Fruits and Vegetables

1. Broccoli
2. Cabbage
3. Cantaloupe
4. Carrot
5. Cauliflower
6. Celery
7. Corn
8. Cucumber
9. Hot Pepper
10. Lettuce
11. Parsley
12. Passion fruit
13. Pineapple
14. Pumpkin
15. Salad Beans
16. Sweet Peppers
17. Tomato
18. Watermelon

TECHNOLOGY PACKS

SWEET PEPPER

November 2015

Background

Production decisions concerning how much effort and resources to invest and which farming practices to follow, have consequences and create opportunities for the farm affecting production levels, input costs, time constraints, and the potentially size of the operation. They also may have implications for resource use and environmental quality.

Numerous information exist on the various aspects of production and handling/ marketing of crops and livestock, the majority of which are outdated, not easily understood and lacking the where with all for addressing present day challenges such as good agricultural practices (GAPs) and food safety and climate change that impact on the environment and rural livelihoods. These issues are also closely related to the importance of the role of primary producers in increasing the earnings of all actors along the value chain in supporting the development of a commercially viable and sustainable agricultural industry.

The production of high quality and easily understood information packages is critical as this forms a basis for farmers to obtain financing from lending institutions and to efficiently increase their production through the availability of modern technology. This will also result in a reduction of rural unemployment and will greatly help in alleviating poverty and other associated social ills.

TECHNOLOGY PACKS

SWEET PEPPER

November 2015

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Table of Contents

Introduction

This Technological Package (Tech Pack) deals with the production and postharvest aspects of sweet pepper.

Also included in the Tech Pack are appendices:

- Template for cost of production
- List of recommended pesticides and application rates
- Good Agricultural Practices data record sheet.

Notwithstanding the identification of any specific pesticide for the control of pests and diseases, this decision is for the discretion of the Ministry of Agriculture Area Extension Officer and the farmer.

However, the mention of any pesticides and other products used in the Tech Pack should strictly comply with local regulations and all instructions provided by the manufacturer. Also, the use of trade names in the Tech Pack is for the purpose of citing examples and is not meant to either endorse or discredit any particular product.

Botanical Description

Sweet pepper (*Capsicum annuum*) belongs to the family Solanaceae. The local name in Creole is Piman Dou. Cultivars of the plant produce fruits in different colours, including red, yellow, orange, green etc.

Capsicum peppers are rich sources of antioxidants and vitamin C. Compared to green peppers; red peppers have more vitamins and nutrients. The level of carotene, like lycopene, is nine times higher in red peppers. Red peppers have twice the vitamin C content of green peppers.

Ecology and Environment

Ideal growing conditions for sweet pepper include warm soil, ideally 70 - 85°F (21 - 29 °C), that is kept moist but not waterlogged. Bell peppers are sensitive to an abundance of moisture and extreme temperatures.

Varieties/Cultivars

Main varieties are California Wonder, Yellow Wonder, King Henry, King Arthur, Early Sunsation and Aristotle.

Seedling Production

In order to produce strong and healthy seedlings, establish a seedling nursery, specifically for seedling production. The area should comprise two sections:

1. A seed germination section which is covered with solid roof to protect the germinating seeds from sun and rain
2. A hardening section with a transparent roof or netting that allows for the penetration of

light for hardening the seedlings. Hardening protects seedlings from transplanting shock when planted in the field.

The entire nursery area should be weed free and preferably totally screened with polyvinyl insect netting to protect seedlings from any insect attack and/or transmitted insect diseases. Seeds are sown either in seedling trays containing peat moss as the growing medium or in peat moss blocks (Plates 1 & 2). Though seeds can be directly sown in the field, the success of germination and survivability of most seeds is not guaranteed as both soil pests and diseases can affect them. To achieve 95 - 100% seed germination and strong and healthy seedlings, seedlings produced in nurseries is the preferred option.

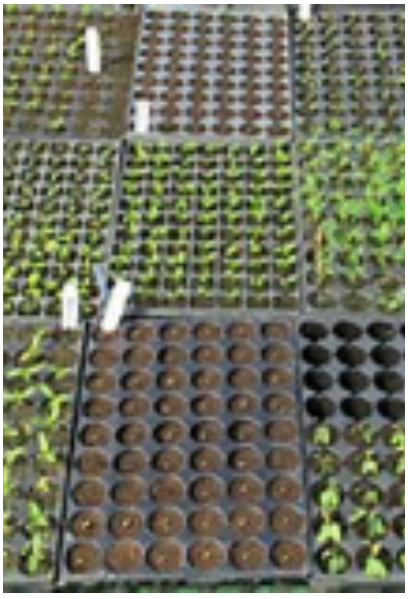

Plate 1 Seedling production in seed trays

Plate 2 Seedling production in nursery

Plate 3 Hardening seedlings

The following practices should be adopted in the production of strong healthy sweet pepper seedlings:

- When purchasing seed material obtain from a reputable source
- Read the label on the seed package. Ensure that the seeds are 90 - 100% viable which must be indicated on the label and is in keeping with the expiratory date
- Use seedling trays for sowing seeds. Ensure that they are sterilized by immersing into commercial bleach solution 1 tablespoon/gallon (5 cc/litre) of water
- Use peat moss as the planting medium
- Treat the planting medium with a broad spectrum fungicide, 6 ounces of Banrot in 15 gallons of water (170 g/68 litres), before placing in trays
- Seedling trays should be placed on raised platforms
- Make a planting hole in each cell and plant one seed per hole
- Water seeds to aid germination

- Spread peat moss lightly ensuring that the seeds are covered
- Cover trays with saran netting to hasten germination
- Place trays in the seed germination section of the nursery
- Remove the covering of saran netting at the first sign of germination
- Water seedlings at least twice per day
- Apply plant nutrient as a foliar spray once per week when seedlings are ½ inch (1.2 cm) in height
- Spray seedlings with insecticide and fungicide once per week for pest and disease control
- Apply fertilizer solution, Tropi-Gro 1 tablespoon/gallon (5 cc/litre) of water twice per week when seedlings are 1 inch (2.5 cm) in height
- Harden seedlings by placing them in the hardening section of the nursery for 3 hours during the early morning and late evening, for 2 - 3 days (Plate 3)
- Expose seedlings to full days of sunlight until ready for transplanting
- Transplant seedlings when they are 3 inches (7.6 cm) tall.

Land Preparation

Two types of production systems are used for growing sweet pepper: "Open Field" or under "Protected Agriculture".

In the "Open Field" the soil should ploughed and rotavated to produce good tilth. The area should be well drained. Organic matter can be incorporated during ploughing. Form beds 6 feet - 8 feet) (1.8 - 2.4 m) wide and 6 - 7 inches (15 - 17 cm) high establishing good drainage (Plate 4). As a precautionary measure against any insect pest in the soil It is advisable to spray the area with a good

Plate 4 Land preparation

Under “Protected Agriculture” the land should be rotavated to a fine tilth and formed into 4 foot (1.2 m) beds. Soil can be left uncovered or covered with a ground cover (Plate 5).

Plate 5 Using plastic mulch as a ground cover

Spacing and Planting

Spacing used will depend on the variety. Large varieties should be planted in rows 3 feet (1 m) apart and spaced 2 feet (0.6 m) within the row (Plate 6), giving 7,260 plants/acre (18,000 plants/ha). Smaller varieties can be spaced as close as 18 inches (45 cm) within the row giving 9,680 plants/per acre (24,000 plants/ha).

Plate 6 Transplanting sweet pepper seedlings

Trellising

In both "Open Field" and "Protected Agriculture" production system a trellis system should be established to keep the plant upright. The trellising involves planting stakes 6 feet (2.0 m) apart along the sides of each row. When plants are about 12 - 15 inches (30 - 38 cm) high, tie lines horizontally onto stakes along both sides of the row about 10 inches (25 cm) above the ground to prevent plants from toppling. A second and third set of lines can be installed if required as plants continue to grow (Plate 7).

Plate 7 Sweet pepper trellis

Irrigation

Irrigation water, especially from streams and ponds, should be sent for analysis to ensure that the water is not polluted or saline. It must be of good quality for irrigation.

Sweet pepper is a deep-rooted crop and therefore it exploits a lot of soil area for moisture; however, it is not a drought-tolerant crop. Insufficient water will result in the formation of undersized fruit, fruit with blossom-end rot and fruit with growth cracks resulting in a large number of rejects. The crop therefore requires an adequate supply of water from establishment to harvest and particularly during fruit production. The best and most efficient method for supplying continuous water is with a drip irrigation system particularly under "Protected Agriculture". Ensure that transplants are placed close to the emitters (Plate 8).

Plate 8 Drip irrigation system in sweet peppers

Fertilization

Specific kinds and rates of fertilizers must be determined from the results of soil and leaf analyses. Composted manure if available should be applied to the soil to help with the uptake of nutrients from inorganic fertilizers; it adds organic matter to the soil, enhances soil structure and growth of micro-organisms. All manure should be well composted to ensure that harmful microorganisms and weed seeds are destroyed.

In "Open Field" production systems, apply 400 lb/acre (450 kg/ha) of 12:12:17+2 at planting. At 4 - 6 week intervals, side dress 200 lb/acre (225 kg/ha) of either calcium ammonium nitrate or 12:12:17+2.

With "Protected Agriculture" NPK fertilizer (20:20:20) is applied every week at the rate of 0.5 gallon (2L)/hour through a drip line fertigation system.

Weed Control

Proper weed management begins at the land clearing and land preparation stage during which time the 'stale seed bed technique' is applied. This involves clearing the land from brush, deep

ploughing and rotavating and then allowing weeds to re-grow. A systemic herbicide (Round-up) is then applied 2 weeks before transplanting when weeds are actively growing and are about 3 – 4 inches (8 - 10 cm) high. The weeds are allowed to fully die covering the topsoil and acting as a mulch suppressing further growth of weeds. Transplanting is then carried out at a high plant population, which can also suppress future weed growth. After the crop has been established further weed control should be done manually or by applying a contact herbicide (Gramoxone) with the use of a shield to protect the plant from spray drift.

Plastic Mulch

An alternative method of weed control is the use of plastic mulch (Plate 10). Plastic mulches can be used commercially for sweet pepper production. Plastic mulch is used to reduce weed pressure, and conserve moisture and fertilizer (Plate 9). Most often drip irrigation is used in conjunction with plastic mulch.

Plate 9 Use of plastic mulch for weed control in sweet pepper production

Advantages of using plastic mulch:

- Plastic mulches will reduce light penetration to the soil. Weeds cannot survive therefore, the cost of weed control is drastically reduced
- Soil water loss is reduced under plastic mulch, and more uniform soil moisture is maintained and irrigation frequency can be reduced. The growth of plants on mulched soil can be twice that of plants that are not mulched. Because larger plants will require more water, mulching is no substitute for irrigation

- Excess water runs off the impervious mulch, and fertilizer is not lost beneath the mulch by leaching, so that fertilizers are optimally used
- The soil under plastic mulch remains loose, friable and well aerated. Roots have access to adequate oxygen, and microbial activity is enhanced
- Cultivation is eliminated, except in the area between the mulched strips, which reduces the frequency of mechanical root pruning. Weed growth in these areas can be controlled by cultivation or by use of a chemical herbicide
- Plastic mulch also keeps the fruit cleaner by reducing soil spatter. When using drip irrigation, the incidence of disease is often reduced because the foliage stays drier.
- Use of reflective mulches reduces the population of certain insect pests, which are vectors of viruses
- Water is shed from the row area by the raised tapered bed so that excess water runs off by the fields, thus reducing drowning and other excess soil water stress.

Disadvantages of using plastic mulch:

- Yellow and purple nut sedges are not controlled by black plastic mulch, and suitable fumigants/herbicides must be applied if nut sedge is a potential problem
- The use of plastic mulch will increase the cost of production for a given crop. These costs should be offset by reduced weed control expense and increased income due to better quality fruit and higher yields.

Mulch film is nearly impervious to carbon dioxide, which is necessary for photosynthesis. Research has shown that high levels of carbon dioxide may build up under the plastic mulch. Because the film does not allow the gas to penetrate, it has to escape through the holes punched for the plants and a 'chimney effect' is created, resulting in carbon dioxide for the actively growing leaves.

Pests and Diseases

The major pests and diseases, symptoms and control/management affecting sweet pepper are indicated in Table 1.

Table 1 Causal agents, symptoms and control of pests and diseases of sweet pepper

Pest & Diseases	Symptoms	Control/ Management
 Plate 10 Leaf miner	Leaf miners are the larvae of various beetles, flies, moths and sawflies. The adult lays eggs on the leaf and the larvae burrow into the leaf and tunnel through it, feeding and leaving a transparent trail. If you look closely, you can often see a dark dot at the end of one of the lines.	The disease can be controlled with the application of contact or systemic insecticides.
 Plate 11 Caterpillars	Damage by eating the foliage, fruit and stems	Apply contact or systemic insecticides.
 Plate 12 Aphids	Symptoms are stunting, deformation, gall formation, withering and dying of plants. Leaves may become curled, wrinkled or cup shaped. The symptoms may be due to the feeding or viral diseases spread by the aphids. Honeydew secreted by the aphids encourages the growth of sooty mold (black in colour) on the leaves.	Elimination of weeds that are alternate hosts to leafhoppers. Also leafhoppers can be controlled by application of foliar and soil applied insecticides.

Pest & Diseases	Symptoms	Control/ Management
 Plate 13 Pepper Viral Diseases	There are several viral diseases that can cause damage sweet peppers these include: Tobacco Mosaic Virus (TMV), Cucumber Mosaic Virus (CMV), Potato Y Virus (PYV), Tobacco Etch Virus (TEV) and the Gemini Viruses. These diseases can occur together as a complex. The symptoms are mosaic on leaves, deformation of leaves, cupping and crinkling of leaves, retarded and stunted plants.	There are no cures for the viral diseases. However, the following measures should be adopted to contain these diseases: • Planting tolerant/ resistant varieties • Management of insect vectors (whiteflies, aphids, etc.) from the seedling nursery and field • Use of seeds that have been specially grown, selected and treated to wash off viral particles • Rogueing of all seedlings and plants showing symptoms of viral diseases and burning them. Wash hands thoroughly before handling other healthy plants • Practice field and crop rotation (with corn, cassava and sweet potato) and the use of higher planting densities.

Pest & Diseases	Symptoms	Control/ Management
 Plate 14 Anthracnose *Colletotrichum. gloeosporioides*	Circular or angular sunken lesions develop on the fruit. Often multiple lesions form on individual fruit. When disease is severe, lesions may coalesce. Often pink to orange masses of fungal spores form in concentric rings on the surface of the lesions. In older lesions, black structures may be observed. The pathogen forms spores quickly and profusely and can spread rapidly throughout a pepper crop, resulting in up to 100% yield loss. Lesions may also appear on stems and leaves as irregularly shaped brown spots with dark brown edges.	Control of the disease is through integrated management techniques. Only seeds that are pathogen-free should be planted. Transplants should be kept clean by controlling weeds and solanaceous volunteers around the transplants. The field should have good drainage and be free from infected plant debris. Practice crop rotation. Sanitation practices in the field include control of weeds and volunteer pepper plants.
 Plate 15 Bacterial Leaf Spot caused by a bacterium *Xanthomonas campestris*	The disease is expressed as numerous spots (brown and black) on the infected leaves. The spots have a central depression on the upper leaf surface and slightly raised brown areas centrally on the lower surface. The spots on the fruits are raised and have distinct holes.	Control measures are through draining soils well, controlling weeds, crop rotation, keeping fruits from soil contact, burning residues from infected fields and spraying with suitable fungicides.

Pest & Diseases	Symptoms	Control/ Management
 Plate 16 Cercospora Leaf Spot caused by the fungus *Cercospora capsici*.	Plants generally display discoloration, spots and poor growth. Pepper leaves may yellow and drop off.	The diseases can be controlled through: • Planting disease-resistant varieties • Rotating vegetable crops every other year • Implementing proper watering and cultivation techniques • Keeping the area free of debris and excess weeds • Control of Insects such as Aphids and Mites.
 Plate 17 Fusarium Wilt caused by the fungus *Fusarium oxysporum*	The disease produces symptoms such as wilting, chlorosis, necrosis, premature leaf drop, browning of the vascular system, stunting and damping-off. Fusarium wilt starts out looking like vein clearing on the younger leaves and drooping of the older lower leaves, followed by stunting of the plant, yellowing of the lower leaves, defoliation, marginal necrosis and death of the plant.	Control methods are improved soil drainage, planting resistant varieties, removing infected plants, use of soil and systemic fungicides to eradicate the disease from the soil, and use of clean seeds each year.
 Plate 18 Wilts, Blights and Collar Rot caused by *Phytophthora* spp, *Sclerotium* spp, *Pithium* spp and *Rhizoctonia* spp	These soil fungi cause root rot and collar rot and the blockage of vessels that take water and plant food from the roots up to the leaves and other parts of the plants. As a result, the leaves wilt and droop.	These diseases can be controlled by rapid drainage, drying of the field by sunshine and spraying fungicides into the root zone of the plant. The best control however, is to plant tolerant varieties.

Good Agricultural Practice (GAP) related to the use of pesticides, requires farmers to maintain up to date records on the application of pesticides to the crop. These records should include trade names, application rates and dates of application. During the harvesting period use pesticides with a very short harvest interval.

Harvesting/Maturity

Depending on the variety sweet peepers can be harvested at the mature green or red/yellow ripe stage. Fruits must be left on the plant to achieve the full ripe colour stage, as peppers do not ripen to full colour after harvest. The harvesting operation should be carried out during the early part of the day when temperatures are much cooler and fruits are more turgid. Fruits should be harvested using a sharp knife or secateurs leaving part of the stalk intact. Harvested fruits should then be placed in field containers.

Field Handling

Harvested fruits should be placed in clean and sanitized field crates, not in bags, and stored temporarily in the shade, protected from the sun and rain during the harvesting period. Mature fruits that have fallen on to the ground prior to harvesting should not be collected. Out-grade fruits that are diseased or damaged.

Preparation for Market

On completion of the harvesting operation, fruits must be transported from the field directly to the storage area. Reject all fruits that show signs of decay, rots, soft spots, sun scald, insect damage, bruises, misshaped or other mechanical damage. Fruits should be washed to remove soil and dried with a damp cloth soaked in a mild solution of commercial bleach 1 teaspoon/gallon (5 ml/L) of water. Do not soak fruits in water and leave the fruit stalk intact.

Yields

Yields vary between 18,000 - 20,000 lb/acre (20,000 - 22,500 kg/ha) depending on the variety.

Storage

Freshly harvested peppers should be stored between 45 - 50ºF (7 - 10ºC) and 95% relative humidity. The typical storage life of peppers under these conditions is 3 - 5 weeks. Storage life is limited by moisture loss. Peppers are sensitive to chilling injury when exposed to temperatures below 45oF (7oC). Symptoms of chilling injury include pitting and water-soaked tissue.

APPENDICES

APPENDIX I: TEMPLATE FOR COST OF PRODUCTION ANALYSIS: SWEET PEPPER

	Input	Quantity	Units	Unit Cost	Total Cost
1.	**Seedling production**				
	Seed material				
	Seedling trays				
	Peat moss				
	Saran netting				
	Fungicide, plant nutrient, insecticide, fungicide, fertilizer (specify names used)				
	Total cost for seedling production				
2.	**Land preparation**				
	Organic matter (if purchased)				
	Insecticide				
	Plastic mulch				
	Trellis material				
	Other land preparation costs (e.g. equipment rental)				
	Total cost for land preparation				
3.	**Crop maintenance**				
	Water/irrigation				
	Fertilizer (specify types used)				
	Weed control (specify chemicals etc used)				
	Pest and disease control (specify chemicals etc. used)				
	Total cost for crop maintenance				
4.	**Harvest/storage**				
	Crates				
	Other materials (e.g. commercial bleach etc.)				
	Estimate any utility costs				
	Transport to market				
	Total cost for harvest/storage				

APPENDIX I: TEMPLATE FOR COST OF PRODUCTION ANALYSIS: SWEET PEPPER

	Input	Quantity	Units	Unit Cost	Total Cost
5.	**Labour**				
	Seedling production				
	Land preparation				
	Crop maintenance				
	Harvest/storage				
	Total cost for labour				
6.	**Rent/insurance**				
7.	**Miscellaneous costs**				
	Total cost of production				

Notes

1. It is recommended that the above data be completed on a per crop basis.

2. The cost of any fixed structures should be considered. For example if a seedling nursery is solely used for to produce sweet pepper seedlings in the year and is expected to last for 10 years, then one tenth of the cost of construction (plus any annual maintenance) should be added at item 7. If, however seedlings for other crops are also produced then these also need to be considered. If sweet pepper seedlings account for half the seedlings in a year, then the annual cost calculated as above needs to be divided by 2. Similar considerations should be given to the cost of any refrigerator, if the crop is stored at a low temperature and to an irrigation system. If the sweet pepper is grown under Protected Agriculture perhaps 1 -2% of the cost of the structure should be added to item 7.

3. The revenue obtained from sale of the crop should be compared with the cost of production to determine the profit/loss on the operation.

APPENDIX II: LIST OF RECOMMENDED PESTICIDES AND APPLICATION RATES

INSECTICIDES	APPLICATION RATE
Pronto 35 SC	3 - 5 teaspoons/gallon of water
Target	1 - 2 teaspoons/gallon of water
Pirate	½ - 1 teaspoons/gallon of water
Fastac	1 - 2 teaspoons/gallon of water
Caprid	½ - 1 teaspoon/gallon of water
Diazinon (Basudin)	¾ - 1½ pints/acre
Admiral	¼ teaspoon/gallon of water
Dipel	1½ - 2 teaspoons/gallon of water
Aza-direct	1 - 2 teaspoons/gallon of water
Cure	½ - 1 teaspoon/gallon of water
Danitol	1 - 2 teaspoons/gallon of water
Cypro	½ tablespoon/gallon of water
Dimethoate (Perfecthion, Rogor 40)	1 pint/acre
Phosvel	1¼ - 2 pints/acre
Orthene	3.2 ounces/acre
Permethrin (Ambush)	½ teaspoon/gallon of water
Padan 50 WSP	2 - 3 teaspoons/gallon of water
Lannate	1 teaspoon/gallon of water
Decis	½ teaspoon/gallon of water
Kelthane 42%	1¼ lb/acre
Orthene 75S	1 lb/acre
Malathion	½ - 1 pint/acre
Sevin	1½ lb/acre
BT (*Bacillus thruingiensis*)	Label rates
Rotenone	1 - 2 teaspoons/gallon of water
Neem X.	8 - 10 oz/gallon of water
FUNGICIDES	**APPLICATION RATE**
Bellis	2 teaspoon/gallon of water
Acrobat	2 - 4 teaspoon/gallon of water
Mancozeb (Dithane M45)	1.5 lb/acre
Cabendazim	2 teaspoon/gallon of water
Daconil	1½ - 2 pints/acre
Benomyl (Benlate)	6 oz/acre
Captan	2 - 3 teaspoons/gallon of water
Peltar	3 teaspoons/gallon of water
Manzate DF	2 - 4 teaspoons/gallon of water
Bravo	1½ - 2 pints/acre
Tri-Miltox-Forte	3 teaspoons/gallon of water
Botrilex	5 - 200 lb/acre
Kocide 101	2 - 4 teaspoons/gallon of water
Cupravit	2½ lb/acre

APPENDIX II: LIST OF RECOMMENDED PESTICIDES AND APPLICATION RATES

WEEDICIDES	APPLICATION RATE
DCPA (Dacthal W-75)	10 lb/acre
Diphenamide	4 - 10 lb/acre
Paraquat (Gramoxone)	1 - 2 pints/acre
Dymid 80W	5 lb/acre
Atrazine 80 (Gesaprim).	1¼ - 1½ lb/acre
Linuron (Lorox)	1 pint/acre
Prometryn (Caparol)	0.8 - 1.6 lb/acre
Sethoxydim (Poast)	1¼ - 3½ lb/acre
Clethodim (Select)	0.094 - 0.25 lb/acre
Prometryn 50WP (Geagard)	2 - 3 lb/acre
Herbicidal Oil (Stoddard Solvent, Kerosene oil)	40 - 80 gallons/acre

APPENDIX III: GOOD AGRICULTURAL PRACTICES DATA RECORD SHEET

Grower name:							
***Name of applicator**	**Date**	**Brand and product name**	**Rate**	**Size of area/no. of plants treated**	**Total application (amount of the product used)**	**Notes/target pest**	**Start/finish time**

*The applicator should be trained or, if not, supervised by a trained or certified person. Proof of training required.