CASHEW NURSERY MANAGEMENT AND GRAFTING TECHNICAL MANUAL

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FOREWORD

Cashew is increasingly becoming the nut of choice given its health benefits and the hype it currently enjoys on the global market. This translates as an increase in demand and ultimately high prospects for producing countries. Despite these opportunities, there still exist several challenges especially in the area of production. Producing countries, most of them in Africa, still struggle to increase productivity and to ensure that their produce are of high quality and meets international standards.

Training has been recognized as one of the most effective tools in addressing this challenge. In this regard, the GIZ/Competitive Cashew initiative (ComCashew) has since 2009 trained over 500,000 farmers from Benin, Burkina Faso, Ghana, Ivory Coast, Mozambique and Sierra Leone. Capacity development of about 300 experts through ComCashew's Master Training Program also ensures that knowledge and experiences are multiplied throughout the African sub region. Regardless of these efforts, there still remains a gap in the availability and accessibility of high-quality training and information materials to promote Good Agriculture Practices as well as good harvest and post-harvest practices.

In response to this ComCashew publishes several production manuals to provide useful and practical information for trainers, cashew producers and anyone looking to go into cashew production. The ***Cashew Nursery management and Grafting Technical Manual,*** one of these manuals, highlights the processes involved in nursery management and cashew propagation as well as nursery pests and diseases and their control. Given the increasing change in trends and improvements in research and technical know-how, revised editions of production manuals are foreseen to provide in-depth and up -to -date technical information to promote continuous improvements in cashew productivity. I am grateful to all financial and technical contributors for their support in publishing this manual and look forward to similar collaborations for a sustainable cashew industry.

Hon. George Oduro,

Deputy Minister

Ministry of Food and Agriculture, Ghana (MoFA).

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1 INTRODUCTION

Improved cashew planting materials are the most important input in cashew production because they determine the potential yields and therefore the ultimate productivity per unit area. Traditionally, the cashew crop is propagated by seed despite its high heterozygous genetic makeup. Trees raised through seeds or seedlings do not result in true to type materials, resulting in wide variations in yields, growth habits and in pest and disease resistance. Such variations can be eliminated by propagating cashew grafts through grafting methods.

This Nursery and Grafting manual is a useful guide for extension workers and nursery operators who can benefit from the information it contains and eventually use it to develop and improve cashew grafting skills in communities. Part A of the manual comprises a step-by-step procedure in nursery management and cashew propagation methods while Part B of the manual covers nursery pests and diseases and their control. Part C looks at the cost of production of cashew seedlings

PART A:
MANAGEMENT OF CASHEW NURSERY

2 CASHEW NURSERY

It is a managed site where cashew seedlings/grafts are raised with special care until they are ready for transplanting into the field.

2.1 Types of Cashew Nurseries

Cashew nurseries vary in size from a hundreds of seedlings grown in the backyard to large scale producing thousands of seedlings per year. They can be grouped into four major nursery types:

i. *Institutional Nursery.* This category of nurseries always belongs to a public or private organization which has a mandate to propagate and distribute seedlings. Such nurseries tend to evaluate the performance of seedlings and also generate technologies. Institutional nurseries tend to serve a cross section of customers who are not commercially oriented. These nurseries have durable structures and operate for long periods of more than 10 years.

ii. *Project Nursery*. The project nursery is a place where technical information and resources produced by institutional nurseries can be accessed. A project nursery promotes development, produces thousands of seedlings per year and tends to operate for longer than five (5) years. It produces planting materials to meet the project's requirements and also caters to the needs of both large and small growers.

iii. *Group Nursery.* A group nursery tends to be operated by households or cooperative groups and has a longer life span. It may be both for commercial and not for commercial purposes. It serves a commercial purpose nursery when it sells seedlings in local markets and as a not for commercial purpose when it produces seedlings to meet family needs.

iv. *Individual Nursery*. This is a nursery set up mainly as an exclusive commercial enterprise producing seedlings for operators' personal farms. The individual nursery produces anywhere from a few hundred seedlings to thousands of seedlings. It serves a community and the size, production capacity and level of sophistication varies widely.

2.2 Factors to be considered for the establishment of cashew nurseries

Cashew is normally seasonal therefore the nursery operations require proper planning and time schedule for timely delivery of seedlings /grafts to growers. (Plate 1: cashew nursery). The following factors are to be considered for the establishment of cashew nurseries.

2.2.1 Site Selection

The nursery should be located on land with similar properties and climatic conditions as the area where the grafts will be ultimately planted out. It is important to pay attention to the following factors when selecting a site for a cashew nursery:

- Wind and shade conditions
- Topography
- Water source
- Soil type
- Transportation costs
- Protection (security)
- Accesibility to the public

2.2.1.1 Wind and shade conditions:

Preferably, the nursery site should be protected against strong, windy conditions. Ideally, the nursery should be sited in an area which is level, but where this is not possible and only sloping land is available, a portion with northern exposure where the temperature is a little lower is preferable. Despite this preference, the nursery site should not be shaded by tall buildings or tall trees. Setting up a small nursery under a large tree is not recommended because seedlings/grafts should be grown in full sunlight after the germination or transplanting period.

2.2.1.2 Topography:

Ideally, the nursery should be located on level land in order to avoid erosion problems especially when heavy rains occur or after irrigation. A low-lying area or a depression that is likely to accumulate rain water should be avoided as a nursery site may be flooded after heavy rains. In general, one must make sure that stagnant water will never accumulate in the nursery. The accumulation of water can be avoided by digging small channels to allow the water to run off.

2.2.1.3 Water source:

Another important consideration is nearness to a water source. It is of prime importance to select a site near a permanent water source which offers a constant supply of good quality water. This is important because the production of grafts last a minimum of 3 to 4 months and occur in the dry season when the grafts have to be watered every day. It is also, important because water costs can significantly increase production cost especially for institutional, project or group nurseries.

2.2.1.4 Soil type:

When seedlings/grafts are to be produced in poly bags, they must be filled with sandy and fertile soil. Therefore, a site must be selected which gives easy access to the types of soil required in order to facilitate the preparation of soil mixtures.

2.2.1.5 Transportation costs:

In order to reduce the cost of transportation and facilitate handling of the grafts, the nursery should be sited as close as possible to the site where the seedlings and or grafts will be planted. In the case of family nurseries, it is better to locate the nursery near the house because of the advantage that water is often available and the close proximity makes it easier to protect the nursery.

2.2.1.6 Protection:

It is important to pay adequate attention to issues of protection when siting a nursery. The nursery should be located where it is easy to protect the seedlings /grafts from animals that could destroy them. If the nursery is a more permanent one, some windbreak should be put in place. This should be taken into account when estimating the size of the nursery.

2.2.1.7 Accessibility to the Public:

Whenever possible, the nursery should be located in a central location so that it is easily accessible to people who have an interest in obtaining services from the nursery. This makes it easier for them to get the grafts and transport them to their fields for planting. It will also provide them with an opportunity to see nursery work in progress and will help raise their interest in production and planting of cashew trees.

Figure 1: A well located cashew nursery

2.3 Layout of Nursery

In an ideal nursery, the poly bags are arranged in a square or rectangular shape. In terms of numbers, one should be able to fit between 150 and 200 poly bags in every square meter. The ultimate size of a nursery will depend on the size of area available and the scale of production anticipated.

When determining the size of a nursery, an additional 20% of land area should be added to the figure calculated for the nursery beds to make room for space needed for alleys, small buildings, work areas, etc. Every row of seedlings within the nursery should have a maximum width of 1 meter and a maximum length of 10meters. If the target production is 2,000 poly bags of seedlings or more, the minimum area needed to produce this amount will be 5m x 6m nursery or 30m sq. not taking into account the alleys and small buildings.

KEY MESSAGES TO NOTE

1. There are four types of cashew nurseries. These are:
    - Institutional Nursery
    - Project Nursery
    - Group Nursery
    - Individual Nursery

2. The following factors should be taken into account when locating a nursery:

    - Wind and shade conditions
    - Topography
    - Water source
    - Soil type
    - Transportation costs
    - Protection (security)
    - Accessibility to the public

3 . Make sure provision is made for adequate land when laying out the nursery to cater for the bags, alley and small buildings.

3 Benefits of planning and budgeting for nursery activities

Planning guides the allocation of scarce resources (e.g. time, human and physical resources) for activities to be undertaken. Planning provides a nursery operator with a better understanding of the economic side of the nursery operation. It helps in the selection of effective and appropriate production processes. The main tools aiding the implementation of nursery activities are: calendar of work, record keeping and cost benefit analysis.

3.1 Calendar of work

Calendar of work helps to estimate the commencement date for nursery operations. It is also a useful guide when making decisions about the need for extra labour and requisition for supplies. Finally, the calendar of work aids in scheduling the time of distribution of grafts.

Table 1:Calendar of Work

ACTVITIES	RAIN & VEGETATION SEASON					DRY & REPRODUCTIVE SEASON						
	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Procuring inputs												
Potting												
Sowing seeds												
Watering												
Scion Collection												
Grafting Seedlings												
Distributing grafts												

3.2 Record keeping

Record keeping helps to maintain a history of activities at the nursery by capturing and storing such information. Records are useful for planning, monitoring and decision making about the performance of the nursery business. Important records in the nursery include: date of potting,

date of sowing seeds, germination, grafting, success rates, pests and diseases attacks, operation or activity schedule showing when casual labour will be recruited and terminated, grafts targets, requests and deliveries as well as observations such as seedling nutrient status, insect pests and disease outbreak.

3.3 Cost benefit analysis

The main expense in nursery operations is the cost of labour. Oftentimes, labour is engaged for unnecessarily long periods. Group and individual nurseries can minimise these costs as these are joint ventures making wider use of family labour. See Part C: Cost of production of cashew seedlings. The information in Part C can be used to assist in determining the selling price of seedlings.

KEY MESSAGES TO NOTE

It is very important to plan and budget for nursery activities. The main tools aiding the implementation of nursery activities are:

- Calendar of work
- Record keeping, and
- Cost benefit analysis.

4 EQUIPMENT, MATERIALS, AND TOOLS

The size of the nursery determines the number and types of equipment, tools,materials and labour to be employed. The following are common equipment, material and tools commonly used in nurseries:

Table 2: Equipment, Materials and Tools

Equipment	Materials		Tools
hand sprayers /pneumatic hand sprayers	agro-chemicals	poly caps	Hammers
Hoses	fence wire	poly sheet	Hoes
pneumatic sprayers	fertile top soil	S and	machetes /knives
Sprinklers	fertilizers/decomposed organic matter	seeds	Saws
wheel barrows	grafting tapes	Shade net or local…	Secateurs
Watering cans	lumber /poles		Shovels
	Nails		soil sieves
	poly bags		Rakes

KEY MESSAGES TO NOTE

The size of the cashew nursery determines the number and types of equipment, tools, materials and labour to be employed.

5 RAISING OF ROOTSTOCK

Rootstock is the part of the plant comprising the root system when grafting is done. It is important for rootstocks and grafted seedlings to be established in good environmental conditions to enable them grow well and produce quality seedlings. The environmental conditions that must be controlled to provide the best conditions for rootstock development include humidity, aeration, light quality, light quantity, temperature and moisture. The provision of structures for shade is the most important intervention for influencing most of these factors (see Plates 2 – 5).

5.1 Advantages of Providing Shade Structures

Cashew seedlings are sensitive to unfavourable environmental conditions such as extreme low and high temperatures as well as excessive moisture and high solar radiation. Such environmental conditions inhibit cashew seedling growth. Shading is important because it allows the regulation of the amount of solar radiation in the nursery to an acceptable level for optimum cashew seedling growth. Shade also helps to reduce evapo-transpiration and to subsequently preserve soil moisture. The optimum sunlight for cashew seedling growth is 50%. Shade must be carefully regulated because allowing more than 75% shade leads to spindly seedling growth known as etiolation as well as disease conditions.

Shade structures can be temporary or permanent. Temporary shade structures are short term structures constructed with easily degradable materials. (Plate 2).

Figure 2: Temporary shade

Figure 3: A mixture of temporary and semi permanent shade

Figure 4: Black semi permanent shade plate

Figure 5: Green Semi permanent shade

5.2 Poly bags

Cashew seedlings are very sensitive to transplanting shock. This can be reduced by the use of poly bags. The use of poly bags reduces disturbances to the roots of seedlings. It also cuts down the handling costs of individual seedlings. There are different types of poly bags. Some bags

have the bottom end closed and are provided with drainage holes. Other bags, known as poly sleeves, are available in different colours, sizes and forms as readymade plastic plant bags with an open bottom. These poly sleeves are cut from a continuous roll. The standard thickness of polybags is >250 micron.

5.2.1 Size of poly bags

The size of poly bag used will influence the volume of pot mixture. For example, small poly bags (11cm x 20cm) are more economical to use in terms of the amount of pot mixture they hold and the space they occupy in the nursery than the use of big poly bags (16.5cm x 20cm). The size of the poly bags influences the growth of cashew plants. For example plants in small poly bags exhaust the nutrients and moisture in the bags more quickly than those in big poly bags. (Plate 6). In addition to the above, it must be noted that the size of poly bags also influences production costs in terms of labour, amount of fertile planting substrate (soil mixture) needed to fill them and transportation.

Figure 6: Plastic planting bags by volume (1)- 6cm diameter x 20 cm height (smallest) (2)- 11cm diameter x 20cm height (most commonly used) and (3)- 16.5 cm diameter x 20 cm

5.2.2 Preparation of Soil mixtures

A good soil mixture is made up of top soil and well decomposed or composted manure (Plate 7).The mixture (substrate) should be free of diseases, light enough for the roots to easily penetrate, hold moisture but drain well and supply all nutrients needed for the seedlings to grow. Where good fertile topsoil is used in preparing the substrate, adequate nutrients will be available in the soil mixture. However, where this is not the case, nutrients in the soil mixture should be supplemented with NPK fertilizer (5 – 10 g/litre) as a starter to provide nutrients to the seedlings. To prepare a good pot mix, mix the components thoroughly to ensure a uniform mixture (Plate 8). The soil mixture should be screened to make it uniform to eliminate large particles and litter. It should be moistened, but not sufficiently wet to form a ball when squeezed in the hand. Moistening helps to make the mix stay in the pot while the containers are being filled, especially for the open end (open bottom) containers.

Figure 7: Mixing

5.2.3 Calculating the amount of POT MIX enquired

To calculate the amount of pot mix required, you should know the volume of the poly bags as well as the number to be filled. The volume is calculated by measuring the height and diameter of the plastic plant poly bag. The mathematical formula for calculating the volume is $\pi r^2 h$, where π is a constant number = 3.1416, r is the radius of the poly bag (i.e. 1/2 the diameter) and h is the height of the poly bag.

Once you know the volume of the plastic plant poly bag, multiply this by the number of bags needed to know the total volume of soil mixture to be used in filling the bags. Similarly, knowledge of the volume of the polybag can be used to calibrate other tools (shovel, bucket, and wheel barrow) to know the volume of soil or pot mix they will hold. Thus, you can:

- Use the poly bag to calibrate the shovel
- Use the shovel to calibrate the bucket
- Use the bucket to calibrate the wheel barrow etc.

Figure 8: calibration of working tools and equipment for soil mixing

Fill the poly bags with pot mixture and keep them under the shade. The recommended soil mixture and how it is obtained is shown in Table 5.1

Table 3: soil mixtures ratio

SOIL TYPE	Use these ratios		
	Top soil	Sand	Manure
Heavy (Clay)	1 part	2 parts	2 parts
Medium(Loam)	1 part	1 part	1 part
Light(sand)	1 part	0 part	1 part

Figure 9: Filling open bottom poly bags

KEY MESSAGES TO NOTE

- It is important to provide optimal conditions for rootstock development by providing shade and ensuring good conditions of the follwing: humidity,areation, light, quality , light quantity, temperature and moisture
- Transplanting shock can be reduced for seedlings by raising seedlings by raising seedlings in poly bags.
- A good soil mixture is one of that is free of disease, light enough for the roots of seedlings to easiily penetrate, holds moisturebut drains well and supplies all the nutrients needed for seedlings to grow.

6 CASHEW SEED SOURCE AND SEED SOWING

6.1 Nut Selection

Cashew nuts for planting should be obtained from mother trees of known excellent performance. They should be fully matured and of high density (heavy) grade to ensure good germination and high vigour of seedlings. The nut should have a minimum weight of 6g. It is advisable to carry out a flotation test to establish the quality of seeds. In a floatation test, nuts (seeds) are put in water and observed. Those that float are discarded while those that sink are selected or chosen. The nuts that sink are selected because they have high viability and germinate quickly.

Figure 10: Seeds floatation test

6.2 How to conduct a floatation test

The following steps will guide you to conduct a floatation test:

a) Choose medium size nuts (seeds).
b) Put the nuts (seeds) in a bucket of clean water.
c) Observe the behaviour of the nuts (seeds) as some float on the water and others sink
d) Discard the nuts (seeds) that float (floaters) on the surface of the water because these do not germinate well.

Soak the nuts (seeds) that sink (sinkers) in the morning for 24 hours to allow them to imbibe water before sowing.

6.3 Estimating seeds required for raising root stocks

Ideally, seeds should be sown as soon as possible after receiving them because they tend to lose their viability or germination capacity over time. It is recommended to use seeds that have not been harvested for longer than six months as such seeds tend to give germination rates of above 80%. As soon as seeds intended for sowing are received, they should be kept in a dryplace and protected against rodent pests. Normally the germination capacity is indicated on the bag. For example, if the stated germination capacity is 80%, it means that 80 seeds would germinate out of 100 seeds sown. It is assumed that, by now, the number of "plantable" grafts is known and therefore the number of seeds needed for a specific production area is also known.

As an example, for a field of 300m x 200m, it was estimated that 144 grafts will be produced in the nursery. If the stated germination capacity is 80%, then 20% more seeds will be needed to compensate for the low germination capacity. In this specific example, calculation is as follows: 20% x 144 = 29 more seeds; therefore the total number of seeds needed is, 29 +144 = 173 seeds.

It is important to remember that the number of seeds to begin with that will yield the required number of successful grafted seedlings depends on the:

- proportion of seeds sinking during floatation test,
- seed germination percentage,
- rootstock culling percentage during grafting, and
- percentage graft success rate.

Example: Suppose 100,000 grafts has been ordered by a customer. How do you estimate the number of seeds to be purchased for rootstocks establishment to ensure that at the end of the grafting operation the ordered number of grafts will be realised?

Let us assume that we have been given the following information:
percentage sinking seed (SS) is 82%; (ii) seed germination (SG) is 75%; (iii) variation in rootstock is relatively low, but expect to graft (G) 90% of properly developed rootstocks, and (iv) the percent success rate will be 85%.

Solution:
The number of grafts (G) needed by customer=100,000
To obtain and supply this number to the customer, the loss at each stage must be calculated and compensated for in the following manner:

a) Given that the grafting success rate will be 85%, it is expected that that there will be a 15% loss after grating. To compensate for this shortage, it is necessary to raise additional 15%

grafts (G) which will be 15% of 100,000. Therefore the number of rootstocks to be grafted will be: 100,000 + (15% of 100,000) = 115,000. Which is simply 100,000 x 1.15 = 115,000 where the decimal number (15) after the decimal point represents the loss.

b) Using the above example as a guide, we can calculate the total number of rootstock to be raised. Given that we expect to graft 90% of properly developed rootstocks, we will have to raise enough to make up for the 10% shortage. This will be 115,000 x 1.10 = 126,500
c) Following the procedures used in the calculations in (a) and (b) above, the total number of seeds to be sown will be: 126,500 x 1.25 = 158,125
d) In a similar fashion to the examples in (a), (b) and (c) above, the total number of seeds needed for the floatation test will be: 158,125 X 1.18 = 186,587.5 or approximately 186,588.
e) From the foregoing example, the total number of seeds that need to be purchased is 186,587.5 or approximately 186,588 seeds. Given that the average weight of a single seed is 6g, the total weight of seeds required is 186,587.5 x 6 = g = 1,119.5kg.

The same approach can be followed to calculate the number of polybags to be filled with pot mixture.

6.4 Sowing the Seeds

6.4.1 Direct sowing

Cashew seeds expire easily. Therefore dry and newly collected seeds (which have not been kept beyond six months) must be sown or propagated as soon as possible to prevent loss in viability. The following steps must be followed:

1. Sow good seeds (seeds that sank during floatation test) at 2.5cm
2. deep with the seed scar facing upward. In other words, the position of the nut during sowing should be the same as it appears on the tree (see Plate 11).
3. Press the soil down firmly to ensure good contact between soil and seed.
4. Water the seed twice a day and mulch them with grass to conserve moisture.

Remove the grass as soon as the seeds germinate. Seeds will germinate within 2 to 3 weeks, depending on the quality of the seed.

Figure 11: Direct seed sowing

6.4.2 Pre-germination

Seeds stored for a couple of months should be germinated on a pre- germination sandy bed of depth 15 cm and 100cm width or in wet jute bags prior to transplanting into poly bags.

Pre-germination and pricking out steps: (previous season seeds).

To conduct pre-germination of seeds prior to pricking out into poly bags, follow the same steps 1– 4 described earlier under direct seed sowing method in section 6.4.1. Observe signs of radicle emergence 15 days after the sowing date. Fill the poly bags well in advance with a good pot mix and water the day before pricking out (see Plate 11).

You should prepare only as many germinating seeds as you can pot within 30 minutes. The following steps should guide you to transplant pre-germinated seeds into poly bags:

1. Lift the germinating seed carefully, holding it by the cotyledons, so that the soft roots do not get damaged.
2. Make a hole in the poly bag mixture using a small stick. Ensure that the hole is in the centre of the poly bag and that it is longer than the roots of the germinating seed to be potted. This will ensure adequate room for the root and prevent damage.
3. Put the seed into the hole, ensuring the roots are not damaged; insert the seed a bit deeper than necessary to ensure proper coverage.
4. Press pot mixture firmly around the seed and water. thoroughly to avoid air pockets in the pot mixture.
5. Keep filled containers under shade for at least two weeks.

Figure 12: Pricking out pre-germinated seeds

KEY MESSAGES TO NOTE

- Cashew nuts to be used in planting(sowing) should be from mother plants which have shown excellent perfomance
- Only good quality seeds with good viability and with individual weight not less than 6g should be sown
- Seed flotation test can help you determine best seeds for sowing
- Where seeds meant for sowing have been stored for longer than two months it is advisable to pre-germinate them on a pre-germinnation sandy bed or in wet jute bags before transplanting into poly bags

7 SCION HARVESTING & PREPARATION

7.1 Source of scions

Scions may be sourced from existing outstanding trees. Farmers' own materials are those sourced from existing outstanding trees found in farmers' fields. Scions may also be obtained from well-established and maintained scion banks.

7.2 Types and quality of scion

Identifying good scions for grafts

Scions for grafting should be from mother trees with desirable characteristics (see Plate 12). Good scions are:

- Pencil size in thickness
- Erect and 12 – 15cmlong
- Greenish brown in colour
- Matured with swollen but not broken terminal bud
- Clean and free from diseases and pests.

Note: Scions with short internodes should be avoided (see Plates 13 & 14).

Figure 13: Scions with terminal buds signalizing to open

Preparation of Scions

It is important to precondition scions before harvesting them for grafting

- Pre-condition scions by removing all leaves 4 – 7 days before harvesting
- Harvest scions on the day of grafting.

Note: If for any reason the scions cannot be used on that same day, keep them fresh in moist cotton wool, moist jute sacks or moist news print and store them in a cool place for not more than 3 days. (see Plates 15 & 16).

Figure 14: Fruit twig from which nuts had been harvested

Figure 15: Preconditioned twig (scion)

Harvesting Scions

- Harvest the scions early in the morning or late in the evening
- Protect them against drying by wrapping them in a moist tissue, e.g. a newspaper, dry grass, hessian cloth, or wet cloth and in a polythene bag immediately after excising. Keep the polythene bags in a cool container.

Figure 16: Scion selection and excising

Figure 17: Scions placed/wrapped in a wet newspaper

- Label all scions bundles properly by indicating the type of tree, cultivar/clone, date of harvesting, and then put the scions in a polythene bag.
- Transport scions in moist cloth and keep them cool in a shady place or in cool dry

KEY MESSAGES TO NOTE

- Scion should be sourceed from outstanding(best performing)mother trees in farmers' own fileds or from well estalished and maintaned scion banks.
- Good scions are:pencil size thickness, erect and 12-15cm long, greenish brown in colour, matured with swollen but not broken terminal bud, clean and free from diseases and pests
- Precondition scions before harvest
- Harvest scions in the morning or evening to protect them in moist tissue
- Label scion and transport them in moist cloth for storage in a cool shady place

8 CASHEW PROPAGATION

Cashew propagation means multiplication of improved grafts and distribution of the grafts to farmers for planting out. Cashew is usually propagated by seeds/seedlings. Seed combines the properties of two parent plants and results in a completely new individual plant with completely new properties. However, propagating cashew through vegetative propagation method ensures the transfer of desirable qualities of the mother tree into the vegetative progenies. Vegetative progenies are generated from parts of the mother trees other than the sexual seeds. They are genetically identical to the mother trees. The genetic uniformity of vegetative progenies of cashew helps to predict field performance and quality of produce.

However, successful cashew propagation by grafting requires knowledge in mechanical, environmental and chemical manipulations of plant as well as other technical skills of the grafter. In addition to this, knowledge of cashew plant growth, development and morphology are also important.

8.1 Types of Grafting (Soft Wood)

There are many typees of grafting. These include: Wedge/Cleft Grafting, Side Grafting, Tongue (Slice or Whip) Grafting, and Chip Bud Grafting.

Wedge/Cleft Grafting: In this type of grafting, scion is trimmed to a wedge shape by cutting off the bottom tip. The apical portion of the rootstock is cut off and a cleft 2 cm deep atthe cut end. Both are also of the same diameter.

Figure 18 Wedge Grafting

(a) (b)

(c)

(d)

Side Grafting: In side grafting ,a slant cut inclined about 35 degrees from the vertical is made on the rootstock. The bottom of the scion is trimmed as a two sided wedge with the outer side shorter than the inner to fit into the rootstock. Making sure that the cambial layers are aligned at least one side.

Tongue (Slice or Whip) Grafting: In this type of grafting an oblique sloping cut or notch is given to both stock and scion. The two perfectly fit upon one another. They are tied together.

Figure 19: Tongue Grafting

(a) (b) (c)

Chip Bud Grafting: In a chip bud grafting , the scion is reduced to a small piece containing one bud. A 45^{O} cut is made to about a quarter of the distance through the rootstock. About 2-4 cm above the first cut a second downward and inward cut is made until itmeets the first cut. A similar size and shape is cut from the scion wood and replaced into the rootstock. The chip bud is wrapped with a grafting tape.



Figure 20: ChipBud Grafting

(a) (b) (c)

8.2 Procedure for Grafting

The overall procedure for grafting can be grouped under the following steps:

sharpening the knife, selecting the rootstock for grafting, preparing a cleft in the rootstock, preparing a wedge shaped scion, matching scion and rootstock, joining the scion and rootstock, protecing the scion from drying, and labelling the nursery stock. Let us examine the above steps in detail.

8.2.1 Sharpening the knife

The knife for grafting should be sharpened thoroughly until it is as sharp as a as a razor blade. To sharpen with a sharpening stone, soak the sharpening stone in water for 2 minutes.

Place the sharpening stone in a stable position and place a flat side of the knife on the sharpening stone. Lift the back of the knife to a height of about 1/2 cm only and move the knife on the stone in circular swing utilizing the full, plane surface of the sharpening stone. To finalize sharpening, pull the knife in backward direction only.

Sharpen the knife on one edge (some types of knives are sharpened on both edges). Continue until a thin ridge of iron is visible on the blade.
Remove the ridge by using a leather belt tool. To test whether the knife has

been sufficiently sharpened try slicing through a piece of paper. The knife is sufficiently sharpened if it slices through the piece of paper easily.

Figure 21: Sharpening a knife

8.2.2 Selecting the rootstock for grafting

To select a rootstock, look for a healthy seedling. A healthy seedling is one that is free of pests and diseases (see Plate 22).

Figure 22: : Root stocks at the appropriate stage of grafting

8.2.3 Preparing a cleft in the rootstock

The following steps will guide you to prepare a Cleft in the rootstock:

- Take a rootstock having a single stem which is in good shape and is well watered.
- Pluck off some leaves, but make sure that you keep a few growing below the graft union.

- Cut the top of the rootstock at a height of approximately 2.5cm from the bottom horizontally.
- Make a smooth vertical cut of approximately 2.5 cm at the centre of the top cross cut downward towards the bottom of the rootstock (see Plate 23).

Figure 23: Making a cleft

8.2.4 Preparing a wedge shaped scion

This is a major exercise in all types of grafting and practicing it often will improve your skills and bring successful results. To begin with, remove any end of a scion that is dry (see Plate 24).
Next, look for a scion whose diameter exactly matches the diameter of your rootstock.

Figure 24: Making a wedge shaped

8.2.5 Matching scion and rootstock

Match the scion and the rootstock by inserting the scion smoothly into the Cleft in the rootstock. Do not press too strongly and do not touch the cut surface of the scion or the upper cut end. During insertion, follow the “bark- to-bark (rootstock and scion) rule”: This rule says you must ensure that the bark of the scion and the rootstock match properly. The best result is received if both sides match perfectly. At the very least, one side of the scion and the rootstock must match, or the graft will not take. Only the cambium which comprises the soft parts of the scion and the rootstock underneath the bark is able to grow over the wound and heal it.

Figure 25: Matching scion and rootstock barks (cambium)

8.2.6 Joining the scion and rootstock

The following steps should be followed to join the scion and rootstock.

- Match the scion and stock diameters precisely in order to ensure proper and intimate contact of the cambiums of the scion and the rootstock.
- Tie the graft union with a 1.5 cm wide and 30 cm long polythene graft tape.
- Start the tying from the rootstock end of the graft (i.e. below graft union) and work upwards. Overlap the rounds of tape the point of the graft union.

- Cover the graft union towards the top of the scion. When only 6 or 7 cm of the tape remains, work downwards to overlap the tape again. Finally, fix the tape with a simple knot.

Figure 26: Joining scion and rootstock

8.2.7 Protecting the scion from drying

To protect the scion from drying out, cover the scion and grafted shoot with a poly cap, The poly cap covering will stop the scion from losing water through surface evaporation. Carefully place the plant in a stress-free environment such as a 50% shade house.

Note: Handle the grafted seedlings carefully. If you have to move the container, hold it at the bottom. Water all containers with grafted seedlings soon after grafting.

Figure 27: Protecting scion and graft union from drying

8.2.8 Labelling the nursery stock

From the moment grafts are made, they should be carefully labelled. Each lot of grafts need to be identified clearly on the label with information such as: variety name and code, date of grafting and other treatments. Put two labels on each lot, one at the beginning of the row and the other at the end.

KEY MESSAGES TO NOTE

- Types of grafting include: wedge/Cleft grafting, side grafting, tongue (slice or whip grafting) and chip bud grafting.
- The components of the grafting procedure are: sharpening the knife, selecting the rootstock for grafting, preparing a Cleft in the rootstock, preparing a wedge shaped scion, matching scion and rootstock, joining the scion and rootstock, protecting the scion from drying, and labelling the nursery stock

9 GRAFT CARE

9.1 Routine Activities

The following routine activities should be undertaken as part of caring for the grafts.

- Keep the nursery tidy.
- Water the plants once or twice a day (depending on the weather)
- Inspect grafts for signs of sprouting after 2-3 weeks.
- Inspect grafts for signs of insect and disease attack,
- Loosen poly caps when the leaves of the new sprouts have fully expanded (4-7 days after sprouting) and signs of growth are visible,
- Remove binding (grafting) tape 2 – 3 months from grafting date, and
- Remove lateral shoots growing below the graft union.

9.2 Root Pruning

Root pruning is the removal of roots that have grown out of the poly bags into the ground. It is done to avoid seedlings establishing in the nursery since they still have to be planted out to the field. Two common methods employed in cashew nurseries to prevent seedlings from establishing in the nursery are “shocking” and “placement on plastic.”

Shocking involves lifting bags and putting them back in their original positions. Placement on plastic surfaces involves placing poly bags containing the seedlings on a spread out sheet of plastic on the ground to restrict surface roots from penetrating into the ground.

If the seedlings are placed on a bare ground (without a poly sheet), then the poly bag with the seedlings should be lifted from its position every week to ensure that the roots do not penetrate the soil.

If the tap root penetrates the soil, the area where the poly bag is placed should be watered heavily such that digging can be done easily to expose about 3-5 cm of the buried tap root. A sharp knife or blade can then be used cut that length before it is lifted. When this is done, the seedling should be transferred to a bigger poly bag with a ball of soil covering the exposed roots. It is important to water such seedlings to reduce shock.

KEY MESSAGES TO NOTE

- Routine activities involved in caring for grafts include: keeping the nursery tidy, watering the plants once or twice a day (depending on the weather), inspecting grafts for signs of sprouting after 2-3 weeks, inspecting grafts for signs of insect and disease attack, loosening poly caps when the leaves of the new sprouts have fully expanded (4-7 days after sprouting) and signs of growth are visible, removing binding (grafting) tape 2 – 3 months from grafting date, and remove lateral shoots growing below the graft union
- Root pruning enables us to remove roots that have grown out by the poly bags into the ground. It is done to avoid seedlings establishing in the nursery

10 TRANSPORTING AND DISTRIBUTING GRAFTS

If the grafts are to be transported, the seedlings should not be watered for about 2-3 days in order to harden the ball of soil around the roots. This will prevent the crumbling of the soil when the seedlings are being lifted into a vehicle. To minimise shock, it is advisable to transport grafted seedlings in the morning or evening.

When the seedlings are off-loaded for transplanting, they should be kept under a shade for at least 3 days to reduce shock before being transplanted in the field. During that period of recovery, daily watering should be done.

Figure 28: Appropriate handling of grafts during transport

KEY MESSAGES TO NOTE

- Avoid watering seedlings for 2-3 days before transporting to harden the ball
- Transport seedlings in the morning or evening to minimise shock
- Keep transported seedlings in shade after offloading for at least 3 days to reduce shock before transplanting in the field
- Water seedlings during period of recovery between offloading and transplanting

PART B:
PESTS AND DISEASES CONTROL AT THE NURSERY

Figure 29: Pest damage on leaves and stem of cashew seedling caused by H. schoutedeni

KEY MESSAGES TO NOTE

- Pests and diseases can be prevented by keeping the nursery clean, weeding and using approved prophylactic treatment on soil
- Common pests encountered in nurseries include: Acrocerops sp. (Leaf miner), Gryllus sp. (Cricket), Caterpillars (Defoliators), Termites, and Helopeltis schoutedeni (Cashew mosquito bug) Follow appropriate procedures given in the text to control specific pests

11 NURSERY PESTS

Nurseries should be carefully protected to prevent pests and diseases attacks. Prevention can include using such measures as keeping the nursery clean, weeding and using approved prophylactic treatment on soil. Some common pests encountered in nurseries include: Acrocerops sp. (Leaf miner), Gryllus sp. (Cricket), Caterpillars (Defoliators), Termites, and Helopeltis schoutedeni (Cashew mosquito bug).

11.1 Acrocerops sp. (Leaf miner)

The larva of the leave miner scrapes and covers the upper leaf surface with a gelatinous secretion which dries to give a silvery appearance. Chemical control may be necessary only when a serious outbreak occurs. To control chemically, spray Cyperdim or Cymethoate Super EC (45ml/15L of water) using a pneumatic knapsack sprayer.

11.2 Gryllus sp. (Cricket)

Crickets cut the stem of young cashew seedlings which, in many cases, results in the death of the plant. When raising seedlings in polythene bags, the land on which the seedlings in poly bags would be placed should be drenched with a solution of 60ml of Hercules (Fipronil) in 15L of water before the seedlings in the bags are placed on it. After this the seedlings should be watered once every month with the Hercules solution using a pneumatic knapsack sprayer. On the other hand, where seedlings are raised on nursery beds, the beds should be watered with the Hercules solution once every month.

11.3 Caterpillars (Defoliators)

Caterpillars feed on young developing leaves of cashew. These caterpillars are the larval stage of moths. In the case of damage from caterpillars chemical control may be necessary only when serious outbreaks occur. To control, spray Cyperdim (45ml/15L of water) or Karate (45ml/15L of water), using a pneumatic knapsack sprayer.

11.4 Termites

Termites destroy seedlings and young plants by biting on fresh stems. This results in the wilting of leaves and death of the plant. When seedlings are to be raised in polythene bags, the land should be drenched with a solution of 60ml of Hercules (Fipronil) in 15L of water before the seedlings in the bags are placed on it. Water the seedlings once every month with the Hercules solution using a pneumatic knapsack sprayer. On the other hand, where seedlings are raised on nursery beds, the beds should be watered with the Hercules solution once every month.

11.5 Helopeltis schoutedeni (Cashew mosquito bug)

Both nymphs and adults of the cashew mosquito bug suck on flush leaves and stems of seedlings. The saliva of the insect is very toxic and the damage to flush leaves and stems is shown by the presence of brownish- black patches which may result in dieback. In severely damaged seedlings the entire leaves are destroyed. Chemical control may be necessary only when serious outbreak occurs. Spray Cyperdim or Cymethoate Super EC (45ml/15L of water) using a pneumatic knapsack sprayer.

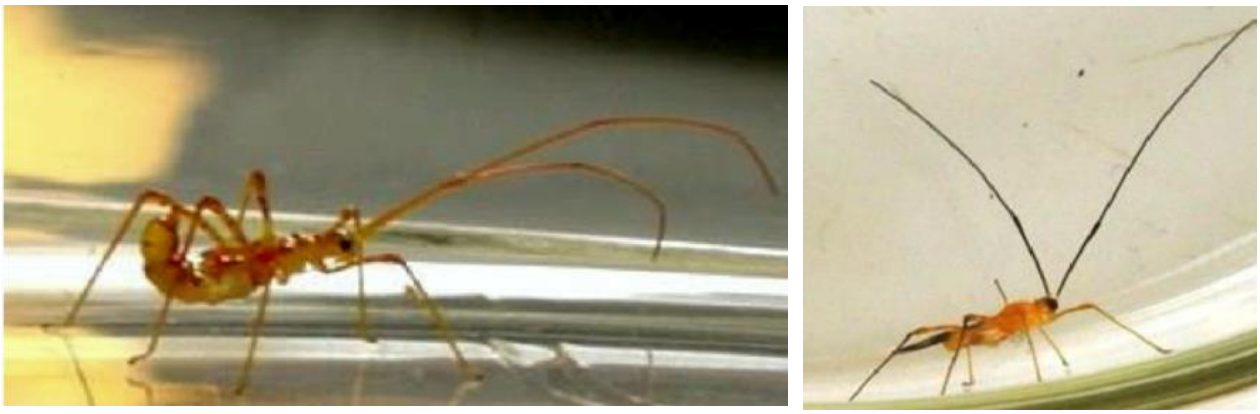

Figure 30: Nymph and adult of H. Schoutedeni

12 NURSERY DISEASES

Diseases can occur in cashew nurseries if adequate care and protection is not provided. A common disease in cashew nursery is the seedling blight.

Seedling blight

Seedling blight is a disease caused by Septocylindrium sp. The disease causes wilting and withering of leaves as a result of the roots getting rotten. To control blight at the nursery, spray Ridomil gold (Cuprous Oxide+Mefonoxam) at 50g/15L of water using a pneumatic knapsack sprayer.

KEY MESSAGES TO NOTE

- A common disease in cashew nursery is the seedling blight
- Control blight at the nursery by spraying Ridomil gold (Cuprous Oxide+Mefonoxam) at 50g/15L of water using a pneumatic knapsack sprayer

PART C:
COST OF PRODUCTION OF CASHEW SEEDLINGS

Table 4: Cost Benefit Analysis for a nursery with a capacity of 10,000 seedlings in Ghana

Country / Region	Ghana	Cashew seedlings WENCHI 1	
Local currency	GHC		
Exchange rate with EUR	5,57	(04.06.18)	
Exchange rate with USD	4,75	(04.06.18)	
Batch / year	1	batch	
Seedlings per batch	10000	root stocks	11000
Year of calculation	2018	WENCHI NURSERY	
Main Product / Variety	Cashew Gra†s	Local from elite trees	
Production technique	Improved (GAP) with 80% of success rate		
Farm gate price	3,00	GHC	per seedling
Success rate	80%		
Number of obtained seedlings	8000	seedlings per	batch
Labour costs	25	GHC per MD*)	

Data filled in for	1	batch		Calculation for	1	batch
	Unit	Quantity	Unit price	Total	Total	Total
			GHC	GHC	EUR	USD
Production						
Main product	kg	8 000	3,00	24 000	4 309	5 053
Gross revenue				24 000	4 309	5 053
Variable Costs						
Labour costs	Unit	Quantity	Unit price	GHC	EUR	USD
filling of nursery bags	Mandays	22	25,0	550	99	116
arranging of nursery bags	Mandays	11	25,0	275		
seeding of nursery bags	Mandays	11	25,0	275	49	58
mentainance - watering, weeding, trimming off-shoots & sparying	Mandays	25	25,0	625	112	132
Grafting	Mandays	120	25,0	3 000	539	632
Transport to scion bank	number	10	50,0	500	90	105
Certification costs	year	1	70,0	70	13	15
Total labour need	Mandays	189				
Total labour costs				5 295	901	1 057
Input costs	Unit	Quantity	Unit price			
Cashew seed-nuts	kg	120,0	5,5	660	118	139
Cost of scion	number of scions	10 000	0,1	1 000	180	211
Top soil	trip (double axel)	1,0	700,0	700	126	147
Nursery bag	pack of 100 pieces	110,0	7,5	825	148	174
Shavitfin 71.5 wp fungicide	liters	1,0	30,0	30	5	6
Victory 72wp insecticide	liters	1,0	30,0	30	5	6
cost of water	water bill	30,0	10,0	300	54	63
Total input costs				3 545	636	746
Total variable costs				8 840	1 587	1 861
Gross margin	= Gross revenue - Variable costs			15 160	2 722	3 192

Fixed Costs						
Depreciations	Unit	Quantity per year	Unit price			
Shade house, period of use: 3 years**)	structure	0,33	4 500	1 485	267	313
Tools and equipment, period of use: 3 years ***)	bulk	0,33	970	320	57	67
Drums for water (5 years life span)	piece	0,2	440	88	16	19
Land (30 years life span)	plot	0,03	3 000	90	16	19
Total fixed costs	= Total depreciations			1 983	356	417
Total costs	= Total variable costs + total fixed costs			10 823	1 943	2 279
Profit (net income)	= Gross revenue - total costs			13 177	2 366	2 774
Unit cost	= Total costs / total quantity of production			1,35	0,24	0,28
Profit/Loss Margin/Seedling	=Farm Gate Price - Unit Cost of Production			1,65	0,30	0,35
Rise in 15% Total Cost				1,44	0,26	0,30
Labour Productivity	=Gross Margin-Input Cost/Invested labour			61,46	11,03	12,94

*)1MD (manday) = 6 hours ofwork

Cost of nursery wood work
Transportation ofwood
Carpenter's labour cost
Shade net
Plastic mulch sheet

***)Composed

wheelbarrow
Mattock
Shovel
Water hose
Wellington boots
Watering can
Hand trowel
Hand fork
Overall jacket
Bow saw
Knapsack sprayer
Budding knife
Pruner

Source: GIZ/ComCashew,