PASSION FRUIT PRODUCTION

GUIDELINES

PASSION FRUIT GROWING GUIDE FOR EXTENSION STAFF AND FARMERS

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INTRODUCTION

The consumption of passion fruit juice and other related products is expanding in Uganda and also on the world market. The passion fruit industry in Uganda appears to have a bright future particularly where the crops have proved beyond doubt that it can thrive in different ecological zones. Markets prospects for passion fruit juice are excellent in the fast growing blended juice trade. A small quantity may give either the characteristic flavor of the passion fruit or it may enhance the other fruit flavours of the blended product. The flavouring trade is another promising outlet for passion fruit since the juice has equally good acceptance as a flavoring in soft drinks and in the baking industry.

In addition to being a potential export product the juice is very popular among Ugandan mothers since they believe that it can be used to rehydrate children, who are suffering from measles, diarrhea and vomiting. The seed of the passion fruit contains a very little oil which is suitable for use in the paint industry, and the hard outer skin, the rind can be made into fertilizer.

The market prospects in Uganda may be significantly improved by the development of new processing procedures, by the discovery of new products and the establishment of processing plants. It is here that, the development of a fruit preservation plant at Namanve by Coca-Cola has deserved special attention our predominantly agricultural economy since it will go a long way to sustain this viable industry.

Variable yields, due to irregular fruit setting and plant losses in the hybrid varieties, are the main factors limiting expansion. In most districts seedling vines have a comparative short commercial life, owing to the incidence of wilt, brown spot and woodiness diseases.

Passion fruits are woody climbers. And for this reason they are best grown on trellises. The plants are characterized by fairly large-lobed or entire leaves. Tendrils at the nodes support the vines as it climbs. The flowers are large and conspicuous with a crown of numerous threat like rays and varying combinations of colours in which purple predominates. They depend largely on insects for pollination. In some species the pollen ripens before the stigma of the same flower are ready to receive it. Hence fruit set depends on cross pollination.
Under Uganda conditions cropping is seasonal depending on the date of planting. There are generally two main harvesting seasons, with intermediate off-season crops. By

judicious pruning, the period of cropping may be controlled and extended within required limits.

There has been considerable doubt concerning future reliability of the source of supply of improved planting materials. Support of the research work being carried out at National Crops Resources Research Institute. (NaCRRI) Namulonge, however, shown determination and willingness on the part of the Government to develop fruit production as a small-holder cash crop enterprise.

A substantial passion fruit industry could be developed when a more reliable source of supply of uniformly high quality fruit is obtained. This is not possible with the planting inferior seedlings. Only if vegetatively propagated varieties are grown in properly cultivated orchards and attention can be given to cultural practices such as fertilizing and spraying will the prospects for the industry improve.

FOREWORD

Uganda is a country whose agro-climatic conditions can support a wide range of Horticultural crops. In the fruit sub-sector, passion fruit growing is gaining popularity day by day. Nevertheless, the knowledge of how to grow passion fruit especially on commercial line is greatly lacking. It is my sincere hope and belief that the birth of this booklet will bridge the gap that has been existing between the researcher, the extensions' and the farmer.

The passion fruit has been growing wild for a long time and people collect fruits for home use and for the market. Once put under organized production the crop faces a host of pests and diseases which must be controlled let alone application of other agronomic practices as outlined in the booklet.

In order to exploit the great production potential that exists and also the great market potential, commercial production is the answer. The writer has carefully and ably handled the factors that are crucial. This makes the booklet a great companion for the grower, the extension worker and the exporter.

PREFACE

Most of our traditional cash crops especially coffee and cotton which we have been most dependent upon for export have been subjected to wide fluctuations in production and price due to unpredictable weather conditions and the instability of world prices. In such situations, the government policy of diversification of agricultural production emphasizes the urgent need for reorganization of an agricultural production through importation or introduction of new improved crop varieties and better methods of production.

There are many horticultural crops which should be improved and cultivated to such standards that they can fetch this country substantial amounts of foreign exchanges.

The Commercial passion fruit industry in this country is relatively new and most of the farmers lack authoritative and authentic information on the best methods of production.

As agriculturists we recognize the great importance attached to the farmers' needs hence this booklet has been designed to introduce the farmer to the basic requisites for better methods of production. It can be used in production of passion fruit in Uganda by farmers and it is recommended for students in the study of passion fruit production.

This booklet discusses the plant forms and day to day problems being encountered by the farmer. It covers the most interesting survey of crop management and marketing.

There are quite a good number of new chemicals which date have bee introduced onto our markets which can be used in passion fruit production. Some of these chemicals might prove to be harmful to the vines if not properly used. In order to avoid disappointments farmers are urged to make use of the existing facilities at Kawanda Research Station to secure information on proper use of these new chemicals. Soil analysis facilities are also available at the station which farmers should not ignore colours in which purple predominates. They depend largely on insects for pollination. In some species, the pollen ripens before the stigma of the same flower are ready to receive it. Hence fruit set depends on cross pollination.

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judicious pruning, the period of cropping may be controlled and extended within required limits.

There has been considerable doubt concerning future reliability of the source of supply of improved planting material. Support of the research work being carried out at Kawanda research Station, however, has shown determination and willingness on the part of the Government to develop passion fruit production as a small-holder cash crop enterprise.

A substantial passion fruit industry could be developed when a more reliable source of supply of uniformly high quality fruit is obtained. This is not possible with the planting of inferior seedlings. Only if vegetatively propagated varieties are grown in properly cultivated orchards and attention can be given to cultural practices such as fertilizing and spraying, will the prospects for the industry improve.

The figure 1 shows some parts of a passion fruit plant.

HISTORY

Passion fruit is a native to S. America, from paraquay, Brazil and Argentina. It is a choice crop of the tropical and subtropical belt because it is one of the fruits that comes into production within one year, and it is referred to as the fruit cash crop. It yields some juice rich in Vit. A,B5 &C

Passion fruit mainly the purple fruited *Passiflora edulis. Sim*., is a semi-woody perennial climber (vine) belongs to the genus Passiflora which includes four hundred varieties, but only a few are considered for commercial cultivation. The crop was probably introduced into East Africa from South Africa in the 19th Century through what was Tanganyika.

Commercial cultivation of the crop begun in Kenya in the 1930's without any significant success due to brown spot disease which devastated the crop. After the re-organization of the industry in 1967, Kenya emerged as one of the leading producing countries of purple passion fruit in the world.

The crop is believed to have been introduced into Uganda in 1935. It became naturalized and many plants are found growing wild around homesteads and in forests. Investigations and experiments conducted at Kawanda Research Station on the purple passion fruit indicated that is very susceptible to brown spot disease (*Alternaria*

passiflora). These investigations led to hybridization between the pruple and yellow or golden passion fruit *Passiflora edulis Var. falvicarpa*, which had proved to be slightly resistant to the disease. Commercial crops of the purple and hybrid varieties are grown to varying extents in Eastern and Buganda regions. The bulk of the crop is grown in Masaka, Mpigi, Mubende, Kasese, kabale, Mbale and Mukono districts in association with other horticultural crops. However, there are some isolated vine yards found still growing wild in Kyaka, and Kasese in Western Uganda. Production has expanded in recent years as the fruit has become appreciated for its pronounced and agreeable flavor and aroma which contributed to the production of high quality juice. Passion fruit juices are also used in flavouring several other products. Without bias, it has been observed that the consumption of passion fruit in central zone is superceeding that of the citrus juice, a juice which has been so popular amongst Ugandan consumers.

SPECIES AND CULTIVARS and desired areas where they best suited for production in the country.

There are several varieties of edible passion fruits found growing in Uganda, these include:

(1) Purple passion fruit – *Passiflora edulis* Sim
(2) Yellow or golden passion fruit – Passiflora edulis Var. flavicarpa
(3) Hard-shelled passion fruit – Passiflora maliformis
(4) Grandadilla passion fruit – Passiflora quadrangularis
(5) Kawanda hybrid passion fruit – (purple x yellow)
(6) The highland yellow passion fruit

(1) **PURPLE Passion fruit – *Passiflora edulis* Sim**.

The purple passion fruit – Passiflora edulis Sim. As the name implies, bears a fruit which is purple when ripe. The plant is a short-lived perennial which is densely covered with dark green, deeply lobed leaves with elongated tendrils in their axils. The large showy bisexual flowers are borne singly on the lead axils on the jointed stalks. The fully ripe fruits are round to oval in shape 4-5 cm (1 ½" – 2") in diameter with a hard, leathery, purple skin. The fruit cavity contains numerous small, black seeds surrounded by a yellowish, aromatic pulp which has a pleasantly acid flavour. The composition of the fruit is, however, very variable but the larger sized fruits tend to contain more juice than



the smaller ones. There are several strains, these vary mainly in the size of the fruit. The largest fruited strain is particularly shy bearer (produces a few flowers).

(2) YELLOW or GOLDEN passion fruit - *passiflora edulis Var. flavicarpa*.

The yellow or golden passion fruit is presumed to have originated in Queensland, Australia, possibly as a hybrid between the purple passion fruit and an unknown species. This variety is recent introduction to Uganda (1970) and has done exceedingly well wherever it has been planted. It differs from the purple passion fruit mainly in colour of the fruit which is yellow at maturity and slightly larger in size. It is however, more vigonous and thrives better in the heavy rainfall areas of Uganda. It has been observed that some selections of this variety have shown signs of unfruitfulness which has been attributed to the protanderous nature of the flowers which means that the stamens ripen before the stigma. The fruits are usually spherical. When immature, the rind is mottled with white spots but the ripe fruit is pale golden or yellow colour. The fruit has a more aromatic and acidic pulp than the purple species.




(3) HARD SHELLED passion fruit – Passiflora maliformis

The hard-shelled passion fruit or the sweet calabash has a relatively small fruit, less than 4 cm (1½") in diameter, with a light green to brownish skin and a very hard rind enclosed within three large cream-coloured bracts. The seeds are small and the pulp is grayish to yellow. The flavor is infenor to that of the purple passion fruit. This species of passion fruit are immure to attack by several diseases and insect pests which cause considerable losses in some other species of passion fruit *(passiflora*).



(4) GRANADILLA – *Passiflra quadrangulari*

The grandadilla is essentially a fruit which has adapted well to most parts in Uganda. High termperatures accompanied by a high humidity, are very necessary for fruiting to occur. Under dry atmospheric conditions, the flowers produce little or no pollen and fruit set is consequently poor. The small fruited variety which is normally grown in Uganda is oval in shape and 15-22 cm (6"-9") long. The fruit is initially green in colour and changes to yellow at maturety when the flesh becomes soft. It has a

characteristically soft and 4 cm (1½") thick which may be eaten together with the large seed and pulp. In this respect, it differs from related species, in which only the seeds and pulp are edible.



(5) KAWANDA HYBRID passion fruit – Purple x Yellow

Preliminary investigations on passion fruit breeding started at Kawanda Research Station in 1970. Three cultivars namely Kiisi, New Guinea and Mubende local, all of the purple passion fruit type – Passiflora edulis Sim. Succumbed to brown spot disease when tested at Kawanda Research Station and Kabanyolo University Farm.

However, the yellow passion fruit – *Passiflora edulis Var. flavicarpa* showed a high degree of resistance to this disease when planted at Kawanda. Mubende local which proved also to be somehow resistant to this disease was then crossed with the yellow species with the aim of producing a variety which combined the fruit quality of the purple passion fruit with the brown spot resistance of the yellow form which was sufficiently true to type to be propagated by seed. Hybrid fruits obtained as a result of this hybridization, though exhibited varying characteristics most of them were found to be very large, with a pulp content about three times that of the purple variety. The colour of the skin was light purple and the aroma was intermediate between the aromas of both purple and yellow parents.



AGRONOMY

Climate and Soils

Passion fruit generally requires a tropical or sub-tropical climate with a moderately high rainfall for optimum growth. The vine, however, cannot withstand very high temperatures. The crop grows almost every where in the country, including areas of high altitude such as Bugisu and Kigezi. Very heavy rainfall reduces the productivity of this crop. If possible, planting should be timed so that flowing occurs during a cool and rather dry season in order to facilitate pollination by insects. The edible species of grown successfully on most Ugandan soils. The main essentials are good moisture, combined with adequate sub-surface drainage.. The vines will succumb rapidly to water logged conditions and for this reason the crop should not be planted in shallow soils with a clay sub-soil.

All varieties are fairly tolerant to acidic conditions and can be grown on soils with a pH as low as 5.5. Strong acid soils (below pH 5.5) should be dressed with agricultural lime at suitable rates.

However, due to the bimodal distribution of rainfall in Uganda, most soils are suitable for all the year round production of high quality fruits.

Selection of Site

A number of factors have to be considered in selecting a site for passion fruit vine-yard. These include aspects of, elevation, shelter, soil type, drainage and accessibility. Aspect may be considered in terms of the prevailing weather conditions; it is essential that the vine-yard be protected against heavy winds and hot weather.

Passion fruit plants grow satisfactory on fertile, well-drained loam soils, but, there is a tendency for vines to produce excessive vegetative growth when they are grown on newly cleared virgin land. On less fertile soils, vines seldom carry excessive foliage and usually crop satisfactorily.

Land Preparation

Land should be well cultivated before planting, since the commercial life of healthy vines may be from four to five years. The initial cultivation should be as deep as possible without bringing too much sub-soil to the surface. If possible, it should be carried out two to three months before the plants are established in the field. Subsequent cultivation will depend on the nature and condition of the soil and should be designed to produce a good tilth. On shallow soils, ploughing should be done along the contours.

The Nursery

What is a plant nursery?

This is where seedlings are first raised from in their delicate stage to when they are able to withstand harder conditions in the field. Such conditions are strong sunshine, wind, hailstorm and rain.

In order to produce healthy seedlings, the nursery bed should be prepared in well-drained soils which are rich in plant nutrients. Such soils should be friable with a satisfactorily soil-air content, free water percolation and containing a substantial amount of humus.

Locating a nursery

The nursery should be located a way from big trees /shade to avoid etiolation, near a permanent source of clean water for all year around watering free from heavy metals, on a gentle slope to avoid s oil erosion, on a good drainage to prevent damping off incidence.

Where possible seedlings should be raised from freshly extracted seeds. The seeds may be extracted from healthy mature fruits selected from healthy plants with good yields. The seeds are separated from the pulp and juice after fermentation for about three days. They are then thoroughly washed, dried in the shade and kept in closed containers or sealed polythene bags until required for sowing. Seedlings may be raised either in seed boxes or seedbeds. It is always advisable to locate the nursery as far as possible from existing passion fruit vines to reduce the risks of the young plants being infected with diseases spread from the old vines.

Nursery construction

There are various types of nurseries such as

1. Wooden poles skirted with polythene at the bottom to prevent water contact that can cause rotting and termite damage, wooden rafters ,rammed floors, shelter made from dry banana leaves ,or palm leaves, or elephant grass, reed fence. The disadvantage of this type of nursery structure is being prone to destruction by fires, termites, rot and the roots of seedlings tend to establish in the ground. Light is not well distributed and is not effectively protected from harsh conditions.
2. Wooden poles skirted with polythene at the bottom to prevent water contact that can cause rotting, rafters, polynet, chain link as perimeter wall and stone aggregates on the floor. This type of structure is quite long lasting, it drains water fast and there I even distribution of light in the shade.
3. Metallic poles, rafters, fence, and concrete floor. This type of structure is long lasting and the plants grow in ideal conditions. The disadvantage is that it is expensive

Soil Sterilization

Soil sterilization by steam is very important in our nursery work since it destroys most of harmful microorganisms and weed seeds contained in the soil without destroying the humus or organic matter.

Small quantities of soil may be sterilized by use of steam. A forty-four gallon or a 200 litre empty metal drum may be used. The soil is heated in a drum as shown in the figure below. The top of the drum is removed. A perforated iron sheet with large holes or a

wire mesh is welded about one third from the bottom. The drum is then placed on a tripod of three stones, allowing about a foot underneath where the fire will be lit to provide a small wood fire. The drum is then filled with water allowing a few centimeters (inches) to reach the pertorated metal sheet. A small quantity of soil, is filled in a hessian bag and placed on the perforated sheet. The drum is them covered on top by either a metal cover, banana leaves or sacking in order to trap the steam. A small wood fire is kept burning under the drum until the temperature of at least 80^0 at the top of the soil has been maintained for at least one hour. If a thermometer is not available a sweet potato or a finger banana (unpeeled) can be place 15 cm (6") below the surface of the soil. When the potato/banana is cooked the soil has been sufficiently steamed. The soil can then be used after it cools to air temperature.

Figure 2: Soil Sterilization by steam

PROPAGATION OF PASSION FRUIT

Raising Seedlings

Raised seedbeds of any convenient width and length depending on the acreage required, are prepared. These should star at the edges to allow excess water to drain away. Seeds are sown in shallow drills about 1 cm (½') deep and 25 cm (6') apart are then covered with soil. A small path is left between the beds in case more than one seedbed are made to facilitate the cultural operations. When seedboxes are used, seeds may be broad cast or sown in shallow drill.

Figure 3: Showing raising passion fruit seedlings in either seedbed or seedbox.

Regular watering is necessary to keep the soil moist until germination take place. Mulching and the use of a light shade are recommended.

The nursery should be kept as weed-free as possible. Seeds may be sown at any time of the year provided that water is available. If possible, seedlings should be transplanted when they are approximately 5 cm (2") high into small individual polythene sleeves or other type of container. When about 15 cm (6") high, they are ready for field planting. Propagation by seed is relatively easy but seedlings show great variation even those raised from seeds of a single fruit.

Vegetative Propagation

A preferable method of raising planting materials is by stem cuttings. Vegetatively propagated varieties of passion fruit are always true to type and the uniformity in growth, yield and quality of the fruit which come as a result make the harvesting and marketing easy.

The choice of cutting to be propagated will in most cases, depend on the qualities of the mother plant. A good plant (e.g. heavy bearer) will produce a good planting material and a poor mother plant will produce inferior planting materials. Cuttings suspected to come from plants infested with "Woodiness" virus should never be used.

(a) Passion fruit stem cutting
(b) Passion fruit stem cutting plant in an individual container

Figure 4: Showing propagation by stem cutting

(a) Propagation by Cuttings

The most desired cutting materials is obtained from well matured wood such as a lateral branch which has at least three to five well-developed buds. The selected vigorous branches are cut and the leaves are removed from the lower two thirds (see figure above). The trimmed lower portion is cut below a node joint and is then inserted in the rooting medium with about lower half of the cutting above the surface (Rooting powder can be used if available since it stimulates the cuttings to root easily). Passion fruit cuttings, like most of the plants require warmth, moisture, a high humidity and a porous medium for rooting. Porous soil, like sand, saw dust and coffee husks make a good propagation media for cuttings. At Kawanda Research Station, the following medium was successfully adopted:

a) One tin of steam sterilized soil
b) One tin of lake sand
c) Two tins of well rotted coffee husks.

Rooted cutting which have been inserted in propagation beds rather than containers should be transferred to individual containers. In transplanting, care should be taken

not to injure the delicate root system. When the young plants have become well established, (after 2-3 months) they should be planted out in the field.

b) Propagation by grafting (wedge)

Propagation by grafting is a very new method to most of our farmers and its use is recommended where we try to avoid certain soil borne diseases such as fusarium wilt, a disease which of late has threatened many vines in the country.

The reader should get acquainted with the following terms:-

i) Scion

The scion is the short piece of detached shoot containing several dormant buds which when united with the stock comprises the upper portion of the graft and from which will grow the stem. It is responsible for supply of plant food from the leaves to the roots and for production of fruits.

ii) **Rootstock**

The rootstock is the lower portion of the graft which develops into root system of the grafted plant. It supports and delivers water and other nutrients to the scion.

The passion fruit seedling to be used as rootstock is raised in a normal manner either in seedbed or seed box. Seedlings are transferred in individual containers and kept under partial shed until they are ready for grafting that is when the stem is about 3-5 mm thick. The union should be at least 10 cm (3-4”) above the soil surface. The wedge grafting technique involves the removal or cutting off the tip of the rootstock and by making a slanting incision through the little tender stem. The scion from a plant of desirable characteristics is made by cutting a long gradually tapering wedge to fit almost exactly into the incision on the rootstock. The latter is then placed on top of the rootstock so that the surface fit well and is bound with plastic strips. The scion should be approximately 10 cm (3-4”) and have at least one or two vegetative buds. The leaves are trimmed off to prevent excessive transpiration. In two weeks time the buds will start growing and the plastic strip can be removed after one month.

Figure 5: Showing different stages of wedge grafting

Transplanting

The seedlings or rooted cutting should be transplanted in the field either in the morning or in the late afternoon. Watering should always follow transplanting particularly in the dry season. The vines are planted either as a single crop in a plantation or orchard or as a filler in between other fruit trees which are slow growing and may be comparatively late in coming in bearing.

In either case, they are wither trained on a trellis or on a bower or flat top system sometimes referred to as a pergola. They can also grow along existing wire fencing when they serve as a good hedge as well as yielding a useful crop of fruit.

Passion fruit is a very suitable crop for growing as a filler due to the relatively small area occupied by the plants and their early fruiting habit.

Field Layout and Spacing

Passion fruit vines particularly the hybrid forms a vigorous climbers which should not be planted too closely. Spacing trials carried out at Kawanda Research Station indicated that a spacing of 3 metres (10”) between rows and 6 metres (20”) between plants within the rows is a suitable spacing. Experience has, however, shown that when the soil is sufficiently fertile, plants established at that spacing tend to overlap each other very quickly, resulting in the production of bushy vegetative growth. It can therefore, be hardened off before transplanting. After the field lay-out has been completed and the plant holes marked, they should be dug 60 cm (2”) wide and 60 cm (2”) deep the top soil should be kept on one side and the sub-soil on the lower side of the plant holes. The plants are then planted in centre of the hole. If they are excessively tall the top portion of growth should be cut back and the larger roots trimmed. With a spacing of 3 metres (10”) apart, the following number of plants per acre/hectare will be required:

a) A 2 x 2 x 2 hole dug for P/F planting
b) The hole filled half way with top soil and FYM

Figure 6: Showing hole digging for passion fruit plants.

Figure 7: Showing spacing in passion fruit plants

1) When the spacing is 6m (20”) apart in the row 222 plants/acre or 556 plants/hectare plants/hectare.
2) When the spacing is 10 m (30”) apart in the row 146 pants/acre or 365 plants/hectare.
3) When the spacing is 12m (40”) apart in the row 108 plants/acre or 270 plants/hectare.

Training the Vine

A few days after transplanting, numerous lateral shoots appear at the base of the plant and many of them out-grow the original terminal shoot. When they attain a length of about 30-35 cm (1”) one healthy vigorous sucker is selected to form the frame work of the vine and all other shoots are carefully cut away. Plants require some support until they reach the trellis wire as they climb.

Figure 8: Showing flat/Top Training

For this purpose, wooden stakes which are long enough are driven into the ground ear the base of each plant. Alternatively, binder twine may be stretched vertically between a short stake in the ground and the top wire. To prevent wind damage, until it reached the wire, the young vine is loosely tied to the stake at intervals of 30 cm (1”). All lateral side branches arising from the stem between the ground and wire should be pruned away when they appear and auxiliary buds may be cut off at the same time to prevent regrowth. If the stem is tied directly to the stake, the string must be loosened before it comes too tight and restricts growth. When the vine reaches the wire, the terminal bud is removed and two lateral branches are allowed to grow in opposite directions. The vines are progressively wound loosely around the wire as they grow. It is very important to disentangle the developing laterals regularly so that they hang freely.

Trellising

A trellis is an upright structure of strips of wood or metal used for supporting vines or other creeping (climbing) plants.

Passion fruits are normally grown commercially on wire trellises but the pergola method, also known as the flat top trellis, may be used.

a) **Vertical Trellis**

The vertical trellis consists essentially of a series of posts 3 m (10”) high set at intervals of 12 metres (40”) usually arranged alternately with the plant spacing along the row and supporting one or two wires strained out.

On hill-slides or where it is necessary to plant on the contour, the trellis may be curved and the posts spaced accordingly. The posts should be of hard wood or other durable timber preferably chemical treated. The intermediate posts are 10-13 cm (4”-5”) in diameter and larger strainer posts an placed at the end of each row, supported by anchor poles. Posts should be buried 60 cm (2”) in the ground. Number 10 gauge galvanized wires threaded through holes bored in the posts and is strained out to take the heavy weight of the vines and their crop without induced sagging.

Figure 9: training on a Vertical trellis

b) Pergola, Arbor or flat-top Trellis Method

A roof of wire netting supported on wooden poles about 2.8 metres (8.5”) high from the ground is constructed. The width and length of the roof will vary according to the area to be cropped. The vines may be planted on the hexagonal system, allowing 6 metres (20”) between plants. One stem is allowed to grow and is supported on a stake or string until it reaches the wire. It is then allowed to spread in all directions and will cover the whole netted area in due course. New shoots are produced every year, after the second harvest; these new shoots will develop to bear fruits. Vines trained by this method may bear even heavier crops than those trained on the trellis system. But the cost of erecting an arbor is likely to be higher than that of the vertical trellis and the pruning is relatively more difficult. Some of the disadvantages of this method are: the tendency of the vines to overlap and inter-twine with consequent lodging of the fruit, difficulty of disease and insect pest control and at times, failure of the fruits to ripen to give the required purple colour.

All the above methods of trellising require heavy and well braced end posts which will withstand the strain of the taut wire and the weight of the vines.

Lifting the vine to the top of the trellis merely aggrevates the intertwining of the foliage and results in depressed yields. A high trellis will overcome this condition with the production of significantly higher yields of saleable fruits.

Some advantages of a high trellis

The height of a trellis is dictated by a number of factors:

1) Except under quite adverse conditions, forms of the Kawanda hybrid passion fruit are extremely vigorous and aggressive plants. This is particularly noticeable in the second year of growth and fruiting. Even with trellis of about 2-3 metres (8") high the vines will trail from the top of the trellis to the ground, covering the fruit and complicating the harvesting, spraying and other operations. Most of this trailing growth should be removed by pruning after the crop has been harvested; it is very difficult to remove it while the vine is fruiting heavily without creating a severe crop loss. With a high trellis, however, this problem is rather less acute.

2) A trellis which holds the vines well above the ground makes it much easier to reach under the vine to apply fertilizers and pesticides, remove or spray weeds with herbicides and harvest the fruits fallen to the ground.

3) A high trellis present a greater surface area of vine to the sun, and in consequence would be expected to produce high yields. Due to the high yields obtained, the cost of construction and other operations involved a higher trellis system can be justified for more conditions.

4) A high trellis requires proportionately heavier construction material than a lower trellis, thus making it more durable.

CROPPING HABIT OF KAWANDA HYBRID (FORMS) PASSION FRUIT

When grown under favourable conditions, some forms of Kawanda hybrid bears a first crop six to twelve months after transplanting. Active growth depends mainly on soil fertility level, vigour of the vine and the month in which the cuttings were transplanted.

On fertile soils healthy cuttings transplanted during the rainy season produce a few fruit within six to nine months of planting. Preliminary investigations at Kawanda research Station showed that, in a normal year, cuttings transplanted at the beginning of first rains were capable of producing saleable fruits towards the end of the second rains. Under normal conditions, the period from fruit setting to harvesting is about seventy days, harvesting taking place when the fruits have attained a light purple colour. It was observed that the honey bees and carpenter bees were the most active pollinating agents. Flowering normally occurs in two distinct periods within a year. Due to this flowering behavior, two main picking seasons have been identified.

The periods of fruit maturity are normally April-July and October – December. However, there may be intermediate off-season crops at time between the two main picking seasons. These periods and crop phasing are based on Kawanda environment and may well vary in other areas.

POOR FRUIT SET IN KAWANDA HYBRID PASSION FRUIT FORMS

The Kawanda hybrid passion fruit was the result of crossing the local purple passion fruit *Passiflora edulis* Sim. and the yellow golden *Passiflore edulis* Var. *flavicarpa*. Experience has show that the local purple passion fruit flowers and sets fruits in all the ecological zones of Uganda. While flowers of the local purple passion fruits open early in the morning and closes at dawn, the of the yellow passion fruit open between one to two O'clock in the afternoon and closes at dawn. The hybrid clones, like the local passion fruit also opens in the morning and closes at dawn.

However, poor fruit set has been observed to be more prominent in the yellow species. These problems of poor fruit set and poor juice have received special attention, since they are proving to be common occurrences in Uganda. A close observation of the floral behavior in the different yellow clones indicate that these may largely be related to pollination and fertilization. It is believed that this plant requires cross pollination of flowers from different vines for successful fruit set. It would appear that the poor set in the hybrid types may be due to factors transferred through the yellow parents. This hypothesis have deserved a more detailed study, especially with a view to identifying the individual factor responsible for poor fruit set in the Kawanda hybrids. A more likely hypothesis, however, is that many farmers may have planted 'Clonal' seedlings for parents with unfruitful tendencies.

Problems associated with fruit setting in the Kawanda hybrid passion fruit are yet to be determined. General observations however, lead to the following tentative recommendations for managing these hybrids.

1) 'Clonal' cuttings which are free from dangerous diseases especially the 'Woodiness' disease should be used in planting. The mother plant should be of desirable qualities; such as heavy bearings, large fruit with plenty of juice and light purple in colour.

2) Different clones which have been identified to be of reasonable good characteristics and are cross-compatible should be planted in the same stand to ensure that pollination takes place successfully.

3) The different clones planted in the same stand should be more or less of the same age since they have to flower at the same time so as to ensure maximum cross pollination.

4) The insect pollinating agents should have a high population to make sure that almost each flower is visited. An apiary (honey bee keeping) can be placed in the vicinity of the vine yard.

PLANTATION MANAGEMENT

a) Weeding

Passion fruit is a comparatively shallow-rooted plant and reacts fairly quickly to a sudden reduction in soil moisture. Except during periods of wet weather, weeds must be controlled to prevent wilting and possible shedding of leaves due to competition for water when the soil moisture is low.

When cultivating or hoeing close to the plant, care should be taken to avoid any injury to the base of the stem or the main roots. Such injuries are liable to result in basal rot and the ultimate loss of the vine. For this reason, it is preferable to remove all weed adjacent to the stem or the vine by hand. Chemical desiccants such as Gramoxone, Round-up or Dalapon can be used for weed control. Care should be taken to ensure that the chemical does not come into contact with the foliage and stems of the plants. Shallow cultivation may be carried out in inter row areas or a sward may be allowed to develop which can be slashed as required.

b) Pruning

Pruning is the systematic removal of dead or living parts from a plant so as to increase fruit production.

Commercial passion fruit vine-yards require regular periodic pruning. Pruning serves a variety of purposes.

Dead wood is removed and the vines are opened up to assist in disease control. Pruning stimulates the production of new fruit bearing laterals. As the fruit is borne on new wood, pruning facilitates the control of cropping and may be used, to some extent, as means of spreading or varying the harvesting period.

While the main leader of the vine is trained on the wire, the fruiting laterals are trained so that they hang down freely from the wire. One a lateral reaches the ground it should be cut off at ground level.

To ensure that the laterals hang freely, the tendrils which cause the vines to become entangled must to remove regularly. During the normal active growing season this operation should be carried out fortnightly.

Pruning may be limited to alternate vines and to cutting the hanging growths as they trail on the ground. However, in more severe pruning or cutting back to the main stem is done it is best to wait until the vines begin active growth at the on set of rainfall. Sever pruning of dormant or relatively in active vines may result in a severe set-back or even death of the vine. There has not been experimental evidence as to what extent pruning should be done under Uganda conditions. But a farmer might be advised to light prune the vines during the first year of cropping.

In pruning, the lateral is cut back to a newly developing side shoot as close to the main stem as possible. Once the borne its' last fruit and where no new side shoots have formed, the expensed laterals should be cut at the second to fruit nodes from the main stem. Dense vines promote the development of leaf and fruit diseases such as the serious brow spot and woodiness. Brown spot is a considerable hazard during periods of high temperature and high humidity.

By pruning and regular removal of dead and dried leaves, reduces the density of the vine during season of high humidity, conditions are made less favourable for re-spread of the diseases.

Some advantages of Training/Pruning of the Passion fruit vine

1) More light and air penetrates the vine to improve fruit colouring and to create conditions less favourable for pests and diseases.

2) Fruit picking is facilitated

3) To remove all dead, old, injured and diseased parts of the vine.

4) To facilitate spraying

5) To prevent vine over-lap

6) To encourage and stimulate development of new growth which will bear the flowers and fruits.

c) Fertilizer Schedule

Passion fruit plants require a plentiful supply of mineral and organic materials. On fertile land, artificial fertilizers may not be needed for the first year or two but thereafter they will usually be required to maintain optimum growth and yields. Less fertile land requires the use of fertilizers from planting onwards. In Uganda experiments have produced no special recommendation as to how much fertilizer should be applied and at what time.

Experiments carried out at Kawanda Research Station to determine how NPK fertilizer influenced the yield of passion fruit did not furnish enough information to enable precise conclusions be drawn. Optimal fertizer application appears to vary from one place to another. But well rotted farm-yard manure or poultry manure can successfully be used at planting time and after every pruning. An application of about 025kg (½ Lb) of Single super-phosphate per plant at planting time will be beneficial.

Conclusive recommendations will be issued as soon as field trials have been completed.

d) Interplanting

It is a deserving idea not to waste the large spaces left in between the passion fruit rows. Annual crops such as egg plant, onions, carrots and some other short term vegetables can be interplanted with passion fruit in the first year when the fruit crop is just getting established.

Other crops such as maize, bananas, sugarcane which tend to drain the plant nutrients heavily from the soil should not be planted.

COMMON INSECT PESTS

A number of insects are associated with the passion fruit plant. Some of these insects are beneficial while others are harmful. The role of the beneficial insects as pollinators is well known.

Experience in passion fruit growing shows that the most important insect pests are:

a) Mealy bugs
b) Passion fruit mite
c) Fruit flies
d) Aphids
e) Whiteflies
f) leaf miners
g) Birds
h) caterpillars

a) Mealy Bugs

These are small, oval, sucking insects with a cottony white waxy covering to their bodies. Infestations generally occur on the tender floral buds and fruits. Adults and nymphs pierce the attacked parts and such the sap. The insect secretes a sugary substance over which a black coating develops. Such development interferes the food manufacture by the leaves and it downgrades the quality of the fruit.

b) The Passion Vine Mite

The passion mite may cause serious damage to the vines. Unless damage from these mites is checked the vines may die or the growth may be so adversely affected that there is a marked reduction in fruit. To the naked eye this mite appears as scattered, reddish patches on the lower surface of the leaves along the mid-rib and veins as well as on the fruit surfaces. The mites attack the young leaves and such the sap, the affected leaves are generally curled. As a result a heavy infestation may cause complete defoliation and the plant may eventually die.

c) Fruit flies

These insect pests puncture the immature fruits while the rinds are still tender. As the fruit enlarges a woody area develops around the puncture. If the fruit is still quite small and undeveloped, the damage may be sufficient to cause it to shrivel and fall from the vine. If the fruit is well developed, it may grow to maturity. At the time of opening, the area around the puncture has the appearance of a small woody crater which disfigures the outer appearance of the fruit but apparently does not impair the quality of the juice.

d) Aphids

Aphids infest passion fruit and plants and suck the sap. On fully grown vines, severe damage seldom results. On seedlings, however, aphids may cause severe damage. Aphids are known to be efficient vectors of passion fruit woodiness virus which is proving to be a serious disease of passion fruit in Uganda.

Occasionally however, there are sporadic attacks by caterpillars, snails/slugs, birds on the vines, fruits. This can be controlled by application of appropriate insecticides and bird scare or trapping.

Routine Pest Control Measures

The control of pests which attack the passion fruit involves two basic problems:

1) The destruction of insects which attack the plant
2) The preservation of the insects whose function in pollination is of vital importance to fruit set.

The problem is complicated because both beneficial and destructive insects are so closely associated with the plant. The injurious insects must therefore be eliminated without destroying the beneficial ones.

An approach to this problem is the proper timing of spray applications. Less damage to the beneficial insects may be caused when a farmer schedules his chemical spray application during periods when the pollinating insects are not active. Some of the chemical insecticides currently available in Uganda include Diaznon, Dimethoate/Rogor, Rocket and Ambush. These can effectively be used to control most of the insect pests with instructions from agricultural extension staff. Furthermore farmers are advised to read very carefully the instructions provided on the labels since most of them covers the range of insect pests they can destroy.

PASSION FRUIT DISEASES

Passion fruit diseases were not considered to be of any serious economic importance until 1969 when the vines were planted at Makerere University Farm; Kabanyolo as an estate crop. During the experiments, it was observed that one of the main drawbacks to the development of passion fruit growing could be the disease problem especially brown spot disease and woodiness virus, although the latter was not very serious at that time. but at the moment it one of the serious disease in passion fruit production

1) Brown spot disease – Altenaria passilorae

The disease is caused by a fungus known as *Alternaria passiflora*; this is characterized by the development of brown spots and lesions on the leaves, stems and fruits.

The attacked stem normally turns brown and this leads to ring barking. As a result the functions of the plant tissues which are responsible for carrying food from the leaves to the roots and vice versa are interfered with and there is subsequent die back. As the infection a progress, the spots enlarges, forming a series of concentric rings and the infected leaves and fruits may fall prematurely. The vines may wither from the affected parts upwards particularly after the stem has become desiccated. The quality and quantity of the fruit juice may be reduced. The fruits

may also shrink and drop from the vine. When the attack is very severe, fruits begin rotting either from the stalk or from the bottom producing a brown colour in the attacked parts.

The disease may infect vines of all ages. Humid conditions, accompanied by slightly higher temperatures than normal may accelerate the spread of the disease.

Control of Brown Disease

a) Field hygiene

This involves the constant removal of all infected material which should be burned or buried at least once a week. The pruning frequency should also be increased during humid periods when the disease appears to spread very rapidly.

b) Chemical Control

Besides keeping the vines reasonably exposed to the sub by judicious pruning, regular spraying is very necessary to reduce losses where the disease is prevalent. Fortnightly to monthly spraying with Dithane M45 at the rate of 30g in ten litres of water, depending upon weather conditions is recommended. If the attack is very severe spraying can even be done weekly. Thorough coverage of the spray is very essential and, to improve this soluble strength wetting agent (Teepol) should be added to the spray. Although there is no experimental proof, some farmers have found the use of powdered detergent like OMO to be a very good substitute for teepol.

2) Woodiness disease

The disease is caused by a virus. The infection is characterized by grossly misshaped fruits which show abnormal thickening and hardening of the tissues of the fruit wall and a reduced pulp cavity. The foliage becomes mottled with dark green areas localized on the raised portions of the leaves. The leaf colour between dark green and the raised areas is yellow green (mosaic appearance). The leaves are frequently misshaped and reduced in size. In some instances there is lack of growth of the terminal shoot accompanied by a bunchiness of the harsh-textured terminal leaves. The disease is one of the most serious diseases of passion fruit and may curtail the commercial life of a vine-yard. The virus is spread by aphids, by the transfer of sap from diseased to healthy plants during pruning and other cultural operations.

Control Measures

Woodiness cannot be controlled by fungal sprays, it is therefore recommended that plants showing typical symptoms of the disease be uprooted and burnt.

Plant hygiene measures should be practiced, especially during training and pruning.

Pruning knives should be sterilized wither is a solution of bleach or any other disinfectant, both before and after use Passion fruits should never be planted again in the same field or in the immediate vicinity particularly where a severe attack has occurred.

3) **Fusarium Wilt**

Fusariam wilt is yet another serious disease in Passion fruit particularly the local purple and the Kawanda hybrids. The disease is soil borne, which means that the fungus lives in the soil from where it attacks the rooting system of the affected plant. The disease spreads upwards along the stem and one can easily recognize brown patches scattered on the stem. The brown patches can easily be mistaken for the brown spot disease and can only be diagnosed by an experienced person. Since the attack originates from the roots the translocation of water and minerals from the soil are interfered with, the plant starts to wither and eventually it dies.

Control Measure

There is no control of this disease once it attacks the plant. A farmer is advised to uproot the plant and burn it and never again to plant that passion fruit which is very susceptible to this disease on the same soil.

Yellow passion fruit is somehow resistant to this disease which researchers are advising farmers to use as a rootstock against this disease.

HARVESTING

Passion fruits mature in about 70 days after fruit setting when they should show a pronounced purple colour. Mature fruits fall to the ground and, when harvesting, vines should be shaken to dislodge any fruit which have been caught in the foliage. Fruits should be harvested in the early morning and kept as cool as possible during handling. During hot seasons, when temperatures are high, it is usually necessary to harvest two to three times daily to avoid fruit sun scorches.

Alternatively, to reduce frequent harvesting during hot weather, a narrow strip under the rows of vines is often allowed to develop a cover of weeds and grass to protect the fallen fruits from the sun burn. Care should be taken to avoid bruising the skin and the fruit should be place, not dropped into the picking container.

It is extremely difficult to determine an average yield per plant, since yields vary considerably according to climatic conditions, age and number of plants per unit area, the trellising system adopted, the pruning methods, disease and insect pests problems and the type of clone or cultivars planted. The bearing behavior of most of kawanda hybrid passion fruit forms has a characteristic pattern, namely a small crop in the first season after planting, followed by a heavy crop in the second and possibly third season, thereafter, a fairly rapid decline.

Owing to the fact that the economic life span of this hybrid is considered to be three to five years, a yield of about 15,000 – 18,000kg/hectare could be expected in a good fruiting year.

PACKING AND MARKETING

Passion fruit is generally wet when picked in the morning. The fruit should be allowed to dry before packing, and all shriveled deformed or damaged fruit should be discarded. The fruit should if possible, be graded into “small”, medium” and “large” sizes to facilitate packing.

Excellent opportunities have existed for increasing the export of passion fruit abroad, notably in Continental Europe. The fruits are packed in paper containers provided to the specifications of the importers. The approximate count and weight is marked on the containers.

Locally, the fruits might have several markets. The passion fruits for processing are harvested in hessian bags since the appearance of fruits is not important.

Fruits are sold almost in all consumer stores in all towns in Uganda and it is not very uncommon to find vendors moving from hospitals, shops or house to house looking for passion fruit buyers.

CALENDER OR SCHEDULE OF ANNUAL OPERATION (SUMMARY)

Uganda has a bimodal distribution of rainfall. March to may season represents the first rains which give a heavier rainfall then the second rains which cover the months of August to November.

The following schedule of annual operations in a normal year may be recommended as an aid to successful cultivation of passion fruits.

1st Year

1) Plant the cuttings or sow your seeds in the nursery bed/seed box between November to December since the planting materials normally take about three months before they are ready for transplanting in the fields.

2) Plough the proposed site for the plantation between Decemner to Jamuary so as to allow the soil to weather and the manure to undergo thorough decomposition.

3) Re-plough the field early in March when it has just started raining, a few weeks before transplanting the rooted cuttings/seedlings. If necessary light watering may follow planting.

4) A few weeks after transplanting between March to April numerous lateral shoots which appear at the base of the plant should be cut off leaving only one healthy sucker to develop to form the future frame work of the plant.

   Spraying against diseases and insect pests may be carried out at this stage and may continue for the whole life span of the plantation.
   A short term cash crop such as beans may be planted in between the rows.

5) May to June – Support the climbing sucker on a tall stake, meanwhile remove all the lateral side branches that may arise from the stem. At the same time make arrangement to erect the trellising poles along with the strained wire they carry.

6) By July the climbing plant is ready for training on the trellis wire regardless of the method adopted. Weeding may commence and if possible mulch individual plants.

7) August – Light pruning is done to enable the laterals arising from the main stem to hang down freely. This is done by removing some few suckers along with some tendrils which might cause the vines to intertwine.

8) A few flowers may start appearing (in case of cuttings) during this time. It is recommended that such flowers should be removed at this stage since the plant is too young to endure the heavy burden of flowering and fruit setting at an early stage.

9) September – Onwards – light pruning follows and in case the plant was left to flower a few fruits may appear which can mature in about two months after the appearance of the flower and successful pollination and fertilization (fruit setting).

2nd Year

10) December – March (2nd Year) the plants may drop off leaves and sometimes the lateral branches may yet dried up. These should be removed regularly accompanied by spray (March 2nd year). On the on set of rains, the plant growth is re-activated and is follows by profuse flowering. It is at this time that pollination and fertilization (first setting) takes place and fruits rich develop at this time give rise to a heavy first crop harvest in June early/August.

BASIC COSTS OF PASSION FRUIT PRODUCTION

The costs for establishing a passion fruit vine-yard are ever increasing and for a successful production a farmer is advised to consider the costs for the following items:

1) Bush clearing
2) Ploughing
3) Hole digging (Man days)
4) Trellising poles
5) Trellising poles
6) Trellising wires
7) Fertilizers (manures)
8) Fungicides
9) Insecticides
10) Cultural operations

    a) Weeding
    b) Pruning/spraying
    c) Harvest/packing
    d) Marketing

APPENDIX A

CONVERSION FACTORS

LENGTH

Basic Units of Length
British Units

12 inches	=	1 Foot
3 Feet	=	1 Yard
220 Yards	=	1 Furlong
8 Furlong	=	1 Mile

Metric Units

10 Milimetres (mm)	=	1 Centimetre (cm)
10 Centimetres	=	1 Decomeetre
10 Decimetres	=	1 1Metre
(1 M = 100cm, 1M	=	1000 mm)
10 Metres	=	1 Dekametre
10 Dekametres	=	1 Hectometre
10 Hectametres	=	1 Kilometer 9 1 Km = 1000 M)

Conversion Factors

1 Inch	=	25.4 Milimetres
1 Foot	=	30.48 Centimetres
1 Yard	=	0.9144 Metre
1 Mile	=	1.609344 Kilometres
1 Centimetre	=	0.393701 Inch
1 Metre	=	1.09361 Yards
1 Kilometre	=	0.62137 Mile

"Indian Standard Conversion Tables for ordinary use.
IS: 1020 June 1967, Indian Standard Institution
University Road. Civil Lines, New Delhi. Re.

British Units:

144 Square Inches	=	1 Square foot
9 Square feet	=	1 Square yard
4,840 Square yards	=	1 Acre
640 Acres	=	1 Square mile

Metric Units

100 Square Millimeters	=	1 Square Centimetre
100 Square Centimetres	=	1 Square decimeters
100 Square Dectimetres	=	1 Square Metre
(1 Sq M	=	10,000 sq cm)
100 Square metres	=	1 Heciare or 1 Sq, Hecto metre
100 Hectares	=	1 Square Kilometre

Conversion Factors

1 Square Inch	=	6.4516 Square centimeters (exact)
1 Square foot	=	9.2903 sq. Decimetres
1 Square Yard	=	0.83613 Sq. Metre
1 Acre	=	0.404686 hectare
1 Square Mile	=	2.58999 square Kilometres
1 Square Centimetre	=	0.155000 Square inch
1 Square metre	=	1.19599 square yards
1 Hectare	=	2.47105 Acres
1 Square Kilometre	=	0.386101 Square Mile

WEIGHT

Basic Units of Weight

16 Drams	=	1 Qunce
16 Ounces	=	1 Pound
28 Pounds	=	1 Quarter
4 Quarters	=	1 Hundred weight
20 Hundred weights	=	1 Ton

Metric Units

10 Milligrams (mg)	=	1 Centigram
10 Centigrams	=	1 Decigram
10 Decigrams	=	1 Gram (1 g = 100 mg)
10 Grams	=	1 Dekagram
10 Dekagrams	=	1 Kilogram
10 Kilograms	=	1 Myriogram
10 Myriograms	=	1 Quintal
10 Quintals	=	1 Metric tone
(1 M. tone	=	1,000 kg)

Conversion Factors

4 Gram	=	0.0352740 Ounce = 0.085735 Tola
1 Kilogram	=	2.20462 Pounds = 1.07169 Seers
1 Metric Tonne	=	0.98420 ton = 26.7923 Mauund
1 Ounce	=	28/3495 grams
1 Pound	=	0.4535942 Kilogram
1 Ton	=	1.01605 Metric tones
1 Tola	=	11.6638 Grams
1 Seer	=	0.93319 Kilograms
1 Maund	=	0.373242 Quintal
9 Pounds	=	350 Tolas (exact)

APPENDIX C

THE EDIBLE FRUITED PASSIFLORAS GROWN IN UGANDA

Serial No.	Common name	Botanical name	Colour
1	Purple passion fruit	Passiflora edulis Sim.	Purple
2	Yellow passion fruit	Passiflora edulis flavicarps Dagner	Canarry
3	West Indian Sweet (Hard-shelled passion fruit)	Passiflora maliformis L.	Yeallowish brown
4	Kawanda Hybrid		Purple

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