PIP

CROP PRODUCTION PROTOCOL

PASSION FRUIT

COLEACP is an international network promoting sustainable horticultural trade.

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In accordance with the Millennium Development Goals, the global objective is to: "Maintain and, if possible, increase the contribution made by export horticulture to the reduction of poverty in ACP countries".

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PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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Disclaimer

The document « Technical Itinerary » (fruit or veg.) describes all the agricultural practices linked with the (fruit or veg) and suggests a pests and diseases control based mainly on active substances supported by the pesticides manufacturers in the European Directive 91/414 review and due to comply with European pesticides residues limits . Most of these active substances have been tested through a field trials programme and the residue level of each active substance has been measured. The pests and diseases control suggested is dynamic and will be adapted continuously integrating all informations gathered by the PIP. Nevertheless, each grower has the possibility to select among the products listed a set of active substances of no concern regarding residues.

It is obvious, that are allowed for usage only those formulations which have been legally registered in the country of application. It is each grower obligation to check with the local registration authorities whether the product he wishes to use is mentioned on the list of registered products.

The PIP's crop protocols and guides to good phytosanitary practices are regularly updated. For further information, see the PIP website www.coleacp.org/pip

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Background and context

▪ Organisations involved

The COLEACP Pesticides Initiative Programme (PIP) that funded this document has an EU action plan to ensure that small/medium-scale growers in African Caribbean and Pacific (ACP) countries can maintain their access to European markets despite new harmonised European pesticide legislation.

This document has been written by crop specialists from the Natural Resources Institute, University of Greenwich, UK, under the PIP service contract entitled: Support service for ACP producer enterprises in revising their technical itineraries to place them in conformity with European regulations.

The Fresh Produce Exporters Association of Kenya (FPEAK) is Kenya's major private organisation that caters for and represents the needs of Kenyan horticultural exporters. FPEAK provides market intelligence, export promotion facilitation, technical support and training services for exporters and their outgrowers.

. The Horticultural Crops Development Authority (HCDA) is a parastatal regulatory body whose aims are to revitalise the horticultural industry by licensing exporters, providing advice to enhance production and marketing of horticultural products.

The two organisations above are important partners in disseminating and promoting information and techniques to enable growers and exporters to maintain and improve the passion fruit export market in Kenya.

▪ Areas covered by the document

At the request of the passion fruit growers and exporters in Kenya, this document is on all aspects of a Technical Itinerary and includes cultural practices and non-chemical pest management technologies. It also incorporates brief sections on broader production and post harvest issues such as nutrition, irrigation, produce handling and production ethics. During the development of this document, productive discussions with stakeholders produced various suggestions relating to passion fruit production in Kenya. These are mentioned in the relevant place in the text and also summarised in Appendix 1.

The overall aim of the document is to ensure that passion fruit growers produce a crop of the highest quality in compliance with European pesticide legislation. The main informational themes of the document are as follows:

- the main elements of passion fruit production;
- the major pests and diseases of passion fruit;
- effective pesticides for the major pests and diseases of passion fruit and their status with regard to European and Kenyan legislation;
- alternative pest management options which might reduce or replace the use of pesticides in integrated pest management (IPM) systems.

In addition it will:

- identify the pesticides essential for continued production for which there is currently no EU MRL;
- provide a source for spin-off information materials suitable for small-scale growers, extensionists, and trainers such as posters, advice sheets and booklets in appropriate languages.

Smallholder challenges

Several difficult challenges face passion fruit growers in Kenya - particularly small scale ones - with two of the most critical being how to ensure quality and traceability.

ENSURING QUALITY

Growers and exporters need to ensure that the crop production methods meet the required standards of the marketing industry in Europe throughout the chain from the farm to the point of exportation. The quality requirements might include ripeness, absence of disease and damage, residues below permitted levels. Hazard analysis critical control point (HACCP) is an approach to identify and prevent problems occurring with respect to food safety within the production process. HACCP requires that procedures are set up to prevent or minimise occurrence of problems.

HACCP involves the systematic assessment of all steps involved in a food production operation to identify all microbiological, chemical and physical hazards so that safety and quality can be guaranteed.

It is not possible to describe in detail the HACCP techniques within this document. There are 12 stages; the planning stages (1-4) and the application stages (5-12). Stages 1 to 4 decide the areas HACCP is to cover, e.g. planting material to packing shed and who is to carry out the assessment and identify parts of crop production that could affect the safety and/or quality of the product. The table below gives a simplified illustration of HACCP applied to two quality aspects of passion fruit production.

TABLE 1. EXAMPLE OF APPLICATION HACCP APPROACH IN PASSION FRUIT PRODUCTION

Stage	Description	Safety issue	Quality issue
Stage 5	Identify all potential hazards at each stage of the production process and detail what controls are in place for each hazard.	e.g., pesticide residues	e.g., some fruit woody (thick skin)
Stage 6	For each hazard identified, determine whether it is a critical control point (CCP) in the safety and quality of the product.	Critical to safety	Critical to quality
Stage 7	Determine the limits for each control point, i.e. what is acceptable.	Residues below MRLs	presence of woody fruit not acceptable in batch
Stage 8	Determine how each CCP is to be monitored to show each is working	Analysis of pesticide residues or verified proof of non-use	Check trees for presence of disease
Stage 9	Determine what the corrective action will be if the limits for each control point are exceeded, i.e. how crop production process is brought back under control and how nonconforming product is dealt with.	Leave longer pre-harvest interval Stop using product Obtain analysis before harvest	Grub out affected trees. Re-plant with certified stock material control insect vectors
Stage 10	Establish a procedure for verifying that the HACCP plan is working	Monitor residue data and rejection rate	Monitor plants in field Monitor rejection rate
Stage 11	Decide what records are to be kept to show HACCP has been applied correctly	Inspection and verification records	Disease log, pack house, woodiness rates and rejection records
Stage 12	Review the plan periodically	Review for each season Review for each supplier	Review for each season Review for each variety Test new varieties for disease resistance

ENSURING TRACEABILITY

A large proportion of the passion fruit crop exported from Kenya is produced on small farms by relatively small scale outgrowers. Pesticides are applied to the crop at several stages to control diseases such as alternaria or pests such as bugs (Hemipteran sucking pests). The products applied have caused historic problems on arrival of passion fruit in Europe due to illegally high residues. The RASFF (Rapid Alert System for Food and Feed) issues were reported in 2005 & 2007 of exceeding MRLs on passion fruits originated from Kenya.

Some of the crop is collected by middlemen or brokers who are intermediaries between the farm and the exporter. Middlemen provide a service to both parties, but there are some problems. Relationships between the producers and the exporters are based largely on supply and demand, rather than formal contractual agreements between the farmer and the exporter.

Quality assurance is not possible with the current modus operandi. Linkages between the different stakeholders are ad hoc, informal and undocumented. Moreover, no systems are in place to ensure that information feeds back from the packer/exporter to the farmer and vice versa. As a result, traceability of smallholder passion fruits is currently inadequate. This will become an increasingly important issue as market demands increase for accreditation (as has happened with other horticultural produce).

One of the first steps to improving the continuity and audit trail between farmers, middlemen and exporters, is to identify all the farms that supply the market. Mapping these farms, and giving a unique identifier to each farm would enable the produce source to be recorded accurately. There will also need to be other processes to formalise the linkages in the supply chain and facilitate an audit capability, such as improved labelling standards and production records. Grower training is needed to inform the growers on the strict residue criteria and the need to control the products applied to the crop, the dose rates of the products and the pre-harvest intervals.

Middlemen, who are the link between growers and exporters need to provide a two-way informational flow. They need to inform their source farmers about pesticides, to keep a note of the source of the crop for the exporter, and maintain good relations between the buyers in town and their farmer group. Unless the supply of passion fruit is managed in a more controlled way, the market access from Kenya will be threatened by further incidents of residues being found when they reach Europe. (see RASFF information on the PIP web site given in the References)

Production of passion fruit in Kenya

Passion fruit is widely grown and valued throughout the tropics and subtropics. The different varieties have fruit which ranges in colour from purple to yellow-orange, and in size and shape from an egg to a tennis ball. Inside its thick protective rind are numerous small seeds covered by a juicy aromatic, sweet-acidic pulp. The sweeter species, which are eaten as fresh fruit, are the type exported for the fresh market. The seeds are consumed with the pulp. The fruit is also made into juice and often blended with other juices such as orange. For this reason all fruit produced is saleable in one of these forms, making it a relatively profitable crop to grow if given sufficient management time. Kenya is one of the leading producers of passion fruit in Africa. Other large producers world-wide include Hawaii, Brazil, Australia, Columbia, Zimbabwe and South Africa. Kenya exports around 1000 tonnes of passion fruit per year. The local market is also important but figures on production are difficult to find.

The establishment and expansion of the passion fruit crop has been hindered by various problems, the major one being disease attack.

Botany and Taxonomy

The passion fruit whose botanical name is *Passiflora edulis* is from the family *Passifloraceae* and is native from Southern Brazil through Paraguay to Northern Argentina. Closely related species include fragrant granadilla *(P. Alata*), Red granadilla *(P. Coccinea)*, and Giant granadilla *(P.quadrangularis)*. More than 55 species of Passiflora are grown for their edible fruit but of these only two are cultivated widely: the passion fruit, *(P. edulis)* and the giant granadilla *(P.quadrangularis)*. The passion fruit plant is a subtropical, shallow rooted, woody, perennial vine that climbs by tendrils. Generally the plant prefers a frost-free climate, although there are cultivars that are more tolerant than others to cooler climates, these varieties may lose some of their leaves during winter, but the roots will often re-sprout even if the top is killed.

The vine is a vigorous climber that clings by tendrils to almost any support. It can grow 15-20ft per year once established but is short lived with an average life span of 5-7 years. The leaves are evergreen, 3-lobed and finely toothed. They are 3-8 inches long, and a deep glossy green. Some varieties have leaves tinged with red or purple. The flowers are single and fragrant, 2-3 inches wide and borne at a node on the new growth. The bloom has white petals and sepals with a corona of white tipped rays that are a rich purple at the base. It also has five stamens with large anthers.

Climatic range

The purple passion fruit is subtropical, whereas the yellow passion fruit is tropical or sub-tropical and is less tolerant of frost. The optimum temperature for production is between 20 and 30 degrees centigrade. The vine will tolerate temperatures down to 6 degrees but growth, pollination and flowering are poor, while temperatures above 30-32 degrees promotes growth at the expense of flowers and fruit and can cause flower drop. One of the greatest causes of reject fruit is rub marks caused by wind damage and poor training on the trellises, therefore choice of a sheltered site or the use of windbreaks will benefit the quality of the fruit produced.

Soil and site requirements

Passion fruit vines are grown on many soil types but light to heavy sandy loams, of medium texture and at least 600mm deep are most suitable and pH should optimally be from 5.5 to 6.5. If the soil is too acidic, lime must be applied. Good drainage and aeration are essential to minimise the incidence of collar rot and vines should always be planted on a ridge. The soil must be free of herbicide contamination since passion fruit is very susceptible.

It is not advisable to re-plant on recently grubbed passion fruit land nor downwind of existing passion fruit crops due to the risk of disease transmission.

Land preparation should take place some months before transplanting and the passion fruit's shallow but extensive root system benefits from well ploughed land. Organic content of the soils should be as high as possible.

Passion Fruit Types

There are two main forms of the passion fruit, the purple and the yellow varieties, with the yellow being distinguished as *P. edulis f.flavicarpa*. Hybrids can be made between purple and yellow passion fruit, which yields intermediates between the two forms.

Principal characteristics of the yellow type:

- Yellow rind and larger fruit.
- More acid flavour.
- Flowers are self-sterile - wind is ineffective because of the heaviness and stickiness of the pollen. They must be pollinated, and carpenter bees are the most efficient pollinators.
- More vigorous vine.
- Less tolerant to frost.
- Resistant to nematodes and Fusarium wilt.
- Brown seeds.

Principal characteristics of the purple type:

- Purple rind and smaller fruit.
- Sweet less acidic pulp richer in aroma and flavour and has a higher proportion of juice (35-38%).
- Can self pollinate but pollination is best under humid conditions.
- Less vigorous vine.
- If crossing yellow and purple types, it is necessary to use the purple parent as the seed parent because the flowers of the yellow are not receptive to the pollen of the purple, and an early blooming yellow must be utilised in order to have a sufficient overlapping period for pollen transfer. These crosses have some ability to withstand 'woodiness' virus.
- Black seeds.

Varieties

Within these broad types, there are several varieties of passion fruit in commercial production and a selection of them is given in Table 2.

TABLE 2. NAMES AND CHARACTERISTICS OF SOME COMMERCIAL PASSION FRUIT VARIETIES

Variety Name	Origin and Characteristics
Australian purple or Nelly Kelly	Mild sweet flavour
Common purple	Naturalised Hawaiian variety. Thick skinned with small cavity
Kapoho selection	A cross of yellow Hawaiian strains. A heavy bearer but subject to brown rot.
Black Knight	Purple cultivar
Bountiful Beauty	Purple cultivar
Sevcik selection	Golden form of the yellow, a heavy bearer but subject to brown rot.
University Round Selection	Hawaiian cross - small fruit and not attractive but high juice yield.
Nelly Kelly	Australian purple cultivar
Waimanalo selection	Consists of four strains, C-54, C-77, C-80 of similar size, shape and colour and C-39 as a pollinator
Nancy Garrison	Purple cultivar
Yee selection	Yellow, round, attractive and highly disease resistant
Ester	Very large purple fruit - variety imported as large passion fruit.
Purple Giant	Purple cultivar
Kahuna	Very large fruit of middle purple colour perfect for juice and produced during long seasons.

The popularity of varieties differs between each country of origin and production, and production of hybrids that are longer season, higher yielding or more vigorous is an important breeding aim.

▪ Propagation

Plants can be propagated by seed. However, the progeny may be variable because the genetic material is mixed during sexual reproduction. Seed should be rubbed clean of pulp and dried in the shade. Fresh seeds are far easier to germinate than seeds that are older than a month or two. Seeds should not be exposed to strong light until they have germinated and the substrate should be sterile. Older seeds can be soaked for at least one day to improve germination. Fresh seeds will germinate in 1 to 3 weeks; older seed may take months.

An easy method of vegetative propagation and one that will preserve characteristics of the parent is by rooted cuttings. Misting or enclosing in a humid atmosphere (a plastic bag enclosing a pot will do for an occasional rooting) improves the success rate.

Layering too can conveniently increase the planting stock, but it is essential that only disease-free plants are propagated. Diseases such as wilts and viruses will transmit to the new plants if vegetative propagation is used.

Grafting is also used to propagate purple passion fruit on hardier rootstock (yellow passion fruit). Although more expensive it gives the opportunity to graft on to a rootstock that is more resistant to nematodes and some diseases (see appendix 2). For grafting, a long, slanting cut is made across the stem of the top variety (scion material), and a similar cut is made through the stem of the stock. The cut surfaces are then placed together to align the vascular vessels and the graft is tied firmly with tape. The graft is enclosed in a small plastic bag tied shut below the graft, and placed in a warm, shady location for 10-14 days or until the union grows together. Then the bag is loosened to admit air and is removed when scion buds begin to grow. The tape is removed before it can constrict the growing stem.

Vines are fast growing once established and will start bearing fruit within a year, but a full harvest is not possible until 12 or more months after planting.

▪ Transplanting

Seedlings should be around 150 mm in length at transplanting and must be hardened off properly by leaving in an open, shaded area for a day or two. Any abnormal seedlings should be discarded and only strong vigorous seedlings selected. Do not disturb the roots or damage the seedling in any way since this will reduce yield potential and longevity considerably.

The field should be pre-irrigated to capacity then the seedlings should be planted slightly shallower than in the seedling tray since deeper planting will increase the chances of damping off and collar rot. It is common for some of the leaves to turn yellow and drop off after transplanting due to planting shock.

▪ Spacing and training on supports (trellises)

Spacing of plants varies with locality for example in Venezuela the highest yields of yellow passion fruit are obtained when the vines are set 3m apart each way. In South Africa, purple passion fruit vines are set 2.5 metres apart in cool areas and 3.5 - 4.5 m apart in warm areas. In other areas plants are planted 2 m apart in rows 1.2 m apart. In general, closer planting constitutes a more intensive system which has the potential to produce higher yields, but the significant drawback is that the plants are much more likely to suffer diseases due to the higher humidity microclimate which it produces. Wider spacings are more suited to low input smallholder production.

Vines need to grow up supports that are around 2m tall or onto a wire trellis system of the same height with one wire at the top and another at around 1.2 m. Because the crop is heavy, posts need to be stout enough to withstand the weight of the vines throughout a season that normally includes the buffeting of strong winds. On hillsides the rows may be placed on contour lines for convenience, but ideally rows should be oriented north-south for maximum exposure to sunlight. The vines should be allowed to grow together along the trellises to promote crosspollination. These trellises should be prepared well in advance of transplanting.

Young vines are trained by tying a piece of sisal twine from the base of the young plant up to the first wire. The growing shoot is then trained upwards by twisting it around the twine. Once it reaches the wire, a lateral shoots is allowed to grow along the wire in each direction. A 2- wire trellis provides 4 laterals growing along the trellis away from the vine's trunk. Every other bud on these laterals is then allowed to grow down and it is these shoots which bear the fruit. The tips of these shoots should be kept cut back at least 10 cm from the soil to avoid them picking up soil-borne diseases.

▪ Water requirements

Regular watering will keep a vine flowering and fruiting almost continuously. However, careful attention must be paid to watering since over-watering can encourage diseases such as collar rot and underwatering can leave the shallow roots too dry and produce shrivelled fruit. Overhead irrigation is not recommended as this can encourage fungal diseases. If it is the only option, overhead irrigation should be carried out in the morning so that the crop can dry out before nightfall.

Fertilisation

Passion fruit require frequent application of balanced fertiliser during the growing season. Fertiliser should be applied four times per year, at a mixture of 10-2-20 NPK. Supplemental urea and potassium sulphate is said to have a favourable effect on production. Excessive nitrogen causes excessive vegetative growth and premature fruit drop, and passion fruit should always be monitored for deficiencies, particularly in potassium and calcium. Essential micronutrients (magnesium, manganese, copper, zinc and iron) can be applied four times per year as a foliar spray. Chlorotic leaves (yellow between the veins) in the winter may be due to cold soil temperatures rather than nutrient deficiencies.

Pollination

Pollination is essential for fruit production on passion vines. Flowers of the purple passion vine may set fruit when self-pollinated, but fruit set will be better if cross pollination of one plant with pollen from another takes place. The other plant must be genetically different, so two cuttings from the same parent will not cross pollinate.

The most effective insect for pollinating passion fruit are certain wild bees such as carpenter bees which can be encouraged by placing hollow logs in the field near the vines. Honeybees are less effective because of their small size and because they may find other flowers more attractive when passion flowers are present.

Pruning

Since the passion vines are vigorous growers, pruning is necessary to keep the plants to a desirable size, to improve aeration in the canopy, and to remove dead wood. Unwanted side shoots should be pruned and tendrils can be removed to prevent tangling. Vines should be pruned hard once a year after harvesting. All dead and weak wood should be cut out and the vine pruned back to vigorous, well-budded stems so that it can resume healthy, active growth. Disinfect pruning shears between each pruning to avoid spreading disease from vine to vine. A good time to make fertiliser application is after pruning.

Normal lifespan of plantations is 3 years due to diseases and diminishing yields. However, pruning branches after fruiting aids in disease control and vigour maintenance and can extend plantation life to five or six years.

Harvesting and Ripening

In Kenya, after the small first year harvest, the two main harvesting periods are July/August and December/January.

Passion fruits are normally hand harvested from vines two or three times per week before they are fully ripe, when they are a light purple colour, or from the ground once they are ripe, on a daily basis. For juice processing the fruit is allowed to attain a deep purple colour before harvesting

There is a rapid and increase in the fruit size during development, and full size is reached 20 Days After Flowering (DAF). Fruit weight also increases rapidly up to 20 DAF and then more gradually towards maturation. After 90 DAF, fruit are fully ripe and many of them can become detached.

On the vine, fruit juice begins to accumulate after 30 DAF and its colour changes from yellow to orange after about 60 DAF with a specific aroma as the fruit matures. Soluble solids content in the juice increases steadily from 20 DAF towards maturation (15-17%). Acidity reaches a peak at 60 DAF followed by a rapid decrease, meaning that the eating quality of the fruit improves after 60 DAF. Soluble solids content in the juice tends to decrease during post harvest ripening. The skin colour remains green up to 70 DAF on the vine, after which there is a rapid change, reaching a purple colour at 90 DAF. Fruit harvested at and before 70 DAF do not develop colour over more than 75% of the surface, and this is unacceptable to UK customers.

Fruits lose weight in storage and there is a linear relationship between weight loss and increase in storage time. Younger fruit exhibit higher weight loss, probably due to a higher metabolic rate and incomplete and soft rind tissue as well as higher surface area to volume ratio. Purple passion fruit can be harvested at a light purple colour, using tools and careful handling to avoid damage. For distant marketing, harvesting can be slightly

earlier, but they may start to shrivel by the time they are purple. If facilities for ethylene treatment are available to ripen fruit, harvesting can be even earlier when the fruits are still green.

Depending on how intensive the production system is, passion fruit can yield between 5 and 30 tonnes per hectare.

Un-refrigerated fruit will last 2 to 4 weeks, coated with a coating product and refrigerated at 4° to 7° it may be kept for more than a month. Both purple and yellow passion fruits begin to lose moisture as soon as they fall and quickly become quite wrinkled if held under hot, dry conditions. While they are still good to eat, they are unsightly and thus unmarketable. Clean fruit can be stored in polyethylene bags at 10°C (50°F) for as long as 3 weeks without loss.

Pest and disease management

Perhaps the most important diseases of passion fruit in Kenya are brown spot caused by the fungus *Alternaria passiflorae* and the woodiness virus. Passion fruit is subject to attack by a wide host range of insect pests. The purple passion fruit is also subject to fusarium wilt, nematode attack, and crown rot and, therefore, may require replanting every 3 to 4 years.

Many of the agronomic and crop husbandry practices described in earlier sections of this document will contribute to prevention of pests and diseases. Some other cultural, biological and chemical methods of crop protection are outlined below.

- Use of resistant varieties.
- Effective vineyard sanitation.
- Planting on mounds or ridges is recommended for better drainage.
- Pruning and leaf thinning to increase air flow and allow more light to reach the canopy
- Application of fungicides.
- Management of temperature and relative humidity during postharvest handling.

Figure 1. Some arthropods are beneficial because they kill pests

All crops have a complex ecology in which many potential pest species are kept in check by the range of natural enemies such as pest-eating beneficial insects, predatory mites and spiders. The naturally-occurring organisms often play a useful role for growers, and reduce the need for sprays. Low levels of pests cause little economic loss, so are tolerated as food for the beneficials. Some non-crop plants encourage these beneficial organisms, for example flowering plants provide nectar for adult predators and parasitoids and hedging plants provide shelter and breeding sites. A well managed orchard may require minimal pesticides. Indeed because some pesticides are particularly disruptive to this biodiverse balance and can cause resurgence of species, their use can create a new pest problem.

Scouting the crop

Management of any crop requires regular inspections to assess how well the crop is doing and whether there are any pest and disease problems. The examination (sometimes called scouting or walking the crop) must be systematic to make sure that a representative sample number of trees is looked at, rather than for example, the ones in a single row or around the field edges.

The main pests in Kenya are held in check when there are sufficient predators, so even when the farmer observes that the pests are present it may be better not to spray with an insecticide that will kill the beneficial insects. Unfortunately scouting rarely reveals the true number of natural enemies (the helpful insects) because they hide or come out only at night, or because they simply fly away when the leaves are disturbed.

Unless the crop has been heavily sprayed, they are usually present, so if there are not too many scales and mites, they can be tolerated, provided the tree is vigorous. Spraying might actually induce a worse pest problem. It is therefore better to make an assessment of the changes in the level of pests between scouting sessions, rather than the overall level of the pests at any one time. Only if the level of pests has risen significantly between scouting operations, and natural enemy numbers are not increasing, should spraying be considered.

The procedure for scouting is as follows. With a small number of vines, they can all be examined. For bigger plantings, select vines to be examined on the basis of chance. Select the row and vine number before entering the field, preferably using random numbers from a table. Examine at least 20 vines per hectare each week. Pest and disease incidence need to be followed over the season. It is useful to have a form or table to record the level of pests. The results can be put into a computer so that the infestation/infection levels can be plotted, or hand drawn onto a graph, so that decisions about interventions (spraying, or introducing natural enemies) can be made based on the trends.

▪ Crop protection interventions

Even if intervention is required for pests, it may be possible to supplement the natural biological pest control that operates in the crop by purchasing natural enemies from a commercial company and releasing them in the crop.

If this is not possible against the pests, or if diseases are infecting the crop, spraying with pesticides may be the only solution.

Pesticides and MRLs

▪ Pesticide harmonisation

There has been a high degree of collective discussion among growers and exporters in Kenya, during the lead-in period to the harmonisation of EU pesticide legislation. Some companies are in a higher state of preparedness than others.

If developments of the EU pesticides regulation are closely monitored and some necessary adaptations are made to technical itineraries, there is no reason why market access for any of the companies should be reduced. Part of this process of adaptation is to obtain MRLs for crucial pesticides.

The current list of pesticides used by passion fruit growers include many active ingredients whose existing MRLs in Europe are set at the limit of determination (LOD). Exporters must ensure absolutely that residues are below the existing MRL when the produce reaches the market place. Tables 3 and 4 summarise the current pesticide position.

It is likely that there will be further restrictions brought about by market and/or consumer demands. In the longer term it is possible that the market will not accept produce that has been treated with any pesticide not approved within the EU, even if they are legal and legitimate in the ACP country, and regardless of residue levels. Some supermarkets already have a list of products that are unacceptable for use during production.

▪ Choosing pesticides for use on passion fruit

There are several important questions to be asked during selection of a passion fruit pesticide for use in Kenya:

1. Is it effective?
2. Is it registered on passion fruit or other produce in Kenya?
3. What is its approval status in Europe
4. What is the EU MRL?
5. Does the European buyer ban its use during production?

Effective products can be identified by various means - recommendations by manufacturers, national and international research institutions, growers' organisations, other growers etc.

Registration status can be determined by consulting the national regulatory authority or checking whether the pesticide label advises use on passion fruit.

Note on the status of active substances in EU

Before a Plant Protection Product can be marketed in EU, its active substance must be approved by the European Commission. Directive 91/414/EEC provides a comprehensive list (Annex I) of active substances that can be incorporated in plant protection products. This Directive and its amendments are available on: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991L0414:EN:NOT

The status of active substances can be checked on the following web site: http://ec.europa.eu/sanco_pesticides/public/index.cfm.

Regulation (EC) No 1107/2009 concerning the placing on the market of plant protection products replaces Directive 91/414/EEC from June 14, 2011. http://europa.eu/legislation_summaries/food_safety/plant_health_checks/sa0016_en.htm

It should be noted that if an active substance is not registered in the EU it can still be used in the ACP countries in food items exported to Europe, provided the residue complies with the EU MRL.

Note on MRLs:

The quantities of pesticide residues found in food must be safe for consumers and remain as low as possible.

The maximum residue limit (MRL) is the maximum concentration of pesticide residue legally permitted in or on food or feed.

MRLs in the EU

Pursuant to Regulation (EC) No 396/2005 harmonized Community MRLs have been established.

The European Commission (EC) sets MRLs applying to foodstuffs marketed in the territories of the EU countries, either produced in the EU or in third countries.

Annex I to the Regulation contains the list of crops (Regulation (EC) 178/2006) on which MRLs are assigned, Annexes II and III contain the MRLs: temporary MRLs can be found in Annex III, final MRLs in Annex II. Substances for which an MRL is not required are listed in Annex IV (Regulation (EC) 149/2008). When there is no specific MRL for a substance / crop a default MRL, usually set at 0.01 mg/kg, is applied.

When establishing an MRL, the EU takes into account the Codex MRL if it is set for the same agricultural practices and it passes the dietary risk assessment. Where appropriate Codex MRLs exist, the import tolerance will be set at this level.

EU harmonized MRLs came into force on 1 September 2008 and are published in the MRL database on the website of the Commission http://ec.europa.eu/sanco_pesticides/public/index.cfm

See also the leaflet "New pesticide residues in food" http://ec.europa.eu/food/plant/protection/pesticides/explanation_pesticide_residues.pdf

How are MRLs applied and monitored in EU?

- Operators, traders and importers are responsible for food safety, and therefore for compliance with MRLs.
- The Member State authorities are responsible for monitoring and enforcement of MRLs.
- To ensure the effective and uniform application of these limits, the Commission has established a multiannual Community monitoring program, defining for each Member State the main combinations of crops and pesticides to be monitored and the minimum number of samples to be taken.

Member States must report results to the Commission, which published an annual report. At present the reports are published by the European Food Safety Authority (EFSA) http://www.efsa.europa.eu/en/scdocs.htm

- In case of detection of pesticide residue levels posing a risk to consumers, information is transmitted through the Rapid Alert System for Food and Feed (RASFF) and appropriate measures are taken to protect the consumer. The database is accessible on http://ec.europa.eu/food/food/rapidalert/rasff_portal_database_en.htm and RASFF publishes an annual report http://ec.europa.eu/food/food/rapidalert/index_en.htm.
- PIP monthly updates on its website a summary of RASFF notification for fruit and vegetable imports from ACP countries.

MRLs in ACP countries – Codex

The Codex Alimentarius Commission was established in 1961 by the Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) with the objective to develop an international food code and food standards. Membership of the Codex Alimentarius Commission is open to all Member Nations and Associate Members of FAO and WHO. More than 180 countries and the European Community are members of the Codex Alimentarius Commission.

The Joint FAO/WHO Meetings on Pesticide Residues (JMPR) is not officially part of the Codex Alimentarius Commission structure, but provide independent scientific expert advice to the Commission and its specialist Committee on Pesticide Residues for the establishment of Codex Maximum Residue Limits, Codex MRLs for pesticides which are recognized by most of the member countries and widely used, especially by countries that have no own system for evaluating and setting MRLs.

The Codex MRL database can be found on the web site: http://www.codexalimentarius.net/pestres/data/index.html?lang=en.

Tables 3 and 4 below present the main pest and diseases of passion fruit, together with the pesticide options available, their EU status, MRLs in Europe, registrations in Kenya and their GAP tested by PIP. It is based on various sources including:

- **A pesticide protocol produced at a meeting organised by FPEAK producers and exporters, who are attempting to develop a common industry-led approach to pest management practices.**
- **A collation of individual company practices gathered together by the Crop Specialists.**
- **Information from pesticides companies.**
- **List of registered pest control products for use in Kenya - April 2010.**
- **Data from the websites listed above.**

Notes on the tables:

- *Inclusion in these tables does not constitute an endorsement of their efficacy, safety or legality in the country of use. Before the use of any plant protection product, consult the label for the crops on which it can be used. Also check with the importer that they (or their clients) permit the use of each specific product during production.*
- *Registration in Kenya - Very few products are registered specifically on passion fruit, products registered for fruit, fruit trees, various crops and horticultural crops are also considered by PCPB to be legally useable on passion fruit. Other pesticides are registered for use on these crops but are not in the tables as no relevant for passion fruit.*
- *EC Status explanations:*
  Annex 1 means inclusion in the positive list of the EC Directive 91/414
  Annex 1 [2] To see which fatty acid is in Annex 1 check on http://scc-gmbh.de/SCC/Annex-I/
  Withdrawn means not included in Annex 1
  Withdrawn [1] means not included in Annex 1 for the time being and the EU Member States have the possibility to maintain authorisations until 31 December 2011
  Resubmitted means after non-inclusion the dossier was resubmitted and evaluation is ongoing.
  Pending means evaluation of this new a.s. is ongoing.

Table 3. Main insecticides and miticides for use on passion fruit

Active substance	EU Status	EU MRL	Codex MRL *	ACP Registrations **	Pests							GAP tested in PIP trials			PHI (days) ***	
					Thrips	Mealy bugs	Spider mites	Aphids	Fruit fly	Fruit suckers	Leaf miner	Dose (g a.s./ha)	Number of applications	Interval between applications (days)	EU MRL	LOQ
Amitraz	Withdrawn	0.05	0.05	Kenya [3]			x					/	/	/	/	/
Acephate	Withdrawn	0.02	0.02		x			x		x		750	3	14	****	****
Acetamiprid	Annex 1	0.01	/		x	x		x		x	x	75	2	14	28 [4]	28 [4]
Azadirachtin	Withdrawn [1]	0.01	/	Kenya [1]	x				x	x		/	/	/	/	/
Buprofezine	Annex 1	0.05	0.05	**Kenya [p]**		x						400	3	14	35 [4]	35 [4]
Chlorpyriphos-ethyl	Annex 1	0.05	0.05	Kenya [1]		x						/	/	/	/	/
Cypermethrin	Annex 1	0.05	0.05	Kenya [1]						x	x	/	/	/	/	/
Dimethoate	Annex 1	0.02	0.02	Kenya [3]	x			x	x	x		300	3	14	28 [4]	28 [4]
Fatty acids	Annex 1 [2]	Not required	/	Kenya [2]			x					/	/	/	/	/
Garlic extract	Annex 1	0.05	0.05				x					50	1	/	21	21
Fenpyroximate	Annex 1	0.02	0.02	Kenya [1]						x		20	3	7	3	3
Lambda-cyhalothrin	Annex 1	0.02	0.02	Kenya [1]	x	x		x	x	x		1250	3	7	****	****
Malathion	Annex 1	0.02	0.02	Kenya [1]	x			x		x		/	/	/	/	/
Methomyl	Annex 1	0.01	/			x					x	/	/	/	/	/
Mineral and white oil	Annex 1	1	0.05	Kenya [3]								/	/	/	/	/
Pirimicarb	Annex 1	1	0.05	Kenya [1]	x			x		x		75	3	7	1	1
Pyrethrins (+ garlic)	Annex 1	0.5	0.05		x						x	96	3	7	1	28 [4]
Spinosad	Annex 1	Not required	/	Kenya [3]			x					3200	3	7	/	/
Sulphur	Annex 1	Not required	/					x				/	/	/	/	/
Tetradifon	Withdrawn	0.02	/	Kenya [3]			x					/	/	/	/	/
Thiamethoxam	Annex 1	0.05	/		x	x		x		x		100	3	14	28 [4]	28 [4]
Thiocyclam hydrogen	Withdrawn	0.01	/	Kenya [1]	x			x		x	x	250	3	14	7	7

* There is no Codex MRL fixed for any of the active substances on passion fruit so LOQ should be used, if the a.s. can be found in the Codex list; "/" means no data in the Codex data base.

** Registrations: p = on passion fruit; 1 = on horticultural crops; 2 = on fruit trees; 3 = on fruits

*** PHI validated by PIP trials

**** Apply only when there are no fruits on the plants

4 At the highest PHI tested residues didn't comply with LOQ, but assuming that degradation is continuous, residues should comply at given PHI

/ not available or not applicable

Table 4. Main fungicides for use on passion fruit

Active substance	EU Status	EU MRL	Codex MRL *	ACP Registrations **	Diseases			GAP tested in PIP trials			PHI (days)***	
					Alternaria	Powdery mildew	Septoria	Dose (g a.s./ha)	Number of applications	Interval between applications (days)	EU MRL	LOQ
Azoxystrobin	Annex 1	4	0.05		x		x	187.5	3	14	1	42 [4]
Bupirimate	Withdrawn	0.05	/	Kenya [3]		x		/	/	/	/	/
Captan	Annex 1	0.02	0.02		x			1600	3	10	****	****
Copper	Annex 1	20	/		x		x	1842	3	10	1	> 7 [5]
Chlorothalonil	Annex 1	0.01	0.01		x		x	1584	3	10	****	****
Mancozeb	Annex 1	0.05	0.05	Kenya [1]	x		x	2000	3	10	****	****
Metalaxyl-M	Annex 1	0.05	0.05	Kenya				/	/	/	/	/
Thiophanate-methyl	Annex 1	0.1	/		x		x	500	3	14	35 [4]	>35 [5]

* There is no Codex MRL fixed for any of the active substances on passion fruit so LOQ should be used, if the a.s. can be found in the Codex list; "/" means no data in the Codex data base.
** Registrations: 1 = on horticultural crops; 2 = various crops; 3 = on fruits
*** PHI validated by PIP trials
**** Apply only when there are no fruits on the plants
4 At the highest PHI tested the residues didn't comply with LOQ, but assuming that degradation is continuous, residues should comply at given PHI.
5 Residues at LOQ level can be expected above the given PHI, when degradation is continuous.
/ not available or not applicable

Sources of GAP validated by PIP trials (boxes highlighted in yellow in previous pages)

Active substance	Commercial product	Manufacturer	Source	
			Year	Country
Acephate	Orthene 97 Pellets	Arysta LifeScience	2005/6	Kenya
Acetamiprid	Mospilan 200 SP	Arysta LifeScience /Nisso	2005/6	Kenya
Azoxystrobin	Ortiva SC	Syngenta	2005/6	Kenya
Buprofezine	Applaud 40 SC	Nihon Nohyaku	2005/6	Kenya
Captan	Captan 80 WP	Arysta LifeScience	2005/6	Kenya
Copper	Daconil 720 SC	Syngenta	2007	Kenya
Chorothalonil	Kocide DF	DuPont	2005/6	Kenya
Dimethoate	Twigathoate 40 EC	Twiga	2005/6	Kenya
Fenpyroximate	Ortus	Nihon Nohyaku	2005/6	Kenya
Lambda-cyhalothrin	Karate Zeon	Syngenta	2005/6	Kenya
Malathion	Fyfanon 50 EC	Anset International	2005/6	Kenya
Mancozeb	Dithane M 45	Dow AgroSciences	2007	
Pyrethrins (+ garlic)	Pyegar EC	JH Biotech	2005/6	Kenya
Spinosad	Tracer 480 EC	Dow AgroSciences	2005/6	Kenya
Sulphur	Kumulus DF	BASF	2005/6	Kenya
Thiamethoxam	Actara 25 WG	Syngenta	2005/6	Kenya
Thiocyclam	Evisect 50 SP	Arysta LifeScience	2005/6	Kenya
Thiophanate-methyl	Topsin M 50 SC	Nisso	2005/6	Kenya

Note : GAPs indicated in previous pages are those corresponding to the PPPs listed above. User of this information should check if the product used is equivalent (same concentration and same type of formulation) to the reference product. If it is not the case, the indicated GAP could not be adequate.

Applying pesticides

Pesticide use can and should be kept to a minimum. However, use of pesticides may be the only way to prevent severe loss of yield or marketability. Even when pesticides are necessary, growers can take several steps to ensure that they are as safe and selective as possible:

- Apply only when necessary. Even if the decision has been made to spray pesticides, the applications should be made as few times as possible, always on the basis of scouting. This will at least give a chance for natural enemy numbers to recover between sprays.
- Choose selective products. Biocontrol products such as Bacillus thuringiensis are highly selective, and there are a few selective synthetic insecticides.
- Calibrate properly and apply reduced volumes of insecticides and fungicides. Smaller nozzles will apply lower volumes and produce finer spray, which will penetrate the foliage better and be retained better. The smaller droplets will also reduce the level of run-off to the soil where the pesticide can affect soil-living natural enemies.
- Target the pest. For example, there are lance modifications which allow the nozzle to be swiveled into an upward-pointing direction. This improves underleaf spray cover and control of pests and diseases which occur there.
- Localise the application. Spot spraying and stratified spraying are methods of spraying only part of a vine or certain vines in the field. This allows natural enemies to survive in the unsprayed areas and to re-enter the sprayed areas when pesticide levels have diminished.
- Time the application carefully. Spraying should be carried out at a time when pests are likely to receive a dose, but natural enemies are not. This will require a sound knowledge of the types and activities of pests and natural enemies in the crop. It may be possible to identify times when natural enemies are less likely to be contaminated by pesticide, for example, spraying in the cool of the morning or early evening is less likely to affect parasitoid wasps which tend to be most active during the warmer parts of the day. However, spraying too early in the morning or too late at night is likely to affect ladybird and hover fly larvae which tend to be most active at night.

Special orchard sprayers are available for large producers with wide enough row spacings, but the high spray volumes they use require a large and heavy spray tank that may damage the roots of the crop. With narrower rows, hose spray systems connected to a tractor-mounted sprayer are sometimes used. These sprayers are crude, inefficient and pose a contamination risk to the operators who handle the hose. Motorised knapsack mistblowers are better, but they are expensive. Less costly lever operated knapsack sprayers may also be used but treating the large crop area is hard work. In all cases, good personal protective equipment is necessary to protect the operator from skin contact with the spray liquid. Respiratory Protective Equipment (RPE) is also required to prevent inhalation of the spray in the confines of the inter-row spaces.

Calibrating spray equipment

Calibration is the process of setting up the spraying to ensure that the correct dose of pesticide is applied to the pests or vegetation. Unfortunately calibration is something that is not always understood, and so it may be neglected. Incorrect doses of pesticide are often applied. Too little may not do the job, and too much will be wasteful and increase the risk of residues in the produce. To get the correct volume of spray and mass of active substance on a given area the machinery needs to be set up, calibrated and operated properly.

Residues

Residues should be kept low for all produce being consumed by people. They are a particularly important issue for growers and exporters who supply the European market. There are very strict criteria and legislation on the acceptable level of pesticide residue on the crop. Importers and retailers make their own checks and all European Member States are required by law to make checks on the quantity of pesticides (mg/kg) on fresh produce.

Whether or not unacceptable residues are caused in produce will depend on several factors. Some of these are inherent to the pesticide such as its persistence after application i.e. how slowly processes such as microbial breakdown, ultraviolet degradation, oxidation, evaporation or washing off remove it. Others are external factors such as the weather after spraying or plant-related factors such as the leaf area of the target crop and how much it increases in the days after application (growth dilution). Several factors are directly related to agronomic choices and practices such as whether approved pesticides are chosen, whether pre-harvest intervals are respected and whether produce is contaminated by drift from other crops or by processing and packing activities after harvest. However, several critical factors influencing residues in produce and the environment

relate to the way in which they are applied. Specifically they will be strongly influenced by the dose of active substance, the volume of spray liquid in which it is delivered, the number of applications, and the droplet size. For example, if the grower thinks he is applying 1000 litres per hectare, but the sprayer operator inadvertently applies 1500 litres, there is an overdose of 50%. In this case, residues are likely to exceed the maximum residue level (MRL) for a greater period than the normal pre-harvest interval. The spray technique too is critical since poor operator performance can lead to non-uniform deposition with areas of heavy over and under-dosing. Sprayer type, quality and state of maintenance also have strong influences, whether the sprayers in question be portable, tractor-mounted or aircraftmounted. These factors are summarised in Figure 2

Records of pesticide usage

Some pesticides are registered nationally for a particular crop, whereas others cannot be legally used on the crop. If a product is registered for a crop, applied properly, and the correct pre-harvest interval is observed, there should be no problems. Some growers may use products that are not registered, either by mistake, or deliberately. This is unwise because their export produce may be rejected. More seriously, the crops from other regions might be in the same batch and thus also rejected. The reputation of the company or the country as a whole is fragile, and market access could be reduced in severe cases. So the supply chain makes strenuous efforts to ensure that these problems do not arise. One system to help reduce the likelihood that an inappropriate product is being applied is to keep strict and careful records of all the pesticides applied to a crop. That is the product, the active substance, the volume rate, the dose and the date when spraying is carried out. Some retail outlets make spot checks and ask to see the crop protection records. It is also a requirement under schemes such as GLOBAL GAP that these records be maintained diligently.

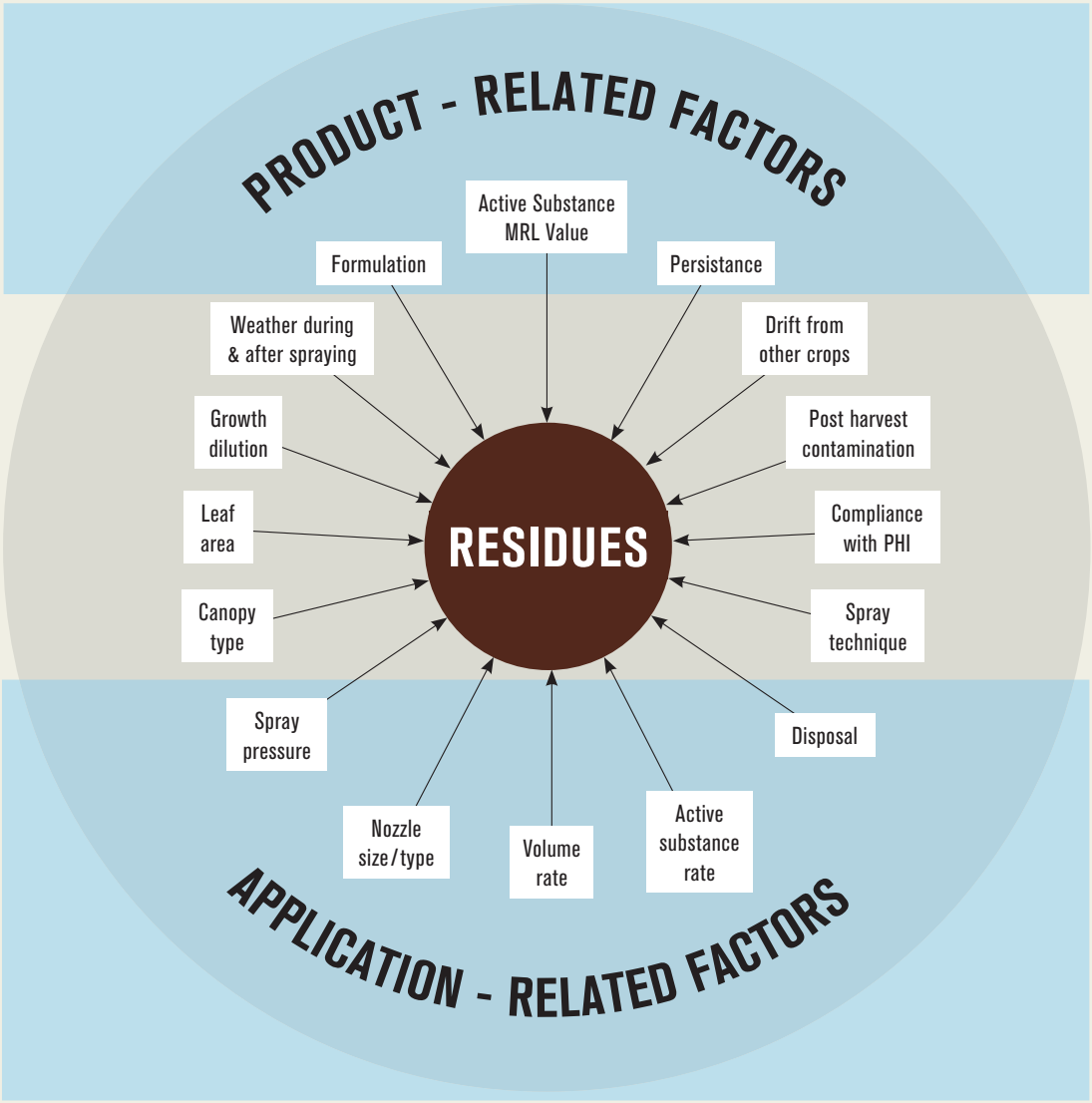

Figure 2. Some factors affecting residues in produce

Safety and protective clothing

It is important that pesticides are used safely and in a way that is not hazardous to the users, the consumers of the produce, livestock or the environment. The most important points are outlined below:

- Choose a product appropriate for the pest or disease to be controlled.
- Choose a product that is as safe as possible to humans (as well as being least harmful to natural enemies and the environment).
- Read and follow the safety and application instructions on the pesticide label and calibrate carefully.
- Wear suitable clothing. If special protective clothing is not available, wear shoes, long trousers and a long-sleeved shirt or jacket then take off and wash the clothes after completing the spraying.
- Rubber gloves (preferably nitrile rubber) must be worn when handling concentrated pesticide. Take particular care as splashes of the concentrated product can be dangerous - eye protection such as goggles or a visor is essential. Even sunglasses can reduce the risk of pesticide splashing into the eyes.
- Wash gloves with hands still in them, then the bare hands after mixing spray, to remove any pesticide concentrate.
- Half fill the sprayer with water before putting the concentrated pesticide in. Then put in the rest of the water, replace the lid and shake the tank. This will ensure that the pesticide is properly mixed with the water.
- Wash off any splashes that fall onto you with soap and water.
- Start spraying at the downwind edge of the crop and move across the wind direction, spraying on the downwind side of your body so that you are not walking through vegetation wetted with spray.
- Do not spray into wind otherwise the spray may be blown back onto you.

Storage of pesticides

A dedicated store or storage box is needed which is secure and lockable (diagram). It is not acceptable to keep pesticides in the house. See Figures 3, 4 and 5.

Figure 3 & 4: Large store for pesticides - internal and external vue.

Figure 5. Small scale lockable pesticide store outside the house

Weeds

Generally hand-weeding is recommended due to the susceptibility of passion fruits to herbicides and to root damage from mechanical weed control.

Post-harvest biology and technology

The amount of yellow or purple colour on the fruit surface is used as a maturity index for fresh market passion fruits. Soluble solids content ranges between 14 and 18% and acidity ranges from 3 to 5% in the pulp. Moisture loss during ripening may be large enough to cause shrivelling of passion fruits but this does not influence the edible portion. Under ripe green passion fruits can be ripened and stored at 20˚C with relative humidity of 85-90%. Ripening is too rapid at 30˚C.

Optimum storage temperatures for purple passion fruits are 7-10˚C for partially ripe fruits (potential storage life 3-5 weeks) and 5-7˚C for fully ripe fruits (potential storage life 1 week). Optimum relative humidity is 90-95%.

Passion fruits are the highest ethylene producers among all fruits with a production range of 160-370 g/kg/hr at 20˚C. This means that passion fruits should not be stored with other fruit that are ethylene sensitive climacteric fruits such as apples, citrus and avocado, because the large amount of ethylene produced by the passion fruits will affect the ripening behaviour of these fruits. Passion fruits could easily be stored with pineapples, which are not sensitive to ethylene, if optimal temperature and relative humidities are similar.

Exposure of green passion fruits to 100ppm ethylene for 1-2 days accelerates their ripening. Once ripening begins exogenous ethylene treatment is unnecessary because of the fruits own high rate of production. Little information is published on responses to controlled atmospheres, but passion fruits may benefit from packaging in perforated plastic films due to reduction in water loss in handling.

Chilling injury can occur on passion fruits kept at 5˚C or lower and include surface and internal discolouration, pitting, water soaked areas, uneven ripening or failure to ripen, off flavour development, and increased decay incidence (www.ucdavis.produce.ac., 2001).

There are three main pathological disorders that can affect stored passion fruit and these are brown spot, caused by *Altenaria passiflorae*, which appears as circular, sunken, light brown spots on ripening fruits. This disease is most severe during warm, wet periods. Phytophthora fruit rot, caused by *Phytophthora nicotianae var. parasitica* appears as water soaked, dark green patches which dry up, and Septoria spot, caused by *Septoria passiflorae* which infects fruits while still on the plant and results in uneven ripening.

Crinkling of the skin results when the fruit lose water by evaporation and transpiration. Although this does not affect the eating quality the appearance puts off consumers. Crinkling can be reduced by postharvest coating or by maintaining high humidity, for example by wrapping fruits in plastic.

Future prospects and perspectives

Like most other exotic commodities, there is enormous potential for growth in the fresh consumption market for passion fruit, which could lead to a significantly higher volume of exports. Further increases in knowledge about husbandry and post-harvest issues should serve to improve quality by refining harvesting time and indices. Breeding programmes aimed at improving pest and disease resistance, whilst maintaining desirable characteristics should be achievable.

The potential of the crop could be further increased if current investigation into the pharmaceutical properties of passion fruits may reveals other uses for the fruit.

There is interest in Europe in the larger-fruited types which are as big as a grapefruit. These are currently being bred and tested in trials in South Africa.

Wider issues

Hygiene

All people involved in production and handling need to be aware of the need to take great care with quality and hygiene requirements for handling of fresh produce.

Premises should be clear of litter and waste, and have adequate provision for waste disposal. All permanent packing and storage sites must have effective pest (including rodent) control measures and these control measures must be recorded. Suitable procedures must be in place to avoid foreign bodies e.g. knives or plasters, being found subsequently within the final packaging. Reusable plastic crates should be cleaned where necessary to ensure they are free from foreign material. All light bulbs, tubes, windows and any other glass or hard plastics, in storage, grading and washing areas must be protected to prevent the contamination of product by broken glass or shards of plastic. Staff must be provided with adequate toilet facilities at all permanent sites and in the vicinity of fieldwork.

Water

The source of water used for final product washing must be to national drinking water standards and recycled water must be filtered. A risk assessment for the source of water for post-harvest washing should be carried out. Based on this, water analysis should be undertaken by a suitably accredited laboratory.

Wastage

Measures taken to reduce wastage and, whenever possible recycle to avoid using of landfill or burning. Organic crop debris may be composted on the farm and reused for soil conditioning. There should be an energy policy which aims at efficiency and minimising use of non renewable energy.

Child and forced labour

Work that is likely to jeopardise the health, physical or mental development shall not be carried out by persons under 18 years of age. Work shall not restrict educational opportunities No children (persons under 16 years of age) shall be employed for any duty or task whether gainfully or otherwise in the work place. Exceptions may be made in smallholder operations where young family members help out on the farm. No farm shall make use of forced labour nor force any one to work against his/her will. Workers shall not be required to deposit their identification papers with their employers.

Health and Safety

Workers committee shall meet at regular intervals, at least twice/p.a., at which staff welfare, health, safety matters can be monitored and discussed, freely and openly. Proceeding must be recorded.

Housing

Every employer shall at all times at his own expense, provide reasonable housing accommodation with adequate clean water, washing and toilet facilities for each of his employees within easy access of the housing or shall pay to the employee such sufficient sum as housing allowance in addition to wages or salary as will enable the employee to obtain reasonable accommodation. Where the employer provides housing, a development and management plan shall be in place.

Health & Safety Risk Prevention

In Kenya the employer shall register his workplace with the Directorate of Occupational Health and Safety Services (DOHSS), Ministry of Labour. There shall be a health and safety committee made up of a Senior Manager, Medical Officer or Safety Advisor, Production Manager, Supervisor and Workers/Union Representative, Committee shall meet regularly and ensure prompt action on its recommendations Proceedings shall be recorded.

Emergency Procedures

Employers shall establish written procedures on getting injured or sick workers to medical facilities as efficiently and safely as possible. An accident/sickness record book shall be in place and carefully maintained.

Training

On induction into the workforce, all personnel shall receive health and safety training and also on reassignment. Thereafter, on a regular two yearly basis. Training shall be from recognised certified trainers able to issue certificates of satisfactory completion to attendees. Training shall include aspects of First Aid in cases of chemical poisoning, handling of chemicals, waste management and fire precautions. Training shall include awareness of environmental issues. In Kenya, employers shall register with the Directorate of Industrial Training (DIT) in accordance with the Industrial Training Act Cap 237 in order to benefit from refunds of amounts expended on training workers.

Medical

Medical treatment for the workforce shall be provided at the expense of the employer except where such injury/illness was contracted during any period when the employee was absent from his place of work or the injury I illness was self-inflicted or the result of substance abuse. All employer's shall be contracted to a recognised medical physician who can visit the farm on a regular basis at fixed times during working hours and be on call to deal with any medical emergency. Complete, continuously updated documentation and statistics are to be kept with regard to sickness, accidents and absences from work.

Medical facilities including First Aid kits and simple medicines' shall be provided on site or nearby staffed with trained first aid I health workers. Where the size of the workforce warrants it, antidotes to pesticide poisoning shall be available with people trained to administer them (Guidelines to Organo-phosphorous (OP) or Carbamate poisoning, monitoring and treatment are available upon application).

Pregnancy

Expectant mothers shall be given due consideration and be assigned to duties appropriate to their physical condition. Where risks are identified, action shall be taken to minimise or eliminate the danger; In particular; pregnant women shall not come into contact with pesticides or dangerous chemicals. There shall be, where possible, provision for the safe care of young children if mothers are required to work in areas hazardous to children and facilities for nursing mothers to feed their infants.

Visitors and contractors

All visits by non-company personnel shall be recorded in a visitor's book or similar. Visitors shall be accompanied at all times by a company representative. Visitors shall be provided with suitable protective clothing or equipment if entering areas where they might be exposed to hazard or injurious conditions.

Fire Precautions

Precautions shall include safe installation and use of electricity and gas, special instructions on smoking and the disposal of cigarette butts, provision and regular servicing of fire fighting equipment and regular fire drills for employees. Relevant safety signs shall be placed prominently in the workplace. All work in the farm shall be organised in such a way as not to endanger the safety and health of the employees. High risk jobs and areas (e.g. spraying and handling of pesticides, construction and maintenance work) shall be specifically indicated and supervised. Increased risk and danger areas and operations shall be recorded in a Risk Register.

Equipment

Signs and posters relevant to the safe operating of machinery shall be prominently displayed. People working with machinery or processes likely to cause bodily injury shall be fully instructed as to the possible dangers and the precautions to be observed. Particular attention shall be paid to transportation related accidents and all machinery shall be fully guarded and be well maintained. Records shall be kept of all machinery maintenance and servicing, where applicable. Employees shall be supervised by a person who has a thorough, demonstrable knowledge and experience of the production processes in which they are involved.

Pesticide stores

Pesticides must be stored in a secure and labelled room separate from other items. The store shall be bunded to contain contaminated water used for cleaning or fire fighting. Stocks should be recorded and used in age rotation to ensure than no products are retained beyond their recommended life. Records should be kept of all applications of pesticides, including product, dose, date, crop and operator.

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Appendix 1. Recommendations for growers/exporters

1. Take steps to improve quality of crop grown by smallholders
2. Set up small demonstration plantations
3. Establish more formal relationship between export companies and growers for traceability (if appropriate involving the middlemen)
4. Improve training
5. Work with the PIP to evolve the document
6. Improve traceability
7. Work with PIP to establish EU MRLs for the essential passion fruit pesticides in Kenya
8. Work with PCPB to establish national registration of essential passion fruit pesticides in Kenya
9. Hold farmer days to train on aspects of production such as pruning, harvesting, use of fertiliser, pest management etc. to smallholders
10. Map smallholder production in Kenya so that the company has information on source of the crop
11. In Kenya, use FPEAK to co-ordinate flow of information and manage the market
12. Establish regular residue analyses at point of packing to prove lack of residues and take pressure off traceability issue

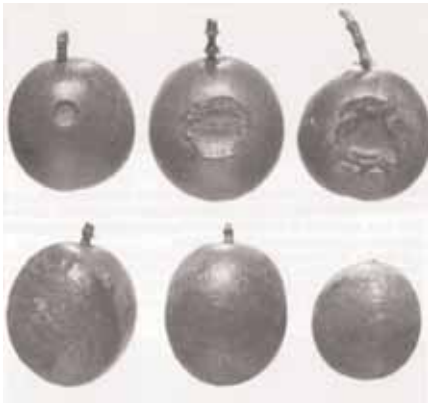
Appendix 2. Pests and diseases of passion fruit

Pest description	Control	Images
Aphids *Aphis gossypii* and *Myzus persicae*		
Aphids are small soft-bodied insects often seen in groups on crop leaves and stems. Winged adults fly to the crop and quickly produce wingless young or nymphs, which are initially about 1mm long. These grow and become adults after a few days and the groups called colonies can expand rapidly, usually on the underside of leaves or on growing points They damage plants by sucking plant sap, spreading viruses, and excreting a sticky liquid that coats the plant. When they suck sap they cause curling, wrinkling, or cupping of the infested leaves giving plants a deformed appearance.	Aphids numbers are usually held in check by predators if pesticides have been used sparingly. Plant the crop in well-prepared, fertile land, but do not apply too much nitrogenous fertiliser as this will make the plant very soft, juicy and attractive to aphids. Plant rows of flowering plants within the crop to encourage biodiversity by providing food and hiding places for predators such as lacewings, ladybirds and hover flies. Spraying with a soapy solution helps to wash off aphids and disturb their breathing. Chemical control of aphid infestations using pesticides may be necessary when numbers build up. Apply the pesticide using a knapsack sprayer fitted with a fine/medium sized hollow cone nozzle.	
Thrips		
Thrips *(Thysanoptera)* injure and cause stunting of young plants. In dry weather, they also feed on leaves, flowers and fruits, leaving them prone to shrivel and to fall prematurely. Thrips adults are small (about 1.5mm in length) and are black, brown or yellowish/orange with tiny hairs. Eggs are laid in small cuts in the plant surface. The larvae which emerge after a few days look like tiny green maggots and are difficult to see on green leaves until they cause damage. The larvae usually drop to the soil to pupate and when adults emerge they crawl or fly back onto host plants.	Natural control by predators is important in control. The main predators are predatory mites, predatory thrips and spiders. These should be conserved by minimising the use of broad spectrum pesticides. Mulching can help to control thrips since it can prevent them reaching the soil to pupate. Thorough cultivation of the soil before transplanting can help to kill pupae in the soil from previously infested crops. Sometimes numbers build up to a level where chemical control is necessary. Apply the pesticide using a knapsack sprayer fitted with a fine/medium sized hollow.	

Pest description	Control	Images
Leaf miner		
The mines are caused by the larvae that live between the two surfaces of the leaf and move around making a tunnel or leaf mine. Adult flies are small yellow and black flies about 2mm long. Eggs are laid in the host plant leaves. When the yellow/orange larva is fully grown, it cuts a slit in the leaf and usually drops to the soil where it pupates just below the surface. Occasionally the larvae do not drop to the soil and the dark orange or brown pupae can be seen on the leaf. In heavy infestations, the activities of the adults in feeding and laying eggs in the leaves cause a white spotting or stippling as in the picture (right) This can kill seedlings and in older plants, allows fungal diseases to enter the leaves. However, the main damage is caused by larvae tunnelling inside the leaves and reducing the productive leaf area. Some leaves may be killed and drop off, leading to yield loss.	Natural control by predators is important in control. Ploughing can help by exposing larvae to predators and can bury others so that they cannot reach the surface. If numbers build up, pesticides may need to be used, but product choice (table 3) and spray timing are important. The pesticide either needs to be trans-laminar (able to pass through the outer layers of the leaves) or systemic (able to pass through the outer leaf layers and move in the plant's sap) to reach the larvae in their mines. Also, heavy use of pesticides can make the problem worse by killing the natural enemies of leaf miner.	
Fruit suckers (such as stink bugs)		
Green Stinkbug *(Nezara viridula)* Brown Stinkbug *(Boerias maculata)* Large Black Stinkbug *(Anoplocnemis* spp.*)*, Black Stinkbug *(Leptoglossus membranaceus).* Adult bugs appear most commonly when the temperature is high just before the rains and they can often be seen mating -connected at the abdomen and often facing in opposite directions. When disturbed, they drop from the plant and stay still. The pests feed on the plant, sucking sap from the growing tips or from developing fruits. Bug attack (by both nymphs and adults) is sporadic and coincides with warm weather. Small puncture marks can sometimes be seen where the bugs have pierced the plant tissue and sucked sap. This weakens the plant and it may become stunted. Affected leaves wither and young plants may even be killed if the attack is severe. On fruits marketable quality proportion is reduced.	On small areas, bugs can be removed and destroyed by hand. Because dry conditions favour bugs, watering and irrigation will discourage them. Old crops or sprouting stumps left in the field will provide refuges for previous infestations so these should be destroyed by digging in deeply. Growing strong-smelling plants such as garlic, onion or parsley near the crop will reduce infestations. Spraying plants with a soapy solution helps to wash off young bugs. If none of these methods is giving satisfactory control, spray with one of the insecticides (see table 3). For sucking pests such as bugs, a systemic pesticide is often best. Apply the pesticide using a knapsack sprayer fitted with a fine/medium sized hollow cone nozzle and follow procedures on safety and pre-harvest interval.	

Pest description	Control	Images
Fruit flies		
These flies are usually around 6mm long with wingspams around 10mm. The wings have spots at the tip or have a characteristic stripe pattern. Some species of fruit fly will attack passion fruits, depositing eggs in young fruits. However, the incidence of this is quite low. If present, the larvae cause the fruits to shrivel and fall, or if the fruits are attacked when nearly mature, there is external scarring.	Fruit flies can often be present at low levels without causing significant economic problems, so control may not be necessary. If high fly populations are causing severe fruit damage, management practices include: Encourage populations of beneficial organisms Practice sanitation: Remove fruits as they ripen. If they fall to the ground, be sure to kill any larvae in the fruits. Use baited traps that contain insecticide. Harvest early before the fruits are soft enough for oviposition by the females. Spot treatment insecticide sprays can be applied to non-fruiting regions of the plants and stakes. Only spray the whole plants with insecticides as a last resort. Traps can be used either to determine how many flies are present (monitoring) or to lure and kill the adult flies.	
Spider mites		
Spider mite adults are small (0.25 mm) pests whose mouth parts are modified for piercing individual plant cells and removing the contents. This results in tiny yellow or white speckles. When many of these feeding spots occur near each other, the foliage becomes yellowish and it often drops. Heavily infested plants may be stunted. The mites may coat the foliage with the fine silk that collects dust. Eggs are round, white/pink and tiny (0.1 mm) and are usually laid on the under-surface of leaves. The six-legged larvae become 8-legged nymphs after several days and become reddish coloured adults after about a week. The webbing on leaves which tends to protect them.	Field hygiene is important as an old crop (or weeds) infested with mites can cause infestation of any new crop. If moving through the crop for weeding, pruning, harvesting or spraying, always leave the infested area until last in order to limit the accidental spread of the mites. Natural enemies such as predatory mites control the pests under some conditions. Some perennial hedges such as pigeon pea are said to encourage these predatory mites. Broad spectrum pesticides, especially pyrethroids should be avoided since they tend to kill the predatory mites, causing spider mite numbers to flare up. Spider mites do not like wet conditions so heavy	

Pest description	Control	Images
Mealy bugs *(Planococcus citri)*		
Mealy bugs are sucking pests that can be serious in the warm season if spraying has killed its chief predators such as the mealybug ladybird, *Cryptoalemus montrouzieri,* which can be purchased for biocontrol release in many countries. The mealybugs are often surrounded by a `cotton-wool´ mass.	These pests are difficult to control with a single insecticide application, because some mealybugs are concealed and not hit by contact sprays. Once adult mealybugs establish on plants, the mobile nymphs move around and spread the infestation. It is not usually desirable or economic to apply insecticides several times on passion fruit. If the infestation is severe, some botanical mixes have been shown to help.	
Nematode		
Nematodes are microscopic roundworms that live in many habitats. Plant parasitic nematodes live in soil and plant tissues and feed on plants by puncturing and sucking the cell contents of the roots. Nematodes can cause severe problems in passion fruit, but only in the purple varieties, as the yellow ones are completely resistant. The most important nematode is the root knot nematode, *Meloidogyne javanica*, which causes severe thickening of the roots. This can cause water and nutritional stress, as the uptake ability of the roots is impaired, resulting in lower yields and fruit drop. Infested trees appear stunted with very few feeder roots. These symptoms are indicative of root lesion nematode problem, but are not diagnostic as they could result from other causes as well. Sometimes patches of unhealthy plants indicate presence of nematodes in the patch. If the plants are not vigorous it may be necessary to dig a test hole to examine the roots and determine whether nematodes are causing the problem.	If nematode problems are suspected, specialist advice is needed. There are some pre-planting treatments with pesticide when there is a history of nematode problems. Under development are some biocontrol methods that use a type of Verticillium or a parasitic species of nematode which attacks the pest. These are only available experimentally at present. Most soil nematodes are not root-feeding so they are harmless to the crop. If plant-feeding nematodes are causing problems it may be possible to improve the soil before re-planting. Maintain high levels of organic matter in the soil (manure and compost) since this reduces nematode numbers. Certain organic supplements such as sawdust, sugarcane waste, compost, and certain green manures are known to suppress plant parasites in the soil. Chemical nematicides are expensive, difficult to use and therefore not recommended for pre-planting treatment for large areas. If it is possible, flooding the soil for a few weeks will reduce nematode numbers, as will bare fallow. If available, covering the soil with a plastic sheet for several weeks prior to planting will reduce nematode numbers.	

Pest description	Control	Images
Fusarium wilt *(causing Crown Canker)*		
Fusarium wilt, arising from the soil-borne fungus, *Fusarium oxysporium* sp. passiflorae. that can cause all or part of the plant to wilt suddenly as the vascular tubes in the stem are blocked by the fungal mycelium.	The disease can be reduced only by grafting the purple, or, better still, purple-yellow hybrids, onto the ï-resistant yellow passion fruit rootstock. Affected parts cannot be cured so should be removed and burned. Snap off the affected parts or grub out the plant. Do not cut tissue then use the knife on healthy plants. It is also a good practice to keep the base of the plant clear of grass and weeds, which flavour fungal growth.	
Fruit spots		
Septoria spot is caused by the fungus *Septoria passiflorae* and is most common in Kenya in summer and autumn. Symptoms are numerous small brown spots on all parts of the vine and fruit and the disease is easily spread by rain, dew and overhead irrigation. Brown spot caused by Alternaria passiflorae in warm weather, is a major affliction of the purple passion fruit in East Africa.	The diseases are spread by rain, dew and overhead irrigation. Effective vineyard sanitation, pruning and leaf thinning to allow more air and light to reach the canopy, application of preharvest fungicides, and proper management of temperature and relative humidity during postharvest handling.	

Pest description	Control	Images
Woodiness virus		
Woodiness virus is a poty virus that is an important disease of this crop. The name describes the symptoms - it makes the plant stiff and woody, and cucumber mosaic virus are very important for this crop. More than one grower in Kenya has given up the crop because of virus diseases. Any vines whose leaves show mosaic or veinclearing symptoms should be removed and destroyed. Woodiness, sometimes called "bullet" affected plants produce small, misshapen fruits with a thick rind and small pulp cavity. If viruses are present in individual plants, aphids can spread the diseases from plant to plant. Cucumber mosaic virus can also affect passion fruit. Two mosaic viruses also attack passion fruits, Purple Passion fruit Mosaic Virus K (PPMV-K) and Passion Fruit Mosaic Virus Mild Yellows (PFMVMY) although little is known about them.	Purple passion fruit is very susceptible, but yellow passion fruit is less affected. Some varieties of the purple type seem to be more resistant or tolerant of the virus. It is good practice to obtain several certified varieties (seeds or plants) for test. Without quarantine checks imported material may spread new problems, so should be cleared by the quarantine agency to prevent any new pest or disease problems being imported. New scions must be approved as virus-free before they can be sold for planting. The diseases are not soil-borne so replanting every 3 or 4 years starts the crop clean again provided that the planting material is clean. Unfortunately potyviruses are spread in seed, so source of planting stock (seeds or grafted plants) is very important.	
Phytophthora blight		
Phytophthora cinnamoni and *P. nicotianae var*. parasitica cause collar rot, fatal blight (stem rot) and fruit rot although the yellow and purple vines have different patterns of susceptibility. The yellow vine is susceptible to *P.cinnamoni,* and the purple vine is more susceptible to *P. nicotianae*. Both fungus strains attack both passion fruits, causing root rot, wilt, damping off and leaf blight.	Effective vineyard sanitation, pruning and leaf thinning to allow more air and light to reach the canopy, application of pre-harvest fungicides, if serious. Proper management of temperature and relative humidity during post harvest handling will reduce fruit rot in transit. These diseases often make it necessary to replant every three years with new stock material.	

CROP PRODUCTION PROTOCOLS

Avocado (*Persea americana*)
French bean (*Phaseolus vulgaris*)
Okra (*Abelmoschus esculentus*)
Passion fruit (*Passiflora edulis*)
Pineapple Cayenne (*Ananas comosus*)
Pineapple MD2 (*Ananas comosus*)
Mango (*Mangifera indica*)
Papaya (*Carica papaya*)
Pea (*Pisum sativum*)
Cherry tomato (*Lycopersicon esculentum*)

GUIDES TO GOOD PLANT PROTECTION PRACTICES

Amaranth (*Amaranthus* spp.)
Baby carrot (*Daucus carota*)
Baby and sweet corn (*Zea mayis*)
Baby Leek (*Allium porrum*)
Baby pak choy (*Brassica campestris* var. *chinensis*), baby cauliflower (*Brassica oleracea* var. *botrytis*), baby broccoli and sprouting broccoli (*Brassica oleracea* var. *italica*) *and head cabbages* (*Brassica oleracea var. capitata* and *var. sabauda*)
Banana (*Musa* spp. – plantain (*matoke*), apple banana, red banana, baby banana and other ethnics bananas)
Cassava (*Manihot esculenta*)
Chillies (*Capsicum frutescens, Capsicum annuum, Capsicum chinense*) and sweet peppers (*Capsicum annuum*)
Citrus (*Citrus* sp.)
Coconut (*Cocus nucifera*)
Cucumber (*Cucumis sativus*), zucchini and pattypan (*Cucurbita pepo*) and other cucurbitaceae with edible peel of the genus *Momordica, Benincasa, Luffa, Lagenaria, Trichosanthes, Sechium* and *Coccinia*
Dasheen (*Colocasia esculenta*) and macabo (*Xanthosoma sagittifolium*)
Eggplants (*Solanum melongena*, *Solanum aethiopicum*, *Solanum macrocarpon)*
Garlic, onions, shallots (*Allium sativum, Allium cepa, Allium ascalonicum*)
Ginger (*Zingiber officinale*)
Guava (*Psidium catteyanum*)
Lettuce *(Lactuca sativa*), spinach (*Spinacia oleracea* and *Basella alba*), leafy brassica (*Brassica* spp.)
Lychee (*Litchi chinensis*)
Melon (*Cucumis melo*)
Organic Avocado (*Persea americana*)
Organic Mango (*Mangifera indica*)
Organic Papaya (*Carica papaya*)
Organic Pineapple (*Ananas comosus*)
Potato (*Solanum tuberosum*)
Sweet potato (*Ipomea batatas*)
Tamarillo (*Solanum betaceum*)
Water melon (*Citrullus lanatus*) and butternut (*Cucurbita moschata*)
Yam (*Dioscorea* spp.)

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