



TRAINING AND PRUNING THE MANGO TREE



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INTRODUCTION



Pruning (including training) is one of the most important activities to be performed on a mango plantation to obtain maximum quantitative and qualitative yield. The main objective of pruning in mango cultivation is to create a good tree structure that permits good light penetration, resistance to wind, less sensitivity to pests and diseases, and easy application of aerial treatments and harvest operations. Training in the tropics should be directed towards obtaining a quick start in production. However, in the subtropics, training should be performed in order to avoid starting production too early which can harm the creation of an appropriate canopy structure before allowing the first crop.

Most mango cultivars have a rather symmetric canopy. Earlier books devoted to mango cultivation in the tropics recommended the removal of dead branches and those broken by wind or weakened by disease as the only pruning practices. At most, only periodic control of canopy growth, both in height and lateral dimensions, was practiced with the aid of rotating saws in more mechanized plantings. It was only in modern mango cultivation that special attention was given to mango pruning in order to create a canopy well adapted to modern intensive mango cultivation.

The main reference books for mango [(de Carvalho Genú and de Queiroz Pinto (2002), Galán Saúco (2008), Litz, 2009)] have academic chapters or sections devoted to mango pruning and many other technical and scientific papers have dealt with this subject. Yet a simple, comprehensive recipe that can be used as a practical guide both in the tropics and subtropics for new mango producers, regardless of their academic background, is needed and is the goal of this report.



Training young trees

Since mango flowers mainly in the terminals (more branches produce more yield), the objective of training is to quickly develop a strong framework with many branches, well distributed along the stem. Adequate training and pruning maximize light interception and result in early production, higher yields, and better control of pests. While most current training aims to develop a mature tree with a spreading inverted umbrella or in a vase shape, a cubic structure is pursued for hedgerow conduction or to facilitate mechanical pruning.

It is generally recommended to keep trees in the nursery until they reach a height of 0.80 m (1 m for long pendulous growing cultivars like 'Keitt') before field planting. All lateral shoots produced below 0.80 - 1 m height should be eliminated in the nursery soon after they appear. Training should begin soon,

about 6-8 weeks after planting in the tropics, but should be done only under favorable conditions for growth, avoiding dry periods in non-irrigated plantings, excessive hot temperatures and cooler winter temperatures. This is especially the case in the subtropics in order to avoid undesired early flowering and vegetative growth.

The following steps should be followed both in the tropics and in the subtropics for training young trees. (Fig.1-5).



Fig.1 Initial pruning cut during training.
Photo: Dr. Maria Hilda Perez Barraza - INIFAP, Mexico

1. Cut the young tree to a single trunk at above 80 cm above ground (at least 1 m for the cultivar 'Keitt' or similar cultivars with long spreading shoot habit). Many cultivars exhibit a strong tendency to produce shoots from the same point on the stem, particularly if the cuts were made just above a terminal node, resulting in weak trees, susceptible to be broken by wind or by excessive fruit load. To avoid this problem, cut the stem just below a node to favor the development of several side shoots from the leaf axils which will then arise from different heights of the main stem.
2. After the initial cut, select 3-4 (preferably 3) healthy and strong lateral shoots emerging from different heights and with an angle of insertion to the main stem between 30 - 45° which will become the main branches of the tree. Once two mature flushes have been produced - approximately when they reach 40-60 cm in the tropics - cut them again below a node, selecting again 3-4 emerging shoots coming from each cut and continue doing the same process until the desired tree structure is achieved or until flowering. In the case of cultivars with long, pendulous habit like 'Keitt,' it may be better to do the successive cuttings after the production of only one mature flush.



In all cases, clean sucker growth from the rootstock by removing all growth produced below the grafting union. Any eventual inflorescence that may be produced, particularly in the subtropics during early canopy training, must be removed (see paragraph *Pruning for control of flowering*).

By the end of the third year after planting in the tropics or more preferably after the third cut, if the trees have developed a sound structure, the mango plant may be allowed to flower, either naturally if low temperatures conducive to flowering occur or by using growth regulators, stopping irrigation and/or nitrate sprays. The last cut is better done in early autumn to take advantage, when possible, of low winter temperature - inducing flowering.



Fig. 2. Young tree formed by 5-6 initial shoots coming from the same point of the stem. Weak tree susceptible to breaking by excessive fruit load.

A somewhat different approach to training has been recently proposed in Florida with a system that offers the possibility of training by combining bending with pruning following the procedure by Ledesma et al., (2016) which is described as: The grafted plant is tipped at 50 cm to induce precocious branching, maintaining two shoots which are tipped after the second vegetative flush. Then each branch is bent, pulling it down to the horizontal (fig. 6). This system has



Fig. 3. Young tree formed by 4 initial shoots coming from different points and with appropriate angles. Good canopy structure for heavy fruit load. Photo: Dr. Maria Hilda Perez Barraza - INIFAP, Mexico

proven to be useful for the cultivar 'Mallika' grafted on 'Turpentine' which develops a strong branch structure and initiates flowering only 10 months after planting.

More time may be necessary, even for the cultivar 'Mallika,' to properly evaluate this bending procedure which can produce and maintain small, mushroom-shaped trees capable of early production of large crops and high-quality fruit in the tropics. The procedure should also be validated for different cultivars, with different variants like the height of the

first tipping in different locations and the long-term effect of it in the full production phase, but it looks promising for mango cultivation.

Mangos can also be trained to grow on trellises with several strings at different heights. The plant should be allowed to grow to the height of the first string, and then the stem should be cut to obtain three shoots. Two of them will be conducted laterally along the string and the other will be allowed to grow erect until it reaches the second string when the process is repeated for the third string. Trellis systems are common in greenhouse cultivation in subtropical locations of Málaga, Spain, and in El Algarve, Portugal, at planting distances of 2.5 x 2.0 m with three horizontal wires, at around 1.00,



Fig. 4. Three year old tree formed from 3 initial shoots coming from different points and angle with the stem. Good strong canopy structure.

Photo: Dr. Maria Hilda Perez Barraza - INIFAP, Mexico

1.80 and the highest at 2.50 m above the soil level (Galán Saúco, 2015 and 2018). Cultivation of mango in trellises is also being studied in Australia and The Philippines and can be also useful for high density plantings in the tropics (Phelps, 2017). Cultivars like 'Keitt' with long shoots are better adapted to this system than other cultivars (fig.7).



Fig. 5. Young tree formed from 3 initial shoots coming from different points and angle with the stem with heavy load.
 Photo: Dr. María Hilda Pérez Barraza – INIFAP, Mexico



Fig 6. Training of trees combining bending and pruning.



Fig 7. Conduction of mangos in trellises. Photo IHSM. La Mayora-CSIC. Málaga, España.

Pruning adult trees



The objective of pruning an adult mango tree, both in the tropics and in the subtropics, is to obtain and maintain a productive tree, full of terminal bearing shoots able to produce well colored fruit of the size demanded by the market. Pruning can be done by hand or by machinery using rotatory saws. However, additional hand pruning is still needed, particularly in the interior of the tree.

During the early productive years until the trees attain the full allotted lateral size (touching the next tree within the line or occupying the maximum space allowed between rows to facilitate full machinery movement between rows or manual operations) pruning will be limited to:

1. Eliminate any diseased and dead inflorescences and those without fruits or with aborted fruits.
2. Cutting all flowering or non-flowering terminals just below the last node immediately after harvest to allow quick production of new shoots which become the new fruiting terminals for the next season.
3. Removing diseased and dead branches.
4. Removing all low growing branches interfering with irrigation management or machinery movement and any internal branches which impede light penetration.
5. Opening the inside of the canopy (once every 2-3 years) by eliminating those branches with

an angle of insertion lower than 45° and all shoots growing toward the inside of the canopy to allow air movement and better light penetration, reducing incidence of pests and diseases, producing more colored fruits, and having the additional advantage of obtaining cauliflory flowering in old wood (fig.8). This operation, as well as the removal of low branches, should preferably be done at the end of the winter to avoid burning of the exposed internal branches due to excessive hot weather or excessive sunlight. However, opening the canopy is not recommended in the subtropics because, due to the slower rate of vegetative development after pruning,



Fig. 8. Canopy opening
Photo: Dr. Maria Hilda Perez Barraza - INIFAP, Mexico

the exposed parts of the tree are not so quickly covered by the foliage and burning of branches can also occur due to exposure to the high summer temperatures. Those branches heavily exposed to the sun should be painted with white paint (vinyl or lime slurry) to avoid sunburn. A fungicide paste should be applied at the pruning cuts especially in the more severe cuts in humid and hot areas.

The pruning operation once trees have attained full size only differs from the earlier years in that:

1. All terminals should be pruned back (always behind a node) in order to maintain the trees at a diameter that permits the use of machinery and allows trees to just touch within the rows. This usually corresponds to the removal of the 2-3 flushes (approximately 0.50-0.75 m back with a width lower than 2.50 cm) produced during the last growing season in the tropics (1-2 flushes in the subtropics). It is more highly recommended to do annual pruning in order to avoid the need of severe pruning which can delay or even inhibit the next year flowering. Terminals should be pruned uniformly around the whole canopy to obtain synchronised vegetative growth which will give rise to synchronous flowering. This operation should be done after harvest in early autumn in order to get mature flushes when low

winter inducing temperatures are conducive to flowering.

2. Eliminate all vertical shoots.
3. Keep the tree at an appropriate height (usually 3.5-4.5 m).
4. If mechanical pruning is used, it is also recommended cutting only branches with a diameter lower than 2.5 cm (1 inch) all around the canopy, keeping the saws with an angle of 25-30° and trying to always get a pyramidal shape to obtain maximum light interception.

The most important reason for pruning is to stimulate uniform production of vegetative shoots for the following season. This is done to avoid competition for water and nutrients between young fruits and young shoots when temperatures are warmer. Because of this, as earlier indicated, it is imperative immediately after harvest to prune all flowering and non-flowering terminals by cutting them below the terminal node and irrigate and fertilize according to tree needs. Late cultivars like 'Keitt' or even 'Sensation' should not be pruned immediately after harvest under subtropical conditions. Otherwise, the subsequent vegetative growth will not have time to mature and flower in the next season and alternate or biennial bearing will occur. In these cultivars, selective pruning of all non-fruiting inflorescences or those with disease problems (e.g., anthracnose, powdery mildew and black bacterial spot) at the end of the spring is

recommended. A minimum of 25% of terminals should be pruned at this time (Galán Saúco, 2008). This selective pruning of part of the tree also preserves foliar surface area during the winter and increases available carbohydrates at fruit set. The other alternative for the subtropics done in Málaga, Spain, is the production of a crop every two years by the following procedure (Hermoso et al, 2018) (fig. 9):

Fig. 9. Induction of biennial bearing in the subtropics.
Photos: Emilio Guirado Sánchez. Spain.



Tree (cv. Keitt) with high production in the precedent year (seen in next spring year 'OFF').



Cutting point.



New shoots emerging after pruning.



Tree at the end of the summer.



Year ON (high yield) - Total or partial machete pruning of terminals to induce a second flowering. This is of great value for cultivars with big fruits like 'Keitt' because with the good fruit set obtained by this practice, the competition between fruits will produce moderate sized fruits preferred by the market.

Year OFF (without fruits) - Spring pruning of productive shoots of the previous year for production of vegetative shoots for next year 'ON.'

Even with adequate pruning, some trees (particularly cultivars with long spreading habit like 'Keitt' and especially young trees when heavy loaded with fruits) will require additional support for low branches to avoid



Fig. 10. Propping pendulous mango branches (Hainan, China).
Photo: Dr. Maria Hilda Perez Barraza - INIFAP, Mexico

fruits touching the soil. The most common system of propping includes the use of a simple supporting stake of around 1 m provided either with a hook and foam cushion or with a hole to which you can tie each of the low branches loaded with fruits. A different system is common in China where only one pole of around 2 m height is placed in the middle of the tree from which raffia tapes extend to each low branch requiring support (fig. 10).

Pruning for control of flowering

Control of flowering through pruning is a major issue during canopy training in the subtropics and in high altitudes in the tropics where winter temperatures low enough to provoke flowering even in nursery plants may occur. All eventual flowers produced during this period (2-3 years depending on cultivars) must be removed to avoid stunting of the trees. Although this problem can be managed with growth regulators like giberellins, the best

method is through manual removal of any appearing inflorescence by cutting them at least 5 cm below the terminal node when the fruits reaches pea size (Galán Saúco, 2008) (fig.11). This normally coincides with spring time when temperatures are not conducive to flowering. Shoots produced on the cut terminals generally develop vigorous vegetative growth instead of new inflorescences. The inflorescences should not be cut at an earlier stage to avoid production of new inflorescences instead of vegetative shoots.

Delaying annual flowering in adult trees to avoid flowering during low winter temperatures (below 15°C) is also very important for commercial cultivation of most mango cultivars in the subtropics or in those places in the tropics where low temperatures may occur during flowering. This is to avoid embryo abortion problems which initiate the production of fruits known as 'mangos niños' in México. Flowering can be delayed or eliminated to obtain a second flowering by manual or chemical means (Galán Saúco, 2008), but only pruning-procedures to obtain a second flowering with good temperatures conducive to a good fruit set of normal fruits are described below:

1. Cut all inflorescences immediately above the terminal node during the full flower stage (fig.12) by the end of winter/beginning of spring to ensure that low temperatures can still occur for



Fig. 11. Removal of inflorescences during training of mango trees.



Fig. 12. Removal of the first flowers and emission of a second flowering in the subtropics.

flower induction and emission of a second flowering.

2. Remove all young vegetative shoots present when cutting the inflorescences to eliminate competition for nutrients and to diminish the presumed flower inhibitor produced in the leaves, probably a gibberellin (Davenport, 1993).
3. If the removal of the first flowering is done in time, a second wave of flowering will occur in most terminals coinciding at the time of fruit set with the onset of warmer spring temperatures. These inflorescences emerge from the basal and axillary buds and generally set normal fruit rather than aborted ones. If the first flowering occurs very early in the season, as it occurs many years

in the subtropics, it may be necessary to wait until the fruits coming from this flowering reach pea size to ensure that new inflorescences develop under warmer conditions. Some cultivars, like 'Lippens' and many polyembryonic types, that are not so sensitive to embryo abortion may not require the delaying of flowering, but flower removal can be useful for the synchronization of flowering or for delaying the harvesting period if market demand justifies.

Fruit and shoot thinning

Thinning fruits in order to obtain adequate size fruits for the market can be useful in years of heavy load for some cultivars that produce several fruits at the same inflorescence. The recommended procedure may be to eliminate around 75% of the inflorescences around the whole canopy and keep no more than two or three of the biggest fruits in the remaining inflorescences. However, these figures depend on the cultivar and must be studied for each particular location. Thinning should be done when it is possible to distinguish normal fruits from those aborted (fig.13).

If foliage is too dense it may be advisable to eliminate part of it in the proximity of fruit to improve their color, but be careful to not expose them too much in order to avoid sunburn that will render the fruits unmarketable.



Fig. 13. Appropriate phenological stage for fruit thinning.
Photo: Dr. María Hilda Perez Barraza - INIFAP, Mexico

Pruning procedure for tree rejuvenation

This can be done to revert trees to a manageable size and shape, with the objective of creating well equilibrated canopy structure with plenty of terminals able to get heavy annual crops. The main objective of this pruning is to recover the productivity of an orchard once this has been lost because of aging and/or inadequate pruning. Trees of moderate size (3-6 m) may only require adjusting tree shape through a reduction of height and width to allow light penetration to the lower part of the canopy and start again pruning operations as it is recommended for adult trees, but old mango plants will require a more severe pruning.

The most usual procedure for this pruning that is usually done after an off year is as follows:

1. Cut the tree with a chain saw at a height of 1 m. If the tree was well formed normally, this cut allows keeping the three main branches (fig. 14). The cut should be done slightly obliquely to avoid water accumulation in the cut during the rainy season. The best time for this operation is at the beginning of spring to ensure quick regrowth after pruning.

2. Seal all the cuts with vinyl or similar painting and add copper hydroxide or an appropriate fungicide to the painting to avoid rooting.
3. Allow emerging shoots to mature and select and conduct the training as explained in the training section either by selecting three vigorous shoots from the single trunk or from each of the main branches if existing.
4. Do not allow the growth of many branches in the center of the tree in order to allow light penetration.

This operation should not be done during the dry season in non-irrigated orchards to avoid the risk of losing the trees.



Fig. 14. Pruning for tree rejuvenation.
Photos: Dr. Maria Hilda Perez Barraza - INIFAP, Mexico



Fig. 15 Pruning for tree rejuvenation in the "Ataulfo" cultivar. Tree is cut above grafting point.



Fig. 16 Pruning for varietal change. Tree is cut above grafting point. Photo: Dr. María Hilda Pérez Barraza - INIFAP, Mexico



Pruning procedure for varietal change

The procedure for varietal change basically does not differ from that indicated for rejuvenating old trees except that the cuts should be done below the grafting point (fig.15-16) unless having an interstock is desired. After the pruning, one should either do top working of the main trunk or grafting with the new cultivar on the selected emerging shoots produced after pruning. A different approach is taken in China where no pruning is done but all the terminals are grafted with the new cultivar (Fig.17). Although this may be quicker, it is generally too expensive especially in big trees due to the cost of hand labour.



Fig. 17. Topworking trees (Hainan, China).
Photo: Dr. Maria Hilda Perez Barraza - INIFAP, Mexico

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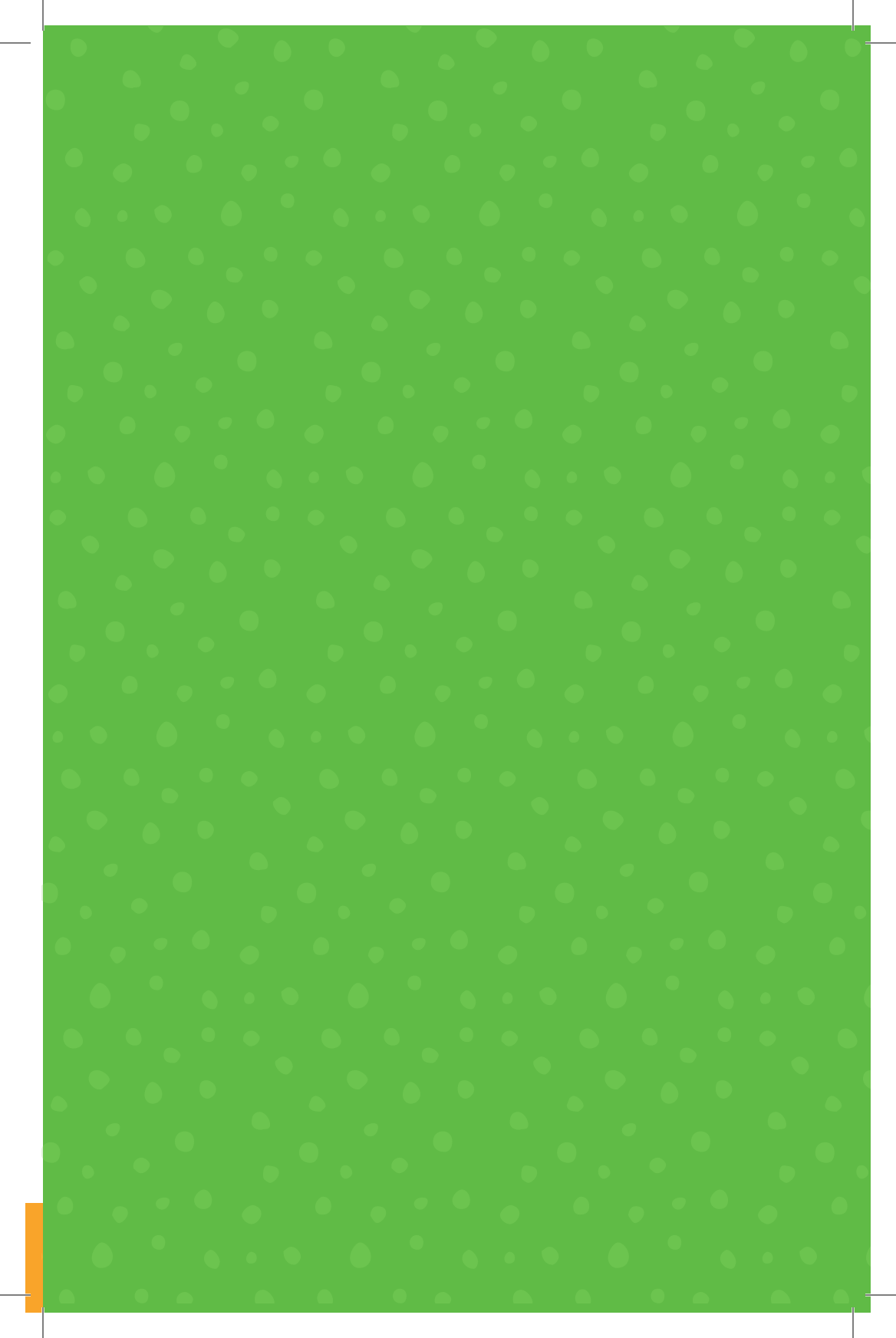
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