CHAPTER II

PRODUCTION

1. A Description of Pre-Harvest Factors Affecting Yield In Mango (Mangifera indica L)

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INTRODUCTION

The countries of the Commonwealth Caribbean have recently initiated programmes to develop mango and other fruit crops for domestic and export markets. Cultivation practices in mango are usually based on general principles of tropical fruit tree culture as there are few documented reports of research conducted on this crop in the region.

In this paper the pre-harvest factors affecting yield in mango are reviewed with particular reference to cultural practices, irregular flowering and nutritional requirements.

DESCRIPTION

Origin and Uses

The mango originated on the Indian sub-continent, and has been cultivated in that region for over 400 years. It has since spread throughout the tropics and has become naturalized in many areas. The mango was introduced to Africa about 1000 years ago, and arrived in the West Indies in the 1700's (Purseglove 1974 ; Cobley and Steele, 1976).

The mango is a popular fruit throughout the Caribbean, although commercial production is limited. Estimated total annual production in the region is approximately 200,000 tonnes, of which 40,000 tonnes (20 percent) is cultivated in established orchards, the major producers being Belize, with Jamica, Trinidad and the Windward Islands producing smaller quantities (Weir et al).

The majority of mangoes are produced from countless seedling trees growing wild or semi-wild, as volunteers, in cultivated areas, or planted in backyard gardens (Weir et al).

Mangoes are consumed primarily as fresh, ripe fruit; but the fruit may also be canned as slices or chunks in syrup, or used in the production of nectars or purees. Over-ripe fruit may be used in chutneys or pickles (Weir et al).

Botany

The mango tree is a large spreading evergreen, with a dense canopy which casts a characteristic deep shade on sunny days. The canopy often consists of a distinct crown of branches, but is often of indeterminate shape with long pendulous branches and no definite crown. The trees range in height, from 10 - 14 m, and may live up to 100 years (Cobley and Steele, 1976).

The leaves are alternate and simple, 12-40 cm long, up to 10 cm wide. The petioles are up to 10 cm long with a pulvinus at their base. The leaves are produced in irregular flushes during which a number of thin, flaccid, reddish-coloured leaves unfold, then become stiff and dark green as they mature (Cobley and Steele, 1976).

The inflorescence is a widely branched, terminal panicle 10-60 cm long, with 1000-6000 reddish-pink or almost white flowers. Both male and hermaphrodite

flowers occur on the same inflorescence, with only about 1-36 percent being hermaphrodite, this ratio varies between cultivars (Cobley and Steele, 1976).

Seedling mango trees begin to bear fruit after 4 - 6 years and production increases until they are about 20 years old, then declines. Production tends to be biennial and fruit take 2 - 5 months to mature. The mango fruit is a fleshy drupe 2.5 to 30cm long, and weighing from a few grams to 2kgs. Shape and size of the fruit may vary greatly between cultivars (Cobley and Steele, 1976).

Ecology

The mango thrives in a wide variety of soils, provided they are not water-logged, alkaline, or rocky; a pH of 5.5 to 7.5 is preferred. Mangoes may be grown at elevations from sea-level to 1330m in the tropics but do best below 665m (Purseglove, 1974).

Mangoes require a rainfall of 750 to 2500 mm per annum, preferably distributed into a distinct wet and dry season. The optimum temperature for growth is 21 to 27°C, and young trees especially cannot tolerate frost (Purseglove, 1974).

FACTORS AFFECTING YIELD

The yield of mangoes is highly variable and depends on the number and size of fruit produced, which in turn is determined by genetic and environmental factors. Genetic factors can only be altered through breeding, however the expression of the genotype can be influenced by environmental factors.

Any discussion of factors affecting yield can be divided into two sections: the first describing genetic factors, and the second describing the effect of environmental factors such as climate and cultural practices, on these genetic factors.

Genetic Factors Affecting Yield

Cultivar

Two main types of mango are generally recognized: the "Indian" and the "Indo-Chinese". The "Indian" types are usually monoembryonic (producing one seedling per seed), and are often highly coloured and fibreless with a distinct aromatic flavour. There are more than 1000 "Indian" type cultivars, included are the more important commercial cultivars, eg. Keitt, Kent, Palmer and Haden (Weir et al). However, the "Indian" type is usually very susceptible to anthracnose.

The "Indo-Chinese" type is polyembryonic (producing more than one seedling per seed), with fibrous, sweet-tasting flesh. The fruit lack attactive coloration and are usually poor bearers, however they are relatively resistant to anthracnose. (but see Thompson Chapter III).

A third type of mango is sometimes described: the "West-Indian" or "South American" type. It is polyembryonic, with fibrous, poor quality fruit, with a distinct turpentine flavour (Hobson, 1969).

The characteristics of several important West Indian cultivars are described in Table 1.

The initial choice of a cultivar will ultimately determine the bearing characteristics of the trees planted, and the response of these trees to subsequent cultural practices.

Flowering and Fruit Set

A mature mango tree in full bearing produces about 1000 infloresences, each with 500 - 6000 flowers. Therefore the potential yield is enormous. However, only 1-36 percent are hermaphroditic, and of these only 15-35 percent are pollinated, and only 0.1 - 0.25 percent reach the harvesting stage (Purseglove 1974; Cobley and Steele, 1976). Fruit drop occurs at all stages of development, and one of the main effects of environmental factors on yield is their influence on flowering, fruit set and fruit drop.

Fruit bud differentiation is thought to be determined by seasonal variations in the carbohydrate/nitrogen ratio and increase or decrease of carbohydrates particularly starch (Singh, 1968). Studies have shown a sharp rise in carbohydrates in shoots prior to fruit-bud differentiation. After flowering the reserve of carbohydrates drops and continues in a depleted stage until harvest. In an "off" year the maximum C/N ratio is reached a month earlier, but the highest value attained is lower than in an "on" year (Singh, 1968).

There appears to be a wide range in the C/N ratio favourable for fruit-bud differentiation in different varieties, and a high C/N ratio is apparently not always the criterion for flower-bud formation. Studies show that while a high C/N ratio and sufficient starch reserve in mango shoots may favour flowering, these by themselves cannot be taken as the decisive factors inducing flowering in different varieties (Singh, 1968).

Pollination is essential for fruit set, and is usually entomophilous. The flowers open during the night and early morning and are visited by short-tongued insects, primarily flies (Purseglove, 1974), but honey bees are also important.

Periodicity

Mangoes are generally irregular bearers, with a heavy crop in "on" years followed by a poor crop in "off" years, a phenomenon known as periodicity in cropping. Periodicity seems to be affected by the age of the tree, with younger trees being able to bear every year. Irregularity usually commences around 10 years of age and is more pronounced in neglected or wild trees (Singh, 1968).

It is generally thought that periodicity of flowering in mango is due to the depletion of food reserves during an "on" year. In addition the tree cannot grow as long as there is fruit on it. Thus the new flush of growth, which in turn produces infloresences, is delayed causing an "off" year (Singh, 1969).

This alternation of "on" and "off" years results in a rhythmic biennial bearing pattern, however various environmental factors such as frost or severe drought, may result in excessive flower or fruit drop turning an "on" year into an "off" year and setting up an irregular bearing pattern. Unfavourable conditions during an "off" year can delay the return of an "on" year, again resulting in an irregular bearing patter (Singh, 1969).

Climate

Rainfall

Mangoes require an annual rainfall of 75 - 250 cm per annum, of which the distribution is probably more important than the actual amount. Mango grows best when at least four months of dry weather occur from flowering to harvest (Mendoza and Suriyapananont, 1984). The onset of the dry period induces a growth check which promotes flowering (Anon, 1974; Anon, 1983).

There is some doubt as to the actual amount of water required during flowering and fruiting. While moisture is advantageous, during the period from flowering to harvest, rainfall promotes flower and fruit diseases. Rain during flowering is especially detrimental since it prevents pollination by insects resulting in heavy flower drop (Jackson et al 1984). In addition, rain, or even heavy dew encourages the flower disease anthracnose (Colletrotrichum gloeosporioides) (Wolstenholme and Mullins, 1982).

In general the fruit develop better in conditions of low atmospheric humidity, which lead to better colour, and decrease the likelihood of disease caused by fungi and bacteria (Mendoza and Suriyapananont, 1984). High humidity favours infection of panicles by powdery mildew (Oidium mangiferae) which results in a drastic reduction in yield (Wolstenholme and Mullins, 1982).

Light

Mango like all green plants requires light for photosynthesis. It is not certain if photoperiod influences time of flowering and season of availability, although flowering is generally initiated during the cool season when days are shorter (Mendoza and Suriyapananont, 1984).

The most noticeable influence of light is the development of the anthocyanin pigment responsible for the red to blue hue on the skin of mature fruit of various cultivars (Mendoza and Suriyapananont, 1984).

Temperature

Exceptionally high temperatures, combined with low humidity may induce parthenocarpy (small seedless fruit). More usually, low temperatures cause pollination failure or can lead to small seedless fruit in some cultivars (Wolstenholme and Mullins, 1982).

Cultural practices

Soil and Fertilizer

As mentioned before, the mango is able to thrive on a wide variety of soils. The presence of a large tap root enables the plant to utilize nutrient and food reserves far beneath the surface, and anchors the plant firmly.

Mangoes do best at a pH of 5.5 to 7.5. On acid soils, dolomitic lime should be applied to bring the pH as close as possible to the optimum of pH 6.8 (Hobson, 1969).

It is felt that periodicity in mangoes is conditioned by nutritional deficiency, mainly of nitrogen and proportionate increase and decrease of nitrogen in the tissues may be the main stimulus for growth or flower formation respectively (Singh, 1968). Excess nitrogen delays flowering, and contributes to the physiological disorders of "Soft Nose" and "Jelly Seed" (Mendoza, Suriyapananont, 1984).

Young trees require at least four applications per annum of a balanced fertilizer, such as 10-10-10, during the first two years, beginning with 0.1 kg per application in the first year (Hobson, 1969; Weir, et al). A rough guide to the quantity of fertilizer required is 0.5 kg per tree per year for every year of age of the tree, up to a maximum of 7 kg for older trees (Hobson 1969).

Once trees begin to bear, the nitrogen content of the fertilizer should be reduced to limit growth and stimulate bearing; types of fertilizer recommended include 16-9-18, 4-1-6 or 3-1-5 (Hobson 1969, Weir. Hobson (1969) recommends that bearing trees should always suffer from a slight nitrogen deficiency.

The frequency of fertilizer application should be reduced to twice per year for mature trees. The first half should be applied as soon as the first panicles are visible, and the other half as soon as the crop has been harvested (Hobson, 1969). Application of fertilizer should be followed by heavy irrigation where possible.

In addition to NPK fertilizer, 1.5 kg of magnesium sulphate per tree can be applied to mature trees. On calcareous soils, annual additional sprays of trace elements, especially zinc should be applied (Hobson 1969).

Increasing potassium and calcium levels decreases the likelihood of physiological disorders (Hobson 1969). The application of potash to trees with a high nitrogen level improves the colour and flavour of fruit. Potash deficiency is associated with small fruit and poor quality while excess potash causes increased physiological breakdown of fruit, due to calcium deficiency caused by high levels of potash in the soil (Mendoza and Suriyapananont, 1984).

Phosphorous deficiency is uncommon in mango, since the requirement for this element is low.

Spacing

The mango is intolerant of crowding and once the orchard becomes too dense, bearing is limited to the upper canopy (Anon, 1974). Crowding decreases the amount of light reaching the inner foliage, and creates a humid micro-climate conducive to disease. Trees may be planted at an initial spacing of 10m x 5m to fully utilize orchard space, however, well before crowding occurs trees should be thinned to a spacing of 10 m x 10 m.

Irrigation

Irrigation, where necessary, should commence only after the onset of flowering, and should cease after harvesting, a minimum of seven weeks (Mendoza and Suriyapananont, 1984; and Hobson, 1969). Infrequent heavy irrigations, penetrating to about 1.2 cm are preferable to frequent light irrigations (Hobson, 1969). It has been found that fruit from irrigated trees are up to 13-23 percent

heavier and bigger than those from non-irrigated trees (Mendoza and Suriyapananont, 1984).

Deblossoming

Deblossoming is the complete or partial removal of flowers or young fruits in an "on" year, in order to increase flowering the next year, thus resulting in a fair crop every year. Food reserves or any flow-inducing substances are conserved by removal of the infloresences in the early stages. Deblossomed shoots, instead of developing panicles and producing fruits, put out new vegetative growth with flowers and fruits the next year (Singh, 1968).

This technique has proved successful in biennial bearing varieties of apples, but its success in mango is not so well documented. The response of mango to deblossoming seems to be a varietal feature. In addition, the response is less marked in over-vigorous or vigorous trees. Severe deblossoming of up to half the tree seems to be necessary in order to get a satisfactory response, but more extensive studies are needed in this area (Singh, 1968).

Ringing

Flowering of mango trees in "off" years and increased flowering in "on" years can be successfully induced by ringing the branches. Ringing is best done by the means of half inch wide cuts immediately after harvesting, and the effect on flowering is seen during the next blooming. There is no residual effect. However, ringing as a regular practice is not recommended except in special cases, such as forcing of blossoming in over-vigorous trees; and the practice can be detrimental to older trees (Singh 1968).

Pruning

Pruning of mature mango trees is not usually required, nor is it recommended, however, training of young plants is essential in order to give them proper shape. This is especially true when the graft has branched too low. At least 75cm of the main stem should be kept free from branching, and the main branches should be spaced in such a way that they grow in different directions, and are at least 20 -25 cm apart. Branches which exhibit a tendency to crossing or rubbing each other should be removed in the pencil thickness stage.

Pruning of mature trees should be confined to the removal of diseased, pest-infested or dried shoots or branches (Anon, 1983).

Smudging

It has been found that mango trees can be made to flower at any time of the year by smudging, providing the tree is in a proper condition and the practice is common in the Philippines (Singh, 1968). During smudging the trees are smoked day and night for about a week from a specially prepared fireplace. Thereafter light fires are made morning and evening for a month or until the trees bloom.

There are conflicting reports in the literature as to whether it is the smoke/CO_2

or the heat which causes flowering (Singh 1968). However, more recently it has been suggested that it is the presence of ethylene in the smoke that induces flowering (Bondad, 1976).

Smudging is most effective when the last growth is well matured and the terminal buds are well formed. Although the method is successful in forcing flowering, it is laborious and expensive.

Bagging

Bagging is a technique that provides a physical barrier between individual fruit and the immediate environment, thus preventing contact between the host and the insect or fruit. Fruit are usually bagged 55 - 60 days from full bloom, and newsprint is the traditional bagging material in the Philippines where the practice is common. Polyethylene bags were found to be unsuitable. Bagging has been found to markedly reduce damage caused by leaf hoppers, anthracnose and stem-end rot (Mendoza and Suriyapananont, 1984).

Diseases and Pests

Mangoes are subject to attack by pests and diseases at all stages of development. Without an effective pest and disease control program, the harvest is considerably reduced. Major pests in the Caribbean region include fruit flies (Anastrepha spp.), scale insects, thrips and slugs. Major diseases include anthracnose (Colletotrichum gloeosperoides), powdery mildew and seedling leaf blight (Weir et al).

The appropriate insecticides and fungicides can be used to minimize the damage caused by pests and diseases, respectively. To be effective, control measures should be applied directly to the portion of the tree to be protected and during the weakest stage of development of the pest and disease (Jackson, et al 1984).

Chemical induction of flowering

In recent years, researchers have tested a wide range of growth regulators and other chemicals in an attempt to increase flowering in mango, and break the cycle of "on" and "off" years. The chemicals with the greatest promise are ethephon and potassium nitrate.

Ethylene in the form of ethephon can be used to induce flowering (Bondad, 1976) however, results are variable, and severe leaf abscission can occur when too high concentrations are used. Chacko et al (1974), based on experiments conducted in India, reported 200 ppm ethephon could be used to induce flowering and fruiting during the "off" year in the notedly biennial cv. 'Langra'. Higher concentrations of ethephon viz. 500, 1000 and 2000 ppm, induced moderate to heavy leaf abscission. Consecutive applications of 200 ppm ethephon for a period of three years did not cause any decline in the yield or vigour of treated trees.

Potassium nitrate can modify the flowering behaviour of mango, making it possible to produce fruit every year. In addition, the use of KNO_3 can advance the flowering and fruiting periods of mango by several months, and can induce

flowering of trees which remain vegetative, but are beyond normal bearing age (Bondad and Linsangan, 1979). The same authors report that spraying with concentrations of KNO_3 at rates as low as 10g/litre, induced 100 percent flowering in several Phillipine cultivars, within 7 to 14 days after spraying.

SUMMARY AND CONCLUSIONS

Mangoes are notorious for their irregular bearing pattern, and fluctuations in yield. The yield of mangoes is determined by a wide range of pre-harvest factors which may be classified according to (i) genetic or inherent factors such as cultivar, flowering characteristics and periodicity of cropping; (ii) climatic factors, such as rainfall, light and temperature and (iii) cultural practices such as fertilizer, spacing, irrigation, flower induction by various means and pest and disease control.

Genetic factors may be manipulated through breeding and through selection of appropriate cultivars for local conditions and potential markets and ongoing selection/screening of new cultivars is required.

Climatic factors are difficult to influence, but may be used to advantage by careful site selection.

Cultural practices are most amenable to change, and exhaustive research is required to determine the practices appropriate to the region, which will result in increased yield. The most immediate need is probably in the area of fertilizer use, in terms of amounts required, timing and composition.

Another promising area which could yield positive results in the near future is the use of growth regulators to induce flowering and even out bearing.

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