

Planting recommendations for farmers' associations

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(Information for private circulation only – compiled from reports written by EABL, Technoserve, Antony Ellman, Peter Griffee, Karl-Heinz Schneider, Anamed, Pedro Melillo de Magalhães)

Seeds

Until high yielding true-type (composite) seeds are available for East Africa, we recommend the use of seeds for hybrid plants from Mediplant (Artemis) . They will have to be supplied each year. 1 gram of seeds contains about 12000 – 13000 seeds . Germination rate is said to be 90%. The recommended number of plants per ha in East Africa are 10000 to 15000 plants per ha, so approximately one gram of seeds is needed per ha. Two types of seeds can be made available: F1 seeds are expensive (about 90.00 USD per g) and therefore have to be handled with great care to keep losses of seeds and seedlings at a minimum. It is possible to increase the number of plants from the seeds by producing cuttings from the lowest branches of the plants, after the plants are about three months old, but this method should only be used to add additional plants if seeds were not sufficient for the area covered. In Tanzania and Kenya, F1 seeds can produce an average yield of 2,5 tons per ha and an average artemisinin content of dried leaves of 1.2 – 1.3 % . Despite the high cost of seeds, net income from F1 seeds is considerably higher if they can be grown successfully.

F2 seeds can be produced locally and cheaply and if lack of spacing in the nursery force the small seedlings to compete with each other, this may mean waste of seeds but leads to self-selection of plants that give a higher yield. With such self-selection and enough rain (or irrigation) 1.5 tons per ha and 0.95% of artemisinin content are possible, even from F2 seeds, although many farmers only achieve 1 ton per ha and 0.65 to 0.85% artemisinin content. In order to minimize risks, it is recommended that farmers first gain experience with F2 seeds and move on to F1 seeds, when they have enough experience with the crop and are ready to employ more careful nursery practices.

Obligation of Growers: Good Agricultural Practices

Growers will undertake to abide by good agricultural practices including:

1. Ecological criteria: Respect for forest reserve areas, cultivation methods that will maintain soil fertility and water preservation in the area.
2. Social criteria: Fair worker employment practices and fair contractual agreements with out-growers are required.
3. No use of un-permitted chemicals and judicious use of permitted chemicals.
4. Fair worker employment practices and fair contractual agreements with out-growers are required.
5. Contamination of leaves during harvest with various impurities has to be avoided, new clean bags and dry storage facilities are also required.
6. Adherence to guaranteed quality standards is necessary.
7. Detailed records of traceability: the product must be traceable from each field to the store.

Planting Recommendations

" *Artemisia annua* (Sweet Wormwood) is an annual shrub of the Compositae family which originates in temperate regions of China but has been widely introduced to South-East Asia, Northern Europe, North America, Brazil, India, Australia and most recently Kenya and Tanzania. Usually it has a single stem which can grow to a height of over 2 metres, and branches with small dissected leaves which spread to a width of about 1 metre. It has a growing season of 6-9 months and in the tropics grows best at elevations around 1000-1500 metres above sea level (The ideal temperature is a variation between 18 – 28 °C). It needs reliable rainfall at planting time and soil acidity not above pH 5.5."

Artemisia has a number of advantages:

- "- it is not edible nor is it saleable on the open market, so theft is unlikely to be a problem as it is with many other crops;
- it is relatively drought tolerant: once established it grows well with a minimum amount of rain, giving a crop even in dry years when some other crops fail;
- it is not susceptible to many pests and diseases." (Technoserve report)

One advantage of the plant is that it keeps away some insects. For this reason it is also a good crop for intercropping in horticultural plots or for growing around the house. This is a way in which it is being used by many Chinese peasants.

1. Physical requirements:

CRITERION	REQUIREMENT
1 Physical Characteristics	
1.1 Altitude	1000-1500m above sea level is ideal: can be higher or lower if maximum/minimum temperature is within desired norms
1.2 Soil type	Reasonable fertility, good water-holding capacity, not liable to water-logging pH not above 5.5, sandy and loamy soils can be used, use of manure strongly recommended.
1.3 Climate	<i>A. annua</i> tolerates daytime temperatures up to 28°C and down to 15°C. Frost is undesirable, especially at young stages
1.4 Rainfall/ water availability	Distribution more important than absolute amount. Reliable rainfall or irrigation potential essential at planting and for 2-3 months after transplanting
1.5 Topography	Slopes more than 15% are unsuitable, though once established <i>A. annua</i> gives reasonable protection against soil erosion
1.6 Vegetation	Open area needed – not too many trees or other obstructions – but if planted by smallholders plots can be small scale and still profitable
1.7 Access	Easy road access is required for seedling and input delivery, leaf collection and extension/ supervision. Distance from farmer's home should not be too great.

2 Artemisia Cultivation:

Artemisia is a labour-intensive crop whose cultivation requires close attention to detail, especially at planting and harvesting time:

Right planting time:

- Planting time: Near the equator the plant can be grown throughout the year but if you depend on rain water for most of your irrigation it is best to start preparing seedlings about eight weeks before the beginning of the rainy season. The plants take about six to seven months from seeding to harvest. Harvesting should be done on days where no rain is expected for at least a week.

1. **nursery:** *Artemisia annua* has tiny seeds (12-13,000 seeds per gram) which must be germinated in a well managed nursery. Since F1 seeds are expensive they are often pelleted and sown in plugs in a carefully tended nursery. The nutritional status of the soil is critical for a satisfactory survival rate, as are soil pH, temperature, moisture level, shading and disease control. A germination rate of over 90% can be expected with fresh F1 Artemis seed.



Hybrid seedlings in commercial nursery, Arusha, Tanzania

If you do not intend to spend any money on industrially produced nursery equipment the following can be recommended: (see below)

First Task: Germinating the seeds in seed trays:

You are invited to experiment a little bit and try the following methods:

- **Most common method for germinating seeds**
 1. Prepare in a big cooking pot a mixture of one quarter of sand, one quarter of old earth, one half of hot water (for instance: 10 tins of sand, 10 tins of old earth and 20 tins of water) and boil this mixture for five minutes. Allow it to cool
 2. Build portable germination-trays:
 - The tray can be of plastic (for instance the lid of a bucket) or wood, or a basket.
 - A germination tray of 50 cm length, 50 cm width (20 inches X 20 inches) would be a good size for 1/3 of a gram of seeds, (for a 1 g package you need three such seeds trays of 50 sq cm (20 ")),
 - Its rim should be at least 5 cm (2 ") high.
 - Make a number of holes into the bottom, large enough so that water can get in.
 3. Fill the soil/sand/water mixture into the germination tray almost up to the rim (5 cm or 2 inches) and wait until the water has drained away
 4. Sprinkle the right amount of tiny seeds (depending on the size of your germination tray) with a sieve on top of the mixture, do not bury them (for a box 20 square inches one third of a gram of seeds (about 300 seeds) is needed.)
 5. Put the tray in a warm and sunny place, if temperature is higher than 30 ° celsius, put it in the shade. Protect the seeds from chicken, ants or birds (if necessary) by covering the tray with a piece of mosquito netting or mosquito gauze and/or placing it on a table.
 6. Keep the soil of your seed moist by inserting the tray in water two to three times a day for ten minutes. (you may create a small pond with a plastic sheet next to the place where you keep the trays, and then fill this pond with the amount of water you need for the trays)
If you have a spraying device you may also water the tray with a very fine spray (mist) from the top
But never use a watering can before the plants have taken root and keep the tray out of the rain since larger drops of water will dislocate the tiny seeds.
 7. After 3-7 days shoots should begin to appear. They should have two leaves. If only one leaf appears, this is a grass seedling. If some seedlings are too close together, transplant one of them with a tweezer to another place in the seed tray.



- **Seed trays of small farmers, Mwanga, Tanzania**

If the plantlets grow very slowly use a small amount of liquid fertilizer ("kic-start", 1.5 cups to 3 litres of water) to make up for nutrient deficiency.

Nursery bed for F2 seeds:

If you are using F2 seed where you do not have to preserve every seed and in fact want to encourage competition between seedlings, you prepare a nursery bed of good clean (preferably sterilised) humus on slightly raised beds and broadcast the seeds onto them.:



F2 seedling nursery, Tengeru, Tanzania

There must be enough room to pass between these beds for watering with a spraying device and for picking out the plants for transplanting. During the first three days the nursery is covered with a cloth to provide shade and protection. Afterwards this cover is put on poles overhead.

Second Task: (about 4 weeks after sowing) transplant seedlings to polyethylene bags

When the seedlings will be 3 cm (1.2 ") high they are ready to be transplanted: put them in a polyethylene bags filled with a bottom layer (1/2) of well rotted compost and a top layer of sand. Use small sticks to make a hole into the bags and to pick out the plantlets. Put these pots into water once a day or water with a sprayer.



plants in polyethylene bags, Mozambique

Note: In the case of F2 plants the polyethylene bag stage is sometimes skipped. The plants are spread more thinly on the seedbeds in the nursery to begin with and are later transplanted right from the nursery bed to the field.

Using cuttings instead of seeds:

Cuttings are made from plants which are at least three months old:

Method of multiplying seedlings by taking cuttings:

Prepare cuttings from the two lowest branches with a razor blade: Cut the branches into pieces about 2 cm long, beginning just below a node from which they grow their small side shoots and ending immediately after another node with some small side shoots. The lower end of your cutting is the one which has a node above it. Now remove the **leaves** from the side shoots at the lower end of the cutting. Also remove leaves coming directly from the stem of the branch at the top but **keep the side shoots and their leaves of the upper part intact**.

Stick the lower end of the cutting in a 30 degree angle in your germination tray (with the same mixture you used for germinating the seeds). Irrigate in the same manner as you irrigated the seeds until they have grown roots.

When seedlings are 3 cms high, transplant them to a nursery bed or into a polyethylene bag.

After about six weeks after taking the cuttings, when the plants are 15 cm high, you can transplant them to the field.

Repeat this procedure with the new plants you have gained this way once more with the new plants you have gained.

If you have the possibility because of irrigation to grow artemisia throughout the year, you can continue this procedure as long as you wish to, but use young, strong plants, never use old plants, which are about to flower.

If you want to, you may also take cuttings from more than the two lowest branches.



Artemisia cuttings for vegetative propagation, Arusha

The seedlings grown from seeds are ready for transplanting approximately 7 weeks after sowing, when they have reached a height of about 10-12 cm.

Hardening: When seedlings are ready for transplanting, they need hardening for about one week : this is done by reducing watering to a minimum and exposing the plants to sunlight. Care must be taken not to overdo the hardening process as this can result in stress to the plants which leads to premature flowering and greatly reduces leaf and artemisinin production.

Before pulling them out, soak the plants in water and keep them moist until they have reached their final destination.

2. land preparation: deep ripping with tined implements to allow the tap root to penetrate any hard pan in the soil while at the same time conserving soil moisture is recommended. If furrow irrigation is proposed ridging of the soil before planting may be required. Pre-planting weed control is essential, using chemical herbicide where necessary. Adding natural manure to the planting holes is important and land preparation should be completed at least one week before transplanting to allow the land to settle. On the day before transplanting the field should be thoroughly watered.

3. transplanting into the field: (about 8 weeks after sowing): Planting the Seedlings out into the field.

This is best done at the start of the rains, since the water content of the soil must be high at transplanting and for several weeks thereafter to avoid moisture stress and premature senescence.

- **Method of planting the seedlings out in the field**
- Plant the seedlings in rows, one meter (3.3 feet apart), and each plant 1m (3.3 feet) apart within the row.
Planting holes should be 30 cm (12 inches) deep, filled with soil mixed with leaves and small branches and dung: The soil should be very loose and wet. If the rains at the period of transplanting are not reliable, irrigation is essential.
When transplanting great care must be taken to avoid bending the tap-root.
The soil must be pressed firmly around the plant to prevent wilting and to help the plant to recover from the shock of transplanting.
Use some mulch on top to prevent soil from drying out.
If you want to, you can intercrop. Artemisia will keep some of the insects away from your other crops.
When the plants are 50 cm high you might apply some manure once a month.
The most important issue is irrigation: Particularly during the first months artemisia needs a lot of water and even later on the soil should never be entirely dry.

4. plant density: the current recommendation with F1 variety is to plant at a spacing of 1m x 1m (10,000 plants per ha). With F2 varieties you may try to grow 15,000 plants per ha

5. fertilizer application: soil testing is recommended in each location to assess the appropriate fertilizer requirement. Manure is always helpful: 20 tons of well rotted manure per hectare is strongly recommended. A nitrogenous fertilizer is often required but is best applied as an organic manure. (Mediplant recommends fertilization with N.P.K of 80-70-90 kg/ha.) Top dressings of urea, Superphosphate and certain micronutrients may be required. (In Vietnam top dressing of urea , and smaller amounts of kali and ashes are the usual practice). Possibly K is not necessary. There are some reports that lack of potassium (K) might increase

rather than decrease the artemisinin content of the leaves. So some experimentation is advised.

6. weed control: young *Artemisia* seedlings are very susceptible to competition from weeds, so good weed control at the early stages after transplanting has a big impact on yield. Field application of herbicide is not recommended, so transplanting into a clean field is the best way of avoiding the need for later hand weeding¹. By 12-16 weeks after sowing, provided crop establishment is good, the ground will be covered and the weed problem is at an end.

7. pests and diseases: one of the attractions of *artemisia* is that until now it has had few natural enemies in East Africa – ants, cutworms and black crickets have been observed to cause some damage on young plants, but only when the field is weedy. A bait of bran, molasses and Gesapon is effective against these pests, as is a pyrethroid spray, but use of agrochemicals on medicinal plants needs to be minimized to satisfy GAP requirements. Cutworms can effectively be deterred by planting small sticks close to the main stem of the plant.

8. irrigation: *artemisia* can withstand dry conditions once it is established, but any moisture stress in the early stages tends to induce flowering and reduced production of both leaf and artemisinin. A rain-fed crop requires at least 600-650mm of rain so early planting is important. Supplementary irrigation is necessary if rainfall is low or unreliable, but over-watering can also be damaging causing leaching of nutrients and reduced root depth: the optimal balance between too much water and too little has to be found.

9. harvesting: As soon as the first flower appear, it is necessary to harvest: the time of harvesting *Artemisia* is critical as most evidence suggests that the artemisinin content of the leaves falls off sharply when flowering begins. In some places, where there is no flowering, harvest would begin when the plants appear to have reached their maximum maturity. With F1 *Artemis* an even stand can be expected with all plants maturing at once, but F2 seed gives less uniformity: some plants will be ready for harvesting earlier than others. Sequential harvesting of plants as they mature can result in significantly increased yields: this is something that smallholders who have planted a small area of *Artemisia* can do more easily than commercial planters. Before you start harvesting consult the weather forecast to make sure there are no rains expected.

10. drying: the plants are stooked in an upright position (like rice or corn stooks) in the field for air drying to a maximum moisture content of 12% or less. This normally takes from 5 to 10 days depending on weather conditions. Exposure to bright sunlight should be avoided as this can affect artemisinin content. The stooks should be turned periodically, but not in the heat of the day as many leaves will fall off when they become dry and brittle. There is also the possibility of harvesting by just cutting off the branches of the plant that carry leaves and drying the leaves of these branches on the stalks (see picture below). If rains interfere with the harvest, do not try to dry the leaves inside some storage facility unless you have drying equipment: Your leaves will grow mouldy and the whole harvest will be spoiled. Transport of the plants or branches for threshing should be done in the morning when they still are a bit wet from dew to avoid that dried leaves are blown away by the wind.

¹ If *Artemisia* is planted as an intercrop between young coffee or in a field of stumped coffee the weeding burden is reduced as it is shared between the two intercrops.



11. *threshing*: branches are threshed: this is done on a clean tarpaulin using a stick. The separated leaves are allowed to dry a bit more (if necessary) and are then bagged.