A GUIDE TO PEPPER PRODUCTION IN ZIMBABWE

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Cover Picture: A pepper plant taken at Horticulture Research Center by Gokoma Bongai in 2008.

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Horticulture Research Institute

Horticulture Research Institute is one of the 15 research Institutions in the Department of Agricultural Research for Development in the Ministry of Agriculture. It comprises of 2 research stations Horticulture Research Center (HRC) at Marondera and Nyanga Experimental Station (NES) at Nyanga.

Horticulture Research Center is located at an altitude of 1600m asl and is primarily concerned with applied research and cultivar evaluations on temperate zone fruit crops and a wide range of vegetables. The center also supplies farmers with virus and nematode free propagation material of strawberry and sweet potato cultivars.

Nyanga Experimental Station is at altitude of 1850m asl. It is concerned with applied research on deciduous fruits, mainly apples with some work in pears and stone fruits like peaches, plums, nectarines and apricots. It is also a Crop Breeding Institute base for potato breeding work and a site for wheat and barley selection.

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1.0. INTRODUCTION

The common name for pepper which includes both sweet and hot peppers are capsicum, cayene, paprika, red pepper and sweet pepper. Pepper belongs to the genus *Capsicum* with a variety of species. Bell peppers, and many hot peppers, are native to Central and North America. Pepper is grown as an annual but sometimes as a short perennial.

Peppers are frost sensitive and grow well in warm climates with a long growing season. Some cultivars of pepper can survive fairly high temperatures e.g. the more pungent, the higher the temperature that can be withstood. During winter most pepper production is done under greenhouses. Peppers grow best in light, fertile, well-drained soils but with proper soil management they can be grown successfully in a wide range of soil types.

Capsicum fruits are consumed in fresh dried or processed form. Sweet pepper is usually eaten raw in salads, but more commonly cooked, fried or processed together with other foods.100g edible portion contains 86g water, 202 kj energy (48 kcal), 2.0g protein, 0.8g fat, 10.3 carbohydrates, 2.6g fiber, 29mg calcium, 6.1mg phosphorus, 2.6 mg iron, 180µg beta carotene (red mature fruits 2.76µg), 0.12 thiamin, 0.15mg riboflavin, 2.2mg niacin and 140mg ascorbic acid (Leung *et al*., 1968)

Lime and Fertilizer Management

Production can be done on any soil type but sands and sandy loams are mostly preferred. Heavy soils should always be avoided because of their poor drainage. The ideal pH lies between 5.5 and 7.0 $CaCl_2$ scale. It is important to keep soil pH in the proper range for production because;

- pH ranges are essential considerations for any fertilizer management program
- pH strongly influences plant growth and the availability of nutrients
- pH influences the activities of micro-organisms in the soil

Correction of soil pH

Lime should be broadcasted and thoroughly incorporated with a disc harrow to a depth of 15-20 cm to neutralize the soil acidity in the root zone. To allow adequate time for correction lime should be thoroughly incorporated one to two months before seeding or transplanting because calcium has limited mobility in the soil.

Soil management

The extent to which the root system of pepper develops is influenced by the soil profile. Root growth will be restricted if there is a hard pan or compacted soil layer. For pepper production, proper tillage is crucial for adequate soil management and optimal yields. A good soil tilth is suitable for direct seeding or transplanting to provide the best soil structure for root growth and development.

The land should be ploughed deeply to allow a rooting depth of 90-120 cm. It is difficult to recommend a specific fertilizer management program that has universal application for all pepper fields. Therefore, fertilizer recommendations based on soil analyses have the greatest potential for providing peppers with adequate fertility. About 25–35 tones of compost or manure per hectare before planting are recommended. Rows and beds are made after soil treatment and soil should be pre-irrigated before transplanting the seedlings. Avoid transplanting in hot weather.

All the recommended phosphorus should be applied during or near transplanting. For each specific season, N rates actually needed will vary depending on rainfall, soil type, soil temperature, irrigation, and plant population, duration of the harvest season, and method and timing of applications.

Approximately 50 percent of the total applied N should be in the nitrate form. High rates of ammoniacal nitrogen may interfere with calcium nutrition and result in an increased incidence of blossom-end rot (BER). Side dressing with calcium nitrate as the nitrogen source often significantly reduces the severity of BER.

Varieties

Table 1: Bell Pepper Variety Description

Varieties	***Days to first harvesting***	***Plant height (cm)***	***Plant habit***	***Lobes per fruit***
California Wonder (OP)	77	69-76	Upright	4
Early Califonia Wonder (OP)	71	56-66	Slight spread	3-4
Jupiter (OP)	70	66-76	Upright	3-4
Bell Captain (H)	72	64-74	Slight spread	4
Bell Boy (H)	70	61-66	Upright	4
Golden Bell (H)	68	51-61	Upright	4
Valencia (H)	80			4
Indra (H)	75			4

Notes: *OP: Open pollinated* *H: Hybrid*

Propagation

Peppers are best started indoors, eight to ten weeks before winter. The anticipated nursery period is long because pepper seeds can be difficult to germinate, and seedlings grow slowly. At sowing, seed should be dressed with some fungicidal dressing such as Thiram which helps in controlling fungal infections such as damping off. The soil should be treated by fumigation or solarisation to control soil borne pathogens. The seed rate used depends on the final field spacing. Seeds can be direct seeded, sown on raised beds or sown in containers.

A few commercial pepper producers grow their own transplants in greenhouses, in plastic covered beds or on raised beds. Seeds are either sown in containers or directly on the ground.

Container growing

The most common type of containerized plant production is one where plants are seeded into speedling trays or plastic cell packs. A well prepared potting mix, with vlei, pine bark and manure is ideal. The media is fumigated to eliminate weed and disease related problems.

Bed production

Greenhouse beds are filled to about 8-10cm deep with potting soil. Ten centimeter width rows are created and seeds are planted no closer than three seeds per 2.5cm of row. This spacing will require about 100 square feet of bed space to produce 10 000 good plants.

Pepper seed will germinate best at 26-29º C. Wide fluctuation in greenhouse temperatures will result in delayed emergence of pepper plants. If natural soil is used in outdoor production it should be weed and disease free. This usually requires that the area be fumigated before using. For outdoor transplant production, seed can either be broadcasted or planted in rows. Row production will facilitate plant pulling and should result in a greater number of usable transplants.
Growing transplants in greenhouse ground beds or benches will reduce the cost considerably over container-grown plants.

Direct seeding

Commercial plant growers begin direct seeding pepper as soon as growing conditions permit. More than one planting may be required before a stand is achieved. If plants reach transplant size before conditions are suitable for transplanting, they may be clipped to retard growth and provide more uniform transplants. There are advantages and disadvantages to this clipping process. If properly timed, clipping will result in more compact plants with larger stems. The recommendations for clipping certified transplants should be followed in order to prevent or lessen disease development.

Hardening

Pepper transplants should be hardened off before transplanting in the field. Hardening off is a technique used to slow plant growth prior to field establishment so the plant can successfully withstand unfavorable conditions in the field.

Some growers use 75 x 45 cm or 90 x 45 cm with a seed rate of about 150-200 grams per hectare. The crop flowers 2 months after transplanting and harvesting lasts for about three months or even more depending on cultivar. Low temperatures and unfavorable water supply will increase the incidence of bud blossom and fruit drop

Crop establishment

For maximum production, transplants should never have fruits, flowers, or flower buds before transplanting. An ideal transplant is young about 20- 30cm tall, with a stem approximately 1-2 cm in diameter, does not exhibit rapid vegetative growth, and is slightly hardened at transplanting time. Seedlings are usually ready between 4-6 weeks.
Peppers may be planted or transplanted on flat or raised beds. Since peppers do poorly in excessively wet soils, a raised bed facilitates drainage and helps prevent "wet feet" in low or poorly drained soils. Keep in mind, however, that peppers planted on raised beds may also require more irrigation during drought conditions. Although peppers may be seeded directly in the field, this is not usually recommended. Direct seeding has several disadvantages:

- Weed control is usually much more difficult
- Direct seeding requires seedbeds with a very fine tilth and careful planting to adequately control depth of planting and in-row spacing
- The field must be nearly level to prevent seeds from being washed away or covered too deeply with water transported soil

Seedlings from the trays are the best because they retain transplant growing medium attached to their roots after removal from the trays. Many growers prefer this type transplant because:

- They are less subject to transplanting shock
- Usually require little, if any, replanting
- Resume growth more quickly after transplanting
- Grow and produce more uniformly.

Transplants should be set as soon as possible after removing from containers or after pulling. When setting plants, roots should be placed three inches to four inches deep. Peppers grow best if night time soil temperatures average more than 15 ºC.

After transplanting (especially within the first two weeks) it is very important that soil moisture be maintained so that plant roots can become well established.

Plant Spacing

The optimal plant population per acre depends upon plant growth habit (compact, medium, spreading), plant size (small, medium, large) at maturity, vigor of specific cultivars, climate, soil moisture and nutrient availability and soil productivity.
Sweet bell pepper types are more compact than many other kinds of pepper and rows should be spaced 90 cm to 100 cm apart with 30 cm to 40 cm between plants in the row. Normally from 30 000 to 37 500 plants per hectare are considered adequate for bell pepper production. Often bell peppers are transplanted 30 cm apart in 85 cm to 90 cm rows. For other kinds of peppers, which produce larger type plants, the population should be decreased accordingly.

Weed control

Weeds can be controlled by fumigation, use of herbicides, hand weeding and mechanical. The first step in avoiding weed problems in pepper seedbeds is to select a weed-free soil mixture or a land area with no history of a severe weed problem.

Fumigation

When fumigating, the area should be tightly covered with an airtight plastic. A registered fumigant is injected under the cover and the seedbed is left undisturbed for three days. Then plastic cover is removed and the soil is aerated for seven days before planting. A properly applied fumigant penetrates the soil and kills most viable seeds. Fumigation for weed control is expensive and dangerous. It must be handled by trained personnel. *(Apply all fumigants in full compliance with label recommendations and precautions).*

Herbicides

Certain herbicides may be used (with or without fumigation) for weed control in both seedbeds and the field. Apply a contact non-residual herbicide prior to seeding or after seeding but before pepper emergence. Weeds germinate and die before crop emergence. Pre-emergence herbicides may be applied immediately after planting, but before crop and weeds emerge.

Mechanical

Mechanical control is use of machinery to control weeds. It is effective during early growth. Once plants begin to bear, mechanical cultivation is not practical. Tractor wheels and cultivators easily damage crops. Mechanical cultivation usually requires supplementary hand weeding for removing weeds in the rows.

Plastic mulch

Plastic mulch with drip irrigation is also an efficient weed control method. Black plastic is the most effective mulch because the color prevents light penetration needed for weed seed germination. The edges of the plastic mulch must be properly embedded in the soil to prevent wind disturbance.

Hand weeding

In the field hand weeding is the safest and least damaging to the crop. However, only growers with small hectarage and abundant labour will favour this method.

Irrigation

Irrigation is essential to produce consistent yields of high quality peppers .Rainfall amounts are often erratic during the pepper growing season and peppers are often grown in sandy soils which have a low water holding capacity. This combination of factors makes supplementary irrigation necessary for commercial pepper production.

Moisture stress in peppers causes shedding of flowers and young fruit, sun scalding and dry rot of fruit. The most critical stages for watering are at transplanting, flowering and fruit development.

Several types of irrigation may be used successfully on peppers. These include drip, flood and overhead. However, the type chosen will depend on one or more of the following factors:

- Availability of existing equipment
- Field shape and size
- Amount and quality of water available
- Labor requirements
- Fuel requirements
- Cost

Drip irrigation

Drip irrigation is becoming more popular for pepper production. Although it can be used with or without plastic mulch, its use is highly recommended with plastic mulch culture. One of the major advantages of drip irrigation is it has a high water use efficiency. Weeds are also less of a problem since only the rows are watered and the middles remain dry.

Flood irrigation

Flood irrigation can also be used in pepper production. After transplanting, 10-15 mm water is applied by flood twice a week for the first two weeks to establish the crop. Thereafter, irrigations are given every three to seven days for two to three weeks.

Overhead Sprinkling

Overhead sprinkling is useful once every week as a method of cleaning the plants.

Pest and Disease Control

Physiological disorders

1. Flower drop

Flower drop in pepper plants is an occasional problem. The flowers drop prematurely before pollination. The causes of flower drop include:

- a response to temperature stress (drop occurs at temperatures greater than 34ºC and less than 10º C)
- a response to water stress
- a response to shade stress which is specific to greenhouse pepper growers
- pepper viruses

2. Flower abortion

Flower abortion actually results from nonfunctional pollen, lack of pollination, or nonfunctioning ovules. These malfunctions occur due to stress, insect or disease problems. Pollination is more effective in the morning hours and thereby more fruit set occurs then.

Maintaining adequate soil moisture helps prevent flower abortion under drought conditions. Overhead irrigation can be used to cool peppers during hot periods to reduce flower loss.

3. Blossom-end rot

Blossom-end rot in peppers is caused by a calcium deficiency. Fruit losses can vary from a trace to about 10 percent or more, depending on variety, weather, culture, and soil type. The first external symptom to appear is a small water-soaked spot at or near the blossom end (opposite the stem) of the pepper. The water soaked spot eventually enlarges with time and becomes dry, sunken, flattened and leathery. Secondary attack by fungal or bacterial organisms may result in fruit rots. Blossom-end rot is most common during prolonged dry periods, when frequent or heavy rains follow an extended dry period, or when soil conditions are unfavorable for calcium uptake.

Lush plant growth can aggravate the disorder because excessive vegetative growth demands may shunt calcium away from the fruit. Calcium is not translocated within the plant from older to younger tissue, therefore young fruit are especially sensitive to a lack of calcium.

There are some indications that certain nutrients can. Certain nutrients such as Nitrogen antagonize the uptake of calcium and intensify blossom-end rot problems. Top dressing should therefore be applied with care during fruit set and development.

To control blossom-end rot, follow the following cultural practices:

- Grow pepper crops on well-drained soils; avoid waterlogged fields. Plant on raised beds to insure good drainage.

- ❖ Apply fertilizers according to soil test results to maintain adequate calcium levels. Avoid the excessive use of ammoniacal or nitrate nitrogen, highly-soluble potassium, magnesium, or sodium salts.
- ❖ Cultivate shallowly especially after fruit set and in dry weather.
- ❖ Maintain uniform soil moisture throughout the growing season especially as fruit are developing.
- ❖ Foliar application of calcium nitrate or calcium chloride

4. Sunscald

Sun scald is a non-infectious problem caused by direct sunlight and high temperatures on the pepper fruit. This problem is common to plants having premature foliage loss (usually from pest or mechanical damage). Nitrogen deficiency after fruit set delays canopy development and increases sunscald problems.

Irregular, light-colored, scalded areas appear on the fruit exposed to direct sunlight. Affected areas become wrinkled and creamy white as fruit ages. Secondary infection by fungi and bacteria may give the affected area a black, gray, or green moldy appearance.

The following cultural practices will help control sunscald:

- ❖ Grow pepper varieties with adequate foliage cover.
- ❖ Control pests that will tend to defoliate peppers.

Poor pepper color is often correlated with overly dense pepper canopies. Proper pepper spacing should allow sufficient light to penetrate the canopy and ensure good fruit coloration.

Diseases

Peppers are attacked by several diseases that reduce yield and quality of fruit every year. The control or prevention of these diseases is very important in pepper production.

Bacterial Diseases

Bacterial leaf spot is the most serious disease affecting peppers. The bacterium *Xanthomonas vesicatoria* causes spots on both foliage and fruit. On young leaves the spots are yellowish-green and usually slightly raised on the lower surface. On older leaves the spots are dark, water-soaked, but not noticeably raised. Enlarged spots have dead, straw colored centers with dark margins. Most of the leaves on severely infected plants turn yellow and drop. In addition, the bacterium attacks the fruit, causing small blister-like, irregular spots. These spots turn brown and develop a warty appearance.

The bacterium is seed-borne and can also over winter on diseased plant refuse in the soil. Infected seed are a main source of initial infection. Infected seedlings carry the disease to the field where it spreads rapidly during wet weather.

Only certified seed and transplants should be used when planting.

Viral Diseases

Pepper mosaic

The viruses which cause mosaic in peppers produce a distinct mottling and distortion of the leaves. Leaves are somewhat wrinkled and often pale green in color. Affected plants take on a bushy shape. Resulting fruit from infected plants are usually malformed. There are at least four viruses responsible for pepper mosaic: tobacco mosaic virus (TMV), tobacco etches virus (TEV), cucumber mosaic virus (CMV), and potato virus Y (PVY).

Tobacco mosaic virus is a mechanically transmitted virus which means the virus can be spread by touching an infected plant immediately before touching a healthy one. Also, tobacco mosaic virus may be transmitted by handling tobacco products before touching pepper plants. The other viruses are insect transmitted, primarily by aphids.

Tomato spotted wilt virus

The virus is acquired by immature thrips and is transmitted only by the adult. Infection to date has been more serious in early planted peppers.

Virus diseases of pepper often cause significant economic losses. The incidence and severity of virus infections may be lessened by using resistant varieties, by eliminating weed hosts, by destroying affected fields immediately after the final harvest, and by controlling the insects which transmit viruses.

Fungal Diseases

Cercospora leafspot

The large oval or somewhat oblong spots with light gray centers on the leaves, stalks and leaf stems make this disease easy to recognize. The disease may be seed-borne, and infection may be traced to infected seedlings grown from contaminated seed. The disease can also be carried over on crop debris. In the field the fungus spores are spread mainly by wind. Unless controlled, it causes severe defoliation. The disease is easily controlled with chemical sprays. The same spray program used for bacterial leafspot will control *Cercospora* leafspot.

Anthracnose rots

Diseased areas develop a dark round sunken spot which often reaches 2.5 cm in diameter. Dark, raised specks are produced in the spots which contain the spores. When the weather is very moist, masses of spores cover the fruiting bodies. These spores are washed or splashed by rain to other pepper fruit, causing new infections. Anthracnose may be introduced by infected transplants, however, the disease has been found to over winter in pepper growing areas. The disease can be controlled under normal weather conditions with a reasonable spray program. Severe losses occur during rainy weather if a disease prevention program is not initiated early in the season.

Ripe Rot

Although infection can occur any time after petal fall, there is no sign of it until the fruit turns red, hence the name "ripe rot." As the fruit ripens, small yellowish spots appear. However, unless the weather is moist, they usually develop no further until the fruits are harvested. These spots may become large, soft and sunken under moist conditions that develop in bags, or in piles of fruit on the ground or in the truck. Ripe rot during packing and storage can be minimized by proper harvesting and handling.

Stem Rot

This disease can be devastating when peppers are harvested in extremely hot weather and submerged in a common wash tank. The disease may not be visible until the peppers are in transit.

Sanitation is the best defense against stem rot. Harvesting peppers after the plants have dried and restricting harvesting to the cooler hours of the day will reduce the spread of the bacterium. Wash water should be changed frequently and the chlorine level should be maintained in the range of 50 ppm. Drying and cooling the peppers immediately also aid in the reduction of this disease.

Nematodes

Three species of Root-knot nematodes *(M. incognita*, *M. hapla* and *M. arenaria)* cause serious economic damage to peppers. These tiny eel-like worms live in the soil and feed on the roots of peppers. Not only do they cause physical damage that interferes with the uptake of water and nutrients, but they allow the establishment of other diseases. Nematode infected plants are generally stunted with pale green to light yellow foliage. Symptoms may be temporarily masked by supplying additional fertilizer and water. Soils infested with root-knot nematodes should be avoided or treated with a chemical before peppers are planted.

Insect Management

Insect pests may damage pepper throughout the growing period. Although some are only occasional pests, others may be common pests in pepper fields every season. The severity of insect damage to peppers is largely due to abundance of the pests which is related to environmental conditions. With many insects, there is no clearly defined method of predicting outbreaks. However, knowledge of their habits and effective control measures will enable growers to avoid or at least reduce the damage they suffer. Pepper is well suited for insect pest management. Even though a variety of insects may attack pepper, early detection of infestations and subsequent scouting two to three times per week is the most cost-effective management strategy.

Seedling pests

Cutworms

Newly set pepper plants may be cut down just above the soil surface by cutworms. Cutworm damage is particularly abundant in fields where there is too much orgarnic matter. The majority of cutworms over winter in the soil as full-grown larvae.

Damage is done when larvae feed at night on pepper seedlings. Greatest damage is often found in wet areas of the fields. Cutworms may also feed on foliage and pods of mature plants.

Use preventive insecticide treatments on fields with a history of cutworms or on pepper fields following grass sod. Where preventive treatments are deemed unnecessary, use directed sprays for cutworm control when 5 percent of the seedlings have been damaged or destroyed and cutworms are still present. All directed or foliar sprays used for cutworm control should be applied late in the day when cutworms are active.

Thrips

Thrips may be present in pepper fields throughout the growing season. Plant injury is caused by both nymphs and adults rasping the leaves and floral tissues and then sucking the exuding sap. This causes reddish, gray or silvery speckled areas on the leaves. With

severe infestations these areas can interfere with photosynthesis and result in retarded growth. Heavy infestations during the bloom stage may cause damage to developing pods. Occasionally thrips aggregate on pods well hidden from sprays. This may result in russeting damage from continual feeding during pod development. Applications of insecticides should be made when 20 percent of plants show signs of thrips damage, or when 10 or more thrips per bloom are found. Thrips are very small, so close observation is necessary. An effective in-field survey method is to place several blooms in a vial of alcohol and count the thrips as they die and settle to the bottom.

Leaf eaters

1. Aphids

Aphids are small, soft-bodied insects that may feed on pepper plants from time of planting until last harvest. Aphids cluster in shaded places on the leaves, stems and blossoms. Establishment of aphid colonies on pepper is often reduced by wet weather, but during cool, dry weather, large numbers of aphids may develop quickly. Feeding by these pests causes the leaves to be crinkled and malformed.

2. Flea Beetles

The name *flea beetle* applies to a variety of small beetles, with enlarged hind legs, which jump vigorously when disturbed. Their injury consists of small, rounded or irregular holes eaten through or into the leaf. Flea beetles may attack peppers at any time during the growing season but are often most numerous early in the season. Insecticides for control of flea beetles should be applied when flea beetles become numerous and defoliation is greater than 10 percent.

3. Leaf miner

Leaf miner infestations are seen as slender, white, winding trails caused by the larvae feeding through the interior of leaves. The leaves are greatly weakened and the mines may serve as points where decay and disease may begin. With severe infestations, heavy

leaf loss may lead to sun scald of fruits. Adult leaf miners are tiny, shiny, black flies with yellow markings. Leaf miners rarely pose a serious threat to pepper production.

4. Spider Mites

The minute 8-legged mites appear as tiny, reddish, greenish, or yellow moving dots on the undersides of leaves. Infested leaves are lightly stipled with pale blotches. In heavy infestations the entire leaf appears light in color, dries up, often turning reddish-brown in blotches or around the edge. Greatest damage to peppers occurs during dry, hot weather which is favorable for development of extremely large mite populations.

Pod eaters

Pepper Maggot

The pepper maggot is the larval stage of a small fly. The natural food of the insect is the horsenettle, but serious damage may occur on pepper. Heavy infestations of pepper maggots occur in fields when adult flies are attracted to rotting fruit caused by damage from other pests. They deposit eggs beneath the skin of peppers, and all larval development is completed inside.

For control of pepper maggots, treatments should begin when flies are first seen in the field. Repeat applications should be made on a three to four day interval.

Pepper weevil

The pepper weevil resembles the cotton boll weevil in general appearance. The pepper weevil is about half as long as the boll weevil. The adult pepper weevil averages about 1/8 inch in length. The mature larva or grub is legless, resembling a white grub, except in size.

The adult female weevil deposits eggs either in buds before the blossom opens or in the fruit. Females may lay 100 to 300 eggs over a one to two month period. The egg hatches into a tiny grub in just a few days. The grub usually tunnels its way into the seed mass in

the center of the pod. There are several generations per season. The weevils have not been found to over winter in commercial pepper fields of Georgia but are brought in on transplants from other areas.

The most important damage is the destruction of blossom buds and immature pods. The crop may be entirely lost if the infestation is severe and early. Infested pods turn yellow (or prematurely red in the case of pimiento peppers) and fall from the plant. Often they are malformed. In many cases the first sign of infestation is a few fallen pods, but by this time serious damage may be already done and within the next 10 days a large part of the crop may fall.

The feeding of grubs within the pods causes the seeds and cores to turn black and often an entire core becomes a mass of decayed tissue and frass. Pods that appear to be sound may show this condition when opened. Feeding punctures in the pods do not materially damage peppers intended for drying, but they appear as dark specks at the bottom of depressed areas and lower the quality of fruit used green or for canning. In the latter case, the punctures appear as black spots when the peppers are cooked. Damage to blossom buds is similar to that done to pods, the larvae feed in the bud and cause it to fall. Feeding punctures in the buds cause them to drop.

Purchase only transplants certified to be weevil free. Plants from Florida should be inspected closely. Growers should not accept any plants with fruiting structures.

During the growing season, cut open and examine fallen blossom buds and small fruits for evidence of infestation. Begin treatments for pepper weevils when any fruit are found infested with adult or immature weevils.

Tomato Fruit worm

Among the most serious pests of peppers is the tomato fruit worm. The larvae vary greatly in color from a light green to brown or nearly black and are lighter on the under parts. They are marked with alternating light and dark stripes running lengthwise on the body.

Eggs are laid singly on the terminals of pepper plants. The eggs hatch in three to five days and the larvae feed first on terminal foliage and later eat into the pods. The larva is rather restless and shift from one pod to another so that a single caterpillar may spoil many pods without eating the equivalent of a single one. The larvae may bore completely inside a fruit but more damage is caused by external feeding.

Several generations of tomato fruit worms may develop each year. Treatments for tomato fruit worm control should be applied when one percent of fruits are infested with larvae or eggs are easily found.

Beet armyworms

Beet armyworms may feed on both the foliage and pods of pepper plants. Eggs are laid in masses on the undersides of foliage. After feeding on foliage for a few days, some larvae may migrate to the pods. They may tunnel into the pod under the calyx or eat directly through the pod wall. Begin treatments at the first sign of egg masses.

Tarnished plant bugs

Tarnished plant bugs are sucking bugs that primarily attack the young flower buds causing them to abort. The young flower buds then turn yellow to black.

Harvesting and Handling

Field maturity

70 to 90 days or more, depending upon the variety

Pepper harvesting time is usually determined by the fruit color required for marketing. Bell (sweet) peppers for the fresh market should be harvested immature while fruits are firm, shiny in appearance and have a fresh green calyx and stem. Irregular shape does not detract from edible quality, but reduces eye appeal which may lower market acceptability. Peppers having soft, pliable thin flesh and pale green in color (for certain

varieties) are too immature for harvest. Fruit injuries which penetrate the fleshy wall increase susceptibility to decay and should be eliminated or minimized.

As bell types mature on the plant, they tend to become sweeter and change from green to "chocolate" and then to red color. It is more difficult to find a market for sweet peppers at this stage of maturity, although some processors will accept these fruits for color enhancement in processed foods. Decayed fruit should be removed to prevent infection of other fruit on the plant.

Pimento peppers are heart-shaped fruits which should be harvested at the red or ripened stage of maturity for processing. Pimento fruit will continue to ripen after they are picked. They will develop an orange-reddish color if left in a well-ventilated area for several days.

All peppers can be classified as having either sweet or hot (pungent) flesh. Bells and pimentos are sweet, while chili types are hot. Chili peppers are usually green when immature and turn red, yellow or orange at maturity, so harvest time depends on market preference. Pungency (hotness) is caused by an oily substance called capsaicin, located in yellow sacks or pustules on the inside wall of the pepper pod. As long as these oil glands are not broken, a hot pepper will remain mild. However, rough handling during harvest and packing can increase a chili pepper's hotness.

Harvesting

Harvesting starts two or three months after planting and continues with regular pickings at intervals of one to weeks for a period of three months. Ripe chilies can be stored at 4.5 –7 °C and will keep for three or four weeks at these temperatures.

Good harvesting management is needed for high quality peppers. Field workers must be trained and supervised to avoid pepper damage. Pepper plants have brittle stems that break easily during harvest. Care should be taken during harvest to reduce plant damage. Peppers must be kept from direct sunlight while holding them in the field. Sunscald develops quickly on exposed peppers. Wet peppers should not be harvested because

surface moisture increases field heat accumulation in the load and enhances disease development.

Post-harvest handling

The importance of post-harvest handling cannot be over emphasized since approximately two-thirds of the total cost of pepper production is invested in harvesting, cooling and packaging. In smaller operations, peppers are dipped into tanks of water or wiped with a soft cloth to remove dirt and sand. If peppers are washed, chlorine should be added to water at a rate of 100-150 ppm and all fruit must be air dried before packaging to reduce storage rots. It is important to avoid bruising of peppers, this leads to white blisters which form underneath the delicate skin. Often this discoloration is not evident until peppers are packaged and stored. These weakened areas allow bacteria and fungi to enter the flesh and cause decay reducing shelf life.

Grading and Packing

Growers should check with their buyers to determine size preference. Peppers must be graded to achieve uniform shape, color and size. Peppers will be disqualified against these merits;

- Defects (maturity, colour and shape)
- Serious damage (scarring, sunburn, insect damage)
- Rots

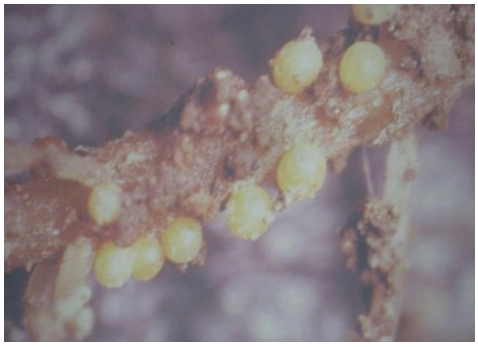
Cooling

Peppers require fast cooling to prevent decay. While several methods could be used, "forced-air" cooling is recommended. Pepper cartons are placed in a specially designed refrigerated room and cold air is pulled rapidly through them using high pressure static fans. Forced-air cooling is more advantageous than room cooling because field heat is removed more rapidly from peppers permitting longer shelf life. However, proper cooling significantly enhances pepper quality and shelf life. Once pre-cooled, peppers must be held at 7-10 ºC and 95 percent relative humidity.

Peppers are subject to chilling injury when held at temperatures below 7ºC. Chilling causes browning of the calyx-stem end and will allow mold organisms to decay the calyx within four to five days. At 1-2 ºC, peppers will develop surface pitting in a few days. Signs of chilling usually don't show up until peppers are moved to a higher temperature such as a display case in a retail market. Peppers are very sensitive to ethylene, a ripening gas produced in excess by certain fruits and vegetables. Ethylene causes a bleaching of the green pigment, chlorophyll, in peppers and results in yellowish, chocolate and red colors. To prevent ethylene damage, don't store ripening tomatoes, apples or peaches in the same room with peppers.

APPENDIX 1. INSECT PESTS

Pest	Symptoms	Control
Cutworm	The seedlings have a clean cut just above the soil surface	1. Drench with Pyrinex 30ml/ 15 l water **OR** 2. Drench with Chlopyriphs as bait. **OR** 3. Drench with Karate 35 ml/100l water
Aphids	Leaves curl inwards	1. Spray with Malthion 25Wp 30g/15 ml water **OR** 2. Spray with Dimethote 15ml/15l water **OR** 3. Spray with Diazinon 15ml /15 ml water
Heliothis Ball worm	Bores into the fruit leaving openings	Spray with Carbaryl 85 WP 30g/ 15l water
Red spider mite	Silvering and molting of leaves	1. Spray with Dimethoate15ml/15l water **OR** 2. Spray with Kelthane 30ml /15 l water **OR** 3. Spray with Diazinon 15ml/15 l water

Leaf miners	White spotting or tunnels on the upper surface of leaves	Spray with Tamaron
Nematodes	Galls on the roots 	1. Avoid planting after susceptible crops **OR** 2. Use nematode resistant cultivars **OR** 3. Drench with Nemat 120ml/15 l water **OR** 4. Apply Curator at 2g/station

APPENDIX 2: FUNGAL DISEASES

Fungi	**Symptoms**	**Control**
Damping off	Poor germination Collapse of young seedlings	1. Dress seed with Thiram 100g/ 100g seed **OR** 2. Spray with Copper oxychloride 30g/15 l water **OR** 3. Spray with Captan 60ml/ 15l water
Early blight	Leaves have brown spots with concentric rings. Points of attachment on fruit appear as a brown to black rot.	1. Spray with Mancozeb 45g /15 l water **OR** 2. Spray with Ridomil 30g/ 15l water
Late blight	Pale green to brown spots. Greenish brown greasy spots on fruits	1. Spray with Copper 30g/15l water **OR** 2. Spray with Mancozeb 45g /15 l water **OR** 3. Spray with Bravo 30ml/ 15l water
Cercospora leaf spot	Large oval or oblong spots with light gray centers develop on leaves. Causes severe defoliation 	1. Spray Dithane M45 30g/10l water 2. Do not use land with previous incidence of disease

Mildews		1. Spray Wettable sulphur 30g/10l water weekly from 1st week of transplanting to harvesting 2.
Anthracnose rots		1. Spray Bravo 2l/ha 4 weeks after transplanting
Ripe rot	Small yellowish spots appear as fruit ripens	1.

APPENDIX 3: BACTERIAL DISEASES

Disease	**Symptoms**	**Control**
Bacterial canker	Wilting of the foliage, stem splitting and mealy breakdown of internal tissues	1. Use healthy certified seeds **OR** 2. Plant on raised beds **OR** 3. Practice crop rotation. **OR** 4. Hot water treatment- seeds are wrapped in a muslin cloth and immersed in water at 50 °C for 25 minutes. Seed is dried before sowing 5. Spray Copper oxychloride 40g/10l water
Bacterial wilt	The plant suddenly wilts	1. Practice crop rotation **OR** 2. Avoid use of areas prone to water logging 3. Spray Copper oxychloride 40g/10l water
Bacterial leaf spot	Form spots on fruits and leaves 	1. Hot water treatment **OR** 2. Use certified seed **OR** 3. Destroy affected debris **OR** 4. Spray Copper oxychloride 40g/10l water

APPENDIX 4: VIRAL DISEASES

Disease	**Symptoms**	**Control**
Pepper mosaic virus(TMV)	Stunting and mottling and distortion of leaves Discoloration of fruits	1. Use certified seed and choose resistant cultivars. **OR** 2. Remove crop debris and roots from the field. **OR** 3. Avoid smoking
Tomato spotted wilt (TSWV)	Overall yellowing spots on leaves or terminal shoots Stunting Results in leaf and plant deformation 	1. Spray against thrips and do not allow volunteer crops in your field. **OR** 2. Use resistant cultivars **OR** 3. Use clean planting material

APPENDIX 5: PHYSIOLOGICAL DISORDERS

Physiological disorder	Symptoms	Control
Blossom end rot	Fruits become rotted on their basal ends 	1. Maintain adequate supplies of water **OR** 2. Apply foliar sprays of Calcium Nitrate or calcium chloride 3. Apply fertilizers according to soil tests to maintain adequate calcium levels 4. Grow pepper on well drained soils
Puffiness	Fruit appear bloated and angular Fruits are light than normal in weight	Sound nutrition regime should be followed
Sun scald	Sudden exposure of fruits to direct sunlight especially during summer 	Care should be taken in pruning and harvesting to avoid over exposure of fruits
Flower drop	Flowers drop prematurely before pollination due to temperature stress, water stress and shed stress	

References

Plant Pathology Department, Florida Cooperative Extension Services, Institute of Food and Agricultural Sciences, University of Florida, PP-201, February 2009. http://edis.ifas.ufl.edu/.