MANGO PRODUCTION MANUAL

Introduction

Mango (*Mangifera indica,* Linn) has an increasing commercial importance all over the world. Reputed as fruit of par excellence, it has assumed a leading position among commercial fruits being rich in vitamins, minerals, carbohydrates, proteins, anti-oxidants, and enzyme with stomach soothing properties. Aside from its contribution to the economy, it has also an ecological function since the tree prevent soil erosion and minimize greenhouse effect.

As an emerging tropical export crop, it is produced in about 90 countries in the world with a production of over 25.1 million tons. Asia is the main producer with 76.9% of the total world production, followed by America with 13.38%, Africa with 9% and less than 1% each for Europe and Oceania

Mango is considered as high value crop, with proper management and favourable growing condition, it could give farmers an average income of 250,000.00 pesos or more per hectare a year. Mango is a permanent crop and as it grows old, with proper management productivity increases. The variety of commercial importance in the country is 'Carabao,' it is known internationally as "Philippine Super Mango" and one of the world's best varieties. Due to its superior, it has a great demand both in local and international markets.

It ranked 3rd among the most important fruit crop, next to banana and pineapple in terms of area planted and volume of production. The mango industry of the country supports about 2.5 million farmers and contributes 17.91 billion pesos to GVA in agriculture with a domestic and export value of 41.60 billion pesos and 31 million US dollars for fresh mango production and 29.7 million US dollars for processed products.

In 2010, the area planted to mango is about 189,436 hectares with 8,526,816 bearing trees and production of 825,676 metric tons of fresh fruits (BAS, 2011). On the other hand, export of fresh fruits reach up to 15,010 metric tons, of which 68% went to Hongkong, 17% to Japan, 5% each to China and Malaysia and the rest to other countries (BPI-PQS, 2009).

Culture and Mangement

Requirements for ideal mango production

A geographical information system (GIS) map for mango developed by DA-Bureau of Agricultural Research (DA-BAR) could be used as guide in determining suitable areas for mango. The following condition should be given attention in selecting areas for establishment of mango orchards.

Distinct wet and dry season. During its productive years mango tree should be exposed to dry period of at least 4 to 5 months. This condition simulates "stress" necessary for the trees to accumulate reserved food and enhance maturation of leaves in preparation for flowering. In contrast, areas with continues rainfall tend to make trees more vegetative and difficult to induce. The following provinces are ideal for growing mangoes: Abra, Antique, Bataan, Batangas, Bulacan, Cavite, Cebu, Cotabato, (South), Davao (North and Southern), Guimaras, Ilocos Norte, Ilocos Sur, Iloilo (South and Western), Laguna (Western), La Union, Negros Occidental (Western), Negros Oriental, Nueva Ecija, Mindoro Oriental, Palawan, Pampanga, Pangasinan, Rizal, Tarlac and Zambales.

Ideally, the dry period should start from flowering and extend through harvest season. This condition also minimizes problem with diseases and hastens the development of high quality fruits.

Soil. Mango is not exacting with regards to its soil requirements, since the trees are deep-rooted and grow over a wide range of soil type and fertility levels. However, for commercial plantation, well-drained soil, moderately rich in organic matter with pH ranging from 5.5 to 7.5 should be selected but the most ideal is pH 6.5. Planting trees in waterlogged areas should be avoided to prevent depletion from oxygen and infection due to soil-borne fungus (*Phytopthora*).

Elevation. For commercial planting, it is recommended that mangoes should be planted at elevation not higher than 600 meters above sea level. Trees grown at higher elevation will have delayed flowering and fruit development and are susceptible to diseases.

Temperature. Temperature influences the period of leaf development, time of flowering and maturity of fruits. A mean temperature of 28°C is favorable for successful mango production. Avoid planting trees in high altitudes were temperatures oftentimes becomes low.

Rainfall. Generally as rainfall increases, the relative humidity also increases hence, incidence of diseases particularly anthracnose and scab are high and control measures are often not economical. Continuous rainfall also makes the tree more vegetative making flower induction difficult. On the other hand, rain at early stages of plant growth is necessary for fast establishment of trees in the field and early flushing of leaves.

Wind. High wind velocity experienced during the months of February and March enhances evaporation of water causing drying of soil and wilting of young plants. In windy areas, grafted trees tend to break-off causing mechanical injuries and subsequent fruit drops. Planting of wind breaks along the orchards perimeter can be done.

Planting materials. For the establishment of new farms, it is recommended that cultivars be chosen based on the resistance to pests, suitability to the site, yield potential and market preference. The following are the recommended strains of 'Carabao' mango as approved and registered in the National Seed Industry Council (NSIC): 'Golez Strain, (formerly 'GES 73'), 'GES 77', 'GES 84', 'GES 8', 'Lamao Strain No.1'. 'MMSU Gold', 'Sweet Elena', 'Talaban', 'Fresco', 'Tanaleon, 'Efondo', 'Guimaras Super ' (formerly 'Galila'), 'JTA Sweet', and 'P-1 King Rodolfo'.

Scions of these registered varieties/strains can be sourced-out from the NSIC registered parent trees or from established foundation/scion groves validated and certified by the Bureau of Plant Industry – National Seed Quality Control Services. Grafted seedlings are available in accredited nurseries of the Bureau of Plant Industry.

Mango Propagation

Mango can be propagated sexually using the seeds and asexually by means of vegetative parts. Propagation by seed is common, however under orchard type management, more growers prefer to plant grafted mangoes instead of seedlings since more trees are planted to a hectare and fruit production is much early.

Advantage of sexual propagation:

1. Trees planted from seeds are deep-rooted, as such anchorage and nutrient exploration are enhanced.
2. Yield of seeded trees are generally high as compared to grafted.
3. Long-lived. Mango trees continue to be productive over hundred years of age.
4. Easy and fast way of multiplying the variety.

Disadvantages of sexual propagation:

1. Seeded trees do not produce fruits that are "true to type." This means that seeds coming from superior fruits do not always come up to the expectations of growers. Hence, sweet and big fruits may not necessarily produce the same characteristics when planted from seeds.
2. Trees have enormous sizes (tall with large canopies). Many of the cultural practices like pruning, spraying, bagging and harvesting are difficult to implement.
3. Seeded trees take longer time to bear fruits. They produced fruits only after 10 to 15 years from planting.

Seeds as rootstock. One important use of seeds is to grow them as source of rootstocks. Healthy and vigorous rootstocks are the key to successful propagation of mango. Several cultivars such as 'Carabao,' 'Pico,' 'Katchamitha' and 'Pahutan' can be grown as rootstocks for 'Carabao' mango. Depending on the variety, rootstocks can be fast growing as in 'Pahutan,' medium as in 'Pico' and 'Katchamitha' and slow growing as in 'Carabao.' The kind of rootstocks used will also influence the size and height of the tree as well as the fruit quality.

Care and proper maintenance of seeds and rootstocks. Seeds should come from **matured** fruits**.** It should be free from insect damage, diseases or mechanical injuries. Avoid seeds coming from processing plants, since most of them are non-viable due to exposure from heat.

Dehusking or removal of the husk is recommended to facilitate fast germination. Be sure that dehusked seeds are plump and plant only those that are free from pest damage or physiological injuries. Healthy seeds should be sown with concave side down, 5 cm apart and 1 cm deep. This position prevents the development of crooked stem after germination.

Seeds may be sown in wooden seed box (20 x 20 x 3 inches) using a medium consisting 1 part compost or organic fertilizer, 1 part sand and 1 part garden soil. Under nursery conditions, a seedbed (2 x 8 m) is recommended. Sawdust or coconut coir can also be used as germinating medium. Germination starts at 10 to 15 days from sowing. Seedling is ready for transplanting 25 to 30 days after sowing or when it has 2-3 pairs of fully developed green leaves. Put seedlings in plastic bags, of 8 x 10 inches containing 1 part garden soil, 1 part sand and 1 part organic fertilizer.

When transplanting older seedlings, leaves should be cut into half to minimize transpiration. Otherwise, this may result to wilting and eventually death of seedlings.

Fertilization is needed a month after transplanting by applying one-half teaspoon of complete fertilizer per seedling or foliar spray of fertilizer with high in nitrogen (1 tbsp. per 20 li water). It is not advisable to fertilize plants immediately after transplanting. Fertilization is repeated at monthly intervals until the plants are vigorous and are ready for grafting.

Water is necessary especially during dry months. Mortality of seedlings is high when water becomes a problem. It is recommended that water should be directly applied in the bag and not poured on the leaves to minimize incidence of diseases specially anthracnose.

Growers should inspect the plants weekly for the presence of insects particularly scales, corn silk beetle, tip borer, cecid fly, thrips and disease such as anthracnose. Insecticide or fungicide should be sprayed when necessary.

Seedlings are ready for grafting when the stems attain 'pencil' size in diameter and are approximately 8 to 10 months old. Rootstocks like 'Pahutan' can be grafted when seedlings are 4 to 6 months old provided these are vigorous and healthy. 'Carabao' and 'Pico' usually are slow growers when used as rootstocks hence; these require longer time for development.

Seedlings should be grown under shade using nets or coconut leaves to prevent drying and scalding of the leaves from direct heat of the sun. Avoid putting the seedlings under mango trees for inoculums of diseases may transfer on the seedlings especially during rainy months.

Advantage of asexual propagation:

1. Asexually propagated trees produce fruits that are "true to type." When planted, the expected characters of the parents are carried to the offspring.
2. Earliness to bearing (precocity) takes a shorter time. Under proper management, grafted trees bear fruits 2 to 3 years after planting. However, it is recommended that the first 4 years of growth should be encouraged for proper establishment in the field.
3. Trees are small in size and several numbers can be planted to a hectare. In addition, many of the recommended cultural practices can be implemented without much difficulty (spraying, inter-row cultivation, bagging and harvesting).

Disadvantages of asexual propagation:

1. Grafted trees are shallow rooted and are easily uprooted by strong winds and typhoons.
2. It is a common notion that grafted trees have shorter life span. However, this is yet to be proven since the oldest grafted trees are approximately 90 years old, yet are vigorous and productive.

Cleft grafting. There are several methods of asexual propagation in mango (inarching, budding, marcotting and grafting). Cleft grafting is commonly used since it is easy to perform and percentage of success is high.

Steps involve in cleft grafting are as follows:

1. Collect scions from identified bearing mother trees. Cut scions to about 6-8 inches long. Scions should be healthy (free from pests) with well-formed buds and about pencil size in diameter. Preferably, these are exposed to sunlight and about 4-5 months from flushing.
2. Other practice includes defoliation of the leaves prior to cutting. This allows the scions to store food that enhanced for fast development of young buds. This practice is often done in small scale propagation of mango and is seldom followed in large nurseries.
3. In the process of grafting, select scions of similar size with the rootstock. Prepare the scion by removing the leaves. Make a perpendicular cut on both sides of the base to form a wedge shape tip.
4. With a sharp grafting knife, cut the rootstock 12 inches from the base. This will provide allowance in case union is not successful.
5. Make incision on the center of the cut portion, enough for the entrance of the wedge shape tip of the scion.
6. Insert the scion in the incision made on the rootstock. See to it that a contact is provided between the scion and stock. Wrapping the union or the point of contact with a plastic strip will insure good grip. This will also prevent the scion from tapering off during the healing process. It is recommended to wrap/cover the upper portion of the scion with plastic strips/bag to prevent drying.
7. When graft is successful, young shoots are visible after two weeks. Immediately expose the shoots by removing the plastic cover to allow subsequent growth. Do not remove the plastic strip that binds the scion and rootstock.
8. Place the grafts under shade and water them regularly. Fertilization can hasten growth. The grafts are ready for disposal or planting after 6-8 months, other farmers may prefer 2-year old grafts for field planting.

9. Hardening of grafts is recommended before planting. This is done by withholding water and gradual exposure of grafts to sunlight. This practice will allow the grafts to resist the harsh environment in the field.

Kinds of planting materials

a. **Grafted mangoes should be purchased from registered nurseries (certified plants).** Accredited nursery operators strictly follows the proper nursery management such as selection of seeds for rootstocks, care and maintenance of rootstocks, preparation of soil media, dehusking, germination, transplanting of seedlings, fertilization, watering, insect-pests and diseases control and grafting techniques. Above all, the scions are taken from registered mother trees.

b. **One-year old vs. 2-year old graft.** One-year old grafts are commonly used as planting materials for mango. However, when these are planted in the field, mortality is oftentimes high and replacement of trees would mean uneven growth. Thus, some growers prefer to use older grafts as planting materials. Although more costly, older grafts are easy to establish, mortality is low and trees flower earlier. The choice of planting materials therefore, depends on the capability of growers considering price, size of the farm and equipment available for hauling and planting.

c. **Single vs. multiple rootstock.** Aside from using single rootstock, growers are inclined to plant mango tree with two (dipod) or three (tripod) rootstocks using approach grafting or inarching. According to proponents of this practice, multiple rootstocks provide better absorption of water and nutrients hence, faster plant growth. In addition, it secures the tree on the ground thus, prevents uprooting by typhoons and strong winds. This method is however, not supported by research findings and is expensive on the part of small growers. Normally, approach grafting (dipod/tripod) is done to assist trees with defective root system especially those infected with disease. This method is also recommended for trees with poor anchorage in the soil. With mango, these problems are not so critical and use of single rootstock is still the best way to propagate the tree.

d. **In 'situ' grafting.** In places where availability of grafted mangoes is a problem, it is recommended to plant seedlings in the field following a desired spacing. When seedlings are about two years old, the branches are grafted with selected scions using the cleft method. With this procedure, several scions can be grafted to a tree. The advantages of in 'situ' grafting are that, management of seedlings in the nursery is omitted and percent of successful grafts is high. However, shading is recommended to prevent death of newly inserted scions.

Establishment of mango orchard

a. **Underbrushing, cultivation and harrowing.** If the area has not been planted to any agricultural crops, cutting of trees/shrubs, clearing and removal of stones, stumps and log should be done. Uprooting of grasses to clear the area from weeds is also recommended. On the other hand, single plowing and two harrowing are necessary for previously cultivated areas. Land preparation should be done in summer to minimize growth of weeds and facilitate plowing and harrowing activities.

b. **Holing.** The best time to dig holes is during summer. When the soil is fertile, 1.0 x 1.0 feet hole can be excavated in the field. If the soil is hard, rocky and infertile, larger holes of 0.5 x 0.5 meter is recommended. One fourth of the area should be filled up with organic matter to provide nutrients for newly planted grafts.

Design and distance of planting. Commercial plantings for mango should follow certain designs for ease of implementing the cultural requirements of trees and to estimate the number of trees needed per hectare. In the square system, a tree is planted at each corner of the square while in the triangular, trees are set in the corners of the triangle, equidistant to each other. About 15 percent more trees per hectare can be accommodated with the triangular design. On the other hand, in the quincunx, a filler tree is planted in the middle of the square to maximize space. Hence, the number of trees per hectare is increased. The square design is commonly used in many orchards.

Recommended spacing for 'Carabao' mango. The main objective of the layout is to space the trees at suitable distances in order to allow ample space for development. It also permits intercultural operations and easy passage of light to discourage pests and diseases. In poor soil the tree makes thrifty growth and can stand closer spacing. On the other hand, in fertile soil, the tree makes luscious growth and produce overlapping canopies within few years hence, wider spacing is necessary.

Another important factor that influence tree spacing is the growth characteristic of the variety. 'Carabao' mango is considered a fast grower, attaining canopy spread of 4.5 m after 3 years. Thus, closer spacing for this variety should be discouraged to avoid over crowding which can affect yield and fruit quality. If intercropping is desired, it is best to have wider spacing to accommodate growth of cereals, vegetables and short maturing fruit crops like guava, cashew, papaya, pineapple and jackfruit. The spacings for 'Carabao' mango are 10 x 10 m (100 trees), 12 x 12 m (70 trees), 14 x 14 m (51 trees) and 16 x 16 m (39 trees), 20 x 20 m (25 trees). However, it is recommended that 'Carabao' mango should be planted at least 14 x 14 meters.

High density planting (use with caution). Close density planting is practiced in Australia, Israel, Mexico and India. The success of this technology is attributed to the variety whose growth characteristic is of non-spreading and responsive to pruning. For 'Carabao' mango, close density planting can pose problem because the tree grows fast and over crowding is easily attained as early as 6 to 8 years after planting. Mango flowers and fruit clusters are borne on the periphery of the canopy and need to be exposed to sunlight. Trees with crowded and overlapping branches do not produce as many flowering tips as compared to those exposed to light. Overcrowding also creates condition favorable for the growth and multiplication of pests particularly hoppers and anthracnose. High density planting at 5 x 5 m (400 trees), is used for scion grove establishment.

Field layout

For flat and slightly rolling areas, layout should be done after land preparation and preferably in summer. The materials needed for the field layout are triangular wooden frame (1 x 1 x 1.5 m), 3 pieces nylon cords (100 m each), meter stick, 6 pieces bamboo poles (4 m), 100 pc bamboo sticks (2 ft) and markers (colored strings).

Steps involved in the field layout are as follows:

1. Set the triangular frame in one corner of the field. Using a 100 m nylon cord, extend one arm of the triangle (westward) and with the other cord, do the same for the second arm (southward). Stretch the cords to form straight lines and fix both ends around the bamboo poles forming a big triangle. This will serve as the reference point or base line for the layout.
2. With the nylon cord, measure and mark the required distance using colored strips. Both ends of the cord should also be stretched and tied to bamboo poles.

3. Move the marked cord inside the big triangle and using the recommended distance of planting, set the cord parallel to the base line, (westward extension of the triangular frame). Fix the ends of the cord on the ground with the bamboo poles. Identify these marks in the field by placing bamboo sticks (staking).
4. Transfer the cord and measure the same distance for the next line. Repeat this procedure until the whole area is laid out.

For high slopping areas, contour layout is practiced in areas with highly sloping lands. The stakes are placed perpendicular to the slope and fixed in the center of the slope to provide straight line drawn from bottom to top. This is accomplished by stretching the nylon cord from the highest to the lowest parts and locating the position of the grafts along the marked points of the cord. Actual planting is done from below to top of the slope. Plant orientation can also be guided with the use of an "A" frame. To assure high percentage of plant recovery, planting should be planned at the start of rainy months when water supply is enough and considered appropriate planting.

Caring of Young Mango Trees

Fertilization. It is important that grafts should get established in the field prior to fertilizer application. Soil and tissue analysis is recommended to determine the needed fertilizer for the crop, however in the absence of such, a general recommendation could be considered. Fertilization is recommended 2 to 3 months after field planting and could be done before in split application, and at the end of rainy season. One practical guide for fertilizer application is the development of young shoots 6-8 weeks after transplanting. The following are suggested fertilizer requirements for non-bearing trees:

1. One year old - 100 g Urea (split application start and end at rainy season) or 200 g manure + 100 g Urea. Fertilizer should be placed few inches from the trunk in a shallow canal constructed around.
3. Two years old - 200 g Urea (split application) or 500 g manure + 200 g Urea.
4. Three years old - 300 g triple 14 (split application) or 1.0 to 2.0 kg manure + 300 g triple 14
5. Four years old – 400 to 500 g triple 14 (split application) or 2.0 to 3.0 kg manure + 400 to 500 g Urea

Irrigation. Death of young trees in the field is usually attributed to lack of water particularly during the dry months (December to April). Manual irrigation using water sprinkler is recommended weekly. Irrigate 2 to 4 liters of water to saturate the soil. This activity should be done continuously for the 2nd and 3rd years of growth until the trees have established in the field. In large plantation, irrigation system (sprinkler and drip) is recommended.

Intercropping. The available space between mango trees can be made productive while waiting for the trees to bear fruits. This practice will not only provide additional income to grower but also keep the area free from weeds and improve the fertility of the soil. Several short maturing trees (inter-fillers) such as citrus, papaya, pineapple, guava, cashew, jackfruit and citrus are recommended as choose intercrops for mango. Choose crop(s) which are easily adopted in the area, requires less management and with high market demands. In cases where the intercrop competes with the main crop for nutrition, water and space, these should be removed. Avoid intercrops which are alternate hosts of insect pests and diseases.

Weed control. Weeds are not the only problem of annual crops but also of perennial like mango. They compete for food and water and serve as alternate hosts for insects and diseases. The frequent burning of mango orchards especially during summer months is also caused by dry weeds which accidentally catch fire.

Ring weeding is recommended for young and backyard trees. This is done by scraping or hoeing the weeds around the base of the trunk. An area of about one meter radius should be maintained weed free. For large areas as in orchard plantation, inter-row cultivation using a tractor is necessary. However, caution must be observed so that the disc or mouldboard plow does not damage the roots of the trees. Soil erosion during cultivation should also be considered.

Cover cropping involves planting of leguminous and creeping crops like tropical Kudzu and Centrosema to suppress the growth of weeds. These plants intercept light minimizing the heat which accumulates in the soil. In addition these crops suppress growth of weeds due to their creeping behavior. When fully matured, these are plowed and incorporated in the soil as green manure to improve soil fertility. Leguminous crops also provide food and habitat for insect pollinators like spiders, praying mantis and wasps.

At present, there are non-selective herbicides (glyphosate) used to replace the laborious and expensive weeding procedure. However, avoid spray contact with any parts of the tree during application since this can result to burning and death of trees.

Insect and Disease control. Insects and diseases damage young trees in the field. Insects attack the leaves, branches and root systems and are prevalent during the dry season. Diseases on the other hand, are rampant during the rainy season and they destroy the leaves and roots of young trees.

1. **Scale insects** (*Aonidiella orientales., Coccus viridis, Aspidiotus destructor, Phenocapsis inday* and *Hemiberlesia palmae)*. These are small scale-like insects usually found hiding underneath the leaves or branches of the tree. Both adults and nymphs destroy the plant by sucking the vital sap resulting to the drying and falling of leaves. Scale insects are abundant during summer and can cause high mortality of young grafts. As plant suckers, scales also excrete sticky fluid called "honey dew" which serves as excellent medium for the development of the fungus, sooty molds. The latter, blackens the leaves and affects the photosynthetic activity of the plant. In addition, while feeding, scale insects inject toxic substances in the tissues resulting in the galling of the branches. Affected parts enlarged and resulted to galling of the branches which do not recover.
   Control. Scale insects, particularly the armored group is difficult to control with insecticides because their bodies are covered with waxes. When contact insecticides are used, stickers are necessary. Insecticides with systemic activity are also preferred. During heavy infestation, pruning of affected parts should be done followed by spray application of insecticides. Fertilize and water the plants to stimulate new growth. When infestation is minimal, brushing them off with soap and water will minimize the problem in the field. Spray plant oil as a mixture of plant oil + insecticide. This chemical is effective for scale insect control.

2. **Tip Borer** (*Chlumetia transversa)*. The adult moth starts to lay eggs when flushes are present. The eggs hatch to small larvae which bore in the shoots and stems, feeding the vascular bundles. Since water and food are prevented from growing up the plant tip (due to the destruction of the food bundles), the top most portion of the plant dies. When dissected, small, pinkish larvae are found inside.
   Control. If infestation is minimal, prune the damaged part and burn/bury them. During severe infestation use systemic/contact insecticides and spray regularly to protect flushes.

3. **Mango Twig cutter/borer** (*Niphonoclea albata*, Newman and *N. Capito*, Pascoe). The adult cuts or girdles the branch/twig. This is done by nipping the branch halfway, then turning around to make another cut just as deep as, but slightly lower than the first cut. Affected parts fail to transport nutrients and water causing the terminal leaves to dry up. Dried leaves on the tree canopy are common sign of twig cutter infestation.

Control: Adults are attracted to young leaves or flushes for egg laying. To prevent or minimize damage, spray the whole canopy with insecticide. Repeat application after one month. Prune damaged twigs and branches. It is advisable to prune in summer to minimize occurrence of disease which may enter the cut tips. Infested parts should also be burned to kill the larvae inside.

4. **Circular white-back borer** *(Callimetopus sp.)***.** This is a long-horned beetle and has very similar habits to the twig cutter/borer. The adult scrapes the bark of young twigs causing death of terminal parts. The insect is easily identified by the circular white mark on the back of its body.
   Control. Like the twig cutter, adults are attracted to young leaves. Insecticides recommended for twig cutter infestation can also be used to protect trees from circular white-back borer infestation. Prune affected parts and burn them.

5. **Corn silk beetle** *(Monolepta bifasciata)*. The adults are small, yellowish beetles and are voracious leaf feeders. Newly formed leaves (flushes) are very attractive to the insect. Infested leaves show holes and under severe attack the entire leaf is destroyed. Damaged leaves are also easily infected by anthracnose, a fungal disease.
   Control. Timely application of insecticide during flushing. Use any contact insecticide recommended for mango.

6. **Grubs** *(Leucopholis irrorata)* and **Termites** *(Macrotermes sp.)*. The insect feeds on the roots and stems of the tree. Under heavy infestation, grafted plants die.
   Control. Granular insecticides such as (a.i.Furadan) (50 g/tree) applied as soil drench will kill the insects in the soil while contact insecticides are necessary for those found on the trunk and branches. It is important to expose the adults prior to application of contact insecticides by destroying earthen tunnels. Eggs of grubs can be prevented from hatching organic matter before applying them as fertilizer.

7. **Thrips** *(Scirtothrips sp.)*. These are small insects and new pest problem during flushing. Leaves affected result to drying and the burning symptom is prevalent.
   ControlSpray contact insecticide particularly underneath the leaf surface where the insect stays.

8. **Anthracnose** *(Colletotrichum gloeosporiodes)*. This is the most common disease of mango and is prevalent during rainy months. Leaves are easily susceptible to the disease especially the flushes. The common symptoms are black, pin size lesions which coalesce to form bigger spots. These spots produce a shot hole appearance on the leaves. Affected leaves dry and fall to the ground pre-maturely.
   Control. Anthracnose can be controlled by pruning the affected parts and spraying with recommended fungicides especially during rainy season. To avoid wetting of leaves during irrigation, direct water only to the roots.

Early Pruning.

1 Formative pruning is done to reduce the height of trees. This is usually done when the tree is about 1m tall, and the terminal portions are cut/pinched to encourage lateral branching.
2 Three (3) to four (4) branches are allowed to grow and then the second cutting or pruning of terminal portions is done until the branches are evenly distributed.
4. For established young trees, 3-4 year old (at least 3 meter tall), where early pruning is not practiced, the tree is center-pruned to control the height and for proper development of lateral branching. This allows sunlight penetration, air circulation, and facilitates spraying, bagging and harvesting operations.
5. Pruning is suggested to be done during the dry season.

Deblossoming. The removal of flowers which develop on young trees should be practiced as it happens as early as the first year of growth of grafted mangoes. The presence of flowers will require nutrients suppose to be channelled for vegetative growth of the plant as early as the first year of grafted mangoes. Hence, early flowering can affect the development of trees resulting to stunted growth.

Caring for trees

Pruning. Pruning is done to remove undesirable and crowded branches which are of no use to the tree. This includes the removal of water sprouts, old, decaying and unproductive dried and overcrowded branches, infected and infested parts to discourage the presence and multiplication of insect pests and diseases. Pruning allowed maximum light penetration and air circulation in the canopy. This minimizes the build up of diseases inoculum and insect population particularly, mango leafhoppers.

Excessive pruning on bearing trees should be avoided. As a general rule, branches which are 2 inches in diameter or less are removed. These usually grow as side shoots from tertiary branches in the canopy. Other branches which deviate from the main limbs are also removed. A well-pruned tree has equal distribution of branches and allows light penetration within the canopy. As a practical guide, a well-pruned tree allows one to see adjacent trees within the vicinity.

Preferably pruning should be done during summer months after harvest. If done during the rainy season, the cut portions should be protected from fungal infection by application of fungicides, paint or coal tar.

Drastic or radical pruning (top working) to change the variety/rehabilitate old trees is the removal of the total or more than 30% of the canopy. It is practice for the trees which are severely infested with insects particularly scales and mealy bugs. It is also done to rejuvenate old trees or replace varieties which are unproductive in the field. Pruning saw, shear and pruning pole are appropriate tools needed. However, if these are not available, ordinary carpenter saw and bolo can be used.

Fertilization. Early researches believe that nutrient level of soils from different mango producing provinces are adequate to support growth and development of trees. This is because mango has an extensive root system capable of extracting nutrients deep in the soil. However, with the discovery of potassium nitrate, induction of trees became common and its yearly application has resulted ill effects as observed in the fields. Continuous use of potassium nitrate specifically at higher concentration resulted to cause leaf defoliation, decline production and low response of trees to flowering. In extreme cases, trees become sickly and non-productive.

A closer look at the problems will reveal that affected trees are usually malnourished and deficiency symptoms of the major elements (NPK) are very glaring hence, the role of nutrition in flower induction is very important.

Soil analysis, tissue analysis recommendation and symptomatology exhibited by trees which lack that certain element(s) are ways to determine deficiency of important elements in mango. The most common procedure employed is soil analysis. Soil samples are taken from the field and submitted to the Bureau of Soil and Water Management of the Department of Agriculture for analysis. Laboratory result identifies the limiting elements, its amount and the corresponding recommendations. It is important to have your soil analysis prior to application of fertilizer. However, in the absence of such, the following recommendation for bearing trees could be observed.

Age (Years)	Rate of Application	Time of Application
5 - 6	500 g to 1 kg Triple 14 or 3 to 4 kg manure + 500 g to 1 kg Triple 14	Apply whole amount at the start of the rainy season or split application with the first half given at the start of rainy days and the remaining before the end of the rainy season.
7 -8	2 kg Triple 14 or 4 to 5 kg manure + 2 kg Triple 14	
9 - 10	3 kg Triple 14 or 5 to 6 kg manure + 3 kg Triple 14	
11 - 15	5 kg Triple 14 + 10 kg manure	
16 – 20	6 to 7 kg Triple 14 +12 kg manure	
20 - above	10 kg. Triple 14 + 15 to 20 kg manure	

Common nutritional deficiency symptoms in mango:

1. **Nitrogen.** Presence of yellow, undersized leaves. Discoloration starts on the base and progress towards the tip. Growth retardation.
2. **Phosphorus.** Usually older leaves shows presence of brown neurotic spots located in between veins. In the advance stage, the leaves become brown, dry up and drop. In some cases, the leaves turn reddish purple along the margins, mature abscission and stem die back occurs.
3. **Potassium.** Distinct symptoms of potassium deficiency occur on older leaves. It is indicated by brown necrosis on the leaf margin which often extends to the tip. Leaf blade appears dull yellowish green to light green. The symptoms are very prominent during dry season.
4. **Calcium.** Similar to nitrogen deficiency except that yellowing of the leaves start at the apical portions and not at the base.
5. **Magnesium.** Deficiency from this element cause considerable retardation of growth and premature defoliation of leaves. In severe cases chlorosis extends up to the midrib and little or no green color remains.
6. **Copper.** Presence of oversized leaves. Usually gum exudations are present on the bark of the twigs and branches.
7. **Zinc.** The deficiency symptom is characterized by the little leaf symptom. As the leaf mature, the margin bent with downward or upward causing the apical portion to curve in the same direction. Veins appear more prominent on the upper surface and appear yellow.

Proper fertilizer application should be observed particularly on big and mature trees (> 30 years old) which are fertilized by digging narrow canals or holes of 15 - 30 cm deep around the trunk following the spread of the canopy. Fertilizer is placed in the holes/canal and covered with soil to minimize volatilization or run off of the chemicals during rainy days. For younger trees (5-30 years old) holes or canals are constructed 1.0-2.0 radius from the trunk.

Foliar fertilizer is recommended at flowering as supplement for optimum growth. The first and second application of foliar fertilizer starts at 14 to 18 and 22 to 25 days after induction which is needed to increase panicle length and in preparation for a good fruit setting. The second application at 35to 40 days after induction encourages fruit setting and retention while the 4^{th} application at 50 to 55 days increases fruit size. Choose foliar fertilizers with major elements (NPK) as well as microelements such as Calcium, Magnesium, Boron and Zinc.

Flower induction. Age of leaves should be between 7 to 8 months. Leaf maturity is observed to be influenced by water stress, temperature and day length. Dark green to coppery green, brittle, crispy and crack or break when squeezed are practical guides that mango leaves considered to be matured.

Spray potassium nitrate (KNO_3) by thorough wetting the leaves. Agricultural grade of KNO_3 or other salts of nitrate at 1 to 3 percent or formulated products (liquid/solid) are recommended. High concentration during cold/rainy months, low concentration during dry months. These rates would vary from 2.0 to 3.0 percent and 1.0 to 1.5 percent for early and late flower induction respectively. One percent means 1 kg of potassium nitrate in every 100 litters of water. Stronger/higher concentration is also needed for younger shoots but often time's chemical induction is not practical. On the other hand, formulated products can be made strong or weak depending on the amount of water added to the inducer.

Follow up spray or dressing. This is usually done during cold months or off-season production and when rain occurs 6 hours after the induction. Spray at lower concentration (50% or ½ of the rate) 2 to 3 days after the first application.

Cultar also known as "paclobutrazole" is a growth retardant which can induce flowering in mango. The chemical is applied as soil drench. However, the response of 'Carabao' mango to application of cultar is not significant.

Flower management. Technically, mango flowers are referred to as inflorescence because it is made up of several individual flowers (floret). Sometimes, the entire flowers are also referred to as panicle. In 'Carabao' mango, a single panicle may have 800 to 2,000 florets. Mango flowers are light yellow in color and turn dark yellow to light orange towards the blooming stage.

Basically, there are two types of mango flower, the male which are relatively small but numerous in number and the hermaphrodites or complete flower. The latter, are bigger and have both male and female parts present in a single flower. Only hermaphrodite flowers develop into fruit, the males fall to the ground. Since, the number of males are higher than the hermaphrodite (3:1), only few fruits will develop per panicle. Without care and maintenance, these fruitlets will continue to drop until only one or two fruits will be retained per panicle. In most cases, nothing is left at harvest.

Foliar application of liquid fertilizer at 14 and 22 days after flower induction (DAFI). This is a very important recommendation to follow since foliar application will enhance mango flowers from the series of developmental stage prior to the development of fruit. Such stages are post emergence, pre-anthesis and full bloom. Likewise, fruit development will commence from fruit set to fruit enlargement and finally on to fruit maturation.

Pest control for important insects/diseases is an important consideration on flower management. Mango flowers are very susceptible to attack of mango leafhoppers and tip borers. Flowers should therefore be sprayed with effective insecticides against these pests. During rainy days, flowers turn black and fall to the ground due to anthracnose. This is a very common disease of mango which is prevalent when moisture is present. Failure of flowers to develop into fruits is therefore influenced by the presence or absence of insects and diseases.

Encourage pollinators (flies and bees) by avoiding application of pesticides at full bloom stage. Fruit setting increases as the presence of natural pollinators hence, many of the insects will be killed during insecticide application at full bloom stage.

Irrigation is advised for weekly application of water to enhance flowers and fruits development. Water can be supplied naturally through rain or artificially. Sources of irrigation may be obtained from drip irrigation system, overhead sprinklers, surface run-off or furrow irrigation.

Fruit management. The presence of numerous flowers is not a guarantee of bountiful harvest. Low fruit setting can occur anytime since there is a predominance of male flowers. In addition, large number of perfect flowers (hermaphrodites) are not pollinated by insects.

In general, less than 1 percent of the hermaphrodite flowers will develop into fruits at maturity. Fruit drop which occur from fruit setting to 60 days after induction is also responsible for the low yield at harvest. Fruit drop in mango is associated with nutrient competition, lack of water during development, insect and diseases, degeneration/abortion of newly fertilized fruits, parthenocarpy (fruits not fertilized) and phytotoxic effects of some pesticide.

Fruit drop should be also viewed as mechanism for survival of the trees. Fruit development is an energy requiring process and the presence of numerous fruits in the panicle would mean large amount of food required for their development. Hence, the tree rejects many of these fruits and retains only those which it can support. To minimize the occurrence of fruit drop at an early stage of development the following are recommended:

a. Foliar applications of fertilizer at fruit set (35 to 40 DAFI) and before fruit bagging (50-55 DAFI).
b. Pest control against major insects/ diseases.
c. Irrigation of trees at weekly interval starting from panicle initiation until one month before harvest.

Fruit drop stabilized at 60 days after flower induction. However, if fruits continue to fall beyond this period, other problems like water, insects/diseases and strong winds have to be considered.

Integrated pest management

Mango is one commercial crop which receives a tremendous amount of pesticides during flower and fruit development. Over the past decades, mango production has become increasingly dependent on chemicals or conventional approaches to pest control. These include calendar spraying (about 8-10 times during flower and fruit development) and the use of different mixtures of toxic chemicals. These practices create economic, environmental and health problems in the countryside.

One management practice which can help address these problems is Integrated Pest Management (IPM). IPM can increase farm profits, maintain good yields, safeguard the environment and reduce health risks to farmers and consumers. It involves the combination of proper cultural management to improve the vigor of the trees, resistant varieties, biological control and other biological procedures to prevent, reduce or mitigate pests. The use of pesticides is included as part of an integrated approach to pest control. However, cultural management practices which tend to prevent pests are emphasized. With IPM, pesticides are used only when absolutely necessary, mainly to control pest infestation. Natural enemies of pests and the use of natural pollinators are encouraged. Environmental contamination is, thus, minimized.

IPM Strategies and Tactics

1. **Pruning -** involves the removal of crowded and unnecessary branches as well as parts damaged by insects and diseases**.** Through pruning the population of insect pests is reduced, discourage multiplication and spread of diseases. Pruning is recommended after harvest, preferably during summer. Well-pruned trees allow light penetration and good air circulation. This creates an environment less favorable for the development of leafhoppers, mealy bugs and diseases like

anthracnose, stem end-rot and scab. In addition, it also facilitates the distribution of spray droplets within the canopy for effective control of pests.

2. **Clean culture -** is done by ring cultivation, sanitation through cleaning of surrounding areas and collection and destruction of infected branches and fruit droppings. This is an effective cultural management practices which limits the development and spread of pests. The practice is very important in minimizing problems related to fruit fly and seed borer infestations. Collection of fallen fruits and burying them deep in the ground to prevent insects from completing the life cycle. This also eliminates the breeding sites of other pests. It is also recommended to destroy sources of disease infection by collecting and burning fallen branches, fruits and other trashes.

3. **Monitoring -** regular monitoring of flowers and fruits for specific pest and population has been proven effective for the success of pest program. This will depend on the comprehensive knowledge of the pest particularly its life history and behavior, distribution, dispersion and seasonal abundance. For example, the nymphs and adults of mango leafhoppers are very destructive to flowers and are abundant during dry season. Their population becomes low when flowers are not available. Thus, the increase of fruit fly population is influenced by availability of suitable host and onset of the season will be detected from a regular visit of the fruit trees.

4. **Chemical control.** Chemicals which are used to control or kill pests are referred to as pesticide. These are power tools in pest management since they are usually effective against large pest population, act within a short period of time and are readily available for use.

5. **Insecticides.** These are chemicals used to control insect pests, classified as inorganic and organic depending on their chemical nature and according to their route of entry. They can be grouped into stomach poisons (act via ingestion and absorption), contact poisons (readily absorbed by the cuticle of the skin) and fumigants (enter through the breathing organs of the insect in gaseous state). Insecticides are formulated either as wettable powders (WP), emulsifiable concentrates (EC) or granules (G).

6. **Insecticide management**

    a. Identify the weak links in the life cycle of insect pests and direct the insecticidal application at these weak links.
    b. Insecticides should be applied based on pest monitoring. For instance, at panicle stage, insecticide application is initiated when 3 hoppers are present per panicle.
    c. Different classes of approved insecticides should be used alternately to delay development of insect resistance.
    d. Apply insecticide as fine spray mists for better control of different insect pests.
    e. Use the most effective insecticides only at very critical stages and when pest population reach very high level.

Fungicide. Most of the diseases affecting mangoes are caused by fungus. Hence, fungicides are an important tool for pest management. Fungicides are generally sprayed on leaves, flowers and fruits of mango as protectants. In other words, they are designed to be present on the plants in advance to prevent infection. New products have also been developed to kill fungi which have already invaded the tissues.

Fungicide management

a. Fungicide should be applied at plant stages that are vulnerable to anthracnose and when environmental conditions are favorable for the development of the disease (need-based rather than calendar-based application).

b. The vulnerable plant stages for anthracnose infection are stages covering flushing (1-15 days after flower bud break) up to fruit set and maturity. The most critical stage for anthracnose infection is from prebloom (about 20 DAFI) up to fruit set (about 35 DAFI).
c. Appropriate use of fungicide should be observed. Protectant fungicides should be applied during less critical period and are effective if they are applied before disease infection is initiated. Systemic fungicides should be applied during very critical periods and usually after infections have started.
d. Protectant and systemic fungicides should be applied alternately to prevent development of resistance. When critical stages (20-35 DAFI) coincide with extremely favorable condition for anthracnose development, a mixture of combination of systemic and protectant fungicides can be resorted.
e. If flushing (1-15 DAFI) coincide with wet and humid conditions, protect flushes by spraying one round of protectant fungicide. Avoid the use of systemic fungicides.
f. Fungicides application should be scheduled base on crop phenology and weather condition.

Bagging. Bagging is recommended to protect the fruit from pests and reduce the spraying of insecticides. Bagging is an important cultural practice for mango since it reduces the number of pesticidal applications and produce fruit of better quality.

This is done when fruits are about chicken's egg size (55 to 60 DAFI). The bags used to serve as physical barrier which prevent mechanical injury, protect the fruits from fruit flies, seed borer, black borer, cecid flies and minimize infection caused by anthracnose, diplodia and scab. If early attack of insect pest is anticipated, early bagging of fruits is recommended (45DAFI onwards).

Steps Involved in Bagging:

1. For bagging materials, imported newspapers are preferred during rainy months since these are sturdy and can withstand strong wind and rain. If this is not available, the yellow pages of the telephone directory can be used. Local newspaper could be used during dry season. Avoid using plastic bags since these can accumulate moisture conducive for the development of diseases. A Chinese pre-formed brown paper bags is available but cost Php 1.00 per piece.
2. A full-page newspaper will produce 6 paper bags, each measuring 8.5 inch in width. This size is appropriate for bagging the fruits. Approximately 294 bags can be made with 1kg newspaper.
3. The bag should be sealed at all sides except the opening with staple wire. Arrange the bags in bundles (100 bags per bundle) and about 3 to 4 bundles be carried each time the bagger climbs the tree.
4. Ladder and ropes are used to access fruits during bagging. Ropes are tied around the bagger's waist with one end of the rope tied to a sturdy branch. The rope must be long enough for adjustment when the bagger transfers position during the operation. Bagging starts from the top of the canopy moving downward.
5. Fruits which are clean and without any abnormality should be bagged. After enclosure, the opening of the bag should be folded and sealed with a staple wire to prevent entry of insects.
6. Avoid bags which are small that fit closely to the fruit. Insects like fruit fly and cecid fly can easily pierce the paper with their ovipositor and lay eggs on the fruit surface. The size of the bag recommended earlier can lessen this problem.
7. It should also be emphasized that bagging does not provide total protection for the fruits. Studies have shown that maximum protection for insect and diseases control varies from 75 to 80 percent. In the field, bags are destroyed by strong winds and rains exposing the fruits to several pests. In such cases, re-bagging is recommended.

Irrigation. Water is essential not only for the development but also for the translocation of nutrients. Although the ideal climatic requirement for mango is five months continuous dry season, water is beneficial to mature trees especially during flowering and fruiting.

Established trees are deep rooted and have the ability to extract water several feet below the ground. However, during flowering and fruiting, moisture should be readily available for optimum growth. Irrigation during flowering and fruiting results to longer flower panicles, increased number of fruits per panicle (fruit set), reduced fruit drop, increased fruit size and improved fruit quality.

For big trees, 100 to 200 liters of water is recommended each week. This is applied weekly starting from flower emergence (12 days after flower induction) to one month before harvest (90 days after induction). This requirement is however, enormous and often times not met in the field.

In places where water availability is a problem it is recommended that bamboo poles 6 inches diameter and 1-2 m high should be placed around each tree. Four of such poles are buried 0.5 m deep and 1 m away from the trunk. The poles are filled with water requirement of each tree during flower and fruit development. Each week, bamboo poles are refilled with water for continuous supply. Plastic pipes (PVC) may replace bamboo poles since the former doesn't stay long in the field.

Water can also be applied to trees using canal, holes, flooding, dike and by drip method. In the latter, a motor pump is provided which forces water into small black tubes. A regulator is provided in each tube which control and distribute the required amount of water per tree. This system is the most efficient way of irrigating trees in the field.

In some orchards, the drip system is a common irrigation facility. This consists of perforated rubber hose, placed in rows or between rows of mango trees. A control unit allows the prescribed volume and frequency of water needed by each tree. With some modification, fertilization can be applied while irrigating the trees and process is called fertigation.

Important Considerations in Irrigation:

1. Irrigate trees at flowering and fruiting stages to enhance faster development of flowers, minimize fruit drop and increase fruit size.
2. Apply water weekly during flower and fruit development and stop 1 month before harvest.
3. Amount of water varies with size of the tree and available moisture in the soil.

List of important pests affecting bearing trees:

Pests Affecting twigs and Flowers

1 **Mango leafhoppers** *(Idioscopus clypealis)*. Nymphs and adults damage the flowers by piercing their mouth parts in the tissues and sucking the plant sap which causes withering, drying and falling of individual flowers. Under severe infestation, no fruits develop. The insects excretes a fluid called "honey dew," an excellent medium for the development of the fungus, "sooty mold" which interferes with the photosynthetic activity of the leaves. It also disturbs fertilization and spoils the appearance of flowers and fruits. Under high insect population, the entire canopy is covered with sooty mold with leaves and flowers turning black.
Prevention: Since hopper population is expected to be high in summer, early induction of mango trees (September, October and November) will prevent hopper problems in the field. Light trapping is also recommended during early stages of flower development to attract and kill adults which are ready to lay eggs. To install light trap, hang the source of light (electric bulb or kerosene operated lamp) on the tree. Place underneath a basin containing mixture of soap and water (1:10). Hoppers which are attracted to the light are drowned in the solution. One light trap is required per hectare of mango plantation. Pruning of crowded branches is an important management practice which discourages hoppers from staying in the tree. Pruning allows good light penetration and makes the habitat unfavorable for hopper development.

Control. To prevent insect build up, insecticides are sprayed to protect the susceptible stages of flower development (bud elongation, pre-flower opening and opening). It is important to monitor the different stages of flower for the presence of the insect. Application of insecticides for hopper control in done based on monitoring and not by calendar spray.

No insecticidal spray should be done when mango flowers are blooming (28-32 DAFI). At this stage, beneficial insects like flies, bees, ants, etc. actively pollinating the flowers. They should be spared from the toxic chemicals. Otherwise, no pollination will occur and the flowers will not turn into fruits.

A fungus known as Hirsutella regulates hopper population in the field. When present, collect them from the leaves, soaked in water and spray them back in the trees. Some botanical insecticides (neem, tobacco leaves, tubli and bulb onions) have been reported to control hoppers.

2 **Mango Tipborer** *(Chlumetia transversa)* . While mango tip borer is a common problem on young shoots, the insect is also observed to destroy the flowers. Newly developed flowers are damaged entirely while mature flowers are cut into half, with the upper portion being destroyed. The insect is becoming an important problem of mango flowers.
Prevention. The adults start to destroy the flowers from bud emergence to elongation. Hence, early spraying of insecticides is necessary to protect these stages especially during summer. Insecticides recommended for hopper control will also protect the flowers of mango from tip borer infestation.
Control.When the larvae are inside the flowers, many of the insecticides are not effective against the pest. Pruning of infested flowers is recommended followed by insecticidal applications to protect non-infested flowers.

3 **Mango Twig cutter/borer** (*Niphonoclea albata*, Newman and *N. Capito*, Pascoe). The adult cuts or girdles the branch/twig. The damage is done by nipping the branch halfway, and then turning around to make another cut just as deep as, but slightly lower than the first cut where adults lay their eggs. Affected parts fail to transport nutrients and water causing the terminal eaves to dry up. Dried leaves on tree canopy are common sign of twig cutter infestation.
Prevention. Adults are attracted to young twigs/branches for egg laying. To prevent or minimize damage, spray the whole canopy with insecticide. Repeat application after one month.
Control. Prune damaged twigs and branches. It is advisable to prune in summer to minimize occurrence of disease which may enter the cut tips. Infested parts should also be burned to kill the larvae inside.

4 **Circular white-back borer.** This is a long-horned beetle and has very similar habits to the twig cutter/borer. The adult cuts the leaves on the terminal portion of the twigs and bore hole on young twigs for egg laying, causing death of terminal parts. The insect is easily identified by the circular white mark on the back of its body.
Prevention. Like the twig cutter, adults are attracted to young shoots/twigs. Insecticides recommended for twig cutter infestation can also be used to protect trees from circular white-back borer infestation.
Control. Prune affected parts and burn them.

5 **Mealybugs** *(Ferrisia virgata/ Planococcus lilacinus).* Both adults and nymphs attack the flowers by feeding on the base, gradually moving up to cover the entire panicle. The florets dry up and drop off prematurely. The "honey dew" produced by mealy bugs attracts red ants and serves as medium for the growth of sooty molds.
Prevention. Bagging of fruits using paper bags sealed at all sides and destruction of red ants are recommended.

Control. Heavily infested parts (branches and leaves) should be pruned and burned. This should be followed by spray application of insecticides recommended for the pest. When bagging is not employed, insecticide sprays are recommended at 75 and 90 days after induction.

6 **Thrips** *(Scirtothrips dorsalis/ Selenothrips rubrocintus).* Adults and nymphs (immature) are emerging pest of flowers which destroys by sucking the vital plant sap causing the flowers to dry, causing a similar to "burning" effect in many plants.
Prevention. Both young and adult insects are sensitive to light. Pruning of crowded branches to allow light penetration will create an environment less favorable for their development.
Control. Application of insecticides at recommended rates. It is important that the chemical be properly distributed on the canopy by adjusting the sprayer nozzle to produce fine mist. Spraying should be done early in the morning.

7 **Green Beetle** *(Anomala sp.)* **and June Beetle** *(Leucopholis irrorata).* Adults have been found to feed mainly on the leaves and occasionally on flower of mango. Lately the insects were reported to attack young fruits by chewing bits and pieces of the peel or skin, particularly near the fruits stalk.
Prevention. Adults can be dislodged from the tree by shaking the branches. Adults that fall on the ground can be manually collected or controlled by spraying of recommended insecticide.
Control. Commonly used insecticides for the control on insect pests on mango could be used.

Insect Pest Affecting Fruits

1 **Mango Seed Borer** *(Noorda albizonalis).* Damage starts when the newly hatched larvae enter the fruit by boring holes on the apex or narrow tip of the fruit. As the larvae develop, they feed on the tissues beneath the skin. The damage area later collapses causing the apex to burst and the fruits eventually fall to the ground. Serious damage is brought about by the destruction of the seed in a short period of time.
Prevention. Fruits showing damage should be picked. Otherwise, larvae will transfer and destroy adjacent healthy fruits. Infected fruits on the ground should also be collected and properly disposed of by burning them to prevent the insect from completing its life cycle. Bagging of fruits at 55 to 60 days after the induction will also minimize damage of the borer.
Control. Adults are active late in the afternoon. To effectively kill them, spray insecticides before bagging. Insecticides are best applied in the afternoon before it gets dark.

2 **Mango Black Borer.** Female adult lay its eggs beneath the skin on any portion of the fruit. As the larva emerges, it bores into the flesh and feed on the pulp ad seeds. The damaged area later collapses and sometimes cracks and the fruits eventually fall to the ground. Presence of larvae can be detected when there are excreta observed on the skin of the fruit.
Prevention. The same method employed in Mango Seed Borer.
Control. Control measures for Mango Seed Borer can be applied.

3 **Mango Fruit Flies** *(Bactrocera phillippensis/B. occipitalis).* Damage on fruits starts during egg laying. Fresh punctures may not be readily recognized until after 3 to 5 days when soft brownish spots appear on the skin and the underlying tissues start to spoil. The larvae cause the major problem since continuous feeding destroys large portion of the flesh. Breakdown of tissues makes the mango fruits unsuitable for consumption. In the field, infested fruits drop to the ground and decay. Under severe infestation, damage to as much as 90 percent of the crop has been reported, making the insect one of the most important pests of mango.
Prevention. Fruit drop should be collected and buried at least half a meter below the ground to prevent the development of the insect. Avoid bruising of fruits during spraying since damaged fruits are susceptible to fruit fly attack. Bagging of fruits at 55 to 60 days after induction (chicken's egg size) will minimize damage from fruit fly. Don't plant papaya, guava, seniguelas

or santol as intercrops for mango. These fruits are preferred hosts of the insect. On the other hand, cashew and calamansi are less preferred.
Control. Male fruit flies are attracted to a chemical known as methyl eugenol. If it is mixed with insecticide such as malathion, it can serve as bait which attract and kill the adult. Place the bait (4 percent Malathion and 96 percent methyl eugenol) in an absorbent board (2 x 2 inches) and distribute 4 traps to a hectare. Field activity of the bait is up to 50 days.

Sustained baiting reduces the male fruit flies thereby decreasing the subsequent insect population in the field. In the absence of the chemical, Basil (a spicy plant) can be grown in the mango orchard. This plant produces methyl eugenol which attracts flies in the field. When Basil is sprayed with insecticides, fruit flies attracted to them are contaminated and get killed.

In addition, protein bait spray can also be prepared to kill both males and females. The bait formulation consists of mixing 220 ml protein hydrolysate, 150 ml Malathion and 12 li of water. Spray the bait mixture on the trees as spot treatment 3 to 4 times at two week intervals during fruit development.

4 **Mango Cecid Fly** *(Procantarinia spp.).* While the damage of Cecid fly is usually associated with galling of young leaves, fruits attacked produced circular, brown scab-like spots randomly distributed on the fruit surface. This damage is commonly called "buti", armalite, and kurikong 'and' saksak walis' by growers Infested fruits retain the scabby lesions up to harvest affecting their quality. The scabby symptom was earlier believed to be associated with Capsid bug injury. However, the presence of small, yellowish larvae confirmed damaged by the Cecid fly.
Prevention. Adults do not stay permanently on mango trees but rather on wild vegetation growing nearby. Underbrushing and clearing of surrounding areas will destroy their habitats. Adults are also sensitive to light. Therefore, pruning discourages the insect from staying on the trees. Early bagging of fruits is recommended to prevent damage of Cecid fly. This should be done at 45 to 50 days after induction.
Control. For insecticides to be effective, late in the afternoon spraying is recommended since adults are active at low light intensity. The surrounding vegetation should also be sprayed to destroy adult populations. Shallow soil cultivation and burning a layer of grass/leaves below the tree canopy to destroy pupae in the soil.

5 **Capsid bug** *(Helopeltis sp.).* The adult is polyphagous and feeds on different species of plants. The eggs are inserted in the stem or leaf tissues and hatch from 3 to 5 days the nymphs undergo five instars lasting from 11 to 16 days. The total development is 20 days. The adults are small and resemble a rice bug. The males are black but the female has an orange to red thorax while the rest of the body is black.
Capsid bug has nocturnal habit and confines most of its activities late in the afternoon or early morning. The adults stay in wild vegetation and visit mango fruits only to feed. This is the reason why the insect is not found in mango trees during daytime. Infested fruits show dry, hard, black spots on the surface separated by corky rings. Young fruits are usually preferred. In well-developed fruits, the spots are only superficial but quality is greatly affected. Fruits that are damaged also fall prematurely to the ground.
Prevention.Early bagging of fruits at 40-50 days after induction is recommended to help minimize fruit damage in the field. Underbrushing and clearing of surrounding areas will destroy their habitats. Adults are also sensitive to light. Therefore, pruning discourages the insect from staying on the trees.
Control.For insecticides to be effective, late in the afternoon spraying is recommended since adults are active at low light intensity. The surrounding vegetation should also be sprayed to destroy adult populations.

6 **Mango Pulp weevil** *(Sternochetus frigidus).* Adult lay eggs on young fruits and the larvae feed on the flesh. Affected fruits fall to the ground. Damage is not visible externally however; the feeding

larvae destroy inner tissues. The pest is found in Palawan which put the province under quarantine.

Prevention. Adults stay away from light. Therefore, pruning is a practical means to discourage movement of insect to mango trees. Fruit drops should be collected and properly disposed or by burying them half meter below the ground to prevent the insect from completing its life cycle. Bagging of fruits is also recommended at 55 to 60 days after induction.

Control. At present, the control measure for the pulp weevil relies on the use of insecticides sprayed on fruits at 15 days interval.

7 **Scale insects.** Several species of scale insects have been reported to attack mango. The most common are green scale *(Coccus viridis);* coconut scale *(Aspidiotus destructor);* shield scale *(Pulvinaria polygonata);* wax scale *(Vinsonia stillifera);* oriental scale *(Aonidiella orientalis)* and tropical scale *(Hermiberlasia palmae).* On bearing trees, high populations of scale insects cause blackening of the canopy due to the growth of the fungus favoured by fluid excretion "honeydew" of the insect. A thin black papery film that covers the affected parts reduced the photosynthetic activity of the leaves.

Green but fully developed mango fruits are susceptible to scale insect infestation. Damage is confined to areas near the fruit stalk or pedicel. It is manifested as white yellow spots in contrast to the green color of the fruit. Scale insect damage is only superficial, but fruit quality is greatly affected.

Prevention.Red ants carry and distribute young scale insects to different parts of the tree. To prevent spread and infestation, ants should be destroyed by spray application of recommended insecticides. Bagging of fruits at 55 to 60 days after induction is a practical way of preventing damage from scale insects. The paper bag should be sealed properly at all sides and should remain intact up to harvest.

Control. Spraying of insecticides is not recommended at near maturity. Prune infested parts preferably during summer. These should be placed in pits constructed at one corner of the orchard. Allow branches to dry until the parasites escape. Burn the remaining debris.

Diseases of flowers and fruits

1 **Athracnose .** The disease is caused by the fungus, *Colletotrichum gloeosporoides.* It occurs in all mango growing areas and is considered as the most serious fungal disease of mango in the Philippines. It attacks the different parts of the tree but major damage occurs at flowering and after harvest. The disease is most serious during the wet season.

Symptoms on the flowers start as tiny black necrotic spots formed at the buds, florets, pedicels and on the main and secondary stalks of the panicle. The disease forms brown streaks and result to blighting of the flower clusters or entire inflorescence. Later, the flowers blacken and dry up. On the fruits, infection occurs during fruit setting until are more half grown. The disease remains dormant in immature green fruits and symptoms only develop when the fruit starts to ripen. Thus, anthracnose is also called a post harvest disease. The latent infection is characterized by circular, brown to black sunken spots on the fruit surface.

Prevention. The development of the disease is facilitated by high relative humidity within the tree canopy. Prune trees after harvest to allow better light penetration, god air circulation and prevent disease development. Practice sanitation by removal of dead and diseased branches and leaves, brisking is also done to remove infected floral parts and morning dew deposits on the flowers thereby reducing the sources of inoculums.

Control. Apply recommended fungicides to prevent or reduce flower and fruit infections. During early inductions, fungicides can be mixed with inducers to suppress germination of fungal spores. Bagging of fruits with materials saturated with fungicides reduces fruit infection. Subject newly harvested fruits to hot water treatment at 52°C to 55°C for 10 minutes. Avoid the use of dry banana leaves and rice straws as packing materials as they may contaminate the fruit with the fungus, *Aspergillus* which causes fruit rot.

2 **Stem end rot –** It is considered next most serious post harvest disease to anthracnose, prevalent during transport and storage. Infected fruit rots completely within 4-5 days and losses due to the disease vary from 3-5 percent. This is a caused by the fungus *Lasiodiplodia theobromae (Diplodia natalensis).* The germinated spores enter the fruit via exposed surface of the pedicel or bruised portion of the ski. The damage is characterized by the appearance of dark discoloration starting from the pedicel end of ripening fruit. Under warm and moist conditions, the lesion progress rapidly and extends towards the distal end of the fruit. The affected skin turns dark-brown to purplish black and the flesh becomes soft and watery.
Prevention. Prune dead/infected branches, leaves and pedicels to remove sources of inoculum. Spray recommended fungicides to prevent the incidence of the disease. Harvest fruits with about 1-2 cm of the pedicel retained and avoid bruising the fruit during harvesting and handling.
Control.Dip newly harvested fruits to hot water at 52°C to 55°C for 10 minutes. Fruits should be packed properly in appropriate boxes or crates with lining and proper ventilation. Do not use banana leaves or dried straws for lining.

3 **Scab**. It is considered as minor disease, mango fruits are seldom spared from the attack of the fungus. This is caused by the fungus *Elsinoe mangiferae* Brit and Jenkins. On young fruits, infection appears as grayish-brown spot with dark irregular margin. Affected fruits fall to the ground. As the spots enlarge, the center cracks forming raised-fissured corky tissues. Generally, lesions are skin-deep and do not penetrate the flesh, however, heavily-infected fruits have low market value. Large spots may also affect the inner tissues. In moist weather, velvety, grayish-brown masses of spores are produced in contrast to the pinkish anthracnose. Scab also attacks the leaves, twigs, as well as the main and secondary branches of the panicle.
Prevention. Prune and collect damaged leaves and branches to reduce fungal spores. Apply protectant fungicides a week after bud break, fruit setting and during fruit enlargement. Bag fruits to reduce incidence of scab; bag should be properly shielded.
Control. Apply copper fungicides. Avoid mechanical injuries on fruits as they become more susceptible to the fungus.

4 **Sooty Mold.** The causal organism is non-pathogenic because it feeds on the tissue surface and does not enter the host. The fungus grows and gets its nourishment from honey dew, the excreta of hoppers, mealy bugs, scales, and other sucking insects. The fungus grows as a thin, profuse, black papery layer on mango leaves. Although no direct damage is done, the photosynthetic activity of the leaf is adversely affected due to extensive growth of the fungus over the leaf area. The normal flowering habit of the tree is affected. The fungus does not completely cover the surface of the fruit, but it appears as irregular black spots starting from the base of the fruit. In some instances, stains appear tear-like as the rain washes the spores down the fruit from the pedicel or twig. Affected fruits are not fit for export.
Prevention. Destroy sucking insects by spray application of recommended insecticides. Bag fruits 45-55 DAFI.
Control. Control the insects which produce the honey dew. Wash and brush with water and soap the fruits with sooty molds after harvest.

5 **Gummosis (Root Rot, Crown Rot**)- Infection is due to the fungus, *Phytophthora palmivora*, largely confined to the bark and is conspicuous in the form of gum exudation. The decline cause of gummosis is slow, although it can be very rapid on a susceptible host and under favourable conditions of temperature and moisture. Gummosis attacks the trunk near the soil, larger main roots, and the fibrous or feeder roots. The first symptom is a profuse gumming on the surface of the affected bark. The infection extends both upwards and lateral. When scraped, affected part is brown in contrast to green healthy tissues.
Prevention. Prior to sowing, sterilize potting media to reduce source of infection as fungus is soil inhabiting. Plant seedlings in well-drained soil and avoid injuring the root and the trunk cultivation. Practice proper cultural management to ensure healthy and vigorous plant.

Control. Scraped infected bark and disinfect exposed wood by spraying 1% potassium permanganate solution. Use standard trunk paint consisting of 2.5% Captan+2.5% Cupravit. If necessary, drench soil with Ridomil (100mg/L) or Aliette to control disease.

HARVESTING AND POST HARVEST HANDLING

Harvesting and postharvest handling are critical operations in preserving the quality of fruits, as such utmost care should be emphasized in these aspects.

Maturity indices. Maturity indices play an important role in determining the final quality of fruits to be harvested. Only mature mangoes should be harvested to ensure better physical appearance and good quality when fully ripe. On the other hand, immature fruits exhibit a greater tendency to loose moisture, inferior quality and lack the aroma and flavor characteristics. To determine fruit maturity, a combination of visual, computational and chemical methods may be used.

1. Days from flower induction (DAFI) is one of the most common ways and basis of determining maturity of fruits. When trees are induce to flower early in season, (August to November) the expected harvesting dates vary from 120 to 130 DAFI. However, fruits mature earlier when induction is done late in season (December to April) and harvesting is from 110 to 115 DAFI. Weather conditions such as temperature and light intensity are important considerations.
2. The following physical attributes of the fruit are also a good indicator that fruits are mature for harvests**.**
    a. Flattening of shoulders and fullness of cheeks.
    b. Presence of "bloom" or powdery deposits present on the peel/ skin of the matured fruits.
    c. Formation of yellow green color near pedicel and yellowing of pulp or the flesh.
3 Flotation method, a procedure to determine maturity of fruits which involves dipping of mango fruits in 1 percent salt solution. Those that floats are usually considered immature while those that sink are mature. In practice, a day before harvest 12 fruits are randomly picked. Place them in 1 percent salt solution (100 g salt in 10 li water). If 9 fruits (75%) submerged in water (sinkers), the entire fruit is ready for harvest.
4 Determining the total soluble solids (TSS) of the fruits. At harvest the fruit should have 7-8 ^{o}Brix to be considered mature for harvest while at ripe stage, fruits with $\geq$15 ^{o}Brix TSS means that these were harvested mature.

Harvesting. Mango fruits should be harvested at the proper stage of maturity to avoid problems associated with moisture loss as well as shriveling of fruits. When immature fruits are harvested, these ripen with inferior quality, lacking in aroma and flavor. The skin does not develop into full color and the fruits are susceptible to physiological and pathological disorders.

Methods of harvesting

a. **Handpicking** is still the best method of harvesting fruits. In handpicking, harvester may use a cutter shear to cut the pedicel of the fruit. In the absence of such, the harvester should pull the fruit downward when harvesting in order that there would be a remaining pedicel on the fruit, thereby minimizing latex flow.
b. **Picking pole** with cutting edge and soft net/basket is recommended in harvesting matured fruits beyond reach. Most often, the harvester has to climb the tree with his pole and collect the fruits. Harvested fruits should be placed in a small basket with linings and carefully lowered down for subsequent transfer to suitable containers. Bruising associated with improper handling should be avoided in order to maintain the good quality fruits. This is done by harvesting only 3 to 4 fruits at a time. Baskets that carry the fruits should also be lined with newspaper. Subsequent transfer of fruits should be avoided.

Harvest fruits between 9:00 A.M. to 3:00 P.M. This is done to allow the tree and fruits to dry, minimizing latex flow which causes staining of the fruit skin when fruits are harvested early in the morning. Leaving short pedicel (2.0 - 5.0 cm) on the fruit helps/reduce and divert latex flow away from the fruit surface. Inverting fruits with pedicel down on newspaper or suitable materials also minimize latex staining of fruits.

Harvesting considerations

1. After harvest keep the fruit bags until sorting and washing
2. Keep harvested fruits in a shaded area and avoid contact of fruits on the ground
3. Collecting baskets (kaings) must be lined with newspaper, do not use banana leaves or rice stalks
4. The use of plastic crates lined with newspaper is encouraged

Minimizing latex stain

1. Trim stem close to the shoulder
2. Allow latex to drip for 20-30 minutes (stem-end down)
3. Dip freshly de-stemmed fruits in 1% alum solution

Postharvest Handling

a. **Sorting, grading and classification**. Sorting and grading operations are essential in the mango commodity system to determine the marketability of the products. These activities can be done either in the farm or packinghouse, manually or through the use of mechanical sorters. Injured, undersized fruits and those with obvious defects should be sorted out in the farm to minimize subsequent handling of the fruits for packing.
Harvested fruits are inspected and sorted as to size and quality (marketable and non-marketable. Marketable fruits should be further classified into different sizes as follows: extra large (375 gm or more), large (290 to 356 gm), medium (242 to 298 gm), small (190 to 240 gm) and super small (160 to 189 gm). Extra care should be considered in handling the fruits to avoid mechanical injuries. It is also advisable to place graded fruits in suitable containers to minimize too much handlings. Fruits should not be stocked/piled on the ground to avoid contamination from diseases particularly fruit rot.

b. **Packaging.** Packaging is usually done in the farm after harvest for local market, however for domestic and export market, packing is done in a packinghouse. One of the most important functions of packaging is to protect and deliver the fruits to the consumers in the best possible condition. Good packaging is necessary to preserve the quality of the produce. Mangoes are easily bruised or crushed and once damaged, the rate of deterioration is increased and the self life is shortened.

   When bamboo basket (kaing) is used, this should be lined with newspaper and protected with wooden planks during transport to provide protection for the fruits against compressiondamage. It varies in sizes from big ones weighing 50 kg to small sizes weighing 35 kg. Bruising and other fruit injuries are common in fruits placed in kaings. To minimize this problem, bamboo baskets should be lined with newsprint's and over loading should be avoided. Organic materials such as rice straw and banana leaves should not be used as they may contaminate the fruit with the fungus, *Aspergillus* which is easily transferable to this fruits.

   Plastic crates, wooden crates and fiber cartons are packing containers for export market. These are durable, long lasting and provide maximum protection for the fruits. However, these are also expensive compared to bamboo baskets. On the other hand, fruits intended for export are packed following the specific requirements of importing countries. In general, fruits are either placed in cell type boxes or wrapped singly at 4 to 10 kg capacities per packaging. Fruits may also require

specific treatment as needed such as hot water treatment (HWT) and vapor heat treatment (VHT).

Postharvest treatments. To minimize infection of diseases (anthracnose and stem-end rot) and to disinfest harvested fruits from insects (fruit flies) postharvest treatments are essential. In addition, several importing countries also require specific treatments to kill the different stages of fruit flies which might be carried during shipment.

a. **Hot water treatment (HWT).** In order to minimize infection from anthracnose and stem-end rot which soon develop after harvest, hot water treatment (HWT) is recommended. Dip newly harvested fruits (less than 24 hrs after treatment) in hot water (52 to 55°C) for 10 min. This is followed by hydro-cooling in tap water for another 10 minutes prior to air drying. Hot water treatment will remove latex stain provided fruits are treated immediately after harvest. Rinse in running water for 10 min, air dry and pack.
   For HWT to be effective follow the temperature requirements strictly. Temperatures below are ineffective and do not kill the fungus while the temperatures above can cause peel scalding. The time required for dipping the fruits should be also strictly observed.
b. **Modified hot water treatment.** It is also used to disinfect fruits from anthracnose and stem-end rot, however the amount of treatment time is lesser compared to HWT. Newly harvested fruits are dip in hot water at a temperature of 60 ^{o}C for 1 minute, followed by air drying then packing.
c. **Extended hot water dip treatment (EHWT).** Fruits for export to China are treated using extended hot water dip treatment for fruit fly disinfestations. Fruits are dipped in heated water until pulp temperature reached 46°C and held for 15 min. This is followed by air cooling for 10 min, hydrocooling for 30 min, air drying and packing. The total treatment time is 2 hrs.
d. **Vapor heat treatment (VHT).** This is used to disinfest the fruit from fruit fly eggs and larvae and a requirement of countries like Japan, Australia and USA. Fruits subjected to VHT are held for 1 hour at relative humidity of >90percent and exposed to a temperature of 46°C for 10 min. The treatment normally requires 4 hours duration. After which, the fruits are wrapped individually and placed in carton boxes.
e. **Irradiation.** It is an alternative to VHT but specifically designed to disinfest mango against mango seed and pulp weevils by subjecting the fruit to irradiation using 300 Gy of Cobalt 60. According to researchers, the use of irradiation in fruit disinfestations is rapid, convenient and safe, however the facility is costly.

Ripening. Natural ripening of fruits at room temperature is still the best. Usually it took 5 to 10 days from harvest to reach full ripening of fruits. Mixing of ripe and unripe fruits is also practice by the farmers for even and transfer ripening. On the other hand, most retailers hasten ripening of mango fruits by placing calcium carbide, (CaC_2) at the rate of 5 to 6 gm per kg of fruit. Carbide is wrapped with newspaper and placed with the fruits in the container.
However, best results are obtained by allowing the fruits to ripen naturally at half-ripe stage and treat with carbide at 1.25 g/kg fruit. This modification in the treatment results to the complete ripening of fruits 8 days after harvest**.**

Storage. Mango should be stored in an area free from decaying plant waste, foul smell and must be fully sanitized to avoid contamination. Low temperature storage can extend the green shelf life of mango. However, chilling injury becomes a problem during prolonged storage. At 12 to14 °C at 85 to 95% relative humidity, 'Carabao' mango can be stored safely for three weeks but an additional 5 days is required at room temperature to fully ripen the fruits.

For distance markets the Postharvest Training and Research Center of UPLB has developed a technology for long term storage of fruits using Controlled Atmosphere (CA). The packed fruits are

stored at a room with 6% oxygen and 4% carbon dioxide. The temperature in the room must be maintained at 13 ^{o}C. CA could retard fruit ripening up to 28 days.

Transport. Careful handling during transport of fruits is essential to minimize damage due to bumps. It is also important not to overstocked the vehicle and the fruits are covered against sunlight and unexpected rain. For long distance travel especially using RORO facilities, refrigerated van is recommended for it is more convenient and practical.

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Cost and Return in Establishing a Hectare of Mango Farm

The cost and return in the establishment of a hectare mango plantation covers estimated expenses from year one to the fifteenth year of production cycle of mango. The establishment observed a planting distance of 10 x 10 meters or 100 trees in a hectare. The estimated costs of supplies, materials, tools and equipments were based on March 2011 prices under Guimaras condition.

Requirements in the establishment of one-hectare mango farm.

1) Equipments and tools

Quantity	Item	Unit Price (P)	Cost (P)
1 unit	knapsack sprayer	2,500.00	2,500.00
2 units	spade	650.00	1,300.00
2 units	hoe	200.00	400.00
2 units	bolo	350.00	700.00
1 unit	crowbar	170.00	170.00
4 units	watering can	125.00	500.00
1 unit	weighing scale	1,200.00	1,200.00
Sub-total			**6,770.00**

2) Supplies and materials

Quantity	Item	Unit price (P)	Cost (P)
110 pcs	grafted 'carabao' mango	30.00/pc	3,300.00
100 m	rope (1.27 cm thick)	7.00/m	700.00
100 pcs	bamboo stakes (1.5 m)	2.50/pc	250.00
1 pc	meter stick	60.00/pc	60.00
1 pc	triangular stick	25.00/pc	25.00
10 kg	complete fertilizer (commercial)	1,200.00/bag (50 kg)	240.00
0.5 L	Insecticides	1,080.00/L	540.00
0.5 kg	Fungicides	1,300.00/kg	650.00
1 roll	plastic twine	120.00/roll	120.00
200 kg	organic fertilizer	180.00/bag (50 kg)	720.00
Sub-total			**6,005.00**

3) Labor

Activity	Man-day (MD)*	Cost (P)
Land clearing, plowing and harrowing	25	7,500.00
Lay-outing	3	600.00
Digging holes and basal fertilization	4	800.00
Fertilizer application	2	400.00
Planting	2	400.00
Staking/propping	1	200.00
Watering (2 MD/week for 12 weeks)	24	4,800.00
Spraying (1 MD/quarter for 4 quarters)	4	800.00
Weeding (1 MD/quarter for 4 quarters)	4	800.00
Sub-total		**16,300.00**

*Labor cost at Php 200.00/MD and 300.00/man-animal day.

Summary of cost of establishing a hectare mango farm.*

Particulars	Amount
Equipment and tools	6,770.00
Supplies and materials	6,005.00
Labor	16,300.00
Total	**29,075.00**

Cost for Pruning Activities

1) Cost of tools and materials for pruning

Year	Pruning shear/saw[1]		Paint/Cultar		Paint brush		Total Cost (Php)
	Quantity	Cost (Php)	Quantity (quart)	Cost (Php)	Quantity	Cost (Php)	
1	-	-	-	-	-	-	-
2	1	400.00	-	-	-	-	400.00
3	-	-	-	-	-	-	-

4	-	-	-	-	-	-	-
5	1	1,000.00	1	200.00	1	50.00	1,250.00
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	1	400.00	2	400.00	-	-	800.00
9	-	-	-	-	-	-	-
10	1	1,000.00	2	400.00	1	50.00	1,450.00
11	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
13	1	400.00	2	400.00	-	-	800.00
14	-	-	-	-	-	-	-
15	1	1,000.00	3	600.00	1	100.00	1,700.00
Sub-total		**4,200.00**		**2,000.00**		**200.00**	**6,400.00**

[1]Price of pruning shear is Php 400.00 while pruning saw is Php 1,000.00/unit.

No pruning activity on the first year.

2) Cost of pruning activities

Year	Cost of tools and materials (Php)	Labor Cost (Php)	Total Cost (Php)	
			Per hectare	Per tree
1	-	-	-	-
2	400.00	200.00	600.00	6.00
3	-	-	-	-
4	-	-	-	-

5	1,250.00	400.00	1,650.00	16.50
6	-	-	-	-
7	-	-	-	-
8	800.00	600.00	1,400.00	14.00
9	-	-	-	-
10	1,500.00	800.00	2,300.00	23.00
11	-	-	-	-
12	-	-	-	-
13	1,000.00	1,200.00	3,000.00	30.00
14	-	-	-	-
15	2,000.00	1,400.00	3,400.00	34.00

Cost of weeding and cultivation/underbrushing activities

Year[1]	Weeding[2]		Cultivation[3]		Total Cost (Php)	
	MD	Cost (Php)	MAD/MD[4]	Cost (Php)	per hectare	per tree
1	-	-	-	-	-	-
2	3	600.00	3	900.00	1,500.00	15.00
3	3	600.00	5	1,000.00	1,600.00	16.00
4	3	600.00	3	900.00	1,500.00	15.00

5	4	800.00	5	1,000.00	1,600.00	16.00
6	4	800.00	3	900.00	1,700.00	17.00
7	4	800.00	5	1,000.00	1,800.00	18.00
8	5	1,000.00	3	900.00	1,700.00	17.00
9	5	1,000.00	5	1,000.00	2,000.00	20.00
10	5	1,000.00	3	900.00	1,900.00	19.00
11	6	1,200.00	3	600.00	1,800.00	18.00
12	6	1,200.00	2	600.00	1,800.00	18.00
13	6	1,200.00	3	600.00	1,800.00	18.00
14	7	1,400.00	2	600.00	2,000.00	20.00
15	7	1,400.00	3	600.00	2,000.00	20.00

Tools used were the same in the establishment

[1]Weeding requirement for 1 year are already included in orchard establishment

[2]Ring weeding at a distance of 1 meter from the trunk for 1-5 years old and canopy drip for 6-15 years old trees

[3]Cultivation of the space in between trees through plowing and harrowing at least once a year

[4]Cultivation will be done every other year and underbrushing will be implemented during the period where cultivation is not done

Cost for fertilization activities (Requirements based on March 2011 prices)

1) Cost of tools and materials needed in fertilization

Year[1]	Plastic pail		Weighing scale		Fertilizer		Total Cost (Php)
	Quantity (pc)	Cost (Php)	Quantity (pc)	Cost (Php)	Quantity (kg)	Cost (Php)	
1	1	60.00	-	-	-	-	60.00

2	-	-	-	-	10	240.00	240.00
3	-	-	-	-	20	480.00	480.00
4	1	60.00	-	-	30	720.00	780.00
5	-	-	-	-	40	960.00	960.00
6	-	-	-	-	50	1,200.00	1,200.00
7	1	60.00	-	-	100	2,400.00	2,460.00
8	-	-	-	-	150	3,600.00	3,600.00
9	-	-	-	-	200	4,800.00	4,800.00
10	1	60.00	1	1,300.00	250	6,000.00	7,360.00
11	-	-	-	-	300	7,200.00	7,200.00
12	-	-	-	-	350	8,400.00	8,400.00
13	1	60.00	-	-	400	9,600.00	9,660.00
14	-	-	-	-	450	10,800.00	10,800.00
15	-	-	-	-	500	12,000.00	12,000.00

[1]Fertilization requirements for 1 year is already included in the establishment

2) Cost analysis of fertilization activities[1]

Year	Tools and Supplies[2] (Php)	Labor (Php)	Total Cost (Php)	
			Per hectare	Per tree[3]
1	60.00	-	60.00	12.60
2	240.00	200.00	440.00	4.40
3	480.00	200.00	680.00	6.80

4	1,440.00	200.00	2,160.00	21.60
5	3,120.00	250.00	3,120.00	31.20
6	4,080.00	250.00	4,050.00	40.50
7	6,000.00	250.00	6,000.00	60.00
8	9,000.00	300.00	9,000.00	90.00
9	10,200.00	300.00	10,200.00	102.00
10	13,200.00	300.00	13,200.00	132.00
11	14,400.00	350.00	14,400.00	144.00
12	17,400.00	350.00	17,400.00	174.00
13	18,600.00	350.00	18,600.00	186.00
14	21,600.00	375.00	21,600.00	216.00
15	22,800.00	375.00	22,800.00	228.00

[1]Cost of fertilization for 1 year is included in the cost of establishment

[2]At 4th year and beyond, foliar fertilization for flowering and fruiting trees will be applied

Cost of Irrigation Activities

11) Cost of tools and labor for irrigation activities[1]

Year	Tools and Supplies (Php)	Labor (Php)	Total Cost (Php)	
			Per hectare	Per tree[2]
1	-	4,800.00	4,800.00	48.00
2	-	4,800.00	4,800.00	48.00
3	-	4,800.00	4,800.00	48.00

4	500.00	6,000.00	6,500.00	65.00
5	-	6,000.00	6,000.00	60.00
6	-	6,000.00	6,000.00	60.00
7	750.00	7,200.00	7,950.00	79.50
8	-	7,200.00	7,200.00	72.00
9	-	7,200.00	7,200.00	72.00
10	750.00	8,000.00	8,750.00	87.50
11	-	8,000.00	8,000.00	80.00
12	-	8,000.00	8,000.00	80.00
13	1,000.00	8,400.00	9,400.00	94.00
14	-	8,400.00	8,400.00	84.00
15	-	8,400.00	8,400.00	84.00

[1]Cost of irrigation for 1 year is included in the cost of establishment

Cost for Induction Activities

1) Tools, equipments, supplies and materials for induction

Item	Unit Price (Php)
Power sprayer	15,000.00/unit
Plastic drum	1,200.00/pc
Weighing scale	
Pressure hose	35.00/m

Plastic container	30.00/pc
Calcium Nitrate ($CaNO_3$)	25.00/kg

2) Cost of tools, supplies and labor for induction activities

Year	Tools and Supplies (Php)	Labor (Php)	Total Cost (Php)	
			Per hectare	Per Tree[1]
1	-	-	-	-
2	-	-	-	-
3	-	-	-	-
4	21,180.00	600.00	21,780.00	217.80
5	250.00	600.00	850.00	8.50
6	500.00	800.00	1,300.00	13.00
7	9,050.00	800.00	9,850.00	98.50
8	1,180.00	800.00	1,980.00	19.80
9	1,250.00	800.00	2,050.00	20.50
10	25,000.00	1,200.00	26,200.00	262.00
11	6,550.00	1,200.00	7,750.00	77.50
12	2,180.00	1,200.00	3,380.00	33.80
13	5,750.00	1,400.00	7,150.00	71.50
14	2,500.00	1,400.00	3,900.00	39.00
15	2,930.00	1,400.00	4,330.00	43.30

3). Details of cost analysis of tools and supplies for induction

Year[1]	Sprayer		Plastic Container		Plastic drum		Hose		$CaNO_3$		Total Cost (Php)
	Quantity (pc)	Cost (Php)	Quantity (pc)	Cost (Php)	Quantity (pc)	Cost (Php)	Quantity (m)	Cost (Php)	Quantity (kg)	Cost (Php)	
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-
4	1	15,000.00	6	180.00	2	2,400.00	100	3,500.00	4	100.00	21,180.00
5	-	-	-	-	-	-	-	-	10	250.00	250.00
6	-	-	-	-	-	-	-	-	20	500.00	500.00
7	-	-	-	-	4	4,800.00	100	3,500.00	30	750.00	9,050.00
8	-	-	6	180.00	-	-	-	-	40	1,000.00	1,180.00
9	-	-	-	-	-	-	-	-	50	1,250.00	1,250.00
10	1	20,000.00	-	-	-	-	100	3,500.00	60	1,500.00	25,000.00
11	-	-	-	-	4	4,800.00	-	-	70	1,750.00	6,550.00
12	-	-	6	180.00	-	-	-	-	80	2,000.00	2,180.00
13	-	-	-	-	-	-	100	3,500.00	90	2,250.00	5,750.00
14	-	-	-	-	-	-	-	-	100	2,500.00	2,500.00
15	-	-	6	180.00	-	-	-	-	110	2,750.00	2,930.00

Cost for Fruit bagging activities

1) Tools, equipments, supplies and materials for bagging

Item	Unit Price (P)
Bamboo ladder	1,800.00/pc
Stapler and wire	50.00/pc & 66.00/box
Old newspaper	20.00/kg
Rope	12.00/m

2) Cost details of tools, equipments supplies and materials needed for bagging

Year	Ladder		Stapler w/ wire		Old newspaper		Rope		Total Cost (Php)
	Qty (pc)	Cost (Php)	Qty (pc)	Cost (Php)	Quantity (kg)	Cost (Php)	Quantity (m)	Cost (Php)	
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-
4	1	1,800.00	3	546.00	5	100.00	-	-	2,446.00
5	-	-	4	728.00	10	200.00	-	-	928.00
6	1	1,800.00	3	546.00	15	300.00	-	-	2,646.00
7	2	3,600.00	5	910.00	20	400.00	-	-	4,910.00
8	-	-	4	728.00	25	500.00	40	480.00	1,708.00
9	3	5,400.00	6	1,092.00	30	600.00	-	-	7,092.00
10	-	-	5	910.00	35	700.00	50	600.00	2,210.00
11	3	5,400.00	7	1,274.00	40	800.00	-	-	7,474.00
12	-	-	5	910.00	45	900.00	50	600.00	2,410.00
13	3	5,400.00	8	1,456.00	50	1,000.00	-	-	7,856.00
14	-	-	6	1,092.00	55	1,100.00	60	720.00	2,912.00
15	3	5,400.00	9	1,638.00	60	1,200.00	-	-	8,238.00

2) Cost analysis of fruit bagging activity

Year	Tools and Supplies (Php)	Labor (Php)	Total Cost (Php)	
			Per hectare	Per tree[1]
1	-	-	-	-
2	-	-	-	-
3	-	-	-	-
4	2,446.00	1,000.00	3,446.00	34.46
5	928.00	1,200.00	2,128.00	21.28
6	2,646.00	1,200.00	3,846.00	38.46
7	4,910.00	1,400.00	6,310.00	63.10
8	1,708.00	1,400.00	3,108.00	31.08
9	7,092.00	1,600.00	8,692.00	86.92
10	2,210.00	1,600.00	3,810.00	38.10
11	7,474.00	2,000.00	9,474.00	94.74
12	2,410.00	2,400.00	4,810.00	48.10
13	7,856.00	2,800.00	10,656.00	106.56
14	2,912.00	3,200.00	6,112.00	61.12
15	8,238.00	3,600.00	11,838.00	118.38

Table 10.a. Cost of Pesticide management per hectare based on induction schedules (Based on March 2011 prices)

Year	Cost of Pesticide (Php) Early induction (September-November)				Cost of Pesticide (Php) Late induction (December-February)				Average Cost (Php)
	Insecticide	Fungicide	Labor Cost	Total	Insecticide	Fungicide	Labor Cost	Total	
1	110.00	216.00	400.00	726.00	110.00	108.00	400.00	618.00	672.00
2	220.00	432.00	400.00	1,052.00	220.00	216.00	400.00	836.00	944.00
3	440.00	864.00	400.00	1,704.00	440.00	432.00	400.00	1,272.00	1,488.00
4	1,171.25	2,437.45	2,400.00	6,008.70	1,062.52	567.75	2,400.00	4,030.27	5,019.48
5	1,494.85	3,656.15	2,400.00	7,551.00	1,880.15	848.25	2,400.00	5,128.40	6,339.70
6	1,993.25	4,874.90	3,600.00	10,468.15	2,506.85	1,112.00	3,600.00	6,218.85	8,343.50
7	2,491.55	6,093.60	3,600.00	12,185.15	3,132.80	1,415.95	3,600.00	8,148.75	10,166.95
8	3,737.35	9,136.55	4,800.00	17,673.90	4,700.35	2,120.50	4,800.00	11,620.85	14,647.35
9	3,737.35	9,136.55	4,800.00	17,673.90	4,700.35	2,120.50	4,800.00	11,620.85	14,647.35
10	4,982.80	12,187.20	6,000.00	23,170.00	6,744.10	2,827.25	6,000.00	15,571.35	19,370.65
11	4,982.80	12,187.20	6,000.00	23,170.00	6,744.10	2,827.25	6,000.00	15,571.35	19,370.65
12	6,228.90	15,227.00	7,200.00	28,655.90	7,833.40	3,534.30	7,200.00	18,567.70	23,611.80
13	6,228.90	15,227.00	7,200.00	28,655.90	7,833.40	3,534.30	7,200.00	18,567.70	23,611.80
14	7,474.68	18,280.80	8,400.00	34,155.48	9,400.30	6,361.40	8,400.00	24,161.70	29,158.60
15	7,474.68	18,280.80	8,400.00	34,155.48	9,400.30	6,361.40	8,400.00	24,161.70	29,158.60

Note:

1) Details of foliar fertilizers, insecticides and fungicides used and prices based on CY-2011

Foliar fertilizer = P300.00/500g; RR= 500g/200 li. water

Lambdacyhalothrin = P1,080.00/L; RR = 1 tbsp/16 li. water

Difenoconazole = P1,330.00/L; RR = 50 ml/50L water

Cartap HCl = P110.00/sachet (12g); RR=1-2 g/16 li. water

Imidacloprid+Beta-cyfluthrin = P265.00/100 ml; RR = 30 ml/100 li. water

Tebuconazole = P1,925.00/kg; RR = 65 g/100 li. water

Phenthoate = P740.00/li; RR = 35 ml/16 li. water

Azoxystrobinr = P6,240.00/li; RR = 10ml/16 li. water

Mancozeb = P630.00/kg ; RR = 375g/200 li. water

2) Induction of trees start at the 4th year and the year thereafter, in which 60% of the trees are induce per year

Cost for harvesting activities

1) Tools, equipments, supplies and materials used in harvesting

Item	Unit Price (Php)
Bamboo ladder*	
Picking pole	60.00/pc
Rope*	-
Old newspaper	20.00/kg
Plastic crate	280.00/pc

2) Cost details of tools and materials in harvesting

Year	Picking Pole		Old newspaper		Kaing		Total Cost (Php)
	Quantity (pc)	Cost (Php)	Quantity (kg)	Cost (Php)	Quantity (pc)	Cost (Php)	
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	2	120.00	5	100.00	50	14,000.00	14,220.00
5	2	120.00	7	140.00	-	-	260.00
6	3	180.00	9	180.00	50	14,000.00	14,360.00
7	3	180.00	11	220.00	-	-	400.00
8	3	180.00	13	260.00	50	14,000.00	14,440.00
9	3	180.00	15	300.00	-	-	480.00
10	4	240.00	18	360.00	50	14,000.00	14,600.00
11	4	240.00	21	420.00	-	-	660.00
12	4	240.00	23	460.00	50	14,000.00	14,460.00
13	5	300.00	25	500.00	-	-	800.00
14	5	300.00	27	540.00	50	14,000.00	14,840.00
15	5	300.00	30	600.00	50	14,000.00	15,200.00

3) Cost analysis of harvesting activity

Year	Tools and Supplies (Php)	Labor (Php)	Total Cost (P)	
			Per hectare	Per tree[1]
1	-	-	-	-
2	-	-	-	-
3	-	-	-	-
4	14,200.00	400.00	14,620.00	146.20
5	260.00	400.00	660.00	6.60
6	14,360.00	600.00	14,960.00	149.60
7	400.00	600.00	1,000.00	10.00
8	14,440.00	600.00	15,040.00	150.40
9	480.00	800.00	1,280.00	12.80
10	14,600.00	800.00	15,400.00	154.00
11	660.00	800.00	1,460.00	14.60
12	14,460.00	800.00	15,260.00	152.60
13	800.00	1,000.00	1,800.00	18.00
14	14,840.00	1,000.00	15,840.00	158.40
15	15,200.00	1,000.00	16,200.00	162.00

Table 1. Summary of Establishment and maintenance cost for one hectare mango orchard.[1]

Year	Establish-ment[2] (Php)	Pruning (Php)	Weeding/ Cultivation (Php)	Fertilizatio n (Php)	Irrigation (Php)	Flower Induction (Php)	Fruit Bagging (Php)	IPM (Php)	Harvesting (Php)	Total Cost per hectare (Php)	Total Cost per tree (Php)
1	29,075.00	0.00	0.00	60.00	4.800.00	0.00	0.00	672.00	0.00	33,935.00	339.35
2	0.00	600.00	1,500.00	440.00	4,800.00	0.00	0.00	944.00	0.00	8,284.00	82.84
3	0.00	0.00	1,600.00	680.00	4,800.00	0.00	0.00	1,488.00	0.00	8,568.00	85.70
4	0.00	0.00	1,500.00	2,160.00	6,500.00	21,780.00	3,446.00	5,019.48	14,620.00	55,025.48	550.25
5	0.00	1,650.0	1,600.00	3,120.00	6,000.00	850.00	2,128.00	6,339.70	660.00	22,347.70	223.48
6	0.00	0.00	1,700.00	4,050.00	6,000.00	1,300.00	3,846.00	8,343.50	14,960.00	40,199.50	402.00
7	0.00	0.00	1,800.00	6,000.00	7,950.00	9,850.00	6,310.00	10,166.95	1,000.00	43,076.95	430.77
8	0.00	1,400.00	1,700.00	9,000.00	7,200.00	1,980.00	3,108.00	14,647.35	15,040.00	54,075.35	540.75
9	0.00	0.00	2,000.00	10,200.00	7,200.00	2,050.00	8,692.00	14,647.35	1,280.00	46,069.35	460.69
10	0.00	2,300.00	1,900.00	13,200.00	8,750.00	26,200.00	3,810.00	19,370.65	15,400.00	90,930.65	909.30
11	0.00	0.00	1,900.00	14,400.00	8,000.00	7,750.00	9,474.00	19,370.65	1,460.00	62,354.65	623.55
12	0.00	0.00	1,800.00	17,400.00	8,000.00	3,380.00	4,810.00	23,611.80	15,260.00	74,261.80	742.62
13	0.00	3,000.00	1,800.00	18,600.00	9,400.00	7,150.00	10,656.00	23,611.80	1,800.00	76,017.80	760.18
14	0.00	0.00	2,000.00	21,600.00	8,400.00	3,900.00	6,112.00	29,158.60	15,840.00	87,010.60	870.11
15	0.00	3,400.00	2,000.00	22,800.00	8,400.00	4,330.00	11,838.00	29,158.60	16,200.00	98,126.00	981.26

Table 1. Estimated Cost and return for a Hectare of mango Orchard.[1]

Year	Harvestable Fruits (kg)	Gross Income (Php)[2]	Production Cost (Php)[3]	Yearly Net Income (Php)
1	0	0.00	33,935.00	(33,935.00)
2	0	0.00	8,248.00	(8,248.00)
3	0	0.00	8,568.00	(8, 568.00)
4	60	1,800.00	55,025.48	(53,225.48)
5	150	4,500.00	22,347.70	(17,847.70)
6	300	9,000.00	40,199.50	(31,199.50)
7	600	18,000.00	43,076.95	(25,076.95)
8	1,500	45,000.00	54,075.35	(9,075.35)
9	2,400	72,000.00	46,069.35	25,930.65
10	3,600	108,000.00	90,930.65	17,069.35
11	4,800	168,000.00	62,354.65	105,645.35
12	6,000	210,000.00	74,261.80	135,738.20
13	7,800	273,000.00	76,017.80	196,982.20
14	9,600	336,000.00	87,010.60	248,989.40
15	12,000	420,000.00	98,126.00	321,874.00

[1]Only 60 percent of the trees will be induced to flower every year.

[2]Fruits farmgate price at Php30.00/kg (year 1 to 10) and Php35.00/kg (year 11 to 15).

[3]See table 1 for detail

The computed return on investment is:

$$\text{Average ROI} = \frac{915{,}804.17}{802{,}282.83} \times 100\% = 114.44\ \%$$