



FEED ^{THE} FUTURE

The U.S. Government's Global Hunger & Food Security Initiative



PASSION FRUIT PRODUCTION MANUAL

(YELLOW AND PURPLE)

OCTOBER 2019

FEED THE FUTURE TANZANIA MBOGA NA MATUNDA

Abstract

Yellow and purple passion fruit are highly nutritious. Well-managed crops can earn a farmer returns of five to ten times the investment. Yellow passion fruit do well in low altitudes 0-900 meters above sea level, while purple passion fruit require higher altitudes, between 1,200-2,000 meters above sea level.



USAID
FROM THE AMERICAN PEOPLE

TABLE OF CONTENTS

TABLE OF CONTENTS	2
1. INTRODUCTION	4
1.1. WHY PASSION FRUIT	5
1.2. COMMON VARIETIES	5
1.3. CLIMATIC REQUIREMENTS	6
1.4. SOIL CHARACTERISTICS AND SITE REQUIREMENTS	7
2. CHOOSING A VARIETY	7
2.1. CHARACTERISTICS OF THE PURPLE TYPE.....	7
2.2. CHARACTERISTICS OF THE YELLOW TYPE.....	7
3. PROPAGATION	7
3.1. SEED SELECTION	8
3.2. SEEDLING METHOD	8
3.3. GRAFTING	9
4. FIELD SELECTION	9
4.1. FIELD PREPARATION AND PLANTING	9
4.2. NUTRIENT MANAGEMENT	10
4.3. IRRIGATION	10
5. TRAINING AND TRELLISING	11
5.1. TRAINING	11
5.2. TRELLISING	12
5.3. PRUNING.....	14
6. POLLINATION REQUIREMENTS	14
6.1. POLLINATORS	15
6.2. RECOMMENDATIONS AND PRACTICES	15
7. IPM IN PASSION FRUIT FARMING	15
7.1. WHAT IS IPM?	15
7.2. HOW DOES IPM WORK?.....	15
7.3. SET ACTION THRESHOLDS	15
7.4. MONITOR AND IDENTIFY PESTS.....	16
7.5. PREVENTION	16
7.6. CONTROL	16
8. INSECT PESTS OF PASSION FRUIT	16
8.1. APHIDS – MYZUS PERSICAE, APHIS GOSSYPII	16
8.2. THRIPS.....	17

8.3.	MEALY BUGS – PLANOCOCCUS CITRI.....	18
8.4.	LEAF MINERS – LIRIOMYZA SPP.	18
8.5.	SPIDER MITES – TETRANYCHUS SSP	19
8.6.	FRUIT FLIES – BACTROCERA CUCURBITAE AND CERATITIS CAPITATE ...	20
8.7.	NEMATODES – MELOIDOGYNE SSP	21
8.8.	BUGS	22
9.	IMPORTANT DISEASES OF PASSION FRUIT	23
9.1.	PEST	23
9.2.	PASSION FRUIT WOODINESS VIRUS (PWV).....	25
9.3.	BROWN SPOT – ALTERNARIA PASSIFLORAE	25
9.4.	SEPTORIA SPOTS – SEPTORIA PASSIFLORAE	26
9.5.	PHYTOPHTORA BLIGHT – PHYTOPHTORA NICOTIANAE VAR. PARASTICA 27	
10.	RIPENING AND HARVESTING.....	28
10.1.	MARKET REQUIREMENTS	29
10.2.	GRADING	29
10.3.	STORAGE	29
10.4.	HARVEST.....	29
10.5.	POST-HARVEST HANDLING	29
10.6.	VALUE ADDITION TECHNIQUES: SORTING, CLEANING & GRADING.....	30
10.7.	PROCESSING.....	30
11.	PRODUCTION PLANNING (700 VINES).....	30
12.	COST OF PRODUCTION	31
13.	REFERENCES	32

I. INTRODUCTION

The Feed the Future Tanzania Mboga na Matunda Activity (FTFT-MnM) is a four-year initiative (January 2017-January 2021). The purpose of FTFT-MnM is to increase the productivity and profitability of horticulture value chains while integrating large numbers of women and youth, and improve the nutritional status of Tanzanians. The activity will achieve this by:

- Scaling improved technologies and practices that lead to increased productivity of women, men, and youth.
- Leveraging horticulture to improve family nutrition (e.g. expanding access to nutrient rich crops and utilization of profits for non-horticultural nutritious food items).
- Scaling market system models to empower value chain stakeholders and improve efficiencies and profitability.
- Strengthening the overall capacity of the horticulture subsector through investments along the value chain.

The geographic scope of FTFT-MnM encompasses 16 districts in the mainland focusing on the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) - Morogoro, Mbeya, Songwe, Iringa - and 10 districts in the Zanzibar Islands of Unguja and Pemba. The activity uses a value chain approach to ensure integrated development. Interventions encourage the development of business relations; efficient transactions; and adoption of innovations and good business practices throughout the value chain.

FTFT-MnM, in collaboration with other stakeholders in the passion fruit value chain in Tanzania, has prepared this Passion Fruit Production Manual to help growers in Tanzania access the necessary information required for production and export. This manual contains several subject matters to consider: land selection, seedling preparation and planting, site designing, and harvest and postharvest procedures required by the passion fruit market.

The passion fruit *Passiflora edulis* is a vigorous perennial woody creeper, native to the tropical regions of America - Brazil, Paraguay, and Argentina. The passion fruit is edible, and has juicy, aromatic, sweet, acidic, and seedy characteristics. The fruit can be eaten alone or in fruit salads, juices, sherbets, ice cream, and jam.

Passion fruit growing has enormous economic potential in alleviating poverty, by creating employment along the value chain through the production, processing, transport, and input supply systems.

The two main commercial varieties grown in Tanzania are the purple passion fruit (*Passiflora edulis f. edulis*) and the yellow passion fruit (*Passiflora edulis f. flavicarpa*).

The establishment and expansion of the crop has been hindered by various problems, the major one being lack of sufficient knowledge on good agricultural practices, as well as pest and disease attack. Lack of pathogen-free planting material is also a major constraint across the country.

- Passion fruit is a vigorous, shallow rooted, perennial vine that climbs by means of tendrils.
- It can grow as tall as 20 feet (6 meters), and its life expectation is 3 – 5 years.
- It is mainly grown for fresh market and juice extraction.
- It is preferred by small-scale farmers due to profitable returns.
- Purple passion fruit is exported mainly to Europe (France, Denmark, & the United Kingdom). It is also widely utilized as fresh fruit or for juice extraction in homes and restaurants. The fruit

provides good market prices in Britain and the European Union. In addition, the Middle East is emerging as an alternative market.

- The yellow variety is mainly grown for commercial processing and small-scale household and hotel juice extraction. The vine is grown for both local and exporting purposes.

The passion fruit is a sub-tropical, shallow-rooted, woody, perennial vine that climbs by tendrils for support. The leaves are evergreen, 3-lobed, and finely toothed. They are 3-8 inches long and a deep, glossy-green color. Some varieties have leaves tinged with red or purple. The flowers are single and fragrant, 2-3 inches wide, and born at the node of new growth. The bloom has white petals and sepals, with a corona of white-tipped rays that are rich purple at the base. It also has five stamens with large anthers.

The crop matures within nine months, and can be harvested four times a year, depending on the availability of rain or irrigation water. The traditional purple variety has a lifespan of between two and a half to three and a half years, whereas the yellow variety can last up to five years under good agronomic management.



Purple passion fruit



Yellow passion fruit

I.1. WHY PASSION FRUIT

Both purple and yellow passion fruit offer excellent returns on farmer investments. A farmer investing in a few plants of passion fruit will pay \$2 (TZS 5,000) per vine, but can expect a net return of about \$11 (TZS 25,000) or more, depending on their level of management (see Cost of Production section) in 30 months. Currently, there is a network of passion fruit buyers who source the commodity, and supply it to hotels, restaurants, open-air markets, supermarkets, and institutions. In Tanzania alone, the domestic market for both fruit types for small-scale processing in hotels, restaurants, and homes is hugely unmet. The international market for purple passion fruit has continued to grow, but the supply continues to dwindle because of increased pest and disease pressure in the neighboring country of Kenya.

I.2. COMMON VARIETIES

Purple Passion Fruit

- Does well in upper midland to upper highland zones (1,200 – 2,000 meters above sea level)
- Produces purple colored fruit of 4 – 5 cm in diameter
- Has superior and aromatic flavor
- Used for fresh market and juice extraction

Yellow Passion Fruit

- Does well in the lower midland and lowland zones 0-900 m above sea level
- Is more vigorous and produces larger fruit of 5 – 7 cm in diameter
- More acidic- used for juice extraction
- Tolerant to Fusarium Wilt
- Tolerant to Phytophthora Root Rot, Nematodes
- Used as rootstock for purple passion fruit
- Popular in the export market



Purple passion fruit



Yellow passion fruit

1.3. CLIMATIC REQUIREMENTS

Purple passion fruit prefers a cool climate, while the yellow variety prefers a warm climate. The purple passion fruit is subtropical, whereas the yellow passion fruit is tropical. The optimum temperature for production is between 20-30 °C. The vines can tolerate temperatures of up to 6 °C, but growth, pollination, and flowering will be poor.

The fruit are easily destroyed by wind, causing rub marks, which leads to rejection in markets. Therefore, windbreaks should be introduced in places where wind damage is a concern.

Altitude	0-900 m above sea level for the yellow variety 1,200 – 2,000 m above sea level for the purple variety
Rainfall	900 – 2,000 mm of rainfall annually
Growing Temperature	Purple variety: 18 – 25 °C Yellow variety: 25 – 30 °C
Soil	Loamy soil that is deep and well-drained pH range of 5.5 – 6.5

1.4. SOIL CHARACTERISTICS AND SITE REQUIREMENTS

Passion fruit vines can grow on many soil types, but prefer light to heavy sandy loams, of medium texture, and a depth of at least 60 cm deep. Soil pH should be from 5.5 to 6.5. If the soil is too acidic, lime must be applied. Good drainage of at least one meter in depth is essential to minimize the incidence of collar rot. The soil should be rich in organic matter and low in salt.

Since the vines are shallow-rooted, they benefit from a thick layer of organic mulch. However, careful consideration has to be made should there be termites and crickets, which can destroy the plants. The shallow but extensive root system benefits from a well-plowed land, which should be done some months before transplanting. The soil should also be free of herbicide contamination.



2. CHOOSING A VARIETY

There are two main passion fruit types, the purple and the yellow varieties. The yellow type has a more vigorous vine and generally larger fruit than the purple.

2.1. CHARACTERISTICS OF THE PURPLE TYPE

- Has a purple peel
- Bears smaller fruit
- Sweeter and less acidic pulp that is richer in aroma and flavor, along with a higher proportion of juice (35-38 percent)
- Can self-pollinate but pollination is best under humid conditions
- Vine grows less vigorously
- Contains black seeds

2.2. CHARACTERISTICS OF THE YELLOW TYPE

- Has a yellow peel
- Bears larger fruit
- More acidic flavor
- Flowers are self-sterile; carpenter bees are used for pollination (wind is not effective in pollination because the pollen is heavy and sticky)
- Vine grows more vigorously and is tolerant to nematodes and Fusarium wilt
- Less tolerant to cold weather
- Contains brown seeds

3. PROPAGATION

Passion fruit generally propagates from seeds. Both the purple and yellow varieties can germinate from a seed, and seedlings can later be planted directly into the farm or grafted onto resistant yellow rootstocks. Raising passion fruit seedlings free of disease is a highly specialized activity that is recommended to be done by a trained, registered nursery, and a certified commercial nursery operator. Purple passion fruit is highly susceptible to soil diseases such as Fusarium wilt, and is therefore routinely grafted onto the more robust sour yellow passion fruit rootstock before planting.

3.1. SEED SELECTION

There are no commercial passion fruit seed merchants. Therefore, nursery operators should ensure they select mature fruit that come from healthy plants. The fruit must be washed and cut to extract the seeds, which are then left to ferment in glass or plastic containers for two to three days. This practice helps to decompose the mucilage around the seed and enhances seed germination. Next, the seeds are washed three times. Any floating seeds or materials must be discarded, and sunken seeds need to dry under shade for at least one or two days. Dry seeds are scrapped with sand until they attain a shiny color. Finally, seeds must soak in a small amount of water overnight and sown into polythene sleeves.

About 700 seedlings are needed to plant an acre of land. However, this amount depends on seed viability and seeds storage. Good seed quality is achieved if fresh seeds are used. Seeds older than six months do not germinate well, but can be soaked for at least one day to improve germination. Seeds should not be exposed to strong light until they have germinated since sun-drying reduces germination percentage. Germination takes 7-10 days for yellow passion seeds and 14-28 days for purple passion seeds.

3.2. SEEDLING METHOD

Seeds are planted directly into the field or into 10 cm-wide by 15 cm-high polythene bags filled with sterilized soil to eliminate root knot nematodes, soil-borne diseases, and other harmful organisms.

Soil should be sterilized to kill pathogens by either sun exposure or direct heat. Three-seed bags are sown at a depth of 1 cm and thinned to leave one seedling per pot as soon as they attain two true leaves.

Clean water should be used to avoid nematodes and disease spread. Borehole or rainwater can be used for seed propagation instead of river water.

Seedlings grow slowly and require three to four months to reach the transplanting height of 60 cm in cool places. In warm places, the seedlings grow rapidly, attaining transplanting height in just two months. Similarly, the use of insect screen netting or greenhouse plastic controls nursery temperatures, making it possible for the seedlings to rapidly reach transplanting height only two months after sowing. Seedlings must harden by gradually reducing shade and watering in the last two-three weeks prior to planting.



Purple passion seedlings in a screen house.



Yellow passion seedlings in a greenhouse.

3.3. GRAFTING

Grafting is an important means of perpetuating the purple passion fruit and reducing nematode damage and Fusarium wilt diseases by utilizing the resistant yellow passion fruit rootstock. Scions from healthy young vines are preferred to those from mature plants. The diameter of the selected scion should match that of the rootstock. A cleft graft, whip graft, or side-wedge graft can be made. The wedge graft is the most commonly used grafting method for passion fruit.



The yellow passion fruit does not necessarily need to be grafted because of its tolerance to Fusarium. However, the purple passion fruit needs to be grafted onto the yellow rootstock before planting. The two seedlings being grafted need to have the same stem thickness to make grafting easier. In cleft or wedge grafting, the rootstock seedling top is cut off to a height of 45 cm with a clean, sharp grafting knife or surgical blade. A split of 25-40 mm long is made on the cut end of the stock. A wedge is then made on the scion that is the same length as the split in the stock. The wedge is then inserted in the split and a thin plastic wrapper (grafting tape) is used to hold the stock and scion together. Then, the graft is enclosed in a small plastic bag tied below the graft, and they are placed in shade until the union grows together.

Alternatively, grafted seedlings are arranged in a tunnel one meter high and covered completely with transparent plastic under a shade net to enhance graftage take. The grafted seedlings stay in the grafting chamber for one week and are then moved to the hardening bay for three weeks, ready for transplanting. The grafting tape is removed one month after transplanting in the field. Within five to seven weeks after transplanting, each plant will have up to four healthy laterals. From then on, the vine grows very rapidly.

4. FIELD SELECTION

Ideally, soil should be naturally free-draining. If not, a suitable drainage system should be installed. This means the water table should not be high. Local advice on drainage should always be obtained, as the type of system required depends on local soil type and rainfall characteristics. If the system is not effective, the life of the crop could be significantly reduced. Aggressive perennial weeds should be eradicated before planting. Where necessary, nutrient levels and soil pH should be improved to what is considered good basic orchard fertility for the soil type. A soil analysis should be made at this stage and all necessary corrections made before planting. The pH should be around 6.0 but not outside the range of 5.5-6.5. Liming is mandatory for acidic soil.

Passion fruit respond favorably to the application of bulky organic manures before planting, especially on light soil.

4.1. FIELD PREPARATION AND PLANTING

Prepare the land by digging deep and removing all perennial weeds. This should be done at least four weeks before planting. Make sure there is no hard pan.

Growers will need about 350 poles in an acre: 9-10 feet high and 150 mm thick, and they must be from mature trees to prevent rot and termite damage. They will also need 120 kg plain galvanized wire (12 gauge), 10 kg sisal twine, and 5 kg for each U-nails (about 670 – 700 plants). Treat the poles 3 feet long

from the base against termites and rots and then use them to build the support system. The support poles should be placed 6-12 m apart and be at least 2 feet deep in the ground. Ensure that the poles are well-packed in the holes so that they do not move around. The poles must also be tied back at the end of the rows to ensure that the wires do not sag. The wires should be 2.1 m above the ground and must be tight to prevent sagging when the plants are fully developed.

Dig the planting holes 60 cm, by 60 cm, and 60 cm deep. Separate the top soil (the first 30 cm) from the subsoil and leave the holes to aerate for at least two weeks. Rows should be 2 m apart and the plants 3 m apart in the rows.

The passion fruit will require a lot of manure, so mix at least 1 debe of old manure plus one to two handfuls (150g) of phosphatic fertilizer (DAP, SSP or TSP), in addition to the separated topsoil. Mix well, and then fill the hole above soil line. For easy identification of planting holes, fix a peg at the center of the hole, leaving it to settle for at least a week before planting. Do not use fresh manure, as this can harm the plants. Liming can be applied at this point if necessary.

Water the hole well one day before planting and then, on the day of planting, remove the bag from the plant without disturbing the roots. Seedlings should be about 45-60 cm in length at transplanting.

Make sure that the plant sits at the same level in the soil as it was in the bag. This is to ensure that the graft junction is at least 30 cm above the ground. Water it again after planting.

4.2. NUTRIENT MANAGEMENT

Passion fruit require frequent application of balanced fertilizer during growing season. This must be guided by the soil analysis results. Four weeks after planting, apply a fistful (about 50 g) of CAN to at least five plants. Repeat every four weeks until the tips of the stems meet the wire. Do not allow the fertilizer to touch the stem but broadcast the CAN around the plant. When the two shoots meet, apply a complete handful of CAN per plant. Soil analysis done at intervals will significantly guide any application. At the beginning of rainy season, apply 50 g of 'NPK' (17:17:17 or 10:20:20) per plant and incorporate it into the soil. Repeat this process at the start of every rainy season (approximately twice a year).

Foliar feeds have been found to be very beneficial and they can be applied as needed. Before flowering, use a vegetative foliar feed, which is high in nitrogen. At flowering, use a flowering foliar feed, which is high in potassium. Note that excessive nitrogen causes excessive vegetative growth and premature fruit drop.

4.3. IRRIGATION

Regular watering will keep a vine flowering and promote fruiting almost continuously. Water requirement is high when fruit approach maturity. If the soil is dry, fruit shrivel and fall prematurely. It is possible to obtain a reasonable yield without irrigation but with it, passion fruit yields double. However, inadequate soil moisture can cause flower abortion, lower fruit weight, loss of fruit, and low yields.

Irrigation is therefore beneficial during dry weather, especially in areas with light, shallow soil. Young vines establish more quickly in dry areas if irrigated. In areas where rainfall is sufficient and on heavier soil types, care must be taken not to induce root rots with excessive watering.

During irrigation, the soil should be well wetted, to the depth of the root zone. Frequency of irrigation will depend on the moisture-holding capacity of the soil and the weather.

The button dripper is a type of drip irrigation commonly used by farmers and depends on plant spacing. Inverted bottles full of water and spot irrigation using either hosepipe or a watering can, are other methods that can be used for passion orchards irrigation.

5. TRAINING AND TRELLISING

5.1. TRAINING

When training vines, the aim is to get them on to the wires of the trellis as quickly and as simply as possible. Push light stakes into the ground beside each plant and attach them to the wires to provide support for the young leaders. One vertical stake should be used for supporting the young leaders. When the young vine starts to grow, choose the two strongest shoots and direct them up the stakes. Remove all other shoots before they attain a length of 8 cm to encourage maximum growth among the leaders.



One month after transplanting, choose the best shoots and remove the rest (left). The two shoots selected are then trained on a pole using loose loops or sisal twine (middle). It takes approximately two to three months for the vines to get to the wire (right).

As each leader grows, tie them loosely upwards on the stick or twist them lightly round the sisal twine and tie them in position. Once the leaders reach the trellis wires, train two of them along the wire at the top, one to the left and the other to the right. Two or three branches from each main leader can also be trained along the wires to serve as secondary leaders. The leaders should be twisted loosely around the wire.



Laterals should hang freely from the wire by the 4th to 6th month.



Fruit start forming and will be ready by the 7th to 9th month.



Aerial view: The passion fruit crop should look like this at four to six months.

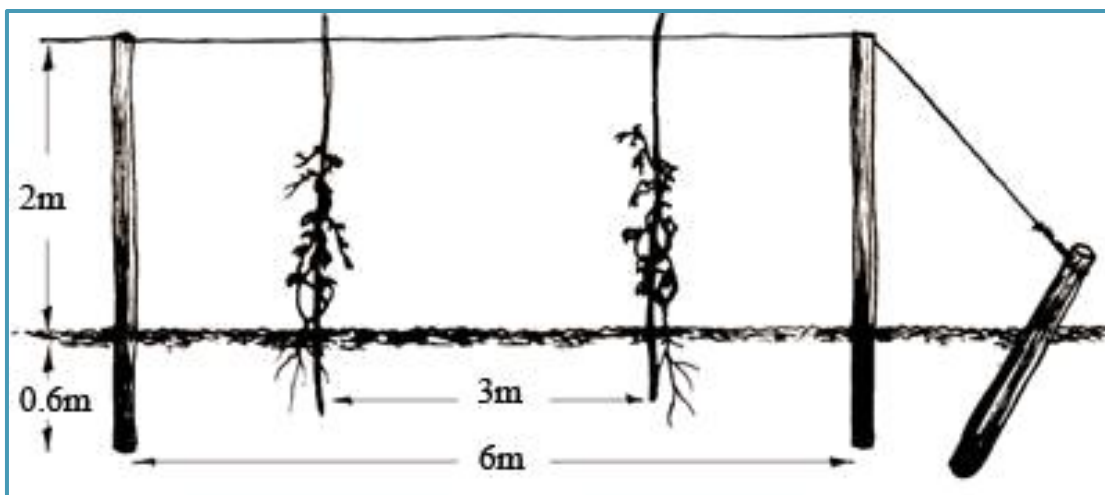
It is important that a lot of care and attention is put into the training of the leaders along the wire, avoiding loops that hang down well below the wire, so that pruning in future seasons can be streamlined.

Flowers that grow up the trellising lines should be removed and allowed to grow on the trellis after the leaders have branched left and right.

In the following season, the vines make considerable growth, and further careful training is necessary to keep the leaders on the wire until they meet up with the neighboring plant. Laterals arising from these leaders will flower and fruit that season.

5.2. TRELLISING

Passion fruit grow best on trellises, where they are well supported. At first, the plants are trained up on stakes 2.1m to produce leaders. Two strong shoots are allowed to grow and all other shoots are removed regularly.



A robust trellis system



Vines before training; see effect of termites on posts (left). Laterals hanging 6.5 feet from the wire (middle). Passion fruit after training on the wire (right).

Trellises may collapse due to termite damage after a year or two. Use good and strong timber, which is either termite-resistant or treated with preservatives. Ideally, use stakes that are 20 cm in diameter and 2.7 m long. Drive the stakes 60 cm into the ground and fasten galvanized wire to them using binding wire. There are various ways of anchoring the wire and rows or posts to keep them upright. Space the poles every 6 m with two passion fruit vines between them.

Once the leader's shoots reach the wires, they are allowed to grow along them to about 1.5 m. The leader shoots should be twined lightly along the wires because tight knots encourage diseases. Secondary shoots will form and hang down, forming curtains of shoots. Try to keep these secondary shoots from becoming too tangled by removing the young tendrils. Cut off shoots, half a foot to one foot, before they reach the ground. Over the seasons, regularly cut out weaker or diseased secondary shoots but never the leader shoots. Cut back shoots which have finished producing fruit at least 9 inches to two feet long. Nip the leader once it attains 1.5 m along the wire to encourage the production of lateral shots which bear fruit.

5.3. PRUNING

Light is the essential factor for flowering, and in passion fruit, this is particularly true for floral development and fruit set. This is why training and pruning are important to ensure adequate exposure of the shoots. The passion fruit vine bears its fruit on the current season's growth, so careful pruning is essential. If the vine is left unpruned, the bearing surface becomes further and further removed from the leaders. As there is no room for unlimited expansion along the trellis, the annual extensions become intertwined among themselves. With the growth of previous seasons, neighboring vines will be short-lived because pest and disease have become rampant as the density of growth prevents adequate spray coverage.



Laterals should be allowed to hang as shown in the pictures above.

When pruning, shorten all laterals to 20-30 cm below each wire, then remove all dead, diseased, and weak growth. This can be done using hedging shears or secateurs. The pruning tools should be sterilized using 10% sodium hypochlorite (jik) solution between each plant. When shortening leaders, the cut should be made to a young side shoot, as dormant buds on older leaders may not shoot and dieback can occur. Clear all pruned material from the plantation and burn as a hygiene measure. Immediately after pruning, spray with an appropriate fungicide to check diseases. A suitable insecticide can also be applied at this time if necessary.

6. POLLINATION REQUIREMENTS

Pollination is essential for fruit production on passion fruit vines. Therefore, fruit set will be better if cross-pollination of one plant with pollen from another takes place. The flowers of passion fruit are self-sterile, and some plants are even self-incompatible. Care must be taken, therefore, in the selection and distribution of compatible clones or cultivars in the field to ensure maximum fruit production. The amount of pollen deposited on the stigma determines the number of seeds and size of the fruit. The ovule must be pollinated, and the seeds developed, if juice is to form in the pulp sac to develop as many as 350 seeds. Unless about 100 ovules develop into seeds, the fruit is likely to be “hollow” (light in weight and with little juice).

Fruit set, seed number, fruit weight, and juice yield correlate with numbers of pollen grains deposited upon the stigma. This shows the importance of adequate bee visitation and pollen transfer between flowers within the brief span of time of stigma receptivity for maximum fruit set.

6.1. POLLINATORS

Honey bees (*Apis mellifera*) and carpenter bees (*Xylocopa* species) are the primary pollinators of passion fruit. Because of their abundance and large size, carpenter bees are undoubtedly the best pollinating agents. Unfortunately, they are scarce or nonexistent in some areas. Honey bees can be established wherever desired, but they sometimes show preference for more attractive plants than passion fruit hence being less effective. Beehives can be kept near the orchards. Honey bees may visit the flowers for nectar, pollen, or both.

Satisfactory fruit are usually obtained with adequate pollinating agents. Hand pollination of the flowers increase the set of yellow passion fruit by 21 percent over open pollination.

6.2. RECOMMENDATIONS AND PRACTICES

One of the major problems in passion fruit production is obtaining a satisfactory set of fruit. One carpenter bee per 50 feet of row or one honey bee per four blossoms may be sufficient. The optimum number for maximum pollination of passion fruit is unknown. Honey bee colonies can be transported and increased wherever and whenever desired.

The yucca plant produces a flower stalk that eventually dries and becomes a chosen nesting site for the carpenter bee. Therefore, this plant might be grown near passion fruit fields. The larger the plantation of passion fruit, the more efficient becomes the activity of the two primary pollinating agents - the carpenter bee and the honey bee - because competing plants are relatively reduced.

On most insect-pollinated crops including passion fruit, the most satisfactory and surest way to supply ample pollination is by stocking the area with sufficient honey bee colonies. The number per acre of passion fruit might vary enormously with the (generally small) size of the crop and with competing plants.

Growers should avoid spraying crop protection products during the hottest times of the day - when bee activity is at its highest. Spraying can be done in early mornings or late evenings.

7. IPM IN PASSION FRUIT FARMING

7.1. WHAT IS IPM?

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices.

IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment.

This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

7.2. HOW DOES IPM WORK?

IPM is not a single pest control method, but rather a series of pest management evaluations, decisions, and controls. In practicing IPM, growers who are aware of the potential for pest infestation follow a four-tiered approach. The four steps include:

7.3. SET ACTION THRESHOLDS

Before taking any pest control action, IPM first sets an action threshold, a point at which pest populations or environmental conditions indicate that pest control action must be taken. The sight of a

single pest does not always mean control is needed. The level at which pests will either become an economic threat is critical to guide future pest control decisions.

7.4. MONITOR AND IDENTIFY PESTS

Not all insects, weeds, and other living organisms require control. Many organisms are harmless, and some are even beneficial. IPM programs work to monitor for pests and identify them accurately, so that appropriate control decisions can be made in conjunction with action thresholds.

This monitoring and identification removes the possibility that pesticides will be used when they are not really needed or that the wrong kind of pesticide will be used.

7.5. PREVENTION

As a first line of pest control, IPM programs work to manage the crop, lawn, or indoor space to prevent pests from becoming a threat. In an agricultural crop, this may mean using cultural methods, such as rotating between different crops, selecting pest-resistant varieties, and planting pest-free rootstock. These control methods can be very effective and cost-efficient, and present little to no risk to people or the environment.

7.6. CONTROL

Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs then evaluate the proper control method both for effectiveness and risk. Effective, less risky, pest controls are chosen first, including highly targeted chemicals, such as pheromones to disrupt pest mating, or mechanical control, such as trapping or weeding.

If further monitoring, identifications, and action thresholds indicate that less risky controls are not working, then additional pest control methods would be employed, such as targeted spraying of pesticides. Broadcast spraying of non-specific pesticides is a last resort.

8. INSECT PESTS OF PASSION FRUIT

A well-managed orchard may have very few pests, hence minimal pesticide use. Regular inspections should be carried out in the farm usually called scouting. Care should be taken when using pesticides to avoid killing the beneficial insects (natural enemies). Spraying should be done when the natural enemies become less and pests increase significantly.

Some of the factors to consider before selection of a pesticide for use in passion fruit plants include the efficacy of the pesticide, approval status for the European market, and the Maximum Residual Levels (MRLs) notifications, if any, and establish that all the pest control products used are registered in the FTFT-MnM Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP).

8.1. APHIDS – MYZUS PERSICAE, APHIS GOSSYPII

8.1.1. Description

These are delicate, pear shaped, soft-bodied insects with long legs and antennae. They are usually green, yellow, dark, or black in color with or without transparent wings. They are often found in small colonies (groups) sucking sap of tender growth.

Aphids damage plants by sucking plant sap, which causes curling, wrinkling, or cupping of infested leaves, giving plants a deformed shape. They spread viruses, e.g. the woodiness potyvirus and excrete honeydew, which coat the plants and lead to growth of sooty mold, which can diminish the photosynthetic capacity of plants. Aphids are usually controlled by natural enemies if they have not been disturbed, for instance, by the use of broad-spectrum pesticides.

8.1.2. Damage

They are mostly found in the crop early in the season and may transmit viral diseases. They distort plant leaves and stems causing necrotic spots on the leaves and stems. The infested plants grow partly and their leaves curl. They secrete honeydew that promote the development of sooty mold on foliage and fruit, which also slows plant growth. Aphids transmit woodiness virus.

8.1.3. Cultural control

Lady bird beetles, lacewings and hover-fly larvae have reportedly been effective between 73 percent and 95 percent in controlling aphids. Soap and water solution sprays can also control aphids. Growing strong-smelling plants such as onion, garlic, or parsley can reduce aphid problems. Rainfall and overhead irrigation discourages aphids. Plant the crop in well-prepared, fertile land, but do avoid applying nitrogenous fertilizer, as this will promote new growth, which makes the plants juicy and attractive to aphids.

8.1.4. Chemical control

Many effective insecticides are available against aphids. The ones that can be used in an IPM approach include, but are not limited to the following: Azadirachtin, Beta-Cyfluthrin, Chlorpyrifos, Bifenthrin, Deltamethrin, Lambda-Cyhalothrin and Pirimicarb. Farmers **must** adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.

8.2. THRIPS

8.2.1. Description

Thrips, order *Thysanoptera*, are tiny, slender insects with fringed wings. They feed by puncturing the epidermal (outer) layer of host tissue and sucking out the cell contents, which results in stippling, discolored flecking, or silvering of the leaf surface. Thrips feeding is usually accompanied by black varnish like flecks of frass (excrement). Pest species are plant feeders that discolor and scar leaf, flower, and fruit surfaces, and distort plant parts or vector plant pathogens. Many species of thrips feed on fungal spores and pollen and are often innocuous.

Thrips damage causes stunting of young plants; they feed on leaves, flowers and fruit.



Thrips and their effects on fruit.

8.2.2. Symptoms

- Attacked plant parts shrivel.
- Attacked flowers and young fruit fall prematurely.
- Feeding by thrips on fruit causes tiny lesions, which affect the marketability of the fruit.

- A heavy infestation causes premature wilting, delay in leaf development, and distortion of leaves and young shoots.

8.2.3. Cultural control

Ploughing and harrowing can kill pupae in the soil from previously infested crops. In some cases, intercropping has been found to reduce thrips infestation. Avoidance of successive planting of susceptible crops reduces the impact of thrips i.e. Crop Rotation.

8.2.4. Chemical control

Use recommended pesticides such as Oxydemeton-Methyl to kill thrips.

8.3. MEALY BUGS – PLANOCOCCUS CITRI

8.3.1. Description

They are 3-5 mm long, soft, elongate oval and somewhat flattened. The mealy bug is often surrounded by a cotton-wool like mass.



Mealy bug colonies on vines and leaves of passion fruit.

8.3.2. Damage

Mealy bugs infest fruit and foliage. They can be serious pests in the warm season if natural enemies, which usually control them, are destroyed by pesticides.

8.3.3. Cultural control

Conserve natural enemies. Mealy bugs are usually controlled by a wide range of natural enemies. Use of pesticides is difficult because some mealy bugs are concealed and not hit by contact sprays. Pesticides may kill these natural enemies leading to mealy bug out-breaks.

8.3.4. Chemical control

Effective pesticides against mealy bugs that can be used in an IPM approach include, but are not limited to the following: Buprofezin, Lambda- Cyhalothrin and Chlorpyrifos. Farmers **must** adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.

8.4. LEAF MINERS – LIRIOMYZA SPP.

8.4.1. Description

The adults are small, black and yellow flies, about 2mm long. They lay eggs, which hatch into small larvae that feed by mining between the upper and lower epidermis of the leaves, making a tunnel as they move

along. Occasionally, the larvae can be within the leaf mine as it feeds. When the yellow larva is fully grown, it cuts a slit in the leaf and drops into the soil where it pupates. When it does not drop into the soil, the dark orange or brown pupae can be seen on the leaf damage.

The act of laying eggs and feeding on leaves can kill seedlings, and in older plants, allows the fungal diseases to enter the leaves. Damage by “mining” causes whitish blotches inside the leaves, kills the leaves eventually making them fall prematurely. This reduces plant yield. During heavy infestations, adults feed and lay eggs on the leaves causing white spotting or stippling. However, the major damage is caused by larvae tunneling inside the leaves and reducing the reproductive leaf area.



Leaf miner effect on passion fruit leaves.

8.4.2. Chemical Control

Pesticides used should be able to pass through the outer layers of the leaves or move into the plants sap. Leaf miners have an ability to develop resistance against pesticides very fast. Regular rotation of pesticides is therefore advised. The ones that can be used in an IPM approach include, but are not limited to the following: Bifenthrin, Cyromazine and Methoxyfenozide. Farmers **must** adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.

8.4.3. Cultural Control

Control of leaf miners by natural enemies is important. For example, use of parasitic wasps, such as *Diglyphus* ssp., has proved effective. Ploughing also helps in exposing pupae to desiccation and natural enemies.

Use of yellow sticky traps or yellow basins filled with water attracts the adult leaf miner, which are later killed. Destruction of hosts, such as old crop debris, as well as having a rotation with non-host crops, can help reduce leaf miner populations in the crop. Neem products are also effective for controlling leaf miners.

8.5. SPIDER MITES – TETRANYCHUS SSP

8.5.1. Description

These are serious pests during dry spells. They are minute reddish brown “spiders” with four pairs of legs of equal length and with an oval body. Their mouth parts are modified for piercing individual plant cells and removing the contents. Their eggs are creamy and usually on the leaf surface. They protect themselves from predation by webs on the underside of the leaves.



Spider mites on passion fruit leaves.

8.5.2. *Damage*

Spider mites are chewing pests, and they feed on leaves and young main veins. They also feed on fruit, causing white speckling. The leaves become spotted, silvery brown or yellow, and often drop. Lack of control may cause the plants to die and lead to low yields. Their feeding causes tiny yellow or white specks, and eventually, leaves become yellowish and may drop, leading to complete defoliation. Heavily infested plants may become stunted. A heavy infestation might also cause vine dieback and shriveling and dropping of immature fruit.

8.5.3. *Cultural control*

Natural enemies such as predatory mites are effective in the control of Spider Mites. For example, e.g. *Phytoseilus persimilis* and *Amblyseius californicus* are very effective when used.

Inter-planting with garlic or onion, spraying with cotton seed oil, olive oil, and garlic, use of resistant cultivars, and planting host plants of predatory mites such as pigeon peas do help bring spider mites on check. Heavy rain or irrigation can reduce their numbers because spider mites do not like wet conditions.

Field hygiene is important for the management of spider mites because old crops or weeds infested with mites can cause infestation of any new crop.

8.5.4. *Chemical control*

Curative and preventive treatments, especially during the vegetative phase, are advisable. Effective pesticides that can be used in an IPM approach include, but are not limited to the following: Azadirachtin, Bifenthrin and Sulphur. Farmers, **must** adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.

8.6. FRUIT FLIES – *BACTROCERA CUCURBITAE* AND *CERATITIS CAPITATE*

8.6.1. *Description*

Fruit flies that feed on passion fruit in Africa include the Melon fly (*Bactrocera cucurbitae*) and the Mediterranean fruit fly (*Ceratitis capitata*). The flies are usually around 6 mm long with wing spans about 10 mm. The wings have spots at the tip or have a characteristic stripe pattern.



Fruit flies on passion fruit.

8.6.2. Damage

Pierced young fruit shrivel and fall. Injuries cause damage that lowers the market value of the fruit. However, the incidence of fruit flies on passion fruit is low and usually of no economic importance. Therefore, control may not be necessary.

8.6.3. Cultural control

Collect and destroy all fallen fruit at least twice a week during the fruit season. Do not put collected damaged fruit into compost heaps. Instead, burn or bury them at least 50 cm deep, so that the fruit flies cannot reach the soil surface. Pick overripe fruit, as they attract fruit flies. Trap crops may be planted to kill the adult flies.

Spot treatment with insecticide sprays can be applied to non-fruiting regions of the plants and stakes. Only spray the whole plants as a last resort.

8.6.4. Chemical control

Some of the products used to control fruit flies in an IPM approach include, but are not limited to the following: Bifenthrin, Buprofezin and Oxamyl.

Farmers **must** adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.

8.7. NEMATODES – MELOIDOGYNE SSP

8.7.1. Description

Amongst nematodes infesting passion fruit, the root-knot nematodes (*Meloidogyne incognita*, *M. javanica* and *M. arenaria*), are the most serious pests. Characteristic symptoms of infestation by root-knot nematodes are formation of galls or knots on roots, yellowing of leaves, stunting and eventual wilting of the affected plants. Nematodes are usually a problem in the purple passion fruit, but not the yellow passion fruit. They are pear-shaped thread like worms about 0.01 inches long. They live in the soil and get food from sucking root sap. This causes root knots also called galls. They can be seen with a hand lens when these galls are cut open.



Roots with Galls (left). Normal roots (right).

8.7.2. Damage

The galls interfere with the movement of water and nutrients effectively. Infected plants are less vigorous, stunted, and respond poorly to fertilizers. Damaged areas appear as irregular patches in the field. Nematode infection makes it easier for other diseases to infect the plant.

8.7.3. Non-chemical control

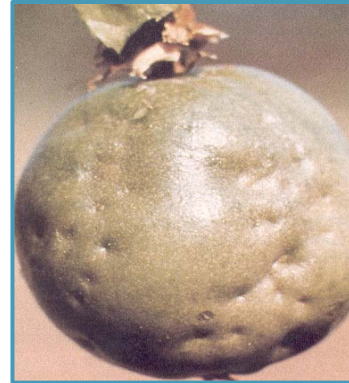
Use tolerant varieties like yellow passion fruit. Practice crop rotation with crops that are resistant, e.g. garlic, cassava, cereals, maize, baby corn, sweet corn, sweet potato, onions, cabbages, kale, or fodder grasses (e.g. Sudan grass). Flooding the soil a few weeks prior to planting and maintaining high levels of organic matter also reduces nematode numbers. Effectively carry out soil solarisation after a deep plough. Use tolerant rootstocks e.g. the yellow rootstock. Maintain high organic matter (farmyard manure / compost) in the soil. Incorporate neem products at transplanting.

8.7.4. Chemical control

There are registered chemicals for nematodes control. They are usually applied as a soil drench. However, most of them are very dangerous and not cost effective for small-scale farmers. Some of the registered chemicals that can be used in an IPM approach include, but are not limited to the following: Azadirachtin, Ethoprophos and Oxamyl among others. Farmers **must** adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.

8.8. BUGS

Several species of sucking bugs feed on passion fruit. The most important include the green stinkbug (*Nezara viridula*), the brown stinkbug (*Boerhavia maculata*), Coreid bugs such as the giant coreid bug or tip wilter (*Anoplocnemis curvipes*) and the leaf footed plant bug (*Leptoglossus membranaceus*).



Brown stink bug (left). Colored stink bug on passion fruit (middle). Stink bug damage (right).

8.8.1. Damage

Bugs suck sap from the growing tips or from developing fruit. The bugs pierce the terminal buds, which eventually wilt and die back. Young plants may die if the attack is severe. The punctured young fruit develop localized hardened spots that remain on the fruit, which reduces their market value.

8.8.2. Cultural control

In small orchards, bugs can be hand-picked and destroyed. Watering and irrigation discourages bugs. Old crops or sprouting stumps left in the field provide refuge for bugs so they should be destroyed or dug into the soil. Growing strong smelling plants such as garlic and onion or near the crop is reported to reduce infestations. Spraying plants with a soapy solution can help to wash off young bugs.

8.8.3. Chemical control

Some of the chemicals that can be used in an IPM approach include, but are not limited to the following: Beta-Cyfluthrin +Chlorpyrifos, Buprofezin, Chlorpyrifos methyl and Lambda Cyhalothrin.

Farmers **must** adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.

9. IMPORTANT DISEASES OF PASSION FRUIT

The most important diseases of passion fruit in Tanzania are Brown spot, Phytophthora blight, and Woodiness virus. Fusarium is not a problem in yellow passion fruit as it is in purple passion fruit. Hence, the yellow passion fruit rootstock is used for grafting purple passion fruit. Brown spot can be controlled using suitable fungicides. Begin protective spraying against Brown spot at the start of the rainy season, or when spots are visible.

Woodiness virus can be a problem if infected planting material is purchased. Good vine pruning will help ventilation within the crop, lowering the incidence of diseases. The following are the main passion fruit diseases.

The following are the major diseases and physiological disorders of passion fruit:

Fusarium wilt, Passion fruit woodiness, Brown spot, Septoria spot and Phytophthora blight.

9.1. PEST

The golden rule is to not spray any insecticide until one is certain of which pest is involved and what amount of pests, at any particular time, will lead to levels of commercial damage which justifies spraying interventions. If pest thresholds are exceeded, only appropriate chemicals registered for use on

avocados for that specific pest may be considered, and only if such usage falls within the scope of accepted chemicals and residues allowed in the various markets.

In the long term, injudicious use of insecticides on a random basis will lead to pest:predator (beneficial insects) imbalance in the orchards, leading to increasingly severe pest repercussions, more costly control, and ultimately, lower profitability.

Integrated Pest Management is advocated whereby 'softer' chemicals may be used depending on scouted observations by trained staff (scouts) at critical times when predator populations are not that susceptible.

Avocado crops are mainly affected by certain insects and arachnids that cause damage by reducing yields and quality. There are also a couple of quarantine pests which **must** be controlled in order for exported avocados to enter various markets. With the purpose of identifying and controlling them, this section presents the economic importance pest in Tanzania.

9.1.1. Description

Fungus infects the plant through the rootlets xylem vessels and then up the plant system. The fungus is usually on infected seeds or seedlings. The fungus also gets into the farm through farm tools, stacking materials, and shoes.



A cross section of a stem damaged by Fusarium wilt.

9.1.2. Symptoms

Fusarium wilt (also called collar rot) symptoms consist of leaf yellowing, the collar region of affected plant at soil level turning brownish, vertical cracking, and vine wilting, followed by a complete plant collapse. On dissection of infected stem, vascular tissues show brown discoloration.

The disease is favored by acidic soil and nitrogenous fertilizers. Presence of root knot nematodes encourages the disease. The disease is also favoured by warm weather. Fungi survive in the soil for many years.

9.1.3. Cultural control

Avoid fields where severe Fusarium wilt has been detected for at least three years. Field hygiene should also be practiced. Where soil is acidic apply lime or farmyard manure.

Avoid excess use of nitrogenous fertilizers and control root knot nematodes. Affected parts should be removed and burned. Snap off the affected parts or remove the affected plant manually.

Do not cut tissue and then use the knife on healthy plants. Keep the base of the plant clear of grass and weeds, which favor fungal growth.

Grafting to wilt-resistant yellow passion fruit rootstocks is the most practical way of control. Use of bio-pesticide like *Trichoderma* spp., which is a fungal antagonist against *Fusarium* spp., can control *Fusarium* wilt.

9.2. PASSION FRUIT WOODINESS VIRUS (PWV)

Passion fruit woodiness virus is a common passion fruit viral disease.

9.2.1. Symptoms

Affected leaves show light and dark green mosaic patterns, often with light yellow speckles. Sometimes small, yellow ring spots may develop on upper leaf surface.

Infected fruit are small and misshapen with a very hard rind and a small pulp cavity. When affected fruit is cut, the inside rind tissue may have brown spots. Some strains of the virus cause cracking of affected fruit.

They are spread by aphids (*Aphis gossypii* and *Myzus persicae*) and pruning knives. The virus has a wide host range including bananas, cucurbits, and many weeds.



Cracked passion fruit are due to Woodiness Virus.



Shapeless passion fruit are also caused by Woodiness Virus.

9.2.2. Cultural control

Use clean planting materials and sterilize the pruning tools. Use yellow passion fruit rootstocks which are resistant to the disease. Remove diseased vines from the field. Do proper weeding. Avoid planting bananas and any member of the cucurbits family e.g. pumpkins, melons, cucumber, etc. near passion fruit fields.

9.3. BROWN SPOT – ALTERNARIA PASSIFLORAE

9.3.1. Symptoms

Symptoms are brown spots that can appear up to 10 mm in diameter on the leaves. They often extend along the veins and dry out in the center. On the stems, spots are up to 30 mm long, and when they appear on the leaf axils may kill the vine, resulting in dieback. On the fruit, spots are light brown, round, and sunken; they often merge, covering large areas, and produce red-brown spore masses. Spores produced on the leaf, stem, and fruit are dispersed by wind-blown rain. Warm and moist weather favor disease development.

9.3.2. Cultural control

Yellow passion fruit and its hybrids are more tolerant of this disease. Field sanitation (collection and disposal of fallen diseased fruit, leaves, and vines) discourages brown spot.

Prune vines to reduce density, which reduces humidity within the crop. It also facilitates better air circulation, light, and spray penetration, and cover.

9.3.3. Chemical control

A timely spray with copper-based fungicides is recommended for preventing the disease. During humid weather, when the vines are growing rapidly, reduce the intervals between spray applications to two weeks to ensure that new growth is adequately protected.

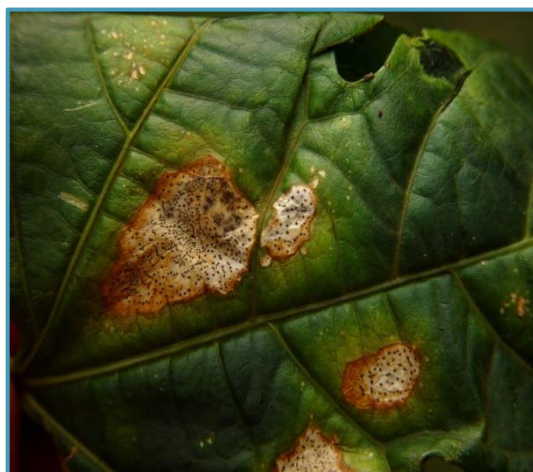
Other sprays that can be used for the control of brown spot in an IPM approach include, but are not limited to the following: Famoxadone + Cymoxanil and Mancozeb.



Brown spots on fruit and leaves of passion fruit.

9.4. SEPTORIA SPOTS – SEPTORIA PASSIFLORAE

The disease may affect plants of any age but becomes more common during fruit set. The disease develops well in moist conditions and is not a problem in the dry season.



Septoria spots on fruit and leaves of passion fruit.

9.4.1. Symptoms

The disease attacks leaves, stems, and fruit. Brown spots, up to 2 mm in diameter, with minute black dots (fruiting bodies containing fungal spores), develop on leaf surface. Infected leaves fall, leading to vine defoliation.

Similar spots can form on the stems, albeit with an elongated form. On the fruit, light-brown spots studded with minute black dots can form. The spots often join to cover large areas of the fruit. Affected fruit ripen unevenly.

Spores produced by black dots (fruiting bodies) are blown to adjacent vines during wet, windy weather thus further spreading the disease.

The disease is spread by rain, dew, and overhead irrigation. Warm and moist weather favors disease development.

9.4.2. Cultural control

Practice field sanitation (collection and disposal of fallen diseased fruit, leaves, and vines). Plant yellow passion fruit and its hybrids as they are more tolerant of this disease. Prune affected shots to reduce density and thereby reducing humidity within the crop. This practice also facilitates better air circulation, light, spray penetration, and cover.

9.4.3. Chemical control

Use of fungicides such as Famoxadone + Cymoxanil, Mancozeb, Trifloxystrobin and Sulphur has been seen to offer effective control in an ideal IPM approach.

Farmers **must** adhere to the recommended tank dose and observe the Pre-Harvest Intervals as advised on the product label.

9.5. PHYTOPHTORA BLIGHT – PHYTOPHTORA NICOTIANAE VAR. PARASTICA



Phytophthora blight on fruit and leaves of passion fruit.

9.5.1. Description

Another fungus strain (*Phytophthora cinnamoni*) causes root rot. Yellow and purple varieties have different susceptibility patterns. The yellow vine is susceptible to *P. cinnamoni*, and the purple vine is

more susceptible to *P. nicotianae*. Both fungus strains attack both passion fruit and can cause root rot, wilt, damping off, and leaf blight. Fungal spores are initially produced in wet soil beneath the vines and are splashed up to lower leaf canopy. The disease is favored by wet and windy weather.

9.5.2. *Damage*

Affected leaves are water-soaked and of light-brown color. They fall readily, leading to defoliation of the vines. Affected areas of the stem are first purple and later brown above the graft union. They may completely girdle the stem causing wilting and vine collapse. Fruit symptoms comprise of large, water-soaked areas. Diseased fruit fall readily, and in wet weather are covered with white.

9.5.3. *Cultural control*

Practice good field sanitation. Prune and keep a grass sward under the vines to minimize spore splashed up to the lower leaves. Graft to resistant rootstocks.

9.5.4. *Chemical control*

The application of copper-based fungicides, every 2-3 months during the wet season, reduces disease incidence in areas where the disease is likely to be serious. Stem lesions may be painted with a copper fungicide. Other fungicides that can be used in an IPM approach include, but are not limited to the following: Famoxadone + Cymoxanil, Mancozeb and Metalaxyl + Mancozeb.

10. RIPENING AND HARVESTING

A full fruit size is reached 20 Days After Flowering (DAF). Fruit weight also increases rapidly up to 20 DAF and then more gradually towards maturation. Fruit juice begins to accumulate 30 DAF and its color changes from yellow to orange after about 60 DAF. The skin color of the fruit remains green up to 70 DAF. Fruit are fully ripe at 90 DAF and start to detach from the vine.

The method to judge when the fruit is ready to harvest is by noticing when the fruit changes color. Ripe fruit will fall from the vine; collect all fallen fruit daily in the morning to avoid sun scorching. It is best to use plastic buckets when collecting the fruit. Place it gently into the container and do not allow it to become bruised by rough handling.

Depending on the climate, there may be one to three harvest peaks (purple passion fruit), or a single, often very long harvest season more common with the yellow passion fruit. Passion fruit yields depend on how intensive the crop production system is and can range from 10-30 tons per acre.

Passion fruit are normally harvested from vines twice per week before they are fully ripe, when they are light yellow or purple in color, or from the ground once they are ripe on a daily basis. For juice processing, the fruit is allowed to attain a deep yellow or purple color before harvesting.

Containers used for harvesting, preferably plastic, must be kept clean and stored away from chemical contamination, and be used solely for this purpose. Fruit are put into crates and then put into plastic gunny bags to avoid shriveling. This practice maintains the freshness of the fruit for over a week or so.

Pickers should be trained in the quality aspects of harvesting, such as observing basic food hygiene principles. Running water must be provided for personnel to clean their hands before and after harvesting. A clean toilet in the field is necessary.

Observe, carefully, the pre-harvest interval of any pesticide that has been used. A wax treatment protects the fruit from drying out and could delay the shriveling process. Fruit should be harvested during mid-morning to avoid skin damage.

10.1. MARKET REQUIREMENTS

Passion fruit are sold as fresh fruit, and the local market requires whole, unblemished fruit that are clean and uniform in color and size. They should have no signs of pesticide residues and should be smooth-skinned with no wrinkles.

For processing any juicy, clean fruit that is free of pesticide residues, with no rots or damage is acceptable. For distant marketing, harvesting can be slightly earlier because if they attain the deep yellow or purple color they start to shrivel.

10.2. GRADING

Follow the guidelines of the fruit buyer. Remove all diseased or damaged fruit, and depending on the requirements of the buyer, remove all wrinkled fruit. There are approximately 14-28 fruit per kilogram (purple passion fruit). Fourteen fruit can equal a kilogram if the fruit size is big and juicy, or as many as 28 can equal a kilogram if the fruit size is small and less juicy. Approximately 6-10 yellow passion fruit make a kilogram. Passion fruit lose weight in storage, which affects storage time.

10.3. STORAGE

The storage life of passion fruit is very short, thus making it advisable to harvest and sell them as soon as possible. It is advisable to choose fruit that feel rather heavy for their size. Passion fruit can be stored at room temperature for up to one week or refrigerated for up to two weeks. It is best to store them in plastic bags and place in crates as this will prevent the fruit from dehydrating.

10.4. HARVEST

Harvesting Period: The crop comes into bearing within seven to nine months after transplanting. The main harvest is obtained 12 – 13 months after transplanting. Harvesting seasons are determined by the rainfall patterns. With irrigation, harvesting can be done throughout the year.

Harvesting Method: Passion Fruit for fresh market should be picked when they have developed their characteristic color (purple or yellow). The fruit fall naturally from the vine when they are ripe. They are suitable for juice extraction.

Yields: With good management and crop husbandry yields of more than six to eight tons per acre per year can be realized. Yellow passion fruit should be stored at 7 to 10 °C with 90 to 95 percent relative humidity for up to two weeks. Purple passion fruit are chilling tolerant and can be stored at 3 to 5 °C for three to five weeks.

10.5. POST-HARVEST HANDLING



Best harvesting stage for purple passion fruit.



Prematurely harvested purple passion fruit.

Fruit are harvested when they are ≥ 75 percent turning yellow or purple. They are then packed in gunny bags lined with plastic to conserve freshness. Use of non-collapsible plastic crates, lined with Khaki paper, is recommended for fruit destined for the export market. Fruit can also be packed directly into export boxes that carry between 2-3 kg.

10.6. VALUE ADDITION TECHNIQUES: SORTING, CLEANING & GRADING

Sorting and Grading: Fruit should have a diameter of 5-8 cm for purple passion fruit and 6-8 cm for yellow passion fruit. The fruit should be sorted into three distinct sizes. Small, medium, and large. Any fruit with defects, such as bruises and spots, are sold together with the small fruit as second grade at lower prices. Medium to large fruit without blemishes are sold as first grade at higher prices.

10.7. PROCESSING

The fruit is easy to process. It is cut in half (lengthwise) and then the seedy pulp is scooped out. The resulting rich juice (natural concentrate) can be sweetened and diluted with water or other juices (especially orange or pineapple) to make cold drinks. The seeded pulp can be made into jelly or combined with pineapple or tomato to make jam.

After harvest, as soon as possible, place the fruit in shallow layers in a cool place to allow for rapid cooling. If storage is necessary, control the humidity and dehydration by packing into khaki bags. Tie these at the top, and put them into plastic bags inside crates with some ventilation to allow the fruit to ripen but not rot.

To avoid fruit damage, fruit should only be transported in non-collapsible cartons or plastic crates. They can also be transported in gunny bags that are lined with plastic paper.

II. PRODUCTION PLANNING (700 VINES)

Planting to First Harvest	Initial Harvest	1 st Main Harvest	Low Season Harvest	2 nd Major Harvest	Low Season Harvest	2 nd Main Harvest
0-8 months	9-12 months	13-16 months	17-20 months	21-24 months	25-28 months	29-32 months
0 Kgs harvested	Quarter kg per vine per week	1 kg per vine per week	Quarter kg per vine per week	1 kg per vine per week	Quarter kg per vine per week	Half kg per vine per week
0	$=(0.25*700*4*4)$	$=(1*700*4*4)$	$=(0.25*700*4*4)$	$=(1*700*4*4)$	$=(0.25*700*4*4)$	$=(0.5*700*4*4)$
Total Kgs	2,800	11,200	2,800	11,200	2,800	5,600

Assumptions:

- I. The passion fruit are irrigated during the dry seasons.
- II. If not irrigated, the crop will follow the rainfall patterns. That will mean production will be reduced by half of the above projected figures.
- III. Pests and diseases should be adequately controlled.
- IV. Appropriate fertilizers should be applied as necessary

12. COST OF PRODUCTION

Feed the Future Tanzania - Mboga na Matunda				
COSTS OF PRODUCTION - PASHENI				
Area	1 Acre			
Yields	220 Bags of 100Kg			
Price	Average Tsh 80,000 per Bag			
Planting days to harvesting	6 Months			
I. COSTS OF PRODUCTION				
A. INPUTS	AMOUNT	UNIT	PRICE	TOTAL
Seedlings	700	Seedlings	1,000	700,000
Fertilizer - DAP	4.0	Bag 50kg	50,000	200,000
Fertilizer - NPK - K	2.0	Bag 50kg	66,000	132,000
Fertilizer - CAN	4.0	Bag 50kg	64,000	256,000
Manure	7.0	Tons	70,000	490,000
Insecticides	5	Litre	47,000	235,000
Fungicides	5	Kg	47,000	235,000
Herbicides	2	Litre	20,000	40,000
Poles	700	Pieces	300	210,000
Posts	350	Pieces	3,000	1,050,000
Bundle of wire	2	Wire 1600M	80,000	160,000
Irrigation costs	216	Litre	2,500	540,000
Sub-Total Inputs				4,248,000
B. LABORERS				
Field clearing	5	Person per day	10,000	50,000
Field preparation	1	Contractor	50,000	50,000
Field preparation: Holes making	5	Person per day	20,000	100,000
Use of insecticides or fungicides	1	Person per day	10,000	10,000
Transplanting	5	Person per day	10,000	50,000
Fertigation	5	Person per day	10,000	50,000
Weeding	10	Person per day	10,000	100,000
Harvesting and packing	50	Person per day	4,000	200,000
Sub-Total Inputs				610,000
TOTAL PRODUCTION COSTS				4,858,000
2. ANALYSIS (INCOME & PROFIT)				
Production (Bag)	160	180	200	220
Selling price (Per Bag)	TZS 80,000	TZS 80,000	TZS 80,000	TZS 80,000
Total Income	TZS 12,800,000	TZS 14,400,000	TZS 16,000,000	TZS 17,600,000
Cost of production	TZS 4,858,000	TZS 4,858,000	TZS 4,858,000	TZS 4,858,000
Profit	TZS 7,942,000	TZS 9,542,000	TZS 11,142,000	TZS 12,742,000
Return on investment	163%	196%	229%	262%



Assumptions:

- I. The yield figures provided are averages.

Yields of as high as 30-40 tons per acre have been achieved with adequate irrigation, timely pruning, fertilizer application, and all other good agricultural practices.

13. REFERENCES

Fintrac Inc. (2014). Purple passion fruit value chain analysis: Case study of Good Neighbour Community Programme and Equatorial Hortifresh Limited. Nairobi: USAID.

Fintrac Inc. (2017). USAID KAVES Passion fruit Value Chain Analysis. Nairobi: USAID Kenya.

Horticultural Crops Directorate . (2018). Validation Report 2015-2016. Nairobi: Kenya National Bureau of Statistics .

Junqueira, C. N., & Augusto, S. C. (2017). Bigger and sweeter passion fruit: effect of pollinator enhancement on fruit production and quality. *Apidologie*, 48(2), 131-140.

Kahinga, N., Muthoka NK, C., & Mbugua W. (2006). Training Manual for Passion Fruit. Thika: KARI/KHDP.

Kibet, N., Lagat, J., & Obare, G. (2011). Identifying Efficient and Profitable Farm Enterprises in Uasin-Gishu County in Kenya. *Asian Journal of Agricultural Sciences*, 3: 378-384.

Knight, R. J., & Sauls, J. W. (1994). The passion fruit . Florida : University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences,EDIS.

Matheri, F., Mwangi, M., Runo, S., Ngugi, M., Kirubi, D. T., Teya, F., . . . Kamau, D. N. (2016). Phenotypic characterization of selected kenyan purple and yellow passion fruit genotypes based on morpho-agronomic descriptors. . *Adv. Crop Sci. Technol.*, 4, 2.

Muthomi, E., & Njogu, J. (2011). The Passion farming Handbook. Nairobi: Kengap Publishing.

Mwirigi, P., Gweyi-Onyango, J., & Mwangi, M. (2016). Agronomic management of yellow passion fruit among farmers in Mbeere sub-county, Kenya. Nyeri: Dedan Kimathi University.

USAID Kenya Horticulture Competitiveness Project (KHCP). (2012). Final Report: Horticulture Retail Audit. Nairobi: Fintrac Inc.