curve. This makes a clean break. Part of the pedicel actually forms a natural seal that will protect the fruit from disease organisms which might cause spoilage.

The time of day and the weather conditions are important for harvesting. Avoid harvesting peppers on a rainy day, as water will promote spoilage. If the fruits become wet, spread them out in an airy location to dry. If they are damaged, this could lead to rotting.

Ideally, peppers should be harvested on the same day they are to be shipped, or on the day before. Reap when it is cooler, either in the morning or late afternoon/evening.

Fruit handling

The type of crates used in transporting and storing peppers is important. Harvested peppers need good ventilation. The black plastic crates that are normally used for packing bananas are not recommended. These absorb heat and will contribute to spoilage. Bags should not be used, as they do not protect the fruits from damage.

It is best to use the shallow ventilated plastic packing crates. Be careful not to over fill or under fill the boxes, as the fruits may be damaged as the crates are moved around while being transported.

When transporting, the crates should be stacked properly to prevent the peppers from being pressed and jolted around. Like harvesting, the produce should be transported in the cooler part of the day to reduce fruit breakdown.

Scotch Bonnet peppers will last for two to five (2 – 5) days at temperatures of 25 - 27° C (77 – 80 ° F). After that, they will start to shrivel and show signs of decay. Lower temperatures will allow the fruit to last for up to 10 days.

Never store peppers with other ripening fruits – especially mangoes, papayas and tomatoes, or they will ripen much faster and spoil more quickly.

Sorting and grading

On reaching the exporter, peppers will be graded. There are two main grades for Scotch Bonnet pepper. Grade A or Grade I, and Grade B or Grade 2. Grade A peppers are those that are of the highest quality. Grade 2 includes those that are of reasonably good quality.

Characteristics of Grade "A" Scotch Bonnet pepper:

- the classic Scotch Bonnet shape – three to four lobes and the characteristic cup and saucer shape;
- the peppers should be a minimum of 3.5 cm or (1½ in.) wide;
- the length of the pedicel (fruit stalk) should be no more than 3cm (1¼ in.);
- the skin should be completely free from spots, bruises or decay ; and
- finally, but very importantly, there should be no harmful chemical residue on the fruit.

Grade A peppers will tolerate some degree of bruising (about 5%). Eight percent (8%) of bruising is tolerated in peppers that are of Grade B quality.



Plate 36. *Scotch bonnet pepper showing 3 and 4 lobes and bonnet.*

Everything else is considered to be "reject quality" fruit. Rejected fruits include all those that are undersized, bruised, split or broken; decaying, insect infested, immature or over-ripe. The shape of fruits also sometimes causes rejection. Mouldy or rotten fruits are not acceptable.



Plate 37. *Grade "A" Scotch Bonnet peppers*

LIST OF WEEDS AND CONTROL METHODS

Weeds	Control Methods	
	Chemicals and Rate	Non-chemical
Grass weeds	<p>Use of selective herbicides:</p> <ul style="list-style-type: none"> • Fusilade -15 ml/5 L (1 tbsp/gal water) • Agil - 15 ml/5 L (1 tbsp/gal water) <p>These may be sprayed on crop without harm</p> <p>Non-selective herbicides Paraquat (Gramoxone etc) 30 ml/5 L (2 tbsp/gal water)</p> <p>This is non-selective contact and burns all green tissue.</p> <p>Caution: use spray shield.</p> <ul style="list-style-type: none"> • Glyphosate (Roundup) 30 ml/5 L (2 tbsp/gal water) <p>This is a slow-acting, non-selective, systemic herbicide.</p> <p>Caution: use spray shield.</p>	<p>Hand weeding, mulching (grass or plastic) use of drip irrigation; inter-row cultivation. Closer spacing also shades the soil and prevents weed growth.</p> <p>Be careful to attack weed problems early as this prevents crop loss as well as saves time and money and contributes to pest and disease control.</p>
Broad leaf or mixed weed population	<p>Use Paraquat or Glyphosate as above. Remember: Fusilade and Agil kill only grasses.</p>	<p>With mixed weeds if grass is predominant these may be treated chemically and the others removed by hand weeding.</p>

LIST OF PESTS AND DISEASES AND CONTROL METHODS

Pest	Control Methods	
	Chemicals and Rate	Non-Chemical
Insects and mites Aphids <i>(greenfly, plant lice)</i>	Actellic - 15 ml/5 L water (1 tbsp/gal water) (also controls other insects, like beetles and worms) Admire - 30 ml/5 L water (2 tbsp/1 gal water) applied to soil at transplanting. Dimethoate - 5 ml/5 L water(1 tsp/1 gal water) (use up to 14 days before first harvest)	Aphids eaten by ladybird, lacewing, and syrphid fly larva. Also parasitized by small wasps. Control ants, which protect aphids from natural enemies and spread them in field. Use corn barrier around field; destroy old pepper field.
Broad mite <i>(Cannot be seen with naked eye: damage symptoms indicate presence)</i>	Abamectin (= Agrimek, Vertimec) 10 ml/5 L water (1 tsp/1 gal water) Pegasus -10 ml/5 L water (1 tsp/1gal water) Top cop -25 ml/5 L water (5 tsp/1 gal water). <i>Use Abamectin and Pegasus only when mites are present and alternate with Top cop.</i>	In early stage severely affected branches may be pruned or whole plants removed from field. Carefully place this in plastic bag and seal. Clear area of other host plants before planting. Ensure seedlings are mite-free.
Pepper midge <i>(Gall midge)</i> <i>(very small insect: damage indicates presence)</i>	Admire - 10 ml/5 L water (2 tsp/1 gal water) Applied to soil at transplanting or 5 ml/5 L Water (1 tsp/1 gal water) sprayed onto foliage later	Destroy old pepper plants and crop residue. Harvest mature fruits promptly and thoroughly. Destroy any infested fruits by deep burying or burning.
Leaf beetles	Readily controlled by most contact insecticides eg. Sevin - 15 ml/5 L water (1 tbsp/1gal water)	Keep fields and borders free from weed hosts. Ensure plants are in good vigor.

Pest	Control Methods	
	Chemicals and Rate	Non-Chemical
Cricket, Cutworm Armyworm	Controlled by residual contact and stomach insecticide applied to soil immediately after transplanting. Eg. Sevin- 15 ml/5 L water (1 tbsp/1gal water); Diazinon - 15 ml/5 L water (1 tbsp/1 gal water) also bait mixture of: 500 g insecticide + 5 kg cornmeal + 5 kg sawdust (or coir)+ 1L molasses (or 500 g dark sugar) Mix to lumpy consistency and spread along rows.	Clear land of weeds and prepare soil well ahead of transplanting. This will destroy cricket nests, as well as bury or expose them to predators. In small fields cutworms and armyworms may be collected by hand and killed.
Hornworm	Readily controlled with contact insecticides where necessary as in case of leaf beetles.	Scout field regularly and look for signs of hornworm. Locate and pick them off and kill them. They usually attack a few plants at a time, so there is no need for wholesale spraying. Where necessary, spraying may be done with bacterial preparation of Agree, Xentari or New Bt.
Budworm <i>(Tiny caterpillar feeding in the unopened flower buds. May be seen with naked eye when bud is opened)</i>	Chemical treatments not confirmed to date. Suggested control: as for pepper midge.	Prepare land well ahead of transplanting and keep fields and borders free of weeds. Keep bearing field in healthy, vigorous state.

Pest	Control Methods	
	Chemicals and Rate	Non-Chemical
Diseases Damping off fungi	Ridomil MZ 30ml/5L (2 tbsp/1gal water) Apply as drench to soil.	Place trays in area with adequate sunlight and aeration. Allow for proper drainage. Do not over water. Remove diseased seedlings and soil from healthy ones. Do not over crowd nursery.
Bacterial spot	Mancozeb, Mankocide 15ml/5L (1 tbsp/1gal water)	The disease is carried in the seed so use disease-free seeds. Avoid over-crowding of field and remove excessive shading.
Cercospora (Fungi) <i>Fruit rot , Leaf spot</i>	Mancozeb or Daconil 15ml/5L (1 tbsp/1gal water)	Harvest fruits promptly and cleanly.
Fusarium wilt	Topsin or Benlate 30ml/5L (2 tbsp/gal water) <i>Apply to soil at transplanting</i>	Ensure vigorous crop growth. Avoid too little or excessive moisture in soil. Remove badly diseased plants with roots and soil from field and burn. Practise crop rotation and fallowing of land.
Sclerotium wilt <i>(Southern blight)</i>	No effective chemical treatment	Prepare land by deep ploughing and allow to burn for some time. Avoid excessive watering. Ensure good drainage of land. Practise crop rotation. Remove affected plants with soil where disease occurs and burn.
Viruses <i>Potato virus Y (PVY) and Tobacco Etch Virus (TEV)</i>	No direct chemical control. Apply chemicals for aphid vector control.	Use barrier crop eg. Corn around field or interplant rows of corn among pepper plants. Mulch field with grass or clear plastic. Ensure seedlings are disease-free at transplanting.

APPENDIX 3.

COST OF PRODUCTION MODEL FOR 1 HECTARE SCOTCH BONNET PEPPER USING DRIP IRRIGATION NEW ENTRANT



OPERATIONS	Unit	# of Unit	Unit costs	Costs
Ploughing	Hectare	1	\$18,450	\$18,450
Harrowing	Hectare	1	\$11,115	\$11,115
Removing stones & debris	Man Days	2	\$400	\$800
Furrowing	Hectare	4	\$7,410	\$7,410
Lining, digging holes, fertilizing	Holes	7,410	\$4	\$29,640
Transplanting	Man Days	7.5	\$400	\$3,000
Applying herbicide & insecticide	Man Days	30	\$400	\$12,000
Applying fungicide	Man Days	1.5	\$400	\$600
Weeding & moulding	Man Days	12.5	\$400	\$5,000
Fertilizing	Man Days	5	\$400	\$2,000
Applying irrigation water	Man Days	20	\$400	\$8,000
Reaping	Man Days	45	\$400	\$18,000
Transporting to packing house	Man Days	20	\$400	\$8,000
				\$124,015
MATERIAL				
Seedlings		7,410	\$8	\$59,280
Fertilizer -15-5-35	50kg	4.5	\$650	\$2,925
-Sulphate of Ammonia	50kg	6	\$700	\$4,200
-Foliar	25kg	1	\$1,705	\$1,705
Fungicide -Mankocide	25kg	1	\$5,980	\$5,980
Insecticide -Diazinon	20L	1	\$11,343	\$11,343
Herbicide -Paraquat	5L	2	\$1,414	\$2,828
Water	Litres/day	16,670	\$0.01	\$24,671
				\$112,932
IRRIGATION SYSTEM				
-Pipes & Fittings				\$17,367
-Pump				\$50,216
-Stand for drum				\$2,000
-Labour				\$5,000
-Transportation				\$12,000
-Tank(3,600L) x 2				\$17,000
				\$103,583
Other Costs				
Contingencies (10% of Labour materials & Irrigation)				\$34,052
Supervision (15% of Labour)				\$18,602
Tools (5% of Materials)				\$5,646
Land Charges (\$6,175 per ha/yr)				\$6,175
Interest (15% on 60% of Labour materials & Irrigation)				\$30,647
				\$95,122
Total Cost				\$435,652
Yield	kg	23,400		
cost per kg				\$18.62
Gross return			\$44	\$1,029,600
Profit				\$593,948

Notes - see assumptions overleaf

COST OF PRODUCTION MODEL FOR 1 HECTARE SCOTCH BONNET PEPPER USING DRIP IRRIGATION EXISTING FARMER



OPERATIONS	Unit	# of Unit	Unit costs	Costs
Ploughing	Hectare	1	\$18,450	\$18,450
Harrowing	Hectare	1	\$11,115	\$11,115
Furrowing	Hectare	4	\$7,410	\$7,410
Lining, digging holes, fertilizing	Holes	7,410	\$4.00	\$29,640
Transplanting	Man Days	7.5	\$400	\$3,000
Applying herbicide & insecticide	Man Days	30	\$400	\$12,000
Applying fungicide	Man Days	1.5	\$400	\$600
Weeding & moulding	Man Days	12.5	\$400	\$5,000
Fertilizing	Man Days	5	\$400	\$2,000
Applying irrigation water	Man Days	20	\$400	\$8,000
Reaping	Man Days	45	\$400	\$18,000
Transporting to packing house	Man Days	20	\$400	\$8,000
				\$123,215
MATERIAL				
Seedlings		7,410	\$8.00	\$59,280
Fertilizer- N.P.K. 11-22-22	50kg	4.5	\$650	\$2,925
-Sulphate of Ammonia	50kg	6	\$700	\$4,200
-Foliar	25kg	1	\$1,705	\$1,705
Fungicide-Mankocide	25kg	1	\$5,980	\$5,980
Insecticide-Diazinon	20L	1	\$11,343	\$11,343
Herbicide-Paraquat	5L	2	\$1,414	\$2,828
Water	Litres/day	16,670	\$0.01	\$24,671
				\$112,932
IRRIGATION SYSTEM				
-Pipes & Fittings				\$3,473
-Pump				\$10,043
-Stand for drum				\$400
-Tank (3,600L) x 2				\$3,400
				\$17,316
Other Costs				
Contingencies (10% of labour materials & Irrigation)				\$25,346
Supervision (15% of Labour)				\$18,482
Tools (5% of Materials)				\$5,646
Land Charges (\$6,175 per ha/yr)				\$6,175
Interest (15% on 60% of Labour materials & Irrigation)				\$22,811
				\$78,460
Total Cost				\$331,923
Yield	kg	23,400		
cost per kg				\$14.18
Gross return			\$44	\$1,029,600
Profit				\$697,677

- Notes-
1. Crop is harvested for six (6) months.
 2. Seedling cost is calculated at five dollars (\$) per seedling. Market price of seedling will vary among producers, estimated here at eight dollars (\$8.00) each.
 3. Number of days for irrigation = 148
 4. Number of units recommended for irrigating 1 ha of pepper is 41,675 litres/day

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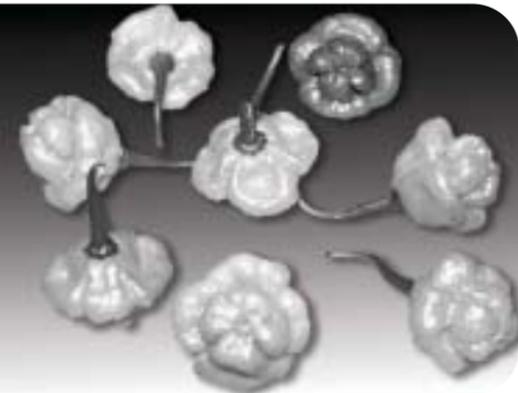
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