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Based on a proposal for a regional tree seed centre in Uganda

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THE DESIGN OF TREE SEED PRODUCTION UNITS

Based on a proposal for a regional tree seed centre in Uganda

by

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Danida Forest Seed Centre (DFSC) *is a Danish non-profit institute which has been working with development and transfer of know-how in management of tree genetic resources since 1969. The development objective of DFSC is to contribute to improve the benefits of growing trees for the well-being of people in developing countries. DFSC's programme is financed by Danish International Development Assistance (Danida).*

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Preface

The requirement for a local production/processing unit for tree seed varies according to local conditions. The sizes will range from large national units to very small private ones:

- **Large**
  Many countries have a large national tree seed centre with facilities for seed processing and with a laboratory for research and officially controlled tests.

- **Medium**
  Many countries also have regional tree seed centres for seed processing only. These centres go under various names, for instance zonal centres or antennas.

- **Small**
  Small local tree seed units are also found, usually run by NGO s, private seed dealers or small nurseries. They operate from modest facilities, one or a few rooms with limited outside space for seed handling.

- **Micro**
  Communal or private tree growers may process very small amounts of tree seed using easily available small containers, baskets or clay pots in their vegetable gardens.

Ideally, one should decide on the appropriate scale of tree seed unit based on information on seed requirements of the various tree species; but in practice, small units tend to grow out of an immediate local need, whereas larger units are established in connection with large, often public, tree planting programmes.

This Technical Note goes through the main basic considerations for deciding an appropriate design of a medium sized tree seed unit. It is based on many years experience with establishment of such units in the tropics and subtropics. It is intended for planners and technicians. It may also serve as inspiration for design of smaller tree seed units, but it is not a do-it-yourself manual. However, some of the ideas may be transformed to serve local purposes and situations.

1. INTRODUCTION

Tree seeds that do not germinate are often damaged while under poor storage and transport conditions. Some seeds are damaged by mechanical injury during processing, some die because they were already infested by insects on the tree, and some seeds may be empty. Most seeds probably die because they are overheated in the sun while they are still moist, because of mould growth and fermentation during temporary storage and processing of the fruit, and large amounts die because they are not kept at the correct moisture content in storage.

A successful seed-procurement operation depends on appropriate treatment of the fruits and seeds. This basically involves three preconditions:

1) Knowing the seed biology of the species you collect.
2) Knowing how to process the fruit quickly with minimum damage to the seed and having appropriate facilities for this.
3) Providing the seed with optimal storage conditions at all stages between collection and sowing.

Seed-procurement operations involve collecting information on how to treat the species you are going to work with in order to be able to arrange facilities that will accommodate the amounts that you are going to produce in a proper way.

The procedures that fruit and seed go through between collection and sowing are basically independent of quantity. The difference between large and small quantities is mainly the amount of mechanisation and size of facilities.

If you begin a production of tree seed for your own use, you may provide shade in flat baskets inside your house, dry the seed outside in the sun, store the dry seed in sealed plastic bottles on a shelf, and test the germination in your vegetable garden, or in a tray with moist sand on the window sill.

If you begin an operation with one or a few seasonal workers, you may operate from temporary buildings or a container until you know how much seed the market can consume. Many of the operations can be done from temporary facilities but you will need to provide correct facilities for seed storage for larger amounts of seed.

There is very little information available on organisation, design and equipment for small tree seed units. This is basically because they should be tailor-made for the amounts and types of seed they are going to produce. In large national seed centres, large amounts of seed will go through the production steps common to most species. For these procedures, facilities and equipment can be designed for optimal production. But in smaller operations you will have to compromise and find the best solutions with the available resources; it is not economically feasible to have machines and facilities for all steps in the production. One has to make do with what is available, easily obtained locally, or temporarily can be adapted to fit the needs. It is difficult to describe exactly how it is done; it depends on the types of tree seed, the amounts, local conditions and possibilities.

The design of a seed-producing unit involves the following steps:

1) Assessing the seed consumption needs for each species
2) Determining how the seeds of each species should be processed
3) Calculating which resources are needed to process the necessary amounts
4) Designing a rational lay-out of production and facilities.

This Technical Note describes these four steps in chapters 2 to 5.

The term 'seed centre' is used as a name for a national (or large) seed-producing unit and 'regional (seed) centre' as a name for a seed-producing unit that does not carry out research and official laboratory tests and only stores seed for a shorter period (one season; maximum two seasons).

References are made to DFSC Lecture Notes (C-series) and various Technical Notes on seed production describing the subjects discussed in detail.

Each seed-producing unit or seed centre is custom built to fit species, production capacity, local environment and infrastructure, etc. Decisions on what equipment to purchase and how to design the physical facilities have consequences on future production capacity and quality. It is therefore strongly recommended that one seeks qualified advice in the establishment phase.

In this Technical Note a proposal for a regional tree seed centre in Uganda with an annual production of 1,500 kg seed is used as a case study.

2. ASSESSING THE SEED CONSUMPTION FOR EACH TREE SPECIES

The production capacity in terms of kg seed to be produced every year should be quantified in advance in order to be able to dimension the facilities to fit the production. The capacity should be based on a survey of the amounts the market can consume. The survey will have to be based on data from planting programmes, nursery capacities, and other seed and plant users.

In order to convert number of hectares to be planted annually to kg of seed to be produced, some figures of conversion have to be used.

Table 1. Species wise conversion from spacing to kg seeds needed per ha.

Species	Spacing m x m	No. of plants / ha	Field mortality %	No. of plants / ha including replacement	Nursery mortality %	No. of viable seeds to sow / ha	Germination %	Purity %	No. of seeds / ha	1000 seed weight g	g seed needed / ha	kg seed needed / ha
X, example	2 x 3	1667	20	2000	50	4000	70	90	6349	35	222	0.222

The number of plants per hectare (10,000 m²) can be found by dividing 10,000 m² by the spacing. For example, at a spacing of 2 x 3 m each plant occupies 2 m x 3 m = 6 m²/plant.

(10,000 m²) / (6 m²/plant) = **1,667 plants/ha.**

Additional plants have to be produced for replanting, as not all plants survive the first season. This is normally 15-35% of the original plants. E.g. at 20% replanting the following will have to be added:

(1,667 plants/ha) + (1,667 plants/ha x 20/100) = 1,667 plants/ha x 1.20 = **2,000 plants/ha.**

Many viable seeds are lost in the nursery as well (poorer germination in the field than during a germination test, losses in the seed beds, during pricking out or transplanting and culls). Nursery losses often require sowing of 1.5-2 times the number of plantable plants required. If 50% of the viable seeds become plants:

2,000 plants/ha x 2 => **4,000 viable seeds/ha**.

Average germination percentage and purity of the species also have to be taken into account. For example, if experience is that average germination percentage is 70% and purity 90%, the amount of viable seeds needed should be divided by these percentages:

(4,000 viable seeds/ha) / (0.7x0.9) = **6,349 seeds/ha.**

Finally the amount of seeds per ha is converted into weight of seed per ha. For this a figure of average weight of 1,000 seeds of the species (1,000 seed weight), or the amount of seed per kg, is needed. If the average 1000 seed weight is 35 g, then the weight needed per ha is:

(35 g x 6,349 seeds/ha) / (1,000 seeds) = 222 g/ha = **0.222 kg/ha.**

The conversions should at least be done for the most important species and species that require special treatment in the production so that one can produce a table, like table 2.

Table 2. Annual seed production of Seed Centre X

Species	Kg seed needed /ha	Annual planting in ha	Kg seed to produce / year

DFSC Lecture Note C-1, Planning National Seed Procurement Programmes, explains the procedures in assessment and calculation of the national seed demand by using the 5- or 10-year plans for national planting programmes.

DFSC Lecture Note C-3, Planning Seed Collections, explains the procedures of collecting data on seed stand production (amounts, resources needed to collect them, and timing of collections), and compiling data on the seed lots as they are being pro-

duced (processing methods, resources, seed quality data, etc.).

Unfortunately there is often a yearly variation in size of seed production in many species. These variations may delay planting targets considerably if not taken into consideration in the form of a buffer stock of seed in store. On the other hand, the appearance of good crop years opens the possibility of producing larger amounts of seed than needed during the next season. The advantage of producing larger amounts in good crop years is lower production price per kg and in some cases better seed quality due to better pollination and lower pressure of pests. For seed collections in remote areas, the cost of collection of several years' demand and storage should also be balanced against annual collections. The balance between availability and storability of the crop on one hand and production price and seed quality on the other hand will have to be taken into consideration when production capacity and the amount of storage space and type of storage are decided.

When the annual seed production of each species has been estimated, the species are grouped into types according to how they are to be processed, and the data entered into a table, Table 3.

Table 3. Annual production capacity of Seed Centre X

Species group	seed kg	fruit kg	fruit litre	collection period months/weeks	production period weeks	equipment and facilities for production	average storage period
Pine sp. (cones)							
Acacia sp. (pods)							
Pulpy sp. (drupes)							
etc.							

Average storage period depends on sowing period in the nursery and on whether a buffer stock is kept. The figures for conversion into kg fruit, volume of fruit, collection period, and production time will have to be extracted from practical experience, from other seed units working under similar conditions, from literature, etc.

3. CONSIDERATIONS ON HOW THE SEEDS OF EACH SPECIES SHOULD BE PROCESSED

When the quantities have been fixed, it should be considered in detail how each species is going to be processed in order to be able to establish which facilities and equipment are needed. For instance, if the fruits of a dehiscent species are collected from the crown of the tree, the following criteria will have to be considered: (1) how many pieces of collection equipment is necessary to collect the required amount of fruits in the period between fruit maturity and dispersal of the seed, (2) how many sacks are needed for the collected fruit, (3) how and for how long the fruits are to be after-ripened in the shade, (4) how the fruits are to be dried, (5) how the seeds are to be extracted, (6) and what equipment and facilities are needed to complete these operations within a reasonable period.

Figure 1 gives a generalised overview of the processes each seed lot may go through depending on type of fruit and seed.

DFSC Lecture Notes C-4 Seed Collection, C-6 Seed Handling Prior to Processing, C-7 Seed Processing, C-8 Seed Testing, C-9 Seed Storage, as well as several of DFSC's Technical Notes (in particular Technical Note 54) describe the technical procedures and equipment for the processes.

There are often several options and levels of mechanisation to consider when deciding how crops of different species are going to be produced. As far as local conditions permit, the choice should be based on the necessary capacity in the individual step of the production, economical feasibility, and an aim at producing seed of high quality.

An example could be the consideration whether the fruits should be collected from the crown by fully equipped permanent labourers or bought from local villagers. Experience shows that the quality and origin of the seed can be better controlled using permanent labourers. On the other hand, local villagers will be more liable to protect the seed source if they can benefit from its seed production, and the cost per kg collected fruit will often be lower.

Another example could be cleaning and grading of extracted seed. There are many cleaning and grading machines available in various sizes with different abilities and capacities. On the other hand, cleaning and grading of an equal quality may be obtained by a skilled person winnowing with a flat basket. Whether cleaning and grading should be done manually or with a machine is a question of balancing the amount of seed to be cleaned annually and the cost and availability of labour against the price of the machine depreciated over e.g. 10 years plus running costs.

A third example could be the necessity for artificial drying and cooled storage. The germination capacity of the seed falls during the period between collection and sowing. The speed of this reduction in germination capacity during storage and transport mainly depends on species and the moisture content and temperature of the seed. The decisive factors then become the time that the seed is to be stored and whether the local climate during the processing season permits sun drying of orthodox species to a sufficiently low moisture content (generally below 8%). DFSC Lecture Notes C-5 Seed Moisture, and C-9 Seed

Storage, and Technical Note 54 discuss the considerations. Please note that some species do not tolerate drying and would deteriorate fast if dried (see DFSC Technical Note 56).

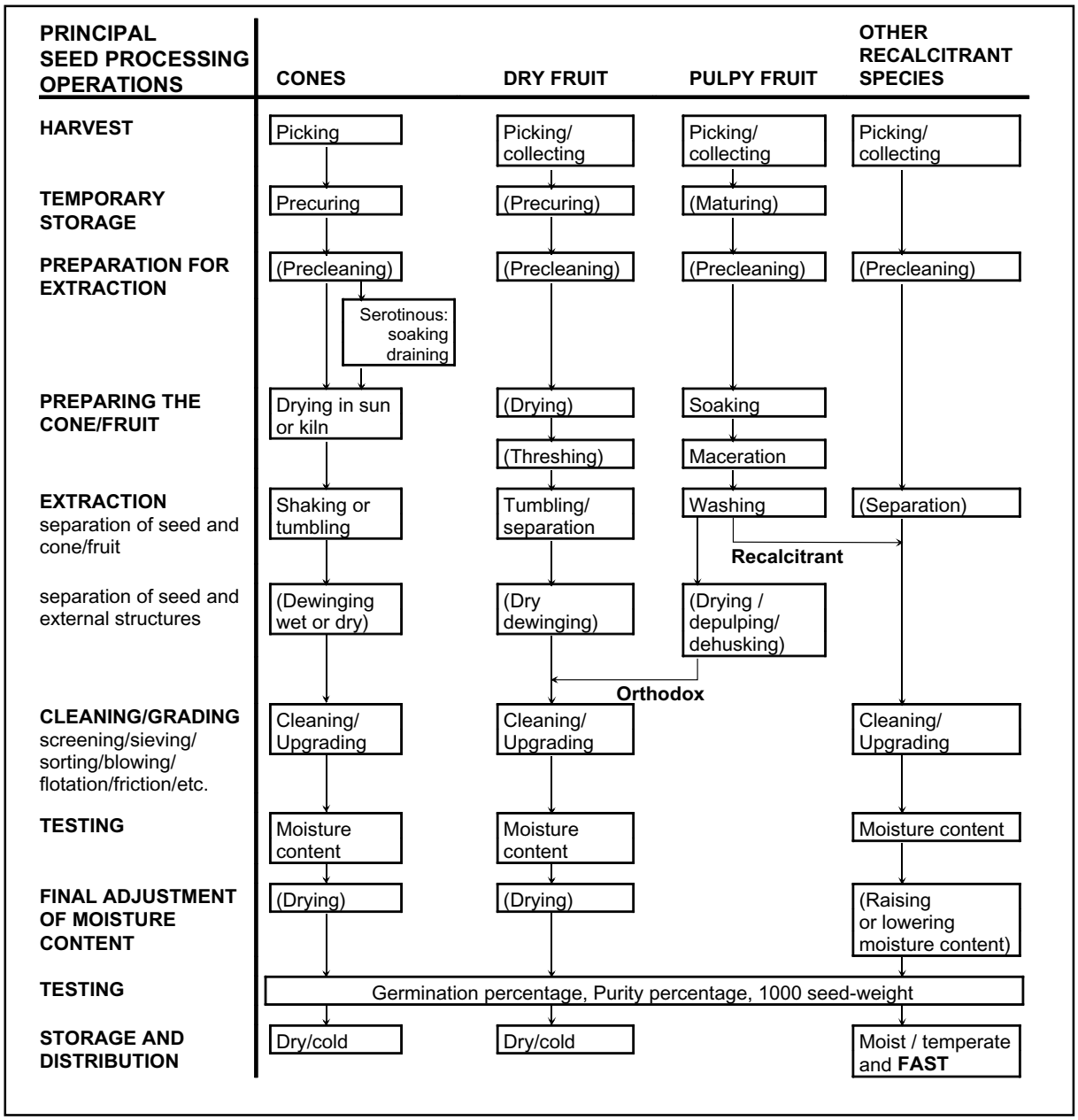


Figure 1. Principal seed processing operations

4. CALCULATING THE RESOURCES NEEDED TO PROCESS THE NECESSARY AMOUNTS

4.1 Equipment

In many cases several species will mature during the same period. The equipment used for one species can therefore not always be used for other species at the same time. For example, the sacks used for after-ripening one species in the shade cannot be used for collections of another species during the same period. Other equipment may be used for various purposes during various periods of the year; e.g. tarpaulins can be used for collections from the ground and as a surface for sun drying.

With data in a table equivalent to Table 3 and with a clear idea of how the different types of species are going to be processed, it should be possible to make a list of equipment necessary for the production. The equipment should be grouped according to process, e.g. crop assessment, collection, temporary storage and transport of fruits, processing, laboratory and storage. For each type of equipment the minimum requirements during the peak season should be calculated, such as how many collectors will be active during the peak of the collection season, and what should each collector be equipped with.

Other examples could be calculations for each species of how many sacks will be required for collection and temporary storage, size of temporary storage facilities for the fruits, and what the processing capacity should be. The size and kind of temporary storage facilities necessary depends on the maximum crop size, collection period, storability of the unprocessed crop and the feasible production rate of the extraction. The following figures are given as an example:

<u>Priority species X</u>	
Maximum crop in a good year	200 sacks
Collection period	5 weeks
Maximum temporary storage of fruit	5 weeks

Weekly average production capacity from collection should be 40 sacks. All the seed will have to be extracted during 5+5=10 weeks. So the extraction process should have a capacity of 20 sacks per week. Maximum amount in store will occur in week number 5 when the last sack is stored but only half the production is extracted. At this point there will be 100 sacks in the store.

In Appendix 1 further examples are given of calculations of production capacities and necessary equipment.

Appendix 3 presents an example of an equipment list for a regional seed centre with a production capacity of 1,500 kg of seed per year.

In the case study of a regional centre in Uganda all equipment that is not optional is purchased. Collection equipment, except steel ladder, is purchased for 4 permanently employed seed collectors. This gives a total budget for equipment purchase of US$ 31,955 (in year 2000).

4.2 Physical Facilities

With the equipment list complete, the next step is to calculate the size of the physical facilities necessary to accommodate the equipment and the production.

The following room functions are generally necessary for a seed-producing unit of some size.

- Store for collection equipment
- Open well-ventilated area under roof for temporary storage of fruits and for dusty seed processing
- Closed well-ventilated 'processing hall', where seed is sheltered and processing equipment can be stored
- A dry deck for sun drying
- Laboratory (and germination room)
- Seed store (and packing room)
- (Office)

If the unit only produces for home use (or is very small), some of the functions may not be necessary, or may be used for other purposes as well. If, for instance, a nursery produces seed for its own use, the collection equipment may be stored together with other equipment; germination testing may be done in seed beds; packing room may not be necessary and office functions may be carried out in connection with an already existing office or in the laboratory.

In the following, the requirements of each function will be discussed using the example of a planned regional seed centre in Uganda assuming that the centre has a yearly production of 1,500 kg seed; that various types of species are produced; that about 20% of the seed production comes from fruits that are depulped, 30% from fruits that are threshed and 30% are difficult or recalcitrant species, and that the unit is not integrated in another production such as a nursery.

4.2.1 Store for collection equipment

Long equipment (e.g. ladders and poles up to 3.5 m) should be kept in the store. It should therefore be a long narrow room with a wide door at one end. There should be 50 cm wide shelves and racks on both long sides. A room of 2.5 x 4 m will be sufficient for fairly large centres. Smaller centres may use the store for other equipment as well, or store the collection equipment in a room used for other purposes.

Room requirements:

* Two tube lights
* One electrical outlet
* No windows (to avoid burglaries)
* Good ventilation (e.g. under roof, or through grilled ventilation holes in wall). The equipment should be able to dry and be kept dry in the store. The leather parts of climbing equipment, which is wet when put away, will disintegrate if mould is allowed to develop
* Easy access for unloading from pick-up

4.2.2 Open well-ventilated area under roof for temporary storage of fruits and processing of dusty seed (see figure 7)

As processing of dry fruits is usually a dusty business, it will, when weather permits it, take place outside under the roof and on the concrete deck in front. Processing machines may be moved from the 'processing hall' for use outside. For a small centre, the open area under roof can be a wide covered walkway. The area under cover should be able to accommodate all the after-ripening fruit waiting to be extracted; there should also be room for several working processes (e.g. winnowing and threshing) leaving ample space for moving about and for over-hang of roof. In the case from Uganda the area was at least 15 m².

4.2.3 Well-ventilated 'processing hall' (see figure 7)

The processing hall provides storage space for processing equipment and seed during seed handling, and working area in poor weather. Possibility of ventilation right through the processing hall is important for seed drying. The size of the room is usually dimensioned so that all the equipment can be placed accessibly along the walls leaving an open work space in the middle.

The equipment for the regional centre in Uganda is used for the following example (see equipment for processing in Appendix 3):

Equipment:	size: width x depth cm
Damas seed blower	100 x 80
24 net trays 100 x 60 cm in 3 stacks of 8 trays (24 x 1.0 m x 0.6 m = 14.4 m² net surface, 14.4 m² x 3 cm thick seed layer = 0.432 m³ seed 0.432 m³/2 litre/kg = 216 kg seed)	300 x 70
baskets, mortars, etc.	150 x 70
4 steep barrels 70 cm in diameter	280 x 70
floor scale	60 x 70
set of hand screens	50 x 50
table (registration, etc.)	150 x 60
initial sub total	1,090 x 50-80 = 1090 cm wall width

Optional equipment that might be purchased at a later stage:

160-180 l concrete mixer	135 x 90
macerator (coffee depulper)	100 x 70
thresher	165 x 90
100" seed cleaner	300 x 300
24 screens for cleaner	150 x 100
sub total for expansion	850 x 70-300 = 850 cm wall width

There should also be wall space for doors wide enough to conveniently move fruits and equipment in and out:

2 sliding or garage doors: 2 x 150 cm	300 cm wall width
Total wall space	2,240 cm

As it is not considered likely that all the optional equipment is purchased within a foreseeable future, and as the corners can only be used in one direction, dimensions of 6 x 4 m that gives approx. 14 m wall-space is chosen.

Room requirements:

* Plenty of windows with adjustable glass louvers for ventilation and light
* Two 1.5 m broad garage or sliding doors
* One water tap, hose tap, wall-mounted sink with drain and floor drain underneath
* Electrical installations splash proof (depending on placing and regulations)
* Electrical 3-phase outlet (if available on the premises; many engines for equipment use 3-phase power as standard)
* Four electrical single phase outlets
* Fluorescent tubes

4.2.4 Concrete deck for sun drying (see figure 7)

The concrete deck should be large enough to easily accommodate all the seed and fruit in the process of being sun dried during the peak season. The deck should be slightly sloping and quite plane to allow fast water run-off and drying after rain. On the low side of the concrete deck there should be a drain for process water from maceration of pulpy fruit. If any significant amounts of pulpy fruits are processed, or if fermenting pulp residues cannot be tolerated in the rain water gutter, then this drain should be kept separate from the rain water gutter.

The area should be at least 4 x 6 m in order to provide space for a standard size 4 x 6 m tarpaulin (see calculations of capacities in Appendix 1).

4.2.5 Laboratory

Dividing samples, grinding moisture samples and sowing seeds for germination tests spread some dust and dirt and are best done standing up at a table.

Counting germination tests also spreads some dirt, but is best done sitting down.

Counting for purity and counting and weighing for 1000 sw are done sitting down at a clean and very stable table (vibrations and draught will make weighing impossible).

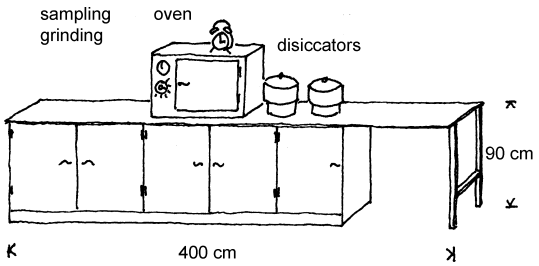
In addition a kitchen table with sink is needed.

Working with germination tests of large amounts of leguminous species produces a very unpleasant smell. Good ventilation or a fume cupboard may be needed for this.

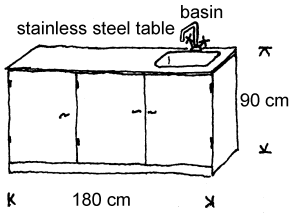
If the annual number of tests is very small, a separate room for laboratory may not be justified. If, on the other hand, a separate room is included as laboratory, it should have sufficient space for all the processes mentioned above. As there is working space for one person (max. two persons) in the laboratory, its capacity is 500-1000 tests per year. Also, the size of the germination room described below may limit the capacity of the laboratory.

Minimum table space for the following functions:

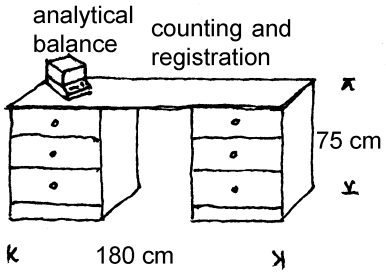
An approx. 90 cm high table 400 x 60 cm for sampling and moisture testing

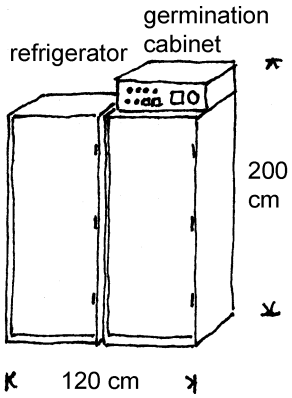


An approx. 90 cm high table with sink 150 x 60 cm



Space for a refrigerator and a germination cabinet 120 x 60 cm, 200 cm high.
An approx. 75 cm high table in front of windows.





The functions mentioned above will fit into a room of 4 x 3 m.

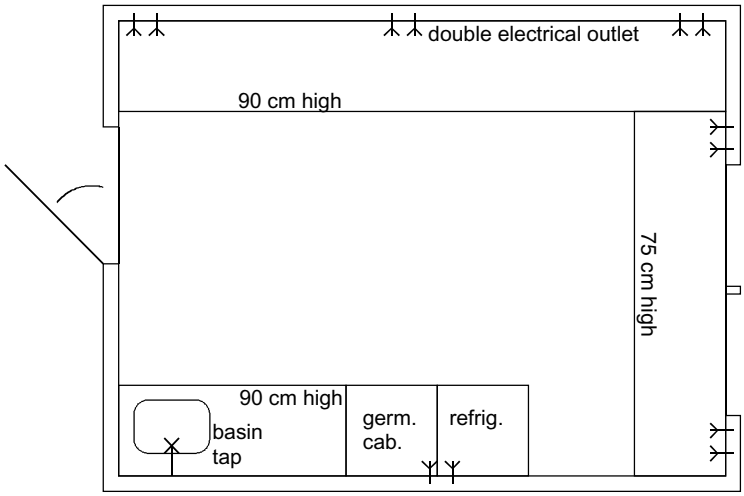


Figure 2. Laboratory, 1:50

Room requirements:

* Fluorescent light tubes
* If possible, electrical panelling above tables and a double electrical outlet every 1.5 m
* To keep the room dry, air conditioning would be preferable in humid tropical climates
* Windows should be of a type that can be closed to a dustproof state
* Low tables should be placed in front of windows for good light for counting seeds
* Tap and drain for sink
* Shelves and cupboards over and under tables
* Where voltage fluctuations occur, a voltage stabiliser is needed for electronic balances and other equipment with electronic parts; germination cabinet, refrigerator, deep freezer and other equipment with small engines will need a fridge guard. A voltage stabiliser common for the whole centre could be considered if the current is unstable and other electronic equipment is present at the centre; larger common voltage stabilisers are generally of a better quality.

4.2.6 Germination room

Germination tests should always be done under the best possible conditions for germination of the species in order to know the maximum possible germination percentage. Germination under optimal climatic conditions in a sterile medium free from pests is generally only possible in a germination room or in a germination cabinet. Under some conditions it may be necessary to test germination outside under nursery conditions; if the number of tests per year is very small, it is better to perform germination tests in sterilised sand in bowls with a glass sheet cover in a light room.

Germination tests in large bowls or boxes with sterilised sand generally give less problems with fungus attacks etc. than germination on blotter paper in a germination cabinet. It is, however, easier to create an artificial temperature regime in a germination cabinet for the species that do not have optimal germination at ambient temperature.

In the case from Uganda approx. 120 germination tests have to be done annually; mainly distributed around two seasons. With a testing time of 4 weeks, a capacity of 40 simultaneous

tests may be sufficient. A germination room is preferred to germination cabinets as the species are collected locally, annual temperature fluctuations are small, and the supply of electricity is unstable. In Uganda, germination is done in sand in bowls with 20 cm diameter, but other boxes or containers can be used. On average 6 containers are used per test (50% of the tests use 4 replicates with 100 seeds in each, 50% use 8 replicates with 50 seed, depending on the size of the seeds).

40 tests x 6 bowls/test = 240 bowls in use simultaneously in the room
240 bowls / (10 bowls/m shelf x 4 shelves in height) = 6 m shelved wall, 40 cm deep

1 table 60 x 100 cm for preparing bowls
1 table 60 x 100 cm with basin

This gives a room of e.g. 2.5 x 4 m

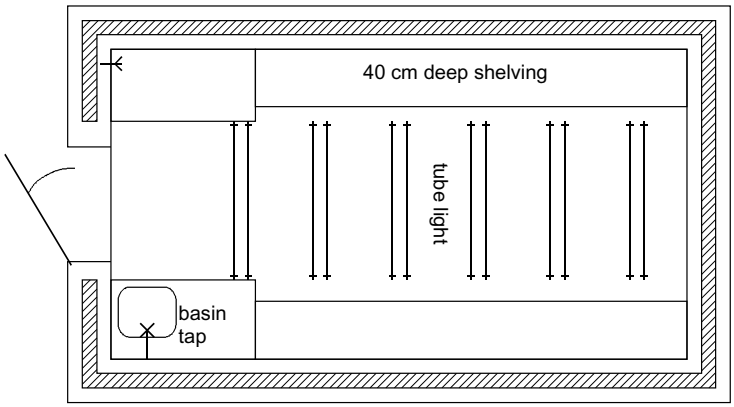


Figure 3. Germination room with insulated cavity walls, 1:50

Room requirements:

* All electrical installations splash proof
* One electrical outlet
* Abundant amount of light tubes in ceiling (in above example e.g. 6 twin, 4', 40W)
* Walls tile covered for washing down
* Sloping terrazzo floor, with floor drain
* Water tap over basin with drain
* Separate tap for hose
* Room insulated to reduce temperature fluctuations: cavity wall with 10-15 cm insulation material, e.g. fibreglass wool
* Possibility of regulating ventilation
* If the room is placed in the building with external walls facing north or south, a large roof overhang should prevent sun from hitting the walls (see discussion on influence of geographical latitude on roof overhang over north and south facing walls in section 5.2). No external walls should face east or west as the sun would heat these walls in the morning or afternoon
* The door should preferably open to the outside to prevent moist air from the germination room entering the neighbouring room
* Easy access to laboratory.

Storing and preparation of the sand for germination is done in a half-open shed of 2 x 2 m, with water tap and drain, concrete floor and a table. If a nursery is immediately adjacent, it could be placed there.

4.2.7 Seed store

The seed should be kept dry and protected from pests by impermeable containers.

The seed store should be a room with shelves and with as low and stable a temperature as possible and with no access for rodents.

It depends on average ambient temperatures, foreseen storage period and species whether the seed store should be without artificial cooling, cooled by air conditioning to e.g. 15°C, or refrigerated to 4°C or to sub-zero temperatures. It will nearly always be cheapest to dry the seed of orthodox species to below 8% moisture content before considering lowering the storage temperature as a means of increasing possible storage period.

The seed store should be insulated to minimise temperature fluctuations. This will also provide the possibility of installing air conditioning to lower the storage temperature to 15°C at a later stage, e.g. for temporary storage of recalcitrant species. Usually the most efficient and durable ways to insulate the seed store are either to build cavity walls and insulate the cavity, e.g. with polystyrene, rockwool or glassfibre wool, or to construct the store from prefabricated insulated steel panels inside an already existing room or hall. A third possibility is to use a second-hand refrigerated container placed under an open roof for shade with adequate ventilation (See Figure 4 and the example in Appendix 2).

If long-term storage at 4°C or sub-zero temperatures is needed at small centres, the cheapest solution is usually a deep-freeze (available from 10-800 litres) as the small amounts of seed would normally not justify a cold storage constructed from prefabricated insulated steel panels. In a tropical climate, a cold store at 4°C should have at least 10 cm insulation.

Non-cooled storage buildings should be shaded and have good ventilation around the walls and over the ceiling of the store. The walls and ceiling could be insulated on the outside and have sufficient internal mass to absorb the heat that slips through the insulation during the day without excessive rise in temperature. In dry areas the external side of the walls can be cooled by water evaporation. The temperature inside non-cooled storages should be monitored so that the cause of any excessive rise in temperature above average ambient temperature can be identified.

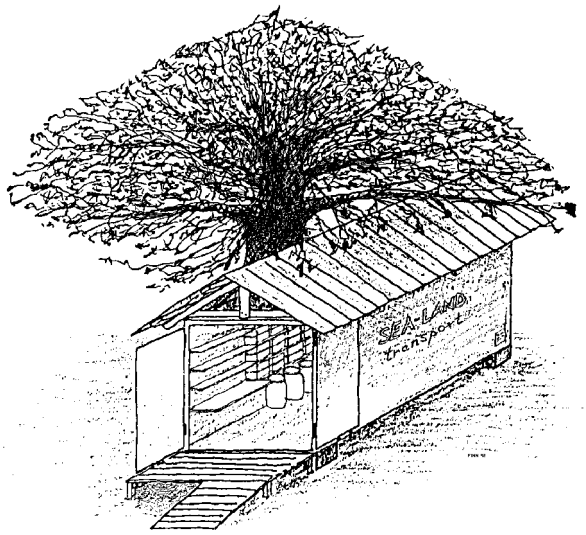


Figure 4. Container used as temporary seed storage

A standard 20' container can be used as a temporary seed store if the following precautions are taken. The walls and the roof of the container should be shaded to prevent the sun from hitting it at any time. There should be adequate ventilation around the container. Seeds placed in the container should be dried down to below 8% moisture content and should be placed in containers impermeable to water vapour.

Temporary storage of small seed lots, e.g. at the nursery, is best done by placing the dry seed in a sealed plastic bag in a metal trunk or in a bottle or jerry can with a seal inside the lid in a cool shaded room.

The size of the store should fit the amount of seeds to be stored in good crop years. Usually the average weight of seeds is around 0.5 kg/litre. For conversion from net volume to gross storage space, allowing for shelving, ventilation, air space within and between containers, access and fittings within the room, a factor of between 6 and 10 can be used. Thus 1,500 kg seed with a specific gravity of 0.5 kg/l would need a gross storage space of 1.5 ton x 2 m^3/ton x (6-10) = 18-30 m^3.

Storage capacity per meter wall with shelving can be calculated if, as an example, it is assumed that large seed lots are stored in 60-litre plastic drums, and smaller seed lots are stored in thick plastic bags in plastic boxes with lids.

The outer dimentions of a 60-liter drum with handles are 40 cm diameter x 62 cm height. The outer dimentions of a 20-liter plastic box are 43.5 cm deep x 33 cm wide x 22 cm high. A realistic internal wall height would be minimum 220 cm. With the barrel occupying 70 cm up from the floor, this leaves 150 cm for th boxes, i.e. 6 shelves. A single shelving unit could then be as follows (see figure 5):

3 boxes 33 cm wide (= 99 cm)
plus legs (5cm wide) for the shelves give a total width of 104 cm.

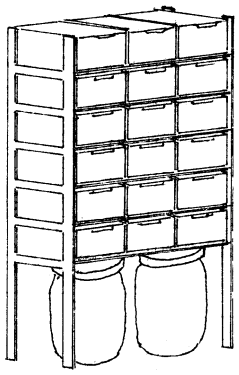


Figure 5. Shelving unit

The capacity of a unit 104 cm wide and 220 cm high would then be: (2 barrels x 60 l) + (6 shelves x 3 boxes x 20 l) = 480 litres.

Where the seed lies loose in the drums, it is normally not realistic to count on more than half of the drums being completely full as the seed lot size will not always fit the drum size and two seed lots cannot be placed in the same drum. Thus the other half of the drums will be more or less empty, e.g. on average half full. In this case 3/4 of the storage capacity will be utilized. The same will normally be the case when storing seed in plastic bags in boxes: there will not be so many boxes with unused space, but there are, on the other hand, a lot of small unused spaces between the plastic bags. 3/4 of the calculated storage capacity of 480 l/unit gives an effective storage capacity of 360 l/unit of 104 cm wide x 220 cm high, or 346 litres per meter wall with shelving 220 cm high.

In the case from Uganda, seed is not stored for more than one year. Production in excess of local needs is shipped to the national centre for cold storage. The regional centre will have an uncooled storage that is sufficiently insulated to allow cooling by air conditioning to 15°C at a later stage if this is necessary:

45 cm deep shelves will hold 346 l seed per metre at 2.2 m high shelving (see equation above). 2.2 m is very high, and we do not know the types of containers and shelving used, so the 346 l/m is reduced to 300 l/m at 2.0 m high shelving.

1,500 kg seed at 0.5 kg/l = 3,000 litres seed.
3 m³/300 l/m = 10 m shelving

Room requirements for a cool store:

* Overhead fluorescent tubes
* Electrical outlet by the door
* Air conditioning for drying/cooling
* No windows (to avoid rodents, insects and heat entering the store)
* Adequately insulated concrete floor
* Good insulation to minimise temperature fluctuations: cavity wall with 10-15 cm fibreglass wool and insulation between roof and ceiling. Space between roof and insulation ventilated
* Good protection against rodents and insects
* Room should be placed with outside wall only facing north or south
* Roof should if possible be shaded e.g. by trees
* Direct access to packing room if packing is not done in the store.

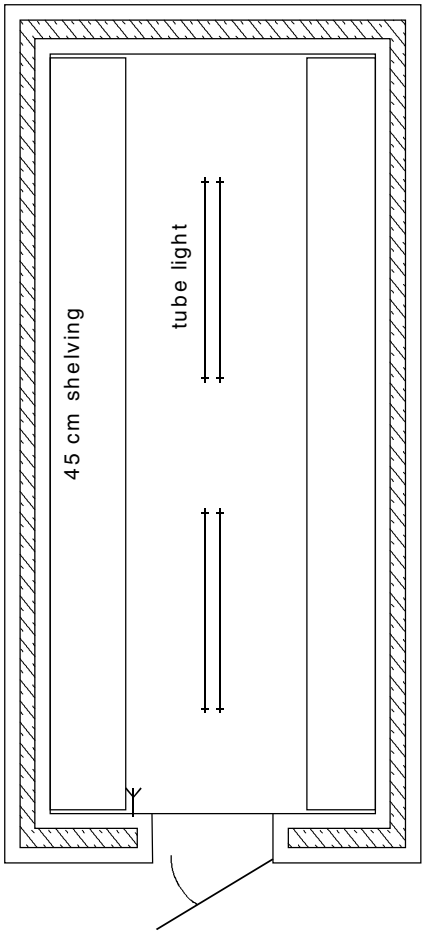


Figure 6: Seed store with insulated cavity walls, scale 1:50

4.2.8 Packing room

There should be facilities for packing seed into storage containers, removing seed from the containers for tests and distribution, for packing seed for distribution and for registrating movements of seed lots in store. Whether a separate packing room is necessary depends on local conditions.

If the storage temperatures are below the dewpoint of ambient air (e.g. a cold store at 4°C in the humid tropics), the removal of seed from the storage containers and packing will either have to be done in an air-conditioned room directly in connection with the store or inside the store in order to avoid condensation on the cold seeds from the store.

In Uganda a table approx. 90 cm high and 250-300 cm wide for registration and packing and 300 cm wall space with cupboards and shelves for packing materials is considered sufficient. In this case there should also be space for a 200 litre deep-freeze for treatment of insect-infested seed because laminated plastic bags for CO_2 may not be available locally.

Room requirements:

* 2 double electrical outlets
* Fluorescent tubes
* Direct access to seed store.

4.2.9 Office

Office facilities should be present for registration and filing of seed data, planning and accounting and storage of stationaries. The size will depend on the size of operations and number of employees. In the case of very small operations the paperwork in connection with office, laboratory and store may all be done in one place.

When there are a number of employees, bathroom and kitchen may also be considered.

5. DESIGNING A RATIONAL LAY-OUT OF PRODUCTION AND FACILITIES

5.1 Open Well-ventilated Area Under Roof for Temporary Storage of Fruit and for Dusty Seed Processing; Well-ventilated 'Processing Hall' and Concrete Deck for Sun Drying

The area under roof, processing hall and concrete deck for sun drying should be adjacent to each other to facilitate transport of seed and fruit during the processing operations. In most cases the logical design is to integrate the three installations as shown in figure 7, where the example of a regional centre in Uganda is shown.

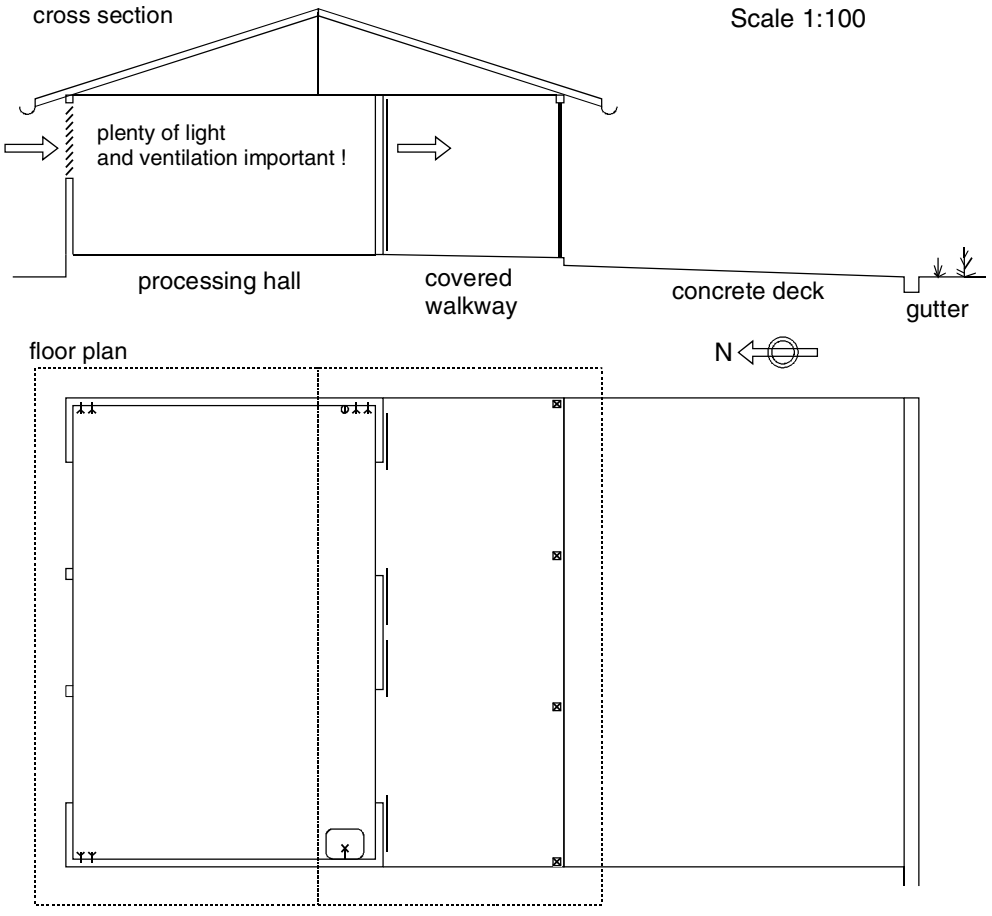
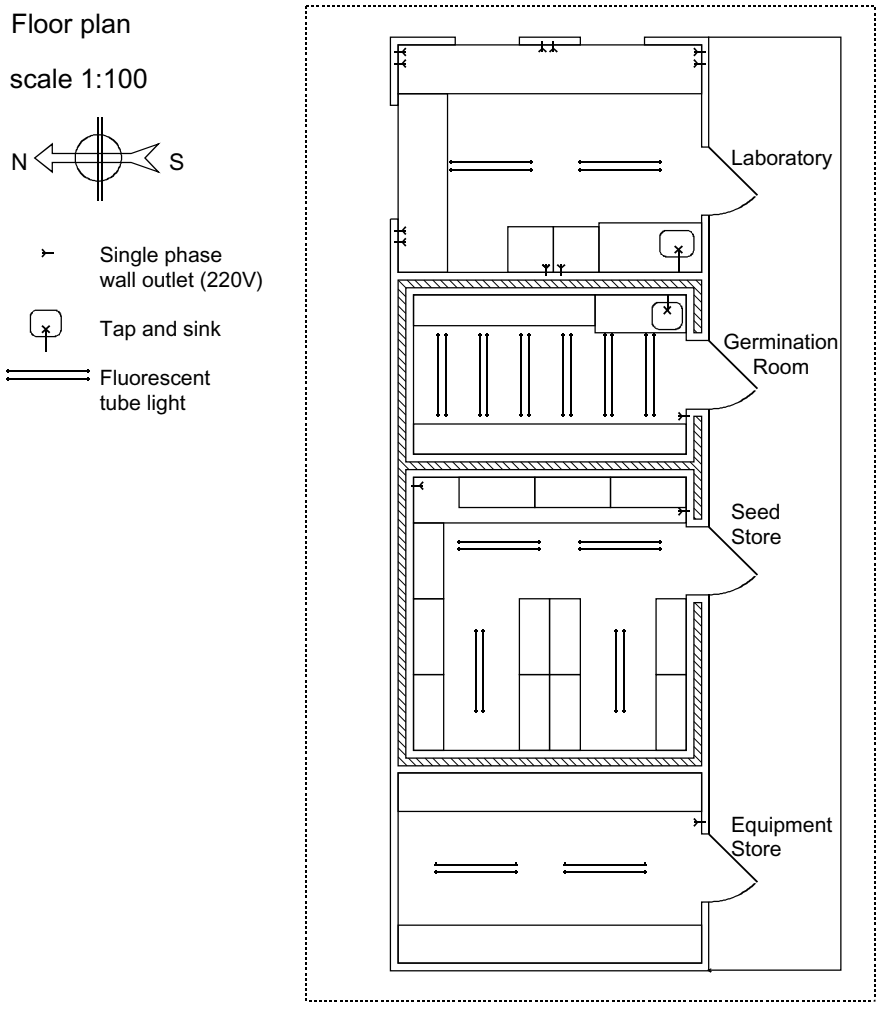


Figure 7. Example of possible seed processing facilities for regional seed centre in Uganda

5.2 Laboratory and Storage Facilities



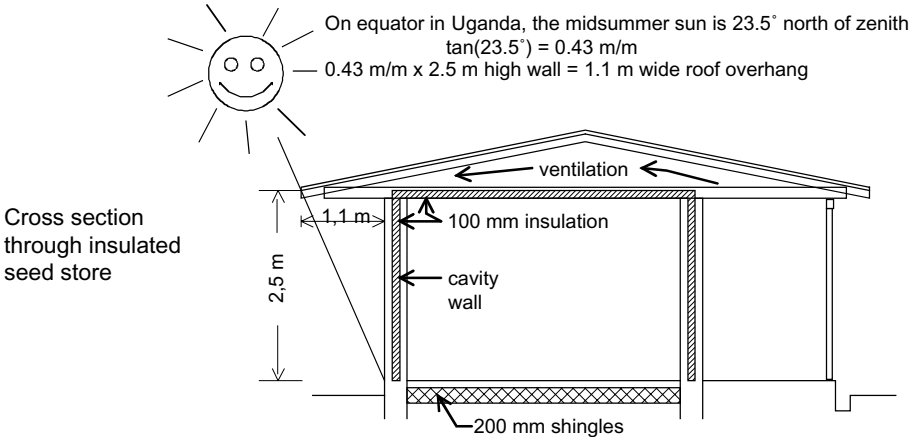


Figure 8. Example of laboratory and storage facilities

When laboratory and seed storage facilities for centres in tropical and subtropical climates are designed, the largest difficulty lies in ensuring temperatures that are as low, and as little fluctuating as possible in the seed store. Small fluctuations in temperature should be insured in the germination room if this is going to be used instead of germination cabinets. In order to achieve this in the tropics, the walls of the two rooms should be protected from direct sun exposure, and they should be adequately insulated.

In order to avoid sunshine, the rooms are placed so that their walls are not external walls of the building facing east or west. The rooms that are available for the external east and west walls are equipment store, laboratory, and perhaps office, bathroom, etc. This leaves the seed store and germination room in the centre of a building with facades facing north and south.

In tropical climates, the roof overhang over walls facing north and south has to be sufficiently wide to ensure that the sun does not hit these walls. At midwinter and midsummer solstice (December and June) the sun will be in zenith over the tropics of Capricorn and Cancer 23.5° south and north of equator. If the building is situated e.g. 10° north of equator, the sun will be 33.5° south of zenith at midwinter and 13.5° north of zenith at midsummer. In tropical climates, a covered walkway is traditionally used in front of buildings with several entrances. If, as in the case above, the covered walkway faces south where the sun stands lower towards the horizon at midwinter, then the roof overhang on the north side should be able to shade this wall when the sun is 13.5° north of zenith at midsummer. For every meter wall height, the overhang should be tangens to 13.5° meter wide. E.g. at 2.5 m height: tan(13.5°) x 2.5 m = 0.24 x 2.5 m = 0.6 m. In figure 8 this is illustrated for a building placed on the equator.

The first step in designing layout of the facilities is therefore to make the jigsaw puzzle of the floor plan. The most efficient lay-out of the seed storage and germination room are long narrow rooms where the inside length of the room is half the length of shelving and tables needed (as shown in figure 3 and 6). With the amount of seed normally stored at a seed centre, this will make the seed store longer than all the rest of the rooms in the house. The shelving will therefore have to be folded into internal walls as shown in figure 8. This will give less storage capacity per m² floor area, but more flexible room dimensions. If, on the other hand, the room is constructed as a cold store, it should be as square as possible to minimise outside surface area.

The seed store should have direct access to the packing room if this is not integrated into the store. A desirable option may be to integrate the packing facilities into the seed store initially, and then move them elsewhere if production increases. There should also be easy access from the production area to the outside with e.g. drums full of seeds on a trolley.

The germination room is a humid room and may contain active fungal spores. It should therefore have a door opening to the outside (at least not into the laboratory, seed store and packing room). There should be easy access to the germination room from the laboratory and from where the sand for germination is prepared.

The store for collection (and other) equipment is usually placed facing east or west where the walls are heated by the sun. There should be plenty of grilled ventilation holes

in the wall to allow wet equipment that arrives from the field to dry. There should be easy access through a wide door for vehicles carrying collection equipment. The room should be 3-4 m long to be able to store ladders and poles as well as hooks and secateurs.

The laboratory should be placed so that it has at least one external wall with large windows in order to provide sufficient light over low tables for seed counting etc. The windows of the laboratory should be adequately dust proof (not glass louvers). In order to avoid fungus and corrosion of equipment in humid climates, air conditioning could be considered if stable power supply is available.

There should be good ventilation between the roof and ceiling of the rooms to reduce sun heating of the seed store, laboratory and germination room. In tropical climates the temperature underneath a traditional roof with ventilation in the gable or end and with corrugated iron-sheet covering may rise to above 60°C. One way to avoid this and ensure sufficient ventilation is to build the rooms with a flat roof and construct a second open roof above.

6. INVESTMENTS, PRODUCTION COSTS AND ADJUSTING THE SIZE OF THE SEED UNIT

The production of 1,500 kg seed annually from a regional centre, as the one in Uganda used as the example in this note, may not produce enough profit to pay interest of the initial cost of establishing the centre:

		Investment US$
25 m² Processing facilities	à 300 $/m²	7,500
52 m² Laboratory and storage facilities	à 500 $/m²	26,000
Furniture and shelves in stores, locally produced		4,000
Equipment for collection, processing, storage, laboratory, etc.		31,955
Small truck		7,000
Total establishment		76,455

If the capital for the investment has to be paid back as the buildings and furniture are depreciated over 20 years, and the equipment and truck paid back and depreciated over 10 years, then the annual expenditure for interest and repayment would be 8,708 US$ at an interest of 7%.

The cost of interest and repayment should be added to the costs of employees, per diems, transport, electrical power, telephone, maintenance and stationary:

Annual production costs:	US$ / year
Employees:	
1 Forester	2,340
1 Forest technician	1,560
1 Driver	1,092
4 Permanent labourers	3,900
Per diems in field: 5 persons x 150 days/year x 17.55 US$/day	13,163
Transport: 20,000 km/year x 0.25 US$/km	5,000
Electrical power and telephone	1,000
Maintenance, stationary, etc.	1,400
Interest and repayment of investment calculated above	8,708
Total annual production cost	38,163

The production cost of each of the 1,500 kg produced annually will then be 25.44 US$/kg. It should be noted that in this case per diems for field work amounts to 34% of the total production costs.

The capital for investment may be more readily available when a centre is constructed as a part of a public organisation than when a private person is establishing a tree seed unit.

The private person or small organisation establishing a seed-producing unit may not be able to raise capital expenditure of the described amount. Also the immediately foreseen seed consumption or buying capacity of the market may be far below the amounts described here.

In the first case a possible solution would be to rent or use already available facilities for the parts of the production where the function of the rooms does not reduce the quality of the seed. This would typically be processing, storage of collection equipment, and office facilities. In appendix 2 is given an example of a second-hand insulated cold storage container refurbished for seed storage, packing and laboratory.

In the second case where seed consumption or buying capacity of the market is smaller than described here, other solutions will have to be found. Usually it would be necessary to accommodate the production in already existing buildings. One would have to look for cool and dry rooms for seed storage, processing facilities with good ventilation and access to water, and a flat and clean area outside with sunshine for seed drying. The equipment costs would be low as the size of the production would not justify the investment in most processing machines. Even seed testing can to a large extent be done using kitchen utensils. It is impossible to describe exactly how e.g. a home production of tree seed should be organised. It would depend on local conditions, but the principles of the production would still be the same as described here and in the C-series of DFSC Lecture Notes.

The centre in Uganda described here has been designed for optimal production with possibilities of expansion at a low cost. In order to expand seed production with 1000 kg annually, more concrete deck and open roof area would be needed. The capacity of the seed store can be increased to 12 m shelving with at least 180 kg seed/m shelving (= 2,100 kg) by raising the shelf height to 2.2 m and moving some packing and registration facilities to the laboratory. A regular laboratory like the one described has far more capacity than required here. An obvious initial solution would be to use the laboratory as office too, especially if the main seed sale is not done in small lots directly to the users.

APPENDIX 1

EXAMPLES OF CALCULATIONS OF PRODUCTION CAPACITIES

In the following the requirements of each function will be discussed using the example of a planned regional seed centre in Uganda assuming that the centre has a yearly production of 1500 kg seed, that various species types are produced, that about 20 % of the seed production comes from fruits to be depulped (80% from seed extracted without use of water), 30% from fruits to be threshed and 30% are difficult or recalcitrant species, and that the unit is not integrated into another production as e.g. a nursery.

The following standards are used in the calculations below:

* 1 kg seed equals 4 kg fruit
* 1 ton pulpy fruit takes up a volume of 2 cubic metres
* (0.5 kg pulpy fruit per litre)
* 1 ton dry fruits takes up 3 cubic metres
* (0.33 kg dry fruit per litre)
* With a 7 cm layer of seed, a tray (60 x 100 cm) holds 42 litres of seed
* One week has 5 working days

Depulping
20 % of 1500 kg = 300 kg seed
300 kg seed x 4 kg fruit/kg seed = 1200 kg fruit
1200 kg fruit x 2 m^3/t = 2.4 m^3 fruit
If processed during 2 months: 60 days x 5/7 days = 43 working days
2.4 m^3 / 43 days = 56 litres/day = 28 kg fruit/day

The capacity of a coffee depulper when hand driven is estimated to be 500 litres fruit per day. The hand driven model has a flywheel with v-belt grove for mounting of power drive, but hand power has the advantages of possible field use and of less damage of the seeds being depulped.

Temporary storage capacity of pulpy fruit in non-corrosive wire netted tray should be 300 kg. With 21 kg in each tray in a 7 cm layer, 15 trays are needed.

Soaking is done in barrels with a capacity of approx. 60 litres (e.g. half oil drums, but preferably plastic 'tubs'). Soaking capacity should be at least 2 days' production, i.e. 112 litres ~ 2 barrels of 60 litres. Additional barrels can be used in the production.

Extraction of dry fruit
80% of 1500 kg = 1,200 kg
1,200 kg x 4 kg fruit/kg seed = 4,800 kg fruit
4,800 kg fruit x 3 m^3/t = 14.4 m^3 fruit
If processed over 5 months: 150 days x 5/7 days = 107 working days then
14.4 m^3 / 107 days = 135 litres/day = 45 kg fruit/day

If average sun-drying time is 2 days, drying capacity should be 270 litres
270 litres in a 4 cm layer covers 6.75 m²
A 4 x 6 m canvas has an effective utilisation space of 3 x 5 = 15 m²

After extraction the seeds are dried on canvas in the sun. To be able to dry different seed lots at the same time, there should be space for at least two (4 x 6 m) tarpaulins. Considering the expected size of the seed lots, several smaller tarpaulins should be procured it possible.

Some fruits to be extracted by drying will arrive still green. They will have to be pre-cured in the shade in wire-netted trays. It is estimated that a capacity of 40 % of the 4,800 kg fruit (1,920 kg) should be sufficient.

1,920 kg x 3 litres/kg = 5,760 litres.
If after-ripening goes on for 4 months = 120 days, and average after-ripening time is 7 days, then capacity should be 5,760 litres x 7/120 = 336 litres
336 litres / 42 litre/tray = 8 trays

Threshing
Approximately 30% = 0.3 x 1,500 kg x 4 kg fruit/kg seed x 3m³/t = 5.4 m³ or 1,800 kg fruit are more or less indehiscent and should be threshed.

The average capacity of a mechanical thresher is estimated to be 24 sacks of 150 litres per day = 3,600 litres. This means that one year's production could be threshed in 2 days. A mechanical thresher is omitted until production rises, unless it turns out to be impossible to thresh the species manually.

Seed storage
The storage capacity of each shelving section depends on how precisely the containers to be purchased will fit into the system. A maximum estimate would be around 480 litres per section, but it is normally not realistic to calculate with more than 3/4 utilisation of the space (half of the containers half filled). This results in a capacity of 360 litres. This gives a capacity of around 180 kg seed per shelving section.

One litre of seed is usually estimated as weighing 0.5 kg. Later, when exact figures are available, such figures can be used instead of standard ones.

Necessary equipment
The calculations above are made on the assumption that everything goes according to optimal plans (so that e.g. two pickup loads with 500 kg pulpy fruit never arrive on two successive days). The calculations also presume that depulping, drying, etc. take place every day. This is however rarely the case. It is not realistic to plan with the equipment being used more than a half to one quarter of the time. The figures for necessary sacks, netting trays, tarpaulins, etc. should therefore be increased accordingly. The necessary seed drying facilities should also be adjusted for the number of sunny days during the processing season.

APPENDIX 2

EXAMPLE OF A TEMPORARY SEED UNIT ESTABLISHED IN SECOND-HAND CONTAINERS

A 40' insulated cold-storage container refurbished for seed storage, packing and laboratory and a 20' container used as equipment store

Second hand steel containers are commonly used for temporary facilities. They are normally used as stores as they lack windows and are difficult to break into.

Standard steel containers can be found in two sizes: 40' and 20'. Prices for second hand containers vary according to state of the container, country, and availability.

Container sizes	Outside measurements m			Inside measurements m			Prices in Denmark year 2000	
	Length	Width	Height	Length	Width	Height	Plain steel	Insulated 7.5 cm, excl. cooling unit
40 feet	12.20	2.44	2.44	12.05	2.34	2.34	US$ 1520	US$ 4880
20 feet	6.06	2.44	2.44	5.91	2.34	2.34	US$ 1050	US$ 3720
Door opening					2.28	2.34		

As there are generally no openings for ventilation in the container, the temperatures inside the container may rise to very high levels if the container is not shaded from the sun. Insulated cooling containers can also be found. They are generally insulated with 7.5 cm insulation. The internal measurements of these containers are 15 cm smaller than normal containers. The insulation does not seriously reduce the temperature rise in an empty container exposed to the sun. The insulation provides the possibility of reducing the temperature inside an effectively shaded container with an air conditioner.

In the example shown below, a 40' insulated container has been used for laboratory, seed store and administration, and a 20' container is used as store for processing and collection equipment. The two containers are placed parallel to each other on a 14x11 m concrete deck that serves as foundation for the containers, working space for the processing operations and deck for sun drying.

A roof covering 14.4 x 7.1 m is built on the containers and support pillars. The roof has open gables to ensure adequate ventilation in order to reduce the temperature in the containers. When the seed unit is placed near the equator, the containers should be placed along an east-west axis and the roof overhang on the north and south side should be 1.1 m (see figure 8). The eastern gable should be shaded by evergreen trees to prevent the sun from heating the eastern wall of the seed store with the air conditioner unit in the morning.

The 20’ container is equipped with shelves and racks along one side for storage of collection equipment (long poles, ladders, etc.). Processing equipment is stored along the other side of the container. The container has been equipped with grilled ventilation to allow drying of moist equipment that is put into the container.

The 40’ container is divided into two parts by an insulated partition wall with door. The eastern end of the container is equipped with shelves along the sides and an air conditioner unit at the end. This room is used as seed store, and will under normal conditions hold approximately 2160 kg seed. The western end of the container is equipped with tables, cupboards and shelves as laboratory, administration and packing facilities. The doors in the end of this container are not used. Instead, a door and windows have been built into the sides of the container.

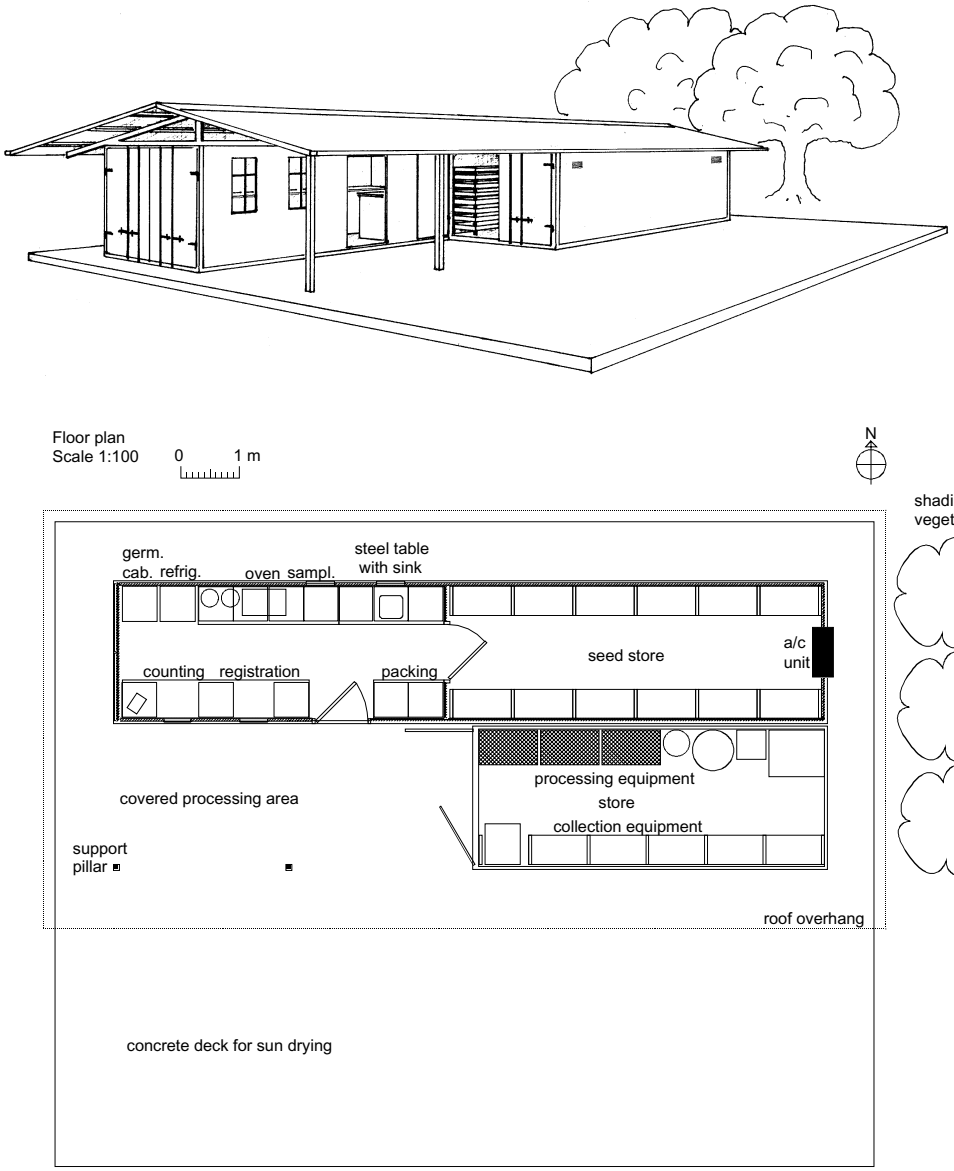


Figure 9. Example of a temporary seed centre built using a second-hand insulated 40’ cold storage container refurbished for seed store, packing and laboratory and a 20’ container used as equipment store.

APPENDIX 3

EXAMPLE OF EQUIPMENT LIST FOR A REGIONAL CENTRE IN UGANDA

Tree Seed Project, UGANDA 13 August 1996
Equipment and materials for Regional Centre

No.	Item	Specifications	Supplier	Remarks	Estimated $ 1996
	ASSESSMENT OF SEED CROP AND PHENOTYPIC QUALITY				
	maps	detailed, covering all seed collection areas	998		70
	maps	1:50,000, 1:250,000, thematic	998	region in Uganda: soil type, climate, etc.	50
1	relascope	cat.no.59795	004		18
1	binocular	7 x 50, e.g. 91163	004	should be handy,waterproof,good	150
1	compass	e.g. 37166 from 004	004/416	adjusted for 0 degrees north of equator	35
1	altimeter	cat.no.43355	004	height above sea level	200
1	clinometer	cat.no.43830+ case37039	004		75
1	borer	cat.no.63341, 16"	004	wood sample drilling equipment	130
1	diameter tape	cat.no.59571	004		46
1	caliper	cat.no.59728, 0-50cm	004		100
24	tree marking paint	cat.no.57667, yellow	004/998	local supplier probably cheaper	90
24	tree marking paint	cat.no.57666, white	004/998	local supplier probably cheaper	85
5	marking gun for paint	cat.no.55807	004/998	local supplier probably cheaper	150
24	cotton flagging	cat.no.58040, white	004	local supplier probably cheaper	35
12	cotton flagging	cat.no.58044, orange	004	local supplier probably cheaper	20
1	tree scribe	cat.no.540	411		20
3	map boards	for field use	998		10
1	cone cutter	see DFSC Lecture Note C-3 Planning seed collection	997		
1	magnifier	cat.no.123149-20	402		14
10	range poles	cat.no.95	411		60
	TOTAL				**1358**

No.	Item	Specifications	Supplier	Remarks	Estimated $ 1996
	CLIMBING AND COLLECTION				
	For each collector:				
1	steel ladder	18 m pipe type	416/417	mainly eucalypts and other trees with straight bole	1000
10	extra straps, ladder		416/417		32
1	aluminum ladder	6 m (2x3 m, expandable, pointed model with hook)	411	available in 5,6 & 8 m. mainly small trees and trees with wide crown	300
1	climbing spur	DFSC model	416	buy for this centre and copy for other centres. Specify length. mainly pines not used every year	120
1	tree surgeon belt	HRW59	201		150
45m	climbing rope	type HN, 12mm, three strand, 3000kg	201	rope for life-line,safety strops and prussik loops. Each climber needs double length from ground to first green branch + 5 m. buy 200m rolls	70
2	carabiners	cat.no. HCK4 2500kg,	201	alu offset D twistlock	26
3	carabiners	cat.no. HCK5 3000kg,	201	alu offset D twistlock	40
2	carabiners	cat.no. HCK2 3000kg,	201	alu offset D screwlock	22
5	collection bags	strong canvas with string closing	416	buy for this centre and copy for other centres	70
10	carabiners for collection bags	rustproof or galvanized	416		16
1	spring scale	12 kg	416		4
1	secateur/pruner	cat.no.523	411	anvil type, not scissors	22
1	aluminium pole	with cone cutter	998/997		60
1	aluminium pole	for tree pruner,	411		60
1	tree pruner	cat.no.74-27cm	411		22
1	pair boots	protected ancle, deep heel	998	buy locally to fit climber	40
1	overall	(boiler suit)	998		50
1	helmet	for tree climbing	411		15
2	pair gloves	cat.no.27B	411	‘rubberized’ nylon	3
1	good knife	e.g. cat.no. 1432	411		5
	TOTAL				**2127**

No.	Item	Specifications	Supplier	Remarks	Estimated $ 1996
	Other collection equipment:				
1	flexible saw	cat.no.81078	004	sawing branches with advanced line technique	25
50m	1.2mm braided nylon	line with weight	416	breaking force app 80 kg, for throwing line over branch	20
	poles, hooksticks etc.		997	see DFSC Lecture note C-4	300
3	tarpaulins	canvas, 4x6m	998		300
4	tarpaulins	armed plast 4x6m	998		50
	hessian sacks	100-150 litres	998		70
1	field kit	tents, blankets, cooking, aid kit, etc.	998	safari shop (if not here then Nairobi)	500
1	first aid kit at centre		998		20
1	slingshot	w. fishing spool etc	416	for advanced line technique	170
	TOTAL				**1455**
	SEED PROCESSING				
24	drying trays	60x100cm, mosquito netting	997	see DFSC Lecture Note - C7	500
30	winnowing baskets	round,weaved, rice cleaning	998		25
3	metal trays	60x100cm	997	metal screens in bottom with punched holes, different sizes, for cleaning macerated seed with water, see DFSC Lecture Note - C7	60
24	hand testing screens	cat.no. 98-12	003	12"x12", stackable, recommended screen sizes attached	624
1	storage rack for 24 screens	cat.no. 98-12SR	003		150
1	lab. air cleaner	type LASTI	424/416	damas seed blower, see DFSC Lecture Note - C7	5000
4	60-80 litre drums	half oil barrel but pref. plastic 60-70 cm diam.	998/416	for steeping pulpy fruit, etc.	30
	mortars, flails, etc.	for manual threshing	998/997		150
1	floor steelyard scale	60x60cm plate, 200kg/100g, tara, e.g. type 46-OSK1 from	431/416	see DFSC Lecture Note - C7	450
1	hanging scale	cat.no. 93514	004/416		245
	TOTAL				**7234**

No.	Item	Specifications	Supplier	Remarks	Estimated $ 1996
	Optional processing equipment:				
1	concrete mixer	160-180 litres, 220V	998	pine seed dewinging, maceration, etc. see DFSC Lecture Note C-7	800
1	cone tumbler		997	see DFSC Lecture Note - C7	500
1	portable thresher	petrol drive, rubber beaters 3,5,8,11,14,18, 25 mm plate	901	see DFSC Lecture Note - C7 for acacia pods, etc.	5000
1	coffee depulper Super Nova	manual drive, rubber and metal breast	202	998?	220
1	drying cabinet	specify capacity	416		
1	'Seed Gun'		416	pretreatment of hard-coated seed from arid zone	1050
	seed cleaning machine:				
1	air-screen cleaner	cat.no. 100"BR	003		3475
1	settling basin	cat.no. 100"SB	003		250
1	motor	cat.no. MTR34C 1725rpm	003	3/4hp,220V,50hz	253
1	single bagholder	cat.no. GM1	003		100
23	screeens	cat.no. 100S, attached spec.	003	see the attached specifications same sizes as the hand screens above except for the bottom blank	1500
	TOTAL				**13148**
	SEED STORAGE AND DISTRIBUTION				
192	wide mouth PE bottle	cat.no.116592-66, 1000ml		402	341
180	-	cat.no.116592-58, 500ml		402	232
50	plastic jerrycans	25 l, seal in lid	998	storage shelves should fit containers see DFSC Lecture Note - C9, p30	250
40	tin or plastic boxes	app. 30x30x40cm	997/998		150
20	plastic drum	60 l, good seal in lid	998	blue type with black lid with clamp	400
	plastic sheet	min 0.1 mm linear low density poly-thene (LLDPE or LDPE)	998	to make bags etc. see DFSC Lecture Note - C9	200

No.	Item	Specifications	Supplier	Remarks	Estimated $ 1996
3	Funnel	cat.no.139785-18	402	also for laboratory	12
2	-	cat.no.139795-10	402	-	2
2	-	cat.no.139795-18	402	-	7
4	-	cat.no.139795-31	402	-	32
2	max/min thermometer	cat.no.139236-01	402		15
2	hygrometer	cat.no.117670-01	402		50
1	plastic bag sealer	audion			
		A SSM 580 SA	407/416		1200
	spare parts for				
	bag sealer	A SSM 580 SA	407/416		100
	manilla labels	6x12cm, cardboard	416/997	preprinted head, see examples	
				in DFSC Lecture Note C-9	500
1	deep-freeze	200l	998		500
2	scoop	cat.no.122S	003		12
	cardboard boxes	w. print	998?		500
	tape	w. dispenser	998?		350
	packing paper		998?		200
1	bench beam scale	SOENLE tabletop:			
		30kg/10g,tara	431/416	see Lecture Note - C7	524
	TOTAL				**5577**
	LABORATORY				
100	grain sample box	cat.no.114080-37	402	for reference collection of species	78
1	seed stick trier	18" cat.no. 235	003		67
1	seed stick trier	39" cat.no. 79-OH	003		132
1	riffle type divider	cat.no. R90	003		400
1	riffle type divider	cat.no. R66	003		392
240	bowls or boxes	for germination	998	if not avilable locally, then:	
100	box	cat.no.114125-46	402	30x22x6 cm	
100	box	cat.no.114125-56	402	17x22x6 cm	
100	box	cat.no.114125-66	402	7x11x6 cm	100
20	container for TZ-test	cat.no.114080-44	402		14
1	moisture tester	cat.no.MGT	003	dicky-john tester	259
1	weight for tester	cat.no.MGT-WT	003	weight for dicky-john tester	21
1	hygrometer	container type,			
		cat.no.444C	003		179
1	hand grinder	cat.no. 438HB	003	with tooth & worm feed	125
1	sieve	cat.no. J 10/64" Round			
		(4mm)	003		27
1	sieve	cat.no. K 2/64" Round			
		(1mm)	003		35
1	sieve bottom	cat.no. E solid bottom			
		pan	003		14
1	oven	LW-201C if for			
		220V, 1 phase	003	75-150 C, forced air circulation	400
1	shelf for LW-201C		003		35
50	metal sample cont.	cat.no.SSC3 with lid	003		100

No.	Item	Specifications	Supplier	Remarks	Estimated $ 1996
2	heat resistant gloves	cat.no.118585-02	402		52
2	desiccators	cat.no.114350-30	402		410
2	desiccator discs	cat.no.114390-30	402		125
2	sealing rings	cat.no.114375-30	402		85
4kg	silica gel	cat.no.311624-01	402		250
1	analytical balance	cat.no.620302-00	402		2258
1	calibration weight	cat.no.623272-00	402		50
1	voltage stabilizer	for analytical balance	998	central stabilizer?	200
1	mechanical balance	cat.no.144500-01, ohaus1650W	402		300
1	weight set	cat.no.144512-01	402	for ohaus1650W	52
1	vinyl dust cover	cat.no.144515-01	402	for ohaus1650W	20
1	scoop & weight	cat.no.703S	003	for ohaus1650W	37
3	scalpels 4	cat.no.134920-04	402		14
3	scalpels 3	cat.no.134920-03	402		14
20	blades B/23	cat.no.134925-02	402		92
20	blades E/11	cat.no.134925-05	402		92
2	forceps	cat.no.663	003		18
2	forceps	cat.no.662	003		13
5	pocket knifes		998/411		40
2	grinding stones	for knifes	998/411		12
2	scissors, good	cat.no.134742-01	402/998?		15
1	electrical burner	GS-1A, + 50 pcs 0.7mm wire	416	scarification of hard-coated seed	100
5	dispensing spoon	cat.no.134995-01	402	sampling	7
2	ruler		998	sampling	4
2	tray	app. 40x60x3cm	998	sampling	15
50	small glass bowls	app.8 cm, round bottom	998	for replicates	50
1	calculator		998		17
1	magnifier, linen tester	cat.no.61083, 5X	004	magnifies 5X	19
1	magnifier, linen tester	cat.no.123149-20	402	magnifies 8X	16
3	wash bottles	cat.no.116820-66	402		12
72	petri dish	cat.no.135280-05	402		91
20	filter paper	cat.no.116180-11	402	petri dish & funnel size	30
1	water filter	incl. candles	998	for drinking water	160
1	1 plate stove	220V	998		50
1	kettle	2-3 l	998		10
3	thermometers	cat.no.138850-01, -20-110C	402		20
1	hygrometer	cat.no.117670-01	402		24
1	psychrometer	cat.no.117655-01	402		25
3	spare wick	cat.no.117656-01	402	for psychrometer	7
2	small sieves	with handle (tea sieves)	998		4
5	adhensive labels	cat.no.53635	004		55
?	plastic bags	approx 8x15 cm	998?	seed samples from store to lab.	100

No.	Item	Specifications	Supplier	Remarks	Estimated $ 1996
2	caliper	cat.no.59592	004		34
2	graduated cylinder	cat.no.129581-18	402	5 ml	7
2	graduated cylinder	cat.no.129641-40	402	50 ml	8
2	graduated cylinder	cat.no.129641-52	402	250 ml	15
2	graduated cylinder	cat.no.129641-66	402	1000 ml	37
1	pH paper test	cat.no.77352	004		4
1	ISTA	Rules and regulations	413	ISTA vol 13 2 1985	
3	box: latex glove	cat.no.118577-08	402	packs of 100	55
10g	tetrazolium	cat.no.311624-01	402		20
1 l	perhydrol, 30% H2O2	cat.no.310737-02 from 402	402/998		20
1	refrigerator	200 l	416/998		500
1	voltage stabilizer	for refrigerator	998	central stabilizer?, a “fridge guard” is enough	200
1	germination cabinet	400l, 15-35C, D/N, light	416		2740
6	100pcs filter paper	cat.no.123.4494	416/406	370x740mm, 600 tests in germination cabinet	100
24	100pcs filter paper	cat.no.111.7151	416/406	235x240mm, 600 tests in germination cabinet	200
1	voltage stabilizer	for germination cabinet	998	central stabilizer ?	20
	soap, brush, towels and drying tray		998		20
	workshop tools	Screwdriver, etc	998		500
	TOTAL				**11823**
	Optional lab equipment:				
1	illuminated magnifier	cat.no.123165-01	402		220
1	base for ill. magnif.	cat.no.123170-01	402		78
1	stereomicroscope	MST131, 7.5-48X + case	416		1580
	TOTAL				**1878**

SELECTED SUPPLIERS

No.	Address	Telecommunication	
003	Seedburo Equipment Company 1022 West Jackson Boulevard Chicago Illinois 60607-2990 USA	Int. Phone: Int. Fax: Email:	+1-3127383700 +1-3127385329 sales@seedburo.com
004	Forestry Suppliers inc. P.O. Box 8397 Jackson MS 39284-8397 USA	Int. Phone: Int. Fax:	+1-6013543565 +1-6013555126
201	Michael Richmond 5-15 Weyhill Haslemere Surrey GU27 1BY UNITED KINGDOM	Int. Phone: Int. Fax:	+44-1428643328/1428644394 +44-1428656787
202	Bentall Simplex Industries Export division Industrial Estate Dunkirk, Aylsham Norfolk NR11 6SY UNITED KINGDOM	Int. Phone: Int. Fax:	+44-263733811 +44-263734845
402	Struers Valhoejs alle 176 DK 2610 Roedovre DENMARK	Int. Phone: Int. Fax: Email:	+45-36708090 +45-36720085 info@struers.dk
406	A.G. Frisenette og Soenner Godthaabsvej 4 P.O.Box 120 DK 8400 Ebeltoft DENMARK	Int. Phone: Int. Fax:	+45-86342244 +45-86345744
407	Genpack Lejrvej 27 DK 3500 Vaerloese DENMARK	Int. Phone: Int. Fax:	+45-42486200 +45-42486261
411	Dansk Skovkontor Kalundborgvej 92 DK 4180 Sorø DENMARK	Int. Phone: Email:	+45-57830110 post@dansk-skovkontor.dk

413	Danida Forest Seed Centre Krogerupvej 21 DK 3050 Humlebaek DENMARK	Int. Phone: Int. Fax: Email:	+45-42190500 +45-49160258 dfsc@sns.dk
416	CMC Automation att: Erik Jespersen Skippershovedvej 10 DK 8585 Glesborg DENMARK	Int. Phone: Int. Fax: Email:	+45-86381359 +45-86381959 finnstub@post7.tele.dk
417	Sven Albertsen Gl. Strandvej 58 DK 3050 Humlebaek DENMARK	Int. Phone:	+45-42190396
424	DAMAS att: Peter Olsen Industrivej 2 Vester Aaby DK 5600 Faaborg DENMARK	Int. Phone: Int. Fax:	+45-62616700 +45-62616851
431	Frederiksberg Vaegtfabrik Sankt Knudsvej 18 DK 1903 Frederikberg C DENMARK	Int. Phone:	+45-31240210
901	Kimberly Seeds 51 King Edward Road Osborne Park 6017 Western Australia AUSTRALIA	Int. Phone: Int. Fax:	+61-9-4464377 +61-9-4463444
997	LOCAL PRODUCE/HOME-MADE		
998	LOCAL DEALER		
999	UNKNOWN		