THE CULTURE OF THE PAPAW*

THE papaya (*Carica papaya*, L.), or papaw as it is popularly called in South Africa, is indigenous to Tropical America, but its exact origin has not been determined. Related species grow wild in that country, and the papaw is believed to have originated from a cross between two of them. It is an important crop and is at present grown in practically all the sub-tropical and tropical countries of the world. As a health-food the papaw has few equals, and it should receive wider recognition in countries outside the tropics.

DESCRIPTION

The papaw is a large herbaceous plant with a hollow and fibrous trunk. The leaves are usually seven-lobed, two or more feet across, and are borne on long leafstalks, so that the general appearance of the tree is somewhat palm-like.

The groves in South Africa are mostly composed of dioecious varieties (male and female flowers borne on separate plants) with a small percentage of monoecious types (male and female flowers borne on the same plant intermixed). With the exception of fruit and flower characteristics, these sex forms are identical in general appearance. The ordinary male and female plants are representative of the dioecious types.

Female.—The flowers are borne on short stalks, 1 to 3 inches in length, in the axils of the leaves, and are characterized by the absence of stamens. The fruit may be oval, pear-shaped or practically round.

Male.—The typical male or staminate tree produces its flowers in clusters on long pendulous flowering branches. Each flower usually has ten stamens and an abortive pistil. Under certain climatic conditions the pistil may on occasions develop normally and the male tree may bear a few fruits, which are usually cucumber-shaped.

Hermaphrodite.—The ordinary hermaphrodite tree is typical of the monoecious types, which may produce various combinations of male, female, and perfect flowers. (Perfect flowers are characterized by a well-developed pistil and stamens). Cucumber-shaped fruits are usually produced; but round, pear-shaped, or irregular fruits may occur in the same cluster with the first type.

The marked variation in the shape of the fruits on the same tree, and the low yield, are the chief objections against the growing of hermaphrodite trees on a commercial scale. The fruit of the female is fairly uniform and

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differs usually only in size, which characteristic, coupled with a good yield, makes the female the most desirable type to grow. It is dependent on the male, however, for the pollination of its flowers, such pollination is essential for the subsequent normal set and development of the fruit of the female tree. Since the fruit produced by the male may be regarded as inferior, the only necessary function of the male is to produce pollen for pollination purposes.

CLIMATIC REQUIREMENTS

The papaw is a heat-loving plant and is very susceptible to frost. In South Africa it thrives best in a sub-tropical climate as exists mainly in the eastern Transvaal lowveld and Natal, but is also grown in certain frost-free areas of the eastern Cape Province. Though atmospheric heat is conducive to fruit development and quality, sunburn does much damage to fruit that is exposed as a result of leaf reduction through frost, wind or other adverse conditions.

Strong winds carrying sand and grit may injure the tender skins of immature fruits, causing the white milky juice (papain) to ooze through the injuries. Such damage renders the fruit unsightly and impairs its keeping qualities. It becomes necessary, therefore, to consider such factors as natural and artificial protection (windbreaks) against wind and frost when a site for planting papaws on a commercial scale is selected.

Under climatic conditions of high relative humidity and comparatively high atmospheric temperatures, papaws thrive but the fruits may not colour up sufficiently when reaching maturity and may remain pale green. Notwithstanding the excellent eating-quality of the ripe fruit, the lack of colour will affect the market price adversely. Experiments have shown, however, that colour may be improved by selection.

SEED AND SELECTION

Since the papaw is cross-pollinated, the progeny is usually very variable, and therefore it is of the utmost importance for the grower to obtain his seed from a reliable source where selection has been in operation for a number of years. If such seed is not available, the grower must select seed only from the best trees, attention being paid to the following points :—Vigour of trees ; size and shape of fruit ; colour of ripe fruit ; thickness of flesh ; quality, yield and optimum spacing of the fruit on the stem so that the shape of the fruit is not affected by overcrowding. The crop produced as the result of the first selection will necessarily be variable, but if the grower persists with this selection program he will be rewarded by an increasingly greater uniformity of the crop after each successive generation. This procedure has already been practised by some growers with considerable success.

It should be mentioned here that the senior author has already made considerable progress in the breeding of desirable and true-breeding papaw varieties. Small quantities of seeds of these strains will probably be available for distribution to farmers after another two to three years of experimentation.

SOWING OF THE SEED

Seedlings may be raised either in beds, in trays, or a combination of these two methods may be used.

Seed-beds.—A good bed should be prepared in the usual manner. The best time to sow the seed is from September to December. The beds are first watered thoroughly, and then shallow furrows, ½ inch deep and 9 inches apart in which the seeds are sown ¼ to ½ inch apart, are made across the bed. Cover the seeds lightly with soil, and water again. To prevent crust-formation, a thin layer of river-sand may be added and it is also advisable to shade the beds with grass or hessian. In order to control damping-off, which is a very troublesome disease when the plants are in the seedling stage, the beds should be well ventilated and not watered during the heat of the day. Some time after germination the seedlings are thinned out to allow a spacing of 2 to 3 inches between them in the row. If the surplus plants are lifted carefully they may be transplanted to an empty bed.

It is important to harden the plants before transplanting, by exposing them to the sun gradually and by watering them sparingly. The hardening-off process should start after the plants are approximately 4 inches in height. If the seedlings are inclined to become spindly, they may be topped a few inches above ground level. The seedlings are ready to be transplanted when they are 6 to 9 inches high. This stage is reached about 2½ months after the sowing of the seed. A few days before the seedlings are transplanted most of the leaves should be trimmed off. Irrigate the beds thoroughly shortly before transplanting in order to facilitate the lifting of the plants, which should then be taken out carefully and wrapped in wet sacking to minimize injury to the roots through exposure.

The disadvantage of this method is that unless climatic conditions are favourable the mortality of the transplants is usually comparatively high. A method which has been practised by a number of growers to lessen the mortality of transplants, and which has met with considerable success, is described in the following paragraph.

A tin can with the bottom removed, or a similar implement, is put around the seedling to be transplanted, and pushed downwards until the top of the can is level with the soil surface. The plant, together with the tin, is now lifted—there being no danger of disturbing the soil around the roots—and is then taken to the field. Here the tin is put in the required place and the plant together with the soil, is removed by exerting pressure on the soil in the tin. For an effective operation of this method it is necessary to have the plants well spaced in the bed.

Seed-trays.—Since papaw seedlings are especially susceptible to damping-off shortly after germination, the sowing of seed in trays is practicable only where this disease is not troublesome. It should be mentioned here that experiments have shown that conditions in trays are more favourable for the development of damping-off fungi than in beds. Where seedlings can be raised successfully in trays they may be transplanted at an earlier stage than those raised in beds. The result is a low mortality of transplants even under comparatively unfavourable conditions.

Seed-beds and Seed-trays.—A method combining the advantages of the growing of seedlings both in beds and in trays eliminates most of the objections against either practice. Sow the seeds in beds in the usual manner, and transplant the seedlings to trays when they are about 3 inches in height. Most of the leaves should be removed on the previous day and the beds well watered to facilitate the lifting of the plants. A tray, the size of a halved paraffin tin, has sufficient room for 30 seedlings. Water well and shade the trays for about ten days until the seedlings have become established. They are then gradually exposed to the sun and the amount of watering is reduced for approximately ten days prior to transplanting. The seedlings are ready to be transplanted three weeks after they have been set in the trays. We have found that very few plants are lost when this method is employed.

Strong tins may be cheaply constructed from sheets of galvanized iron.

INITIAL PREPARATION OF SOIL

Though the papaw will grow fairly well on soils of low fertility, growers are warned against the tendency to produce this crop under such conditions. For the best results, a soil rich in plantfoods is necessary and if the soil is deficient in any plantfood constituent, suitable fertilizers should be added.

The soil should be well prepared by ploughing and discing to obtain the required friable condition. To facilitate irrigation, the layout should be such that the rows will be on the contour allowing a regular slope to 1 to 2 per cent. The planting holes, approximately 2 feet in diameter and 2 feet deep, should be spaced 10 feet on the square. About 1 to 2 months prior to planting, apply one bucket of well-rotted kraalmanure and ¼ lb. superphosphate to each hole, and mix well with the soil.

TRANSPLANTING AND THINNING

Since, on the average, about 50 per cent. of the seedlings are males, that is, unproductive trees, it is necessary to plant 3 to 4 seedlings, one foot apart, in each planting hole. Transplant only on cool and cloudy days or preferably in rainy weather. The planting holes should be watered shortly before and immediately after the setting out of the plants. If possible the transplanted seedlings should be protected against the sun by means of grass shelters, until they have become established.

As soon as the plants start to flower they are thinned out to one, and occasionally to two, per planting hole, in such a manner that there will be approximately one male to every 20 females in the final stand. This ratio of males to females is necessary to provide adequate pollination for normal fruit development. Under favourable conditions ripe fruit may be picked off a tree one year from the time of the sowing of the seed.

CARE OF ESTABLISHED PLANTS

Established papaw plants are comparatively drought-resistant. However, to ensure high yields and sound fruit, and to protect the fruits against sunscald, good leafgrowths should be encouraged by judicious irrigation. Some

growers believe that the quality of the fruit is impaired by irrigation during the winter months. This notion is, however, not supported by the results of our experiments and is apparently not well founded, when factors of low yield and sun-scald, as a result of reduced foliage due to lack of soil moisture, are taken into consideration. The frequency of irrigation during the dry period will depend on soil and climate and the size of the trees. In general, an irrigation every 2 to 3 weeks will be sufficient.

In our experiments, basin-irrigation has given excellent results. The basins are constructed around the trees and enlarged as the plants grow bigger, so that the whole root-zone area can be irrigated thoroughly.

The fertilizer program will depend on such factors as natural soil fertility, nature of previous fertilizer application, previous crops grown, and the condition of the plants. However, the following recommendations should serve as a general guide for fertilizer application.

As soon as the plants have become established, a light top-dressing of quickly-available nitrogenous fertilizer such as nitro-chalk, sodium nitrate or ammonium sulphate, should be given and its application repeated two months later. Under average conditions, an annual application of approximately 10 tons of kraalmanure and 700 to 800 lb. of superphosphate per morgen should keep the soil fertility at the required level.

During the summer months, a cover-crop such as sunnhemp can be grown between the rows. This will help to remove excessive soil moisture during the rainy season, will control weed-growth, and will maintain the organic matter and nitrogen content of the soil.

Root-cutting is harmful, and discing should therefore be resorted to instead of ploughing. Do not disc too deeply or too close to the trees when fertilizers or cover-crops are incorporated with the soil.

HARVESTING, PACKING AND MARKETING OF THE FRUIT

The harvesting season usually starts in April and may last until the end of December, with the peak during September and October. In cooler climates the initial ripening of the fruit may be delayed till spring, in which case the picking season may extend to January or February. Under favourable growing conditions brought about by factors such as judicious irrigation during the dry season (May to September), a high soil-fertility level, and other cultural practices, the plants may continue to flower and set fruit, and thus serve to prolong the marketing season, within limits. Yields may vary from 20 to over 150 fruits per tree, depending on climate and soil.

The stage at which papaws are to be picked will depend chiefly on the distance from the market and the season. Midwinter fruit should be picked at a much later stage than spring or summer fruit, because of the marked effect temperature has on the speeding-up or retarding of the ripening process subsequent to picking. Fruits picked too early do not develop the required flavour, texture and colour, whereas fruit picked at too mature a stage will lack keeping quality. The best guide is to pick at the latest stage possible for the fruit to reach the consumer in a sound condition.

In order to reduce wastage, the fruit should be handled carefully during havesting, transport and packing. The use of picking-gloves will minimize fruit injuries during picking, and will also protect the picker's hands against the milky juice of slightly immature fruits. Such juice, owing to its strong digestive action, may in the long run cause considerable discomfort. The picked fruit is placed in woodwool-lined lugboxes and carted to the packhouse to be graded and packed.

The number of fruits per standard papaw box measuring 18 in. by 12 in. by 6 in. varies from 4 to 7 (depending on size). Medium-sized fruit which allows the packing of 6 fruits per standard box is preferred. It is important that the fruits packed in the individual boxes should be at the same stage of maturity. Papaw boxes must be limed with woodwool, and the fruit packed firmly in woodwool with a thin layer of woodwool placed on top before the lid is put on. For sending to distant markets, it is preferable to wrap the individual fruits in ordinary large-sized fruit wrapping paper.

For marketing under the National Mark Scheme, the following regulations should be observed :—

Papaws must be graded as follows :—

1. (*a*) *First Grade.*—Papaws must be free from blemishes, injuries and bruises. Fruits packed in the same box must be at the same stage of ripeness, uniform in size and of one variety only. Fruits must not be too green or too ripe, and the flesh must be firm.

(*b*) Fruit must not vary more than 5 per cent. from the foregoing requirements in respect of condition and external appearance.

2. (*a*) Only new and clean boxes must be used.

(*b*) The boxes must be of the following external dimensions : length 18 in., width 12 in., depth optional.

3. (*a*) Papaws must be packed wrapped.

(*b*) Boxes must be packed to full capacity.

(*c*) Fruit showing signs of any disease must not be packed under the National Mark.

(*d*) The count must be clearly marked on the boxes.

Further particulars in this connexion may be obtained from the Bureau of Domestic Markets, P. O. Box 8,045, Johannesburg.

PAPAIN

The milky juice which exudes from green fruit when the skin is lanced contains the ferment papain, which is considered to be a very valuable ingredient in medicine as a remedy for certain digestive troubles.

In the light of the unpublished investigations of H. van Elden of the Subtropical Horticultural Research Station, Nelspruit, and the experience of other workers, the procedure for the extraction and drying of papain may be briefly summarized as follows :—

Contrary to the general conception that non-metallic knives should be used when lancing the fruit for the extraction of the milky juice, it was found by van Elden and others, that special steel knives may be used without discolouring

the latex. A steel-bladed knife has the advantage that a clean light incision can be made rapidly, without getting any of the green chlorophyll in the exuding juice.

The latex containing the papain is best obtained from full-grown, or nearly full-grown, well-developed green fruit by making 2 to 4 longitudinal incisions not more than $\frac{1}{8}$ in. deep. This operation may be repeated every 3 to 7 days. It has been found that better yields are obtained if only a few incisions are made at a time, the tapping being done over a long period until the fruit is covered with incisions approximately 1 cm. apart. The flow is most abundant in the early morning. Very young fruits give a latex that is rather weak in digestive power, while ripe fruits give very little, if any, milky juice. In South Africa we have a more or less definite period, from February to August, for tapping.

Only non-metallic containers, such as glass or porcelain dishes, should be used to collect the latex, because the juice acts on the metal and becomes discoloured. Coagulation soon begins and the mass adhering to the surface of the fruit must be carefully scraped off. Considerable time and labour would be saved if a convenient and efficient vessel could be devised which could be quickly put in place to receive the juice, permitting the operator to proceed to the next tree in the meantime.

The juice must be dried promptly after it is collected or decomposition, which destroys the value of the product, will occur. Sun-drying is practised to some extent, but it is much more satisfactory to dry the latex in a properly ventilated oven operated at 50 to 55° C.

One form of drier is about 3 feet broad, 3 feet deep, and 6 feet long. The sides and ends are made of brick, and openings are provided at both ends, one for the flue and the other to admit fuel. A foot from the top, which is open, a sheet of iron is placed, and upon this one or two inches of sand are laid to modify and distribute the heat arising from the fire beneath. The coagulated juice is spread upon brown linen stretched upon frames, which are made to fit the top of the drier. The temperature should not exceed 50 to 55° C., since great heat destroys the ferment. The dry and flaky material can be ground in a coffee-mill, preferably when the material is warm, and it should then be in the form of a light cream-coloured powder, this powder should be placed in bottles, which should be tightly sealed.

Little information is available as to yields. Amounts of papain extracted per plant vary considerably; 20 to 250 grams per tree, or from 60 to 350 lb. of dried latex powder per morgen may be produced. Coagulated latex produces 25 per cent. of its weight of dried powder. The latex is harvested through three seasons. By the fourth season the fruit is so high on the trunk that the cost of collecting the juice becomes prohibitive.

The price of the crude product is in the neighbourhood of 10*s*. per lb. It is a debatable point whether the production of papain is South Africa will be a paying proposition. Factors which will decide this favourably are cheap labour and high yields. The lancing operation, though it does not affect the quality of the ripe fruit, renders such fruit unsightly and hence unmarketable.

Such fruit is valuable in processing, since quality only, and not outward appearance, is the chief consideration here. It is considered that the collection of papain may become a profitable sideline in this and other countries, provided that it can be produced in conjunction with the manufacture of other by-products such as canned fruit pulp, conserve, butter, chutney, jelly, &c.

USES OF THE PAPAW

According to Livingstone, the leaves, stems, roots and fruits of the papaw, can be put to fifty different uses of which only fifteen have so far been utilized. The fruit may be canned—as butter, chutney or jelly—be crushed for soda fountain use, or used as ice-cream flavouring or for syrups. The ripe fruit is frequently used in fruit salads or cooked as a vegetable. Rind and seed are processed for sale as a pickle relish. It is said that tough meat may be rendered tender by cooking it with green papaw fruit, or wrapping it in crushed papaw leaves. The fruit contains vitamins A, B, C and D which are vital for health.

The following recipes are given by Pope :—

Papaw Cocktail.—Cut papaw in dice or balls and serve in glasses with cocktail sauce and chipped ice. Or serve in the same manner with orange, lemon or lime juice, and a little sugar.

Papaw Whip.—To 1½ cups of papaw pulp, add juice of 1 lemon, ½ cup sugar and beat into 2 stiffly-whipped whites of eggs.

Papaw Pickle.—Make syrup of 1 measure sugar and ½ measure vinegar. Add a few whole cloves and peppercorns and 2 measures of half-ripe papaw cut into small pieces. Boil until tender.

Orange and Papaw Butter.—To 1 measure papaw allow ½ measure oranges. Wash oranges well. Squeeze out seeds and juice. Put skins through a meat chopper and add to the juice, strained free from seeds. Add papaw pulp cut in small pieces (without rind) and boil all together ; then add as much sugar as pulp. Boil again for 15 to 20 minutes.

Baked Papaw.—Cut papaw in halves lengthwise. Add a little sugar and orange, lime or lemon juice, or a little cinnamon in place of the juice. Bake 20 minutes and serve immediately on taking from the oven. This is a vegetable.

Green Papaw Preserve.—Cut the fruit into slices. Peel and prick well on all sides. Cut into required sizes, put into lime water (1 tablespoon lime to 12 cups water) and leave overnight. Drain and place the fruit in a boiling syrup made of equal quantities of sugar and water. (Allow 1 lb. of sugar for every 1 lb. of fruit). Boil until the fruit is transparent and the syrup of the right consistency.

Green Papaw (Vegetable).—Papaw, as a vegetable, is not unlike vegetable marrow. The papaw must be very green, *i.e.*, the flesh still quite white. Boil rapidly. When tender, strain, mash or leave in little cubes. Add butter and salt to taste.

INSECT PESTS AND DISEASES

Fortunately, the papaw has very few enemies. Insect pests are of minor importance and these will therefore not be mentioned here.

There are only two papaw-diseases that are of any consequence in South Africa, and these are described below.

Foot-Rot Disease.—The general symptoms of this disease are the following :— A marked reduction in growth vigour of mature plants, resulting in a yellowing of the leaves and, in extreme cases, complete defoliation. Examination of the base of the trunk will reveal that rotting of the stem slightly above and below ground-level has started. According to Wager the disease, which is caused by a Pythium fungus, becomes evident when the plant is subjected to unfavourable growth conditions such as poor drainage and poor soil fertility. When these unfavourable factors are remedied, the disease may be easily controlled.

The Pythium fungus is sometimes very troublesome in seed beds where it may cause damping-off of the seedlings. To control damping-off, it is advisable to sow the seed in clean soil, if possible ; water only in the early morning or late in the afternoon, and provide good ventilation.

Stem Rot (Anthracnose).—The Plant Pathologist at the Sub-tropical Horticultural Research Station, Nelspruit, states that this disease appears in three stages on the papaw, *viz.*, on the fruit, causing a rot in black round spots from $\frac{1}{4}$ to 3 inches in diameter ; on the petioles ; and on the trunk. Infected petioles will remain attached to the tree after maturity, whereas healthy ones will fall off. The fungus may gain entry into the stem through such infected petioles. The rotting of the stem due to anthracnose differs from that caused by Pythium (described above) in that the infection in the case of the former is usually well above ground-level, whereas in the latter case it is at or just under ground-level.

The following are control measures. Remove and burn infected petioles ; if the infection is bad the trunks may be sprayed with a 4–4–50 Bordeaux mixture ; in severe cases the infected portion is cut away and painted with Bordeaux paste, which is made by mixing Bordeaux powder with raw linseed oil.

Any further information relating to the culture of the papaw may be obtained from the Chief Horticulturist, Box 994, Pretoria. Those who desire advice in connexion with (1) diseases of the papaw, and (2) insect pests attacking papaws, should communicate with (1) the Principal Plant Pathologist, Box 994, Pretoria, and (2) the Chief Entomologist, Box 513, Pretoria, respectively.