NICARAGUA

ARAP

Agriculture Reconstruction Assistance Program

GROWERS MANUAL FOR PRODUCTION OF CASHEW NURSERY AND PLANTATION

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1.0 ABOUT THE CASHEW

1.1 Background

The cashew (Anacardium occidentale) belongs to the family Anacardiaceae which also includes other tree crops like mango and pistachio. Cashew is a fast growing, ever green perennial tree well suited to the wet/dry tropical climate in parts of Nicaragua. The tree has a long productive life, perhaps up to 50 years, although in poor conditions the economic life would be reduced.

The cashew produces a nut containing a kernel, and also a fruit known as the cashew apple. The nut is processed for the kernel, which is sold as an edible nut and is the main economic product. The cashew apple has various uses, it can be eaten as fresh fruit, or processed into juice and other products. There is also a by-product from processing the nut. Cashew nut shell liquid (CNSL) can be extracted from the spent shells of the nut during processing, and this product has various industrial uses.

The cashew tree originated in NE Brazil, and its cultivation has now spread to many tropical countries. To day, the major producing countries are India, Vietnam, Brazil and Tanzania. The major export markets for the kernel are USA, Europe, Canada, Japan and Australia. China has also emerging as a major market. In addition India has a growing domestic market. The world production of cashew has doubled in the past 25 years, however world demand has increased at the same rate so that kernel prices have remained relatively stable over this period

1.2 Environmental Conditions for Cashew

Soil cashew prefers a free draining, light textured deep soil. Sands and sandy loams with no compacted areas to a minimum depth of 1.5 meters are ideal. Soil should be moderately acid to neutral, pH of 5.5 to 7.0. Cashew will grow well on soils of low fertility, provided sufficient nutrients are applied.

climate cashew prefers a frost free, tropical climate, where the mean monthly temperature does not drop below 10 degrees C. Temperatures in excess of 40 degrees C can be tolerated.

cashew also requires distinct wet and dry seasons. Total annual rainfall should preferably be between 1,000 to 2,000 mm with a clear dry season of about 5 – 6 months

1.3 About the Biology of Cashew

In good conditions the cashew tree will commence production of crop in two years, and in average conditions in three years. The growth curve of the tree normally shows the maximum rate of growth of the canopy (and crop) in years 3 to 6, and thereafter the rate slows until a 'mature' size is reached about year 10. Depending on the varietal characteristics the tree may then continue to increase in size marginally.

**Phenology - ** the cycle of vegetative and reproductive growth of the mature cashew tree follows a distinct pattern, where the monthly timing of each phase will depend on local climate conditions, and especially temperature and availability of water. In hot coastal tropical areas (as evident in Chinandega/Leon), there are generally three flushes of growth during the year. The flowering, fruit development and cropping occurs during the dry season. When ripe the crop (nut and apples) will fall to the ground. The first growth flush (called post harvest flush) occurs after the cropping has finished. The second growth flush (wet season flush) occurs during the main wet season period, and it is during this time when the major vegetative growth occurs. The final flush (pre-floral) occurs soon after the commencement of the dry season. An understanding of the crop cycle of cashew will help in management decisions such as pest management, fertilisation and irrigation.

Floral biology – the cashew tree produces bothy male and hermaphrodite flowers on the same panicle. There are more male flowers produced than hermaphrodite flowers produced, the ratio is generally 10 male to 1 hermaphrodite, but this can vary depending on the variety. The sex ratio can also vary during the flowering period . In addition more than 80 % of the hermaphrodite flowers drop before they produce a mature nut. In terms of timing, male flowers typically open earlier in the day, while hermaphrodite flowers open later in the early afternoon. The female part of the hermaphrodite flower is receptive to pollen from the male flower for about 6 hours, and for better nut set pollination should occur within this time

Pollination and nut set – cashew is pollinated by insects (native bees, honey bees, flies, wasps). Although a large number of flowers are produced on a panicle, nut set is relatively low because of the low sex ratio and poor pollination. Sometimes poor pollination can be caused by a lack of pollinating insects and in this case the inclusion of honey bees can help. Nutrition, water availability and pest damage cam also influence nut set.

1.4 Cashew Varieties

Cashew does not grow true to type from seed, and seedlings vary in several characteristics including growth habit (tree size and canopy shape) and nut quality. **Total yield** is influenced by canopy size, but it is also influenced by management (nutrition, irrigation).

Growth habit – can vary from spreading, open trees with few terminal branches to upright, intense branching trees with a large number of terminal branches. The upright, intense branching types have a much higher yield potential because of the greater number of panicles per unit of canopy area. They also require less pruning and are easier to manage.

Nut size– influences kernel size and larger kernels receive higher prices

Recovery rate – is the weight of kernel expressed as a % of the whole nut. This determines the yield of kernel and the price a processor may pay for crop. Kernel recovery % may vary from 20 % to about 38 %.

As cashew seedling do not grow true to type, the only way to plant a cashew plantation with high quality trees is to

- make selections of seedlings trees based on the criteria mentioned above
- produce replicates by vegetative reproduction.

1.0 ECONOMIC CONSIDERATIONS

2.1 Production

Maximum returns will be achieved in cashew production if the following points are followed,

1. Cashew should be grown only in favourable environmental conditions.

2. Where possible only the best cashew varieties available are planted in the recommended spacings. The ARAP program of importing and evaluating cashew seedlings has the objective of producing high class cashew varieties for use in Nicaragua.

3. Correct management of the young tree and its canopy

4. Careful attention must be given to correct nutrition, pest management, and also to water application regimes if irrigation is used.

The returns that growers will receive from cashew production may vary, largely depending on the skill of the grower and his level of management. Cashew yields will become commercial in third year, and will keep increasing until about the 10^{th}, whereafter they will remain stable for the economic life of the tree (25 to 50 years depending on environmental conditions and management).

Growers who plant good cashew varieties in good environmental conditions and use irrigation with a good nutrition program and pest control may achieve from 2,500 kg to 3,000 kg/hectare of crop with high quality nuts when the trees achieve maturity (year 10). This is a gross return at the farm gate of about US$ 2,375 to US$ 2,850 per hectare (US$ 1,660 to US$1,995 per manzana). Exceptional growers may achieve higher yields, 3,500 kg/hectare or more. (See Gross Margin analysis in Appendix 2)

Growers who do not use irrigation, but otherwise adhere to recommended criteria indicated above may achieve a crop of 1,500 kg to 1,750 kg per hectare. This is a gross return at farm gate of US$1,350 to US$ 1,575 per hectare. (US$ 945 to US$ 1,100 per manzana) About 20 % of the income value will be attributable solely to the higher nut quality achieved by planting good varieties. If growers do not plant good varieties then their income could be significantly less than indicated above.

Growers should not be concerned about **market demand for cashew**. The world market is very large with total world production at about 900,000 MT of raw nuts. While world production has doubled in the past 25 years, demand has increased at the same rate with the result that prices have remained relatively stable. World prices for cashew kernel W320 grade (the majority grade in the market) are shown in Appendix 1. They show that occasionally crop shortages in major producing countries (India, Vietnam, Brazil) can lead to higher prices for cashew (years 1981, 1999). However in normal prices have averaged about US$ 2.50/lb over the past 25 years. This trend for relatively stable prices is expected to continue.

Given the very large size of the world market, any developments in Nicaragua will make no impact on market outcomes.

3.0 HOW TO PICK A GOOD VARIETY

3.1 Screening Process

All cashew seedlings should be planted in similar conditions and receive a consistent management, so as to isolate and measure the genetic characteristics. The selection process involves

- the monitoring of performance of the trees over a long enough period in order to obtain a good measure of the seedlings potential.
- making selections based on the important criteria
- cloning the selected seedling by grafting or budding to produce replicates of that variety. These replicate trees are then used as "sources of scions (yemas) for the large scale production of the selected variety
- these varietal trees are then used for commercial plantings.

In making selections it is necessary to have sufficient data in order to have reasonable certainty of a correct decision. While monitoring a trees performance up to maturity (10 + years) would give a perfect data on the trees' potential, this is not a practical option in the business world. **Therefore in the balance of time and certainty of result it is recommended that a minimum of 3 years of data from immature trees is required** While in good conditions the trees may commence yielding in the second year, it is advisable to disregard this early yield as conclusive data. Serious crop data collection should commence in year 3 and continue in years 4 and 5. At age 5 the grower should have sufficient data to make a selection with confidence, however he should continue to monitor the selected tree after year 5 just for additional confirmation of his selection.

The final objective is to plant large scale commercial areas with a relatively small number of the elite varieties. The screening process may begin with 100s or 1,000s of trees, but perhaps only about 10 % representing the very best should be used for commercial production. <u>However it is important not to eliminate any of worthwhile trees from the plantings as it is always possible that they may have some characteristics that can be utilized in a future hybrid breeding program.</u>

3.2 Data required for Selection

The important criteria for selecting a good variety are as follows,

kernel size **-** W320 grade or larger. (W320 is 300 – 320 kernels per lb, or 1.41 gm kernel should be minimum size). W320 is the grade in most demand while larger kernels (W240, W210 etc) fetch higher prices.

recovery % **-** is ratio of weight of kernel (minus testa) to weight of whole nut. A minimum recovery of 30 % should be set for selection. A recovery of about 35 % is very rarely found but achievable.

total yield - no absolute figure is given, apart from selecting those tree that yield in the top 10 % of trees under selection

tree shape - (growth habit). Cashew only produced fruit on the canopy surface and therefore a tree with a natural **dense canopy** will have a greater potential for cropping (greater canopy area). In addition a **compact and upright** growth habit will increase the potential for higher density plantings – and allow higher yields per hectare.

time of bearing - some types are naturally early bearing, this is they produce their crop earlier in the season. An early bearing variety saves production costs as their more intense management period is reduced. It also is a guarantee that the crop will be collected before any premature start to the wet season.

3.3 How to Collect the Data

All trees in the plantation should have a unique number for identification, an easy system is (1) a row number and (2) tree number. In the first two years all trees are observed for performance, and if possible the trees which appear to have the most potential should be identified prior to the 3rd year harvest. However you can add or subtract from this list based on your observation of the potential of the 3rd year harvest.

You should spread the net quite wide at this stage – if you have 1,000 seedlings under trial, try and pick the best 100. If resources are limited at least pick the best 50.

The steps of data collection for the above 100 selected trees is as follows,

1. The crop from all of the 100 trees should be isolated so that an accurate measure can be made of the **total yield**. On conclusion of the harvest the apple is removed and the total nut crop is weighed and recorded. Apart from the requirements of further sampling the crop may be used for commercial purposes.

2. Trees should be assessed for both **dense canopy** and **upright growth habit**. This is a qualitative assessment, and trees can be assessed as having (1) good, (2) medium, or (3) less favourable levels of above characteristics.

3. A sample of 30 nuts from each tree is removed for nut quality analysis and the following steps taken to make the assessment for both **kernel size.**

   (a) soak nuts in water for ¾ days to soften shells.

   (b) cut through shell (wearing gloves as protection against CNSL)

   (c) remove kernel with testa attached

   (d) dry kernel with testa at 65 degree C for 4 days

   (e) weigh kernel with testa (KT) and adjust weight at 5 % moisture using formula (KT – (KT x 0.066] x 1.055

2. For analysis of **recovery rate** the following steps are undertaken with the same 30 nut sample as above.

   (f) weight 30 nuts (total weight) before soaking as required above. (it can be assumed that raw crop after harvest in Nicaragua climate will be at 10 % moisture level)
   (g) take kernel weight of 30 kernel from (e) above and express as % of total weight of (f)

It should be noted that the analysis for recovery rate and kernel size requires professional input and use of some equipment. It may be more appropriate for some growers to contract the collection of this data to a suitable institution.

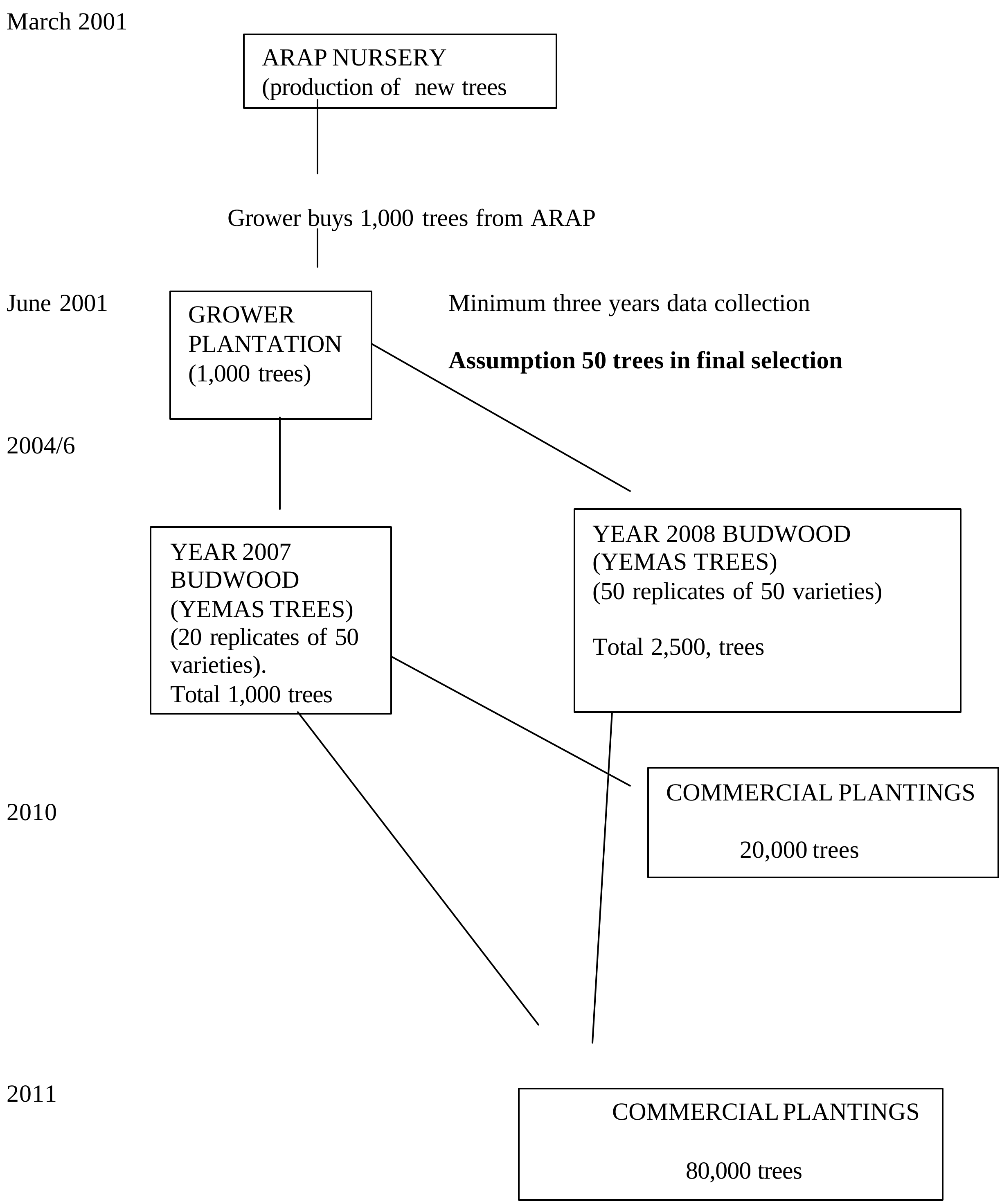
Following the collection of data on 3rd year harvest, it may be appropriate to reduce the number of selections to a reduced elite group, to perhaps 50 % of the original selections. This reduced group should be evaluated in similar fashion in years 4 and year 5.

It is also advisable that growers make an early guess as to which trees may end up as their final selections. In this case the grafting of one or two replicates of these selections will significantly reduce the time required for large scale multiplication later on. It is important not to take more than a couple of scions (jemas) off each tree so as not to jeopardize future cropping of this tree (which is still under evaluation).

3.4 Multiplication for Commercial Production

The 'raw material' for the new varieties are the replicate trees grafted from the selected mother trees. These replicate trees are grown solely for the production of scions (yemas), they are a budwood nursery (yemas plantation). This budwood nursery should be planted and maintained similar to the other trees, and when their role of providing scions (yemas) is over these trees revert to a commercial cropping role.

<u>A Development path for a Grower who buys 1,000 new seedlings from ARAP may be as follows</u>.



<u>The potential rate of production on selected varieties is exponential thereafter</u>

4.0 TECHNICAL DETAILS - NURSERY

4.1 Nursery Infrastructure

The nursery should be located on level ground, and in sheltered position (away from strong wind). It must be located close to a source of water. There should also be a sufficient sheltered area adjacent to the nursery to allow the young trees to be held for two weeks in full sunlight prior to planting in the field.

It is important to have sufficient area in the nursery for both (1) holding trees and (2) for working space. With two litre planting bags of 10 cm diameter there are 100 bags /sq meter. Allowing for 60 % working space, this requires a nursery area of 250 sq meters or 16 by 16 meters to propagate 10,000 seed.

The following items are required for the nursery operation

- shade cloth (50 % sun penetration) for roof, need to avoid direct contact of sun on seedlings, so may also need walls of shade cloth, say 1 meter of shade hanging from roof.
- water supply, either overhead sprinkler system, or hose that allows application of water by hand.
- planting bags of poly material, size 2 litre, of dimensions 10 cm and height 25 cm.
- growing medium, a suitable mixture is 50 % coarse sand and 50 % sandy loam soil.
- slow release fertilizer (NPK) in granule form
- foliar fertilizer (NPK + micro- nutrients)
- elements for possible nutrient disorders, (Iron chelate and Zinc heptahydrate)
- insecticide, dimethoate (40 % active), together with backpack spray and protective clothing.

4.2 Preparation

(a) The planting bags must be filled with the growing medium, and a small amount of slow release fertilizer is added. The planting bags can be placed in groups of 100 in the nursery.

(b) The cashew seed is sown in the planting bag, 1 cm to 2 cm below the surface of the soil. The seed should be positioned with the curve of the seed facing upwards.

(<u>Note</u>, when using seed of unknown quality, it is recommended to undertake a float test on the seed prior to planting. The float test involves putting the seed in a shallow tank of water to determine whether the seed contains developed kernel or not. Those seed that float should be discarded, while those that sink can be used for planting).

(c) The seed will usually take about 15 to 20 days to geminate

4.3 <u>Nursery Operation</u>

(a) The planted seed should be monitored **on a daily basis** for any signs of abnormalities (insect attack, nutritional deficiency etc).

(b) **Water** should be applied on regular basis, twice a day may be appropriate in hot humid conditions.

(c) An application of **NPK foliar nutrition containing micro-nutrients** should be commenced once the young seedlings are about 10 cm in height, this application to be repeated every two weeks while seedlings are in the nursery. The foliar application should be used with a wetting agent to improve the uptake of the nutrients by the seedling.

(d) Any **weeds** found growing in the pots should be removed by hand.

<u>The objective</u> is to grow the seedlings to a sufficient level of maturity inside the nursery to allow them to be moved outside into full sun for a '**hardening off'** or acclimatization process. The seedlings are ready to move from 'under shade' into full sun, in a position just outside the shaded area when the following situation applies,

- the seedlings appear healthy
- they have grown to a height of minimum 25 cm, and up to acceptable 30 cm
- the plant has sufficient foliage so that it shades the soil in the bag (it is important that the soil in the bag does not become too hot).

The time taken for the seedlings to grow to 30 cm will depend on the conditions, however in normal circumstances this could be from 8 to 10 weeks.

The move into 'full sun' is to allow them to grow further while fully acclimatizing to the weather conditions in the field prior to planting. The time spent in the 'hardening off' phase will depend on what conditions are likely to be experienced in the field, For example,

1. **If conditions in the plantation are expected to be good**, ie favourable weather conditions, well prepared planting holes, no weed competition, good management in the field, then the trees could be trans-planted when the have attained a height of about 35 – 40 cm, after about 2 to 4 weeks in the 'hardening off ' phase.

2. **If conditions in the plantation are expected to be poor,** ie less favourable weather conditions, weeds, less well prepared planting holes, possible less attentive management, then the trees should be grown to a larger size, ie at least 45 cm before transplanting. In this situation the trees may be held in the 'hardening off' phase for 4 to 6 weeks.

It is necessary to guard against holding the trees in the nursery (and remaining in the bags) for too long a period, or **the root system will become 'pot bound'**. This is a condition where then root system has out grown the area available in the bag, and probably be reached if the trees are still contained in the bag at 6 months of age.

There are two likely problem areas with the seedlings in the nursery (see below), and these are described in the following paragraphs

- nutritional deficiencies
- insect pest damage

4.4 Grafting

Grafting is the most practical method of vegetative reproduction to produce clonal trees. Grafting involves the use of vegetative material or scions cut from the selected mother tree, and these are then 'grafted' on to the recipient rootstock. There are a number of techniques of grafting in common use, two of the techniques in common use are **side grafting** and **wedge grafting.**

The stages involved in wedge grafting are as follows,

(a) rootstock should be grown to 20 to 25 cm in height (6-8 weeks)

(b) scions cut from mother tree, scions should be (1) as long as possible in length, (2) free of and insect damage or disease. After cutting scions should be placed in wet paper bag and kept cool. (scions have a short shelf live of perhaps 36 to 48 hours even in best of conditions, so should be grafted onto rootstock asap

(c) rootstock to be decapitated about 60 % up stem, making sure that some leaf foliage remains on lower stem.

(d) wedge is cut into top of decapitated rootstock stem, and corresponding wedge is cut on end of scion to ensure firm joint. (important that all cuts are with firm strokes with no raged edges)

(e) scion is joined to rootstock and union is made firm with tape or strong pegs. A plastic bag is put over top of graft union.

(f) If humidity conditions not sufficiently high it, success in grafting can be improved by placing grafted tree in a enclosed plastic 'sweat tent'.

(g) grafted tree has plastic bag above graft union removed when 2 new leaves have grown on new graft (2/3 weeks). Grafted tree can be removed from plastic sweet tent when a further 2/3 leaves have grown (4 weeks).

(h) grafted trees removed from sweat tent are placed in 50 % shade for two weeks before being placed in full sunlight to 'harden off' prior to planting in the field

The total period from grafting to planting clonal tree in the field will depend on many factors but is frequently about 12 weeks .

4.5 Nutritional Deficiencies in the Nursery

The best defence against nutritional deficiencies is to apply a foliar spray containing micro – nutrients as indicated in 1.3 (c) above. However if deficiencies are to occur the most likely are of (1) iron, and (2) zinc

Iron Chlorosis

Deficiency of iron can cause high mortality in young seedlings. In the early stages of the deficiency the seedlings growth will be affected, later visible symptoms perhaps after 4 weeks will appear, where the whole leaf except the leaf midrib turns yellow. In addition after 8 – 10 weeks black spots will be seen on the leaves,these spots may give the appearance of a fungal attack.

The recommendation is to take a proactive approach and not wait for any symptoms to appear, because by the time symptoms are evident much damage has been caused. At 6 weeks of age apply a mixture of one tea spoon of **Iron Chelate** to 10 litres of water. This mixture is probably best made up in watering cans and applied as a drench on the seedlings. One application of iron chelate will very likely be sufficient to eliminate any chance of a problem.

Zinc chlorois

The symptoms show the development of reduced leaf size and subsequent poor growth of the seedling. If symptoms appear it is necessary to apply an aqueous 0.1 % solution of **zinc heptahydrate** (or other) to the seedlings. One application is usually sufficient to cure the deficiency and normal leaf size and growth is restored.

4.6 Pest Damage in the Nursery

There is very limited information on pests of cashew in Central America. *Leptoglossus zonatus* (chinche), and other species are known to be a major pest of cashew in El Salvador, and chinche is known to breed and feed on a range of other crops such as curcubits, maize, sorghum etc. However chinche is usually associated with attack on developing crop in cashew and so is likely to be an issue with small seedlings in a nursery.

It is estimated that the following insects may be the prime cause of damage in the nursery,

- thrips, especially *Selenotrips rubrocinctus*
- aphids, possibly *Aphis gossipi*
- mites
- caterpillars

Thrips – a more detailed description of thrips is given in the plantation section, however in general thrips are very small sap sucking insects that concentrate their activities on the underside of the leaf . Their main impact is to remove fluids from the seeling and hence they reduce the health of the plant, and in severe cases this could cause death in young plants.

Aphids and mites are also small insects that feed by sucking sap and having a debilitating affect on the seedling. Mites will be found on the underside of the leaf. Caterpillars are leaf feeders and from second instar to adult status can destroy significant quantities of leaf tissue.

The recommended solution is for a **careful daily monitoring of the seedlings** in the nursery to be undertaken by a person with to evaluate the insect status of the trees. If this level of monitoring is possible then the timing of remedies can be left to when a pest threshold has been reached. However if expert monitoring is not possible then it is recommended to undertake a regular program of prophylactic sprays to maintain control.

The recommended approach is

- remove all caterpillars found on the leaves by hand. Their numbers and presence are likely to be low.

- spray with dimethoate (40 % active) at ratio of 1 : 1,500 every 3 weeks. (this chemical requires operator to use protective clothing. Note , alternative chemical can be used depending on local availability.

5.0 TECHNICAL DETAILS – PLANTATION

5.1 Plantation Design

The conditions for a budwood plantation will be the same as for a commercial plantation. The following points are relevant,

1. Select area that has **correct environmental conditions**. Rainfall and temperatures are suitable throughout Leon and Chinandega districts, so need to confirm that soils are deep, (1.5 metres) of free draining soils, and (b) pH of 5.5 to 7.0 It is preferred that soil structure analysis is undertaken of (1) sand, silt, clay %, and pH to **confirm suitability of soil structure** before any significant plantings are made.

The ideal soil structure is more than 80 % sand and pH of 6.0 to 6.5. Soils with less than 60 % sand would be much less suitable. pH of below 5.0 or above 7.5 are not suitable, however these can be remedied at a cost by applying special fertilizers.

2. Selected area should be level, **or less than 10 % slope** is preferred. If grown on steeper slopes, drains may have to be dug to divert excess water away from plantation

3. Do not disturb **watercourses,** leave line of buffer trees to keep them stable, and do not plant trees where water may gather in depressions.

4. **Irrigation** (if used), get professional advise on design, best locations and sizes of pumps, filtration system and irrigation lines. **(experience has shown that drip irrigation system is the most cost/efficient method and the system to supply up to minimum of 3ML of water per hectare of cashew trees per year is required.**

5.2 Site Preparation

1.Clear land of trees and heavy grass, however if possible leave native trees standing on edges of plantation to act as **windbreaks.** Cashew trees are susceptible to damage from high winds. If strong winds are an issue and native trees are not already planted on site then consideration should be given to planting of windbreak trees.

2. **Fire** is a major hazard for cashew, it is important that a 20 metre area around the plantation is cleared and kept free of vegetation as a **firebreak.**

3. The rows for the cashew trees must be measured and marked out by placing a peg to show location of tree hole. If site is on a slope rows should be planted out across the slope.

4.Tree shape between cashew types can vary significantly, and spacings used can vary from 5 meters up to 10 and 12 meters. We cannot accurately predict the future shape of the trees to be planted from the imported seed. However a significant number of the mother trees have an upright growth habit and the progeny should largely be similar. For the planting in Nicaragua we have to use a consistent spacing that is

(a) as concentrated as possible to minimise land use,

(b) be large enough to accommodate then vast majority of trees to be planted without major pruning efforts.

The recommended spacing to use with these trees is 8 by 7 metres, (8 metres rows and 7 meters between trees). If space is a problem a spacing of 8 by 6 metres would also be acceptable. If should also allow some **inter-cropping** for the first 2/3 years, until the growing cashew tree canopies close up.

5. The **planting holes** should be marked with a peg. They should be dug about 35 cm deep and 15 cm wide. The removed soil should be left beside the whole.

5.3 Planting of trees

There are a number of important factors relating to condition and timing of planting the cashew trees,

1. Only trees that have **sufficient maturity** should be planted out in the plantation. Sufficient maturity could be defined as a healthy plant with a minimum height of 40 cm to 45 cm. Assuming reasonable growing conditions in the nursery this level of maturity should be attained in 3 to 4 months. In addition these trees should have **good leaf colour**, be **free of pests and diseases**, and **fully hardened to sunlight** before being planted out in the plantation.

2. The following **planting procedure** should be followed.

- water pots well one day before planting

- do not plant trees at hottest time of day, do it morning or evening

- place small amount of NPK slow release fertilizer in planting hole and cover with 2 cm of soil

- remove tree from bag, examine roots of tree and straighten any extended roots sticking out of bag.

- cut bottom off poly ba g, place remainder in planting hole, cut the side of the bag, slowly slide the bag off without disturbing the roots (disturbance of root system can cause losses).

- fill in loose soil around tree, and make firm with hands, do not jump with feet to har den soil.

- if rainfall is deficient in next 4 weeks , water trees twice a week for 4 weeks.

When planting cashew trees the **position of the tree in the hole** is important. The top of the soil in the planting bag is known as the ‘nursery level’. When plant ing the ‘nursery level should be about 10 cm below the level of the ground. However it is important that only 2 cm of fresh soil is laid on top of the ‘nursery level’ of the planting bag, the remaining 8 cm of space will be filled due to erosion over time.

The tree position described above indicates a deep level of planting, **the benefits of this approach to planting are as follows,**

1. Better stability against wind damage because the lateral roots will radiate from the trunk at a lower level, and less chance that soil erosion will cause instability.

2. Root system is in contact in soil at deeper level where soil moisture levels will be higher and longer lasting.

6.0 MANAGEMENT OF TREE CANOPY

6.1 Pruning

Pruning and tree shaping in cashew is important because

(1) the cashew crop is produced only on the canopy surface and a closing of canopies between different trees in a mature state can cause die back and a loss of crop.

(2) cashew trees can be highly variable in shape and size, and many types have a tendency to grow more than one trunk and lateral branches close to the ground. If left unchecked these shapes can be inefficient in terms of plantation spacing and lower branches can hinder management including weeding and harvesting.

The shaping given to a juvenile tree will determine the type of tree for the remainder of it's life, therefore pruning and shaping during the first 1/2 years of life may be required.

The system of pruning and shaping recommended should commence once the tree is no more than one meter tall as follows,

- remove any small branches near the ground (40 cm)
- select up to 4 of the most upright side branches, and shorten these branches to 45 cm. Remove other side branches.
- Trees should be examined every 3 months for first 18 months with a view to pruning, especially removal of low lateral branches. Lateral branches below a minimum of 80 cm should be absent by the time the tree is two years old.

Pruning of mature trees should be kept to a minimum as major removal of vegetation at this time can have a detrimental impact on the tree. However if (1) the correct tree spacing was selected, and (2) pruning and shaping of the juvenile tree was correctly undertaken, then no significant pruning

6.2 <u>Weed Control</u>

Weed control is also important as weeds compete with the cashew tree for water and nutrients. It is necessary to remove weeds within the root zone of the tree (ground above root system). There are a few ways this can be done,

- if mulch is available this can be placed in a ring around the tree 15 cm deep, keep mulch 10 cm away from base of trunk.

- weeds can be killed with chemicals (weedicide)

- weeds removed by mechanical methods (or by hand)

Weeds should also be controlled between the rows. This can be done by **inter-cropping** with certain crops for 2/3 years before the tree canopies close in. In addition a legume crop like *Arachis pintoi* can be grown to both control weeds and fix nitrogen for the trees.

7.0 NUTRITION

Cashew has developed a reputation for being a 'low input' crop, however experience has shown that a good nutrition program is required for consistent good yields of good quality crop. In reality cashew has been shown to be highly responsive to inputs.

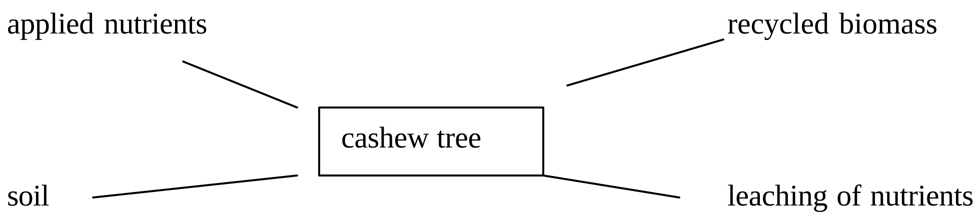
7.1 <u>How to Determine a Nutrition Program</u>

Nutrients are required for both (1) crop production (nut and apple), and also (2) for vegetative growth of the tree in the annual growth cycle. It has been estimated that the requirement of nutrients for a mature tree to produce a crop of 10 kg of raw nut (and apple crop) is as follows.

(table 1)

	gm
nitrogen (N)	236.0
phosphorus (P)	35.0
potassium (K)	163.0
calcium (Ca)	20.5
magnesium (Mg)	26.5
sulphur (S)	16.5
iron (Fe)	4.55
manganese (Mn)	0.6
zinc (Zn)	0.7
copper (Cu)	0.25

The sources of nutrients for the cashew tree will be (1) from the soil, (2) from applied nutrients, and (3) from recycled biomass. Leaching of nutrients represents a loss from this nutrition cycle.



Following significant research nutritional standards for cashew have been developed (table 2 below), and these standards represent the calculated **nutritional standard for cashew** which shows the calculated nutritional status of a 'healthy tree'. This nutritional status is based on nutrient status of dried leaf tissue. The objective of a nutritional program is to supply sufficient nutrients to allow the tree to

1. make the required vegetative growth
2 produce the crop
3. return tree to healthy status

Table 2 **Suggested deficient and adequate ranges of nutrients from pre -floral flush leaves**

nutrient	deficient	adequate range
nitrogen (%)	< 1.4	1.4 – 1.8
phosphorus (%)	< 0.1	0.12 – 0.14
potassium (%)	< 0.68	0.72 – 1.1
calcium (%)	< 0.11	0.24 – 0.75
manganese (%)	< 0.11	0.22 – 0.31
sulphur (%)	< 0.08	0.11 – 0.14
copper (mg/kg)	< 7	> 7
zinc (mg/kg)	< 12	> 20

manganese (mg/kg)	> 26	91 – 204
iron (mg/kg)	> 92	148 – 165
boron (mg/kg)	> 39	56 – 67

The recommended 'technical' method of determining the nutrient requirement program is to

(1) Undertake a **leaf nutritional analysis** once a year (best time for initial analysis is after harvest), which will determine the nutrient status of the tree at beginning of crop cycle. To take leaf samples, select semi-mature leaves from a number of different trees in the plantation so as to give a representative reading of the plantation. A minimum of about 30 leaves should be selected as sample. This sample can be submitted to a laboratory for analysis. (Quimicos ??, Leon)

(2) This 'nutrient status' can then be compared to a **nutritional standard for cashew (table 2 above.),** which shows the calculated nutritional status of a 'healthy tree. The nutritional program is then designed to apply sufficient nutrients to allow the tree to produce the expected crop **(table 1)** and return to a healthy status **table 2)**

The calculation of a nutrition program requires some professional input. In the event that growers lack the professional input, then an alternative approach suggested is <u>to initially use a standard nutrition program developed in Australia, and later make adjustments based on their local experience.</u>

The following program is based on

(1) good environmental and management conditions
(2) use of irrigation to obtain maximum yields,

If growers have irrigation, then it is recommended that they use **fertigation** . Advise on use of fertigation system is shown in Section 6.5

Table 4.

<u>gms of element/tree/year</u>

	Yr2	Yr3	Yr4	Yr5	Yr6+
nitrogen	200	400	600	800	1200
phosphorus	30	80	100	140	170
potassium	150	400	600	400	1200
calcium	100	100	200	300	400
magnesium	100	100	200	250	300
sulphur	5	10	20	30	45
iron	1	2	4	6	8
manganese	0.2	0.4	0.5	0.7	1.0
zinc	0.2	0.4	0.6	0.8	1.2
copper	0.1	0.2	0.2	0.3	0.4
boron	0.1	0.2	0.3	0.4	0.5
molybdenum	0.001	0.001	0.001	0.001	0.001

Forms of nitrogen suitable for fertigation include urea, ammonium nitrate, and mono-ammonium phosphate (MAP). **For information on suitability of fertilizers for use in fertigation see appendix 1, <u>Types of Fertilizers to Use</u>**

For young (year 1) trees, the fertilisers (apart from nitrogen and potassium) applied before transplanting the tree into the field should be enough for the first year of growth. To provide sufficient nitrogen and potassium, apply 50 gm each of N and K per tree, in soluble form (see appendix 1). These nutrients should be applied by fertigation in two applications, (1) within one month of transplanting, and (2) six months after transplanting.

In the event that growers do not use irrigation, then their yield expectations will be lower (perhaps down 40% to 50 %). In this event the suggested nutrition program should be at the <u>50 % level of the figures in table 4</u>.

7.2 Timing of Fertilizer Application

The cashew has a distinctive growth cycle of vegetative growth followed by reproductive growth that produces the crop. The two periods of high demand for nutrients are

(1) vegetative growth in cashew trees, in Nicaragua this will be in the period June to September

(2) flowering and fruiting, which will occur January – April.

For growers using fertigation, it is advised that some (40 % of annual application) fertilizer is applied after harvest and just before the vegetative growth period begins, ie May. More fertilizer (40 %), can be applied at the start of the flowering period (December/January) and the remaining 20 % at time of between peak flowering and nut development (February/March)

For growers without irrigation, the recommendation is that the total fertilizer to be applied is split into two applications as follows,

(1) 40 % at commencement of wet season rains
(2) 60 % immediately after cessation of wet season rains.

7.3 Application of Micro-Nutrients

Cashew has a requirement for micro-nutrients, and it is more efficient to apply micro-nutrients (zinc, copper, molybdenum, boron, iron, manganese) as foliar sprays than as soil applications or through the irrigation system. This is because foliar sprays can be targeted better by application direct on to the target tissue. Soil applications of micro-nutrients can be unavailable to the plant because these nutrients can become unavailable to the tree because of low soil moisture levels in the top 5 cm of soils. Foliar sprays can be applied on as-required basis and can be incorporated with an insecticide application.

The requirement for micro-nutrients can be determined by leaf analysis, and these results can be compared with the nutrition standards of cashew (see table 2.) The optimum concentrations of product for foliar spray applications are shown in table 3.

Table 3.

Foliar Applications to Cashew

nutrient	product	%	concentration of product (g of product/L)	note
zinc	zinc sulphate heptahydrate	0.5	5	Add 3g/L of calcium hydroxide to prevent foliage burn.
copper	copper sulphate or copper oxychloride	0.5	5	as above
boron	boric acid or solubor	0.1	1	
molybdenum	sodium molybate	0.05	0.5	
manganese	manganese sulphate	0.5	5	
iron	ferrous sulphate	0.5	5	

7.4 Fertilizer Application via Irrigation System

If growers are using irrigation then Fertigation, or the use of the irrigation system to apply soluble fertilizers is recommended because of the following,

- fertilizers can be applied more effectively to the 'feeder'` root zone
- is more convenient, and can be applied more regularly
- saves labour costs

Only soluble fertilizers can be used in a fertigation system- see Appendix 1. Types of Fertilizers to Use for information on which fertilizers are soluble. The following steps should be taken before fertigation is attempted

1. Get a laboratory test on water quality. Make sure an iron content analysis is included. No specific water quality standards are required apart from (10 electrical conductivity of water should not exceed 0.8 dS/m, and total dissolved ions should be less than 600mg/kg (ppm).

2.Fertilizer is dissolved in a drum or tank, and then a concentrated solution is injected into the irrigation system using a special fertigation injection pump.

3. When fertigating use a three stage approach, first, irrigate without fertilizer until soil is moist. Second, inject fertilizer, and third, after injection of fertilizer is completed, continue to run irrigation for a while to flush out all residue of fertilizer.

4. Regularly flush out irrigation system with small amount of chorine to ensure no accumulation of algae

8.0 IRRIGATION

Although cashew trees nay not be showing symptoms, water stress at critical times during the development of the crop can dramatically impact yield and nut quality. Therefore careful utilization of irrigation is a key factor in achieving good plantation performance.

8.1 Water Requirement

Required rates of water application should be based on (1) soil moisture conditions, and (2) the requirements of the tree for vegetative growth and cropping. And these rates can be calculated using different technologies such as tensiometers, or neutron probe, and/or enviroscan probe. Use of these technologies, especially the more sophisticated enviroscan probe can give accurate data on the required volume and timing for water. (see 7.2). However, in the absence of using this technology a **guide to irrigation rates** can be obtained from research in Australia where a recommended range of rates and timing of water application for cashew in the deep sandy soil types typically in that country for growing cashew.

The recommendation is that growers use the standards below, and **make adjustments based on their individual conditions.**

Young trees (year 1 to 3)

Year 1 - it is assumed that planting of young trees is undertaken in the wet season, and therefore for first dry season apply 20 litres of water per week per tree, twice per week.

Year 2	- early dry season	150 L/tree,	every 7 – 14 days
	- middle dry season	100 L/tree,	every 10 – 14 days
	-late dry season	200 L/tree	every 7 – 10 days
Year 3	- early dry season	200 L/tree	every 7 - 14 days
	- middle dry season	200L/tree	every 10 – 14 days
	- late dry season	250L/tree	every 7 – 10 days

Trees year 4 +

growth stage	volume applied (litre/tree/application)		frequency
pre-flowing flush	mini-sprinkler	400-500	every 7 – 14 days
	drip	250	every 7 – 10 days
flowering, early nut set	mini-sprinkler	400-500	every 10 – 14 days
	drip	250	every 7 – 10 days
main fruit set and nut drop	mini-sprinkler	500	every 7 days
	drip	250	every 3 – 7 days

8.2 To Schedule Irrigation

There are two methods that can be used to estimate the required water application rate (organise the irrigation schedule), these are

1. Evaporative Method, uses the approach of estimating the volume of water removed by evaporation and replacing this amount. Its use involves using the average daily evaporation rate (E) during the proposed irrigation period and multiplying this with a 'crop factor' (K) and canopy area of the tree (C). Then knowing the precipitation rate of the sprinklers or drippers used will allow calculation of the irrigation schedule (hours of operation).

In this calculation the previously estimated crop factor (K) for cashew is 0.8 at peak flowering to 1.1 at peak nut set. For example at Chinadega, if daily evaporation is say 6 mm at peak flowering time. and the trees have a diameter of 3 meters, the water requirements can be calculated as follows,

6/1000 x 0.8 x (3.142 x 3 x 3) = 169 litres/day. If a grower is using 2 drippers per tree, each of 16 litre/hour capacity, then irrigation must operate for 10 hours to return to status quo. The advantage of evaporative method is that it is easy to use requiring no equipment. However it is open to error as the results are based on a somewhat arbitrary devised input data.

2. Soil based methods.

(a) Tensiometers

A relatively inexpensive devise that can installed and operated by growers. However their disadvantage is that they are relatively inaccurate and do not effective monitor the top 10 cm of soil.

Tensiometers should be positioned in the tree row about one month after planting. Two tensiometers (one 30 cm long, and the other 60 to 90 cm long are placed in each irrigation block. The 30 cm tensiometer is installed to depth of 15 cm and 60 cm tensiometer to depth of 45 cm. The two tensiometers should be about in a position inside the drip line. Read tensiometers before 8 am, start irrigation when tensiometer reads 20 centibars (on sandy soils), and 30 to 40 centibars on heavier soils. Stop watering when the reading on the deep tensiometer falls to 10 centibars.

Reposition tensiometers every second year to a new drip line position.

(b) Neutron Probe

This is a sophisticated device often used by professional irrigation consultants to advise clients on watering recommendations. The mode of operation involves setting up several access holes in the plantation to different soil depths into which the sensors on the probe extract readings. The neutron probe is more accurate than the tensiometer, but to be useful it requires regular reading to be taken. It also does not accurately measure soil moisture in top 10 cm of soil.

(c) Enviroscan

The enviroscan is a continuous moisture –monitoring device based on capacity sensors. The sensors are mounted on probes installed in PVC tubes, which are installed after the trees are established. The sensors are linked by cable to a data logger which receives measurements at a regular interval. The data from a logger is then down-loaded into a computer every few days to provide near 'real time' recommendations for irrigation. Enviroscans are more accurate than tensiometers or neutron probes, and they can accurately measure moisture levels in the top 10 cm of soil. However they are expensive. Items of equipment and usually require specialized training for operation.

9.0 INSECT PEST MANAGEMENT

9.1 Background to IPM

Integrated pest management (IPM) has evolved in recent years as an alternative approach to the use of chemicals because of increasing **problems associated with chemical use. These problems are**

(1) over-reliance on chemicals has resulted in development in insecticide resistance and the elimination of natural enemies, environmental contamination and unacceptable residues in final product.

-(2) pesticide applications can be costly, especially if poorly applied.

The key features of insecticide applications are

(1) Insecticides are a waste of money if the pest is absent or their numbers are below an economic threshold of damage.

(2) Insecticide treatments need to target the insects most susceptible stage of life, and they must be applied with calibrated equipment capable of delivering a lethal dose to the pest.

IPM works by first determining an economic damage level (EDL) (the lowest pest population density that will cause economic damage). The EDL can be considered the point where the damage is equivalent to the cost of control. Pest populations are then monitored and control measures are only undertaken when pest populations reach the EDL. Beneficial insects are also monitored as sometimes these beneficials alone can keep the pest populations under control. In addition successful pest management depends on understanding the pattern of tree growth (tree phenology) as a number of insect species feed only at specific times in the growth cycle (caterpillars on new flush, thrips on new and developed leaves, and Leptoglossus sp on maturing crop

9.2 How to Use IPM

The various stages of IPM are as follows

- insect monitoring
- encouraging beneficial insects
- insecticide applications

Insect monitoring - The first stage is to develop a system of insect monitoring. This requires acquiring some knowledge of the appearance, life history, and appearance of the major pest species.

Once you have a working knowledge of the major species you can develop a system for monitoring for pest numbers as follows. For every 500 trees planted you should aim to monitor 10 evenly distributed trees. An experienced person will require one hour to monitor 10 trees. A practical method of monitoring is to divide the tree into quadrants and thoroughly examine on quadrant chosen at random on each tree. The objective is to observe the level of pest damage in the area under survey, and this data is recorded. The suggested EDL thresholds should be as follows,

caterpillars	10 % – 15 % fresh damage
thrips/aphis	5 % - 10 % fresh damage
Coreidae sp (Leptoglossus)	6 % - 10 % fresh damage
stinging insects (Myridae)	6 % - 10 % fresh damage

Once damage level are recorded at the EDL thresholds, **then insecticide applications should be made. However if the growers do not have the experience or confidence to undertake accurate insect monitoring, then they can undertake a prophylactic approach to pest control as follows,**

1. **When insect populations appear to be noticeable undertake spray.**
2. **Do another spray in three weeks to kill all pests not kill in first spray because they were not in vulnerable part of life cycle**

Encourage beneficial insects – one of the main problems of using chemicals is the elimination of beneficial species, and in their absence pest species may repopulate more rapidly than the beneficial insects

The major beneficial species are mantis, predatory bugs, (*Geocoris sp)*, spiders and species of ants including *Isidomyrmex sanguineus* and *Oecophylla sp* (which unfortunately are not found in Central America. **Natural enemies are frequently found in native bushland** and therefore it is suggested that where possible native trees should be left around plantations. These trees can also be useful in providing a natural windbreak for the cashew trees.

9.3 Use of Chemicals

The following chemicals (or natural agents) are suggested for use against potential cashew pests

aphids	dimethoate endosulphan
thrips	endosulphan
caterpillars	bacillus thuringiensis trichlorfon
monoleptra	carbaryl
mealy bug	dimethoate maldison methidathion
leaf miner	dimethoate triclorfon
Leptoglossus	permethrin dimethoate triclorfon malathion

9.4 Pests of Cashew in Central America

Little research has been carried out on cashew pests in Central America, however two species can be considered as potentially major pests.

Leptoglossus sp **(chinche) –** is a Heteroptera Coriedae with a wide range of distribution over a wide range of crops. Geographically found in North and South America, Asia. Africa and Australia. They feed on crops as diverse as coffee, cotton, almonds, dates, tropical fruits, citrus, sorghum and maize.

It is only in Central America that Leptoglossus has become a major pest of cashew. So far four species of Leptoglossus have been identified in cashew in El Salvador – zonatus, stigma, concolor and cinctus. Of these zonatus appears to be the most common. All four types are very similar in biology and life history.

Leptoglossus zonmatus is a large insect, being 20 mm long as an aduld, dark brown in colour with a whiteish stripe over its back. The details on life history are as follows,

Eggs - laid in long brown chains on host plants (curcubits, legumes, pumpkins, cucumbers, and possibly also sorghum and maize.

Hatch	- in 7 to 17 days depending on temperature
Nymph	- 24 to 34 days at 35 degrees C, - 80 – 137 days at 20 degrees C
adult	- 48 – 74 days at 35 degrees C - 176 – 260days at 20 degrees C

Leptoglossus damage cashew by feeding on the developing nuts before the shells harden and mature. The Leptglossus pushes its proboscis through the shell to suck nutrients out of the kernel. This results in kernel necrosis, however these symptoms are usually only evident later. Usually the nuts tend to continue to develop normally, however after processing the kernels are exposed and found to be damaged by black sopts. This is potentially a major cause of loss in cashews in Central America**. Leptoglossus can be controlled by a wide range of insecticides, see 9.3**

Thrips – *Selenothrips rubr ocinctus*
A Thysinoptera, a widely spread insect of many tropical and sub tropical countries. It ffeds on a wide range of crops including cocoa, avocado, mango, guava, and cashew.

Thrips are very small insects, adults being only 2 mm long. They complete a life cycle in about 50 days and the female can lay 30 to 60 eggs which leads to explosive population increases in suitable climatic conditions. They prefer dry conditions, heavy rains can lead to major population declines

Thrips are leaf feeders, they feed on the underside of the leaf to avoid direct contact with the sun. They appear to target smaller trees, especially those in poor condition or under stress. The impact of thrips attach is one of dehydration of the tree. Lacewings are an effective naturalenemy of thrips.

Thrips can be controlled by a number of insecticides including endosulphan. Symptoms of thrips damage can be seen in Appendix 4

9.5 Future Priority

Very little research has been undertaken on insect pests of cashew in Central America, which is quite different to the pest regime in almost all other cashew growing countries. In these other countries Tea Mosquito – *Helopeltis sp* is the dominant pest and biological control work undertaken elsewhere has been primarily aimed at this pest. No worthwhile work on biological control of chinche has been attempted, indeed even the important species involved in cashew in Central America is not well understood.

The lesson from elsewhere is that the reliance on chemicals to control pests brings diminishing results, and the only sure long term solution is then use of natural agents to control pests. Research in Australia over the past 8 years has perfected a system of biological control in cashew using the weaver ant *Oecophylla smaradgina.* It has been found that not only does the use of *Oecophylla* give a cost efficient protection system against all significant cashew insect pests, it also allows higher yields that even the most rigorous chemical program because where chemicals kill pests and beneficial insects (predators, pollinators), *Oechopylla* have both no impact on pollinators and a neutral impact on most other predatory insects.

Unfortunately *Oecophylla sp* is not indigenous to Central America and so it is unlikely to ever be useful in these circumstances. **However it highly likely that other insects in Central America may have predatory or parasitic habits against chinche and some of these have been previously identified - *Trichopoda sp*, a parasitic wasp.**

It should be a priority of a future cashew industry in Nicaragua and Central America to support as a top priority research work to find natural agents fro the control of chinche especially, and to follow the work through to development of a working system.

10.0 DISEASES

Diseases are relatively rare in cashew, especially where cashew is grown in dry low humidity environments. The only disease that may be significant is anthracnose, a fungus disease caused by *Colletotrichum gloesporiodes*. It tends to be prevalent in hudid conditions when the temperature is less than 30degrees C. It is also more common in cashew where trees have closing canopies and when the trees are putting out new growth.

Anthracnose can cause damage and loss of crop. **The recommended solution is as follows'**

1. Ensure trees are pruned to allow sunlight to enter canopy
2. Apply copper hydroxide

11.0 HARVEST

Cashew will produce their crop over about a six week period. This is a genetic characteristic so the actual period will vary depending on the tree grown. In a seedling plantation the harvest period may be quite extended, perhaps as much as four months. However in a plantation of grafted clonal trees the harvest period could be significantly reduced.

11.1 <u>Pre -Harvest Clean Up</u>

Growers should ensure that the plantation is in a good condition to allow easy harvest collection. Because of (1) the original tree selection program favouring up right growth habit trees and (2) pruning and tree shaping program carried out in the first year, the trees in the plantation should have no obstructing lower branches.

I addition the area under the tree should be kept free of weeds and any other litter obstructive foliage.

11.2 <u>Harvesting Nuts</u>

When mature the cashew nut and apple will fall to the ground. **It is not recommended to try and harvest the crop direct from the tree as this could lead to the removal of immature fruit.** The apple is a highly perishable product so if it is intended to use the fruit for commercial uses it would be necessary to organise frequent harvest rounds, -

virtually on a daily basis. If only the nut is to be used, then harvest rounds are much less frequent, perhaps no more than once in one/two weeks.

11.3 Post Harvest Handling

Cashew nuts can be stored for up to 12 months in good condition provided then following steps are taken,

(a)Crop should have apple removed. It is easier to do this when the crop is fresh. If is left in the sun for some days before harvest, then the dried apple may be difficult to remove.

(b) Crop should be cleaned of stones and extraneous material.

(c) Dry nuts in the sun for three days. Use either concrete floor or tarpaulins as the base. The objective is to reduce the moisture content from a usual 12 % at harvest down to 8 % for long term storage. **Do not over dry the nuts as this could lead to overheating and damage to the kernel from leaching of CNSL.**

(d) Nuts should be stored in hessian (jute) bags, and placed in a warehouse where there is a good airflow to keep temperatures moderate. It si also advisable to store the filled bags on pallets, rather than directly on concrete floors, as this will improve airflow and assist in reducing damage from pests. **The nuts should not stored in bags made of plastic or other materials impervious to air flow, as this can lead to over-heating and damage to the crop.**

(e) Pests in storage can cause damage to the crop. Luckily the shell of the nut is resistant to most pests in storage, however it is wise to take precautions against rats.

(f) Above all the storage area should be water tight to prevent mould/fungus growth

APPENDIX 1

KERNEL PRICES W320 GRADE 1981TO 2000

SOURCES **- MANN PRODUCTEN**

- AMBERWOOD TRADING

- MICHAEL`WARING TRADING

APPENDIX 2

GROSS MARGIN ANALYSIS – One Hectare

Based on high input maximum production

Profile of gross margin at tree maturity at year 10.

Gross Income

		$	$
3,500 kg at US$ 1,000/MT (crop price based on W320/W240 and 30 % recovery)			3,500

Costs

Nutrients	N – 1044 gm urea/tree at $10/45 kg - 156 gm potassium nitrate at $25/50kg	90	
	P – 566 gm triple super at $45/45kg	100	
	K – 1,200 gm potassium nitrate	239	
	Micro-nutrients (2 foliar sprays)	40	
Insecticide	materials (4 sprays p.a) at $12/hectare	48	
	labour ($7/hectare/spray)	28	
Irrigation	based on pumping from 50L/sec borehole 5.6L/hour diesel motor at $2/gallon diesel, 250L/tree/week water to trees and 34 week irrigation season	30	
weed control	hand labour, three sweeps per year, 5 man days per hectare at $3/man day	15	
harvest	4 harvest sweeps, at 60 trees per man day at $3 per man day	36	
crop drying/clean	2 MT/man day at $3 per man day	5	
other	materials, 10 replacement jute sacks (re-useable)	10	
	administration etc	10	
	marketing costs, say 2 % of crop	70	721
		------------	------------
	Gross margin per hectare $		**2,779**

Gross Margin Analysis (2)

Years 1 – 9

Estimated yield curve		
	year 1	nil
	year 2	5 %
	year 3	20 %
	year 4	35 %
	year 5	55 %
	year 6	70 %
	year 7	80 %
	year 8	90 %
	year 9	95 %
	year 10	100 %

Note – with good genetic material and high level of inputs, it is possible ‘tree maturity’ would be attained in less than 10 years.

APPENDIX 3.

TYPES OF FERTILIZERS TO USE

	available source	solubility
nitrogen	urea	25 %
	ammonium nitrate	25
	ammonium sulphate	50
	potassium nitrate	25
	calcium nitrate	30
	mono-ammonium phosphate	25
	di-ammonium phosphate	40
phosphate	superphosphate	25
	mono-ammonium phosphate	40
	di-ammonium phosphate	insoluble
potassium	potassium chloride	25
	potassium sulphate	10
	potassium nitrate	25
calcium	lime	insoluble
	dolomite	
	gypsum	
magnesium	dolomite	insoluble
	magnesium oxide	
sulphur	potassium sulphate	10
	ammonium sulphate	50
	magnesium sulphate	70
iron	ferrous sulphate	20
boron	boric acid	50
zinc	zinc-sulphate hepta-hydrate	75
	zinc oxide	insoluble
copper	copper sulphate	50
molybdenum	sodium molybdate	50
manganese	manganese sulphate	70

APPENDIX 4

SYMTOMS OF PEST AND DISEASE DAMAGE