Ministry of higher education and scientific research

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Course handout:

Production of seedlings and seeds

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This course handout is intended to students in the field of natural and life sciences for the specialties:

Licence3: Agroecology.

Licence 3: Plant biotechnology and breeding

Preface:

The production of seedlings and seeds is a fundamental aspect of agricultural practices, particularly for food crops with extended life cycles, including vegetables, forestry, and fruit. It is crucial to possess exceptional skills and attention to detail in order to cultivate plants of optimal quality at the optimal time. As with direct seeding, it is vital to comprehend the advantages and disadvantages of growing one's own plants. The objective of this course is to assist growers, hobbyists and prospective growers who are still students in making informed decisions about growing seedlings for their farming system.

What factors facilitate the practice of plant cultivation?

* It is beneficial for seed conservation purposes, as it naturally results in fewer losses than direct sowing.

* Furthermore, it facilitates the production of species and, most importantly, enables the regulation of varietal selection.

* The production of local crops and the harvesting of them at an earlier stage in their growth cycle allows for the conservation of energy and time, due to the greater efficiency of recovery and the greater uniformity of the crops.

* Crop rotation is a simplified process which improves soil use from sowing to planting. In general, this results in greater resistance to disease.

* The crops are less susceptible to external factors than they would otherwise be.

These factors contribute to a greater degree of uniformity in the harvested produce.

In light of the aforementioned considerations, the objective of this document is to function as a reference guide rather than as a tool, assisting students in establishing their own micro-businesses and comprehensively investigating this promising field of agricultural economics following their graduation.

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Introduction :

The growth in global population and the concomitant rise in standards of living are precipitating an increased demand for food, forest land and vegetation to support animal husbandry. This is resulting in considerable pressure on the environment. One of the techniques introduced by humanity to meet its needs with minimal environmental impact is genetic improvement, which enables the production of higher yields from a single individual. Vegetative propagation is one of the most prevalent techniques employed. Furthermore, the selection of plants for the purpose of seed improvement represents an efficacious alternative. The various stages of agriculture and agro-industry that humanity has undergone throughout history have been closely linked to the capacity to shape and select plants, animals, micro-organisms, and so forth that provide them with the resources they require. In this context, the production of plants and seeds represents a straightforward method of maintaining and preserving the conformity of the most interesting varieties and cultivars (Abdelguerfi and Talamali, 2002).

Nevertheless, plant breeding has long been the simplest and most effective way of developing a new variety from parents with diverse characteristics worth developing and maintaining. In this approach, breeding has always taken into account quality requirements and industrial constraints.

It is important to stress that improvement and selection differ between different categories of plant species; the selection methods used for ligneous plants are different from those used for the production of new seeds. In fact, ligneous plants are generally improved with a view to agroforestry, the main problem being the large-scale propagation of trees and shrubs used in agroforestry and applied in agroecology.

With the advent of modern biotechnologies, and genetic engineering in particular, certain problems of biosafety and bioethics have arisen as a result of crossing the boundaries of reality (Abdelguerfi and Laouer, 1997). And it is thanks to the emergence of various regulations and patents that these modern techniques have made it possible to adopt a new approach to organic agriculture from the point of view of sustainable development.

First part: Woody plants.

The term 'woody plant' refers to a category of plants that produce a significant amount of organic macromolecule called 'lignin'. This category includes trees, shrubs, and bushes. Woody plants have lignified bundles in their stems, which makes them more resistant than non-lignin-producing plants. They have true stems that contain wood in the heartwood and sapwood. Stems are composed primarily of cellulose and lignin, which provide structural support for the vascular system responsible for transporting water and nutrients from the roots to the aerial parts of the plant, as well as photosynthates from the leaves to the rest of the plant. This composition makes seed propagation difficult, necessitating the use of alternative methods such as vegetative propagation.

1. 1. General information on woody plant propagation techniques:

Vegetative propagation involves producing identical copies of the mother plant, with the same genome.

This method is in line with the concept of cellular totipotency, which means that each plant cell has the ability to reproduce identically and form a whole plant genetically identical to the mother plant.

Indeed, each plant cell has the potential to multiply and organize itself into different tissues, allowing for the reconstruction of an entire plant. This property of totipotency is used by many species in nature, such as strawberry runners, raspberry suckers, potato tubers, yam rhizomes, tulip bulbs, and other onions, as adaptations for vegetative reproduction.

Vegetative propagation techniques utilize totipotency for species propagation. Successful vegetative propagation programs require young plant material because vegetative propagation techniques are sensitive to the aging of the mother plant. To apply these techniques, a rejuvenation phase is necessary, which involves obtaining young releases of strains obtained naturally.

1.2. Vegetative propagation techniques:

Vegetative propagation involves reproducing individuals identical to the mother plant without resorting to sexual reproduction. This mode of reproduction is closely linked to the ability of plants to grow indefinitely. It is the meristematic (embryonic) cells that are constantly regenerating. In addition, parenchymal cells have the ability to divide and differentiate into multiple cell types, enabling the plant to regenerate using the genetic material of the mother. The principle of vegetative propagation is that a complete individual with all its parts (roots, stems, and leaves) can be reproduced from a plant fragment. The vegetative apparatus fragment used for faithful reproduction is called a 'propagule'.

The main techniques for vegetative propagation

are cuttings,

layering,

grafting, and

micro-propagation.

1.2.1. **Cuttings:**

The cutting is a form of vegetative propagation that involves using a fragment of root, stem or leaf. By taking cuttings from the individual to be multiplied, it is possible to generate copies whose genotype, growth and architecture will generally be identical to the mother plant. To achieve this, several steps must be taken, including healing, formation of new cells, induction of root formation and their attachment to vascular tissues, and initiation of root system elongation (Figure 1).

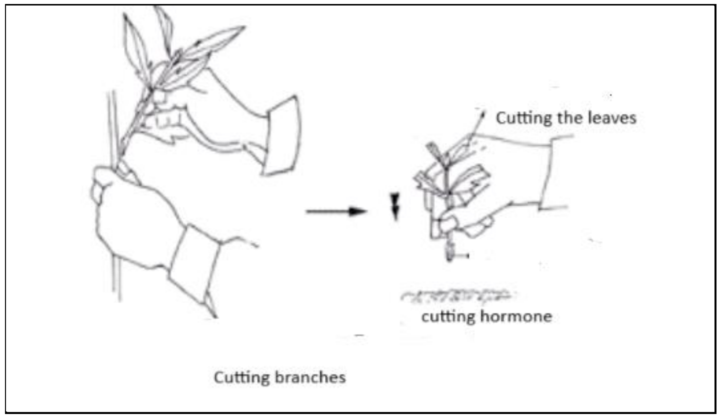


Figure 1: Cutting of woody plants.

1.2.2 Layering:

Layering is a vegetative propagation method that involves rooting a part of a plant, usually a branch, without separating it from the mother plant, unlike cuttings.

The chances of recovery are much higher as long as the layer continues to receive sap throughout the rooting process. It is a slower process than cutting and requires flexible or creeping vegetation, which limits the candidates for layering. This technique is particularly suitable for climbing plants.

There are various methods of layering:

a. <u>Layering in clumps</u>: This propagation technique is used by professionals to produce a small number of plants. The first technique involves covering a shrub almost entirely with a dune of soil and waiting for the buried branches to produce roots. This method is often used for quince, fig, hazelnut, and shrub plum trees.
b. <u>Layering by coating</u>: is the most common and is used for flexible shrubs such as mimosa and climbing hydrangea. This section describes two techniques for propagating shrubs. The second technique, known as layering by coating, is the most common and is used for flexible shrubs such as mimosa and climbing hydrangea. To propagate the shrub, select a young and flexible branch at the base of the plant. Cut a few leaves from the middle of the branch and make an incision in the bark (refer to Figure 2). Dig a small trench that is 5 to 7 cm deep. Apply rooting hormone powder, such as AIA or AIB, to the incisions. Bury this part of the branch in the trench and secure it with ties. In the autumn, check for the presence of roots and then detach the branch.

Figure 2: Layering stages.

a. Layering with long wood: This technique is a variation of layering by coating. It involves burying the longest possible portion of the branch, which will cause several buds to grow and produce multiple plants, such as vines or honeysuckles. (Figure 3).

b. Layering in pot: This is a version of layering by coating, but the stems are rooted in pots, which are typically used for vines.

c. Serpentine layering: This technique, also known as arch layering, is a method of plant propagation in which a long, woody and flexible shooter branch is laid down several times to create several layers on the same vine.

d. Air layering: A longitudinal incision of 5 cm is made on the branch, and the exposed wound is coated with rooting hormone. The layer is then wrapped in a bag containing moist foam. Roots should appear within two to three months. (Example: Lilacs and maples).

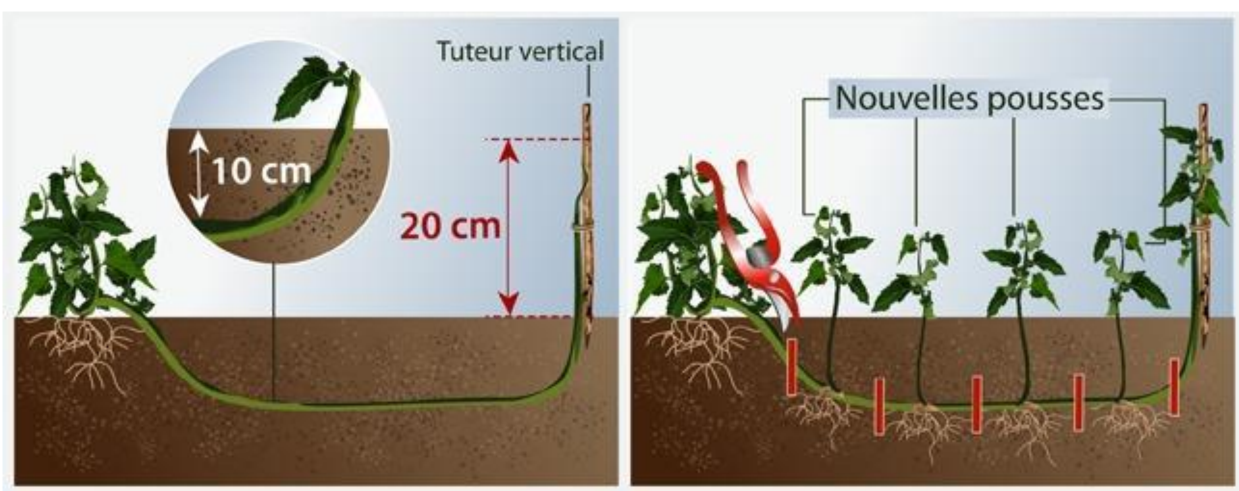


Figure 3: Marcottage by wood coating.

1.2.3. Grafting:

Grafting involves joining a plant fragment (the graft) onto another plant (the rootstock). It is a common method used to propagate roses and fruit trees. Grafting is preferred when seeding is unreliable and cuttings are difficult or impossible. It is also useful for adapting a plant to a specific soil or climate. This technique is a rapid way to create stem shrubs such as roses and willows (Figure 4).

During grafting, it is crucial to ensure compatibility between the graft and the rootstock. They should belong to the same species or at least the same family. Ideally, young plants of the same species from seedlings (known as francs) should be used as rootstock to avoid any compatibility issues. This method also allows for the use of a wild plant as rootstock and a domestic species as a graft.

The grafts taken must be healthy and vigorous. These should be young shoots of the year, taken from the end of the branches.

When carrying out a grafting operation, several factors should be considered, including:

- environmental conditions such as climate, temperature, and humidity,
- as well s the nature of the graft (whether by branch or by bud),
- the optimal time for the transplant,
- the modality of intervention, and the most suitable tools.

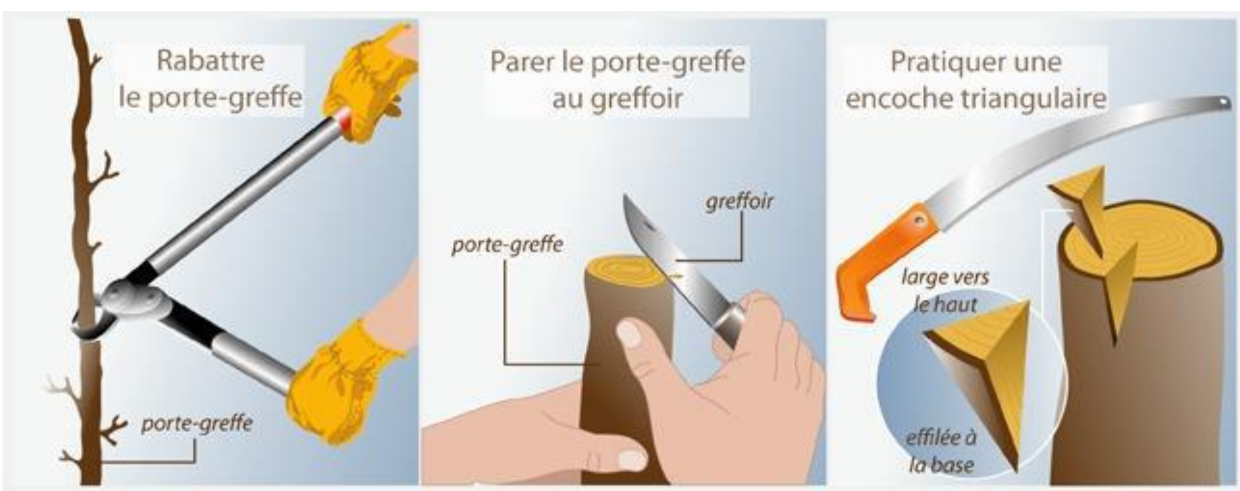


Figure 4: The grafting process.

1.2.4. Micro-propagation techniques: Micro-propagation involves taking a plant fragment and replanting it on synthetic media to produce individuals identical to the mother plant. This technique is useful when conventional vegetative propagation methods can transmit diseases or when creating a new species or preparing it for different environments with varying abiotic stresses (Figure 5). Plant micro propagation, also known as plant tissue culture, is a technique that isolates, sterilizes, and incubates cells, tissues, or organs of chosen plants in a growth-promoting aseptic environment to create a large number of plantlets.

Stages of micropropagation:

There are 4 stages of micropropagation:

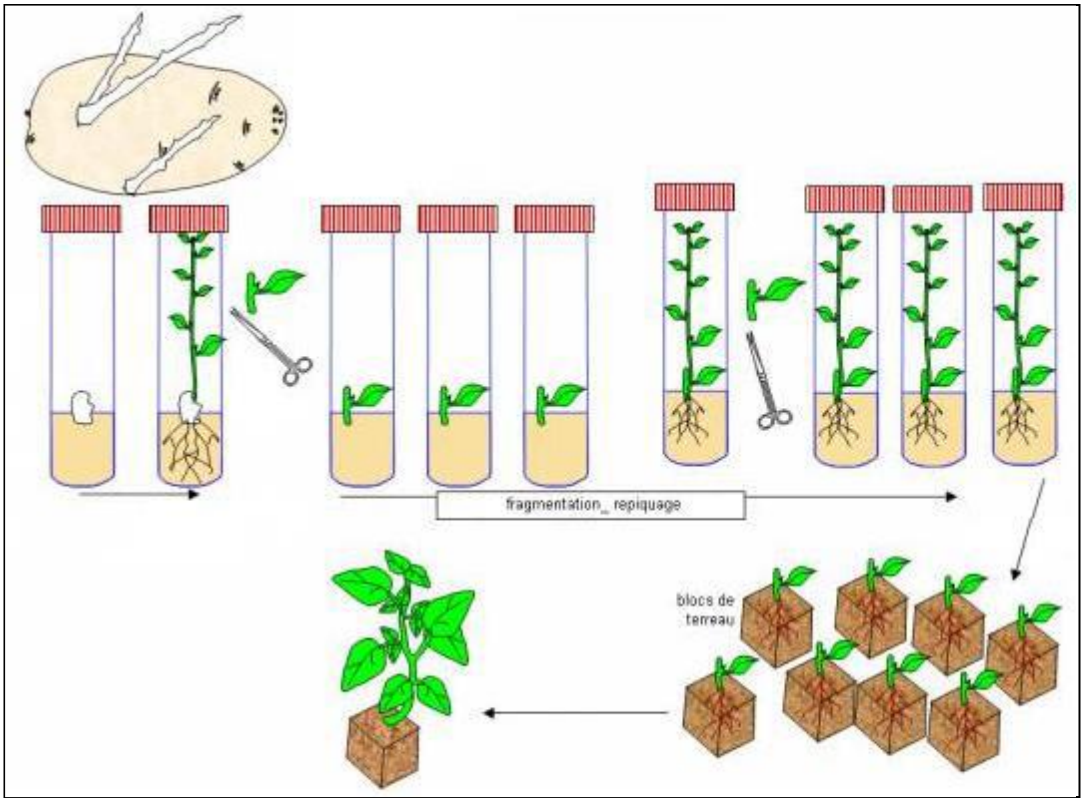
Pre Stage 1: Selection of Stock Plants

Stage 1: Establishment of Aseptic Culture.

Stage 2: Multiplication of Explants.

Stage 3: Rooting of Regenerated Shoots or Somatic Embryo Germination.

Stage 4: Acclimatization or Transferring of Plantlets to Soil.



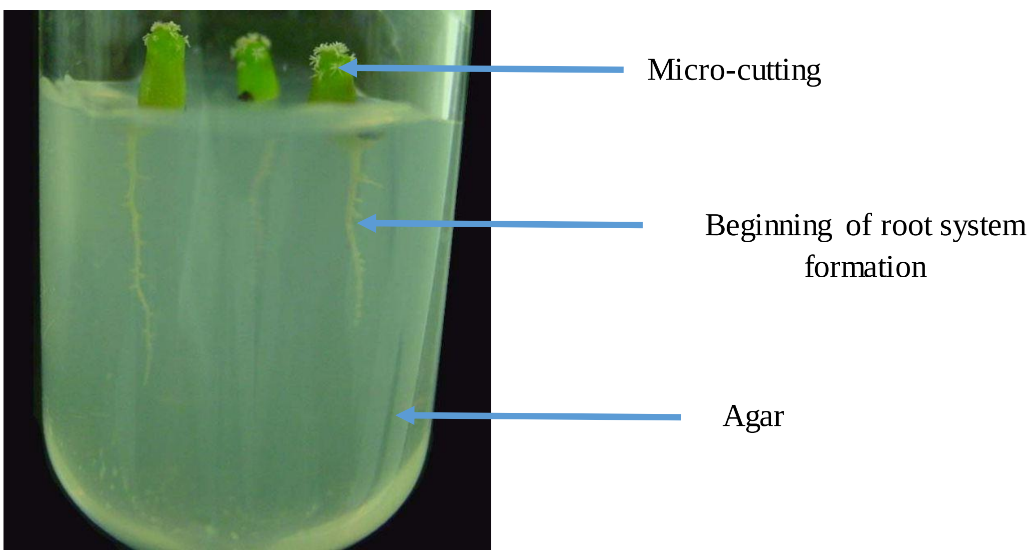


Figure 5: Micropropagation.

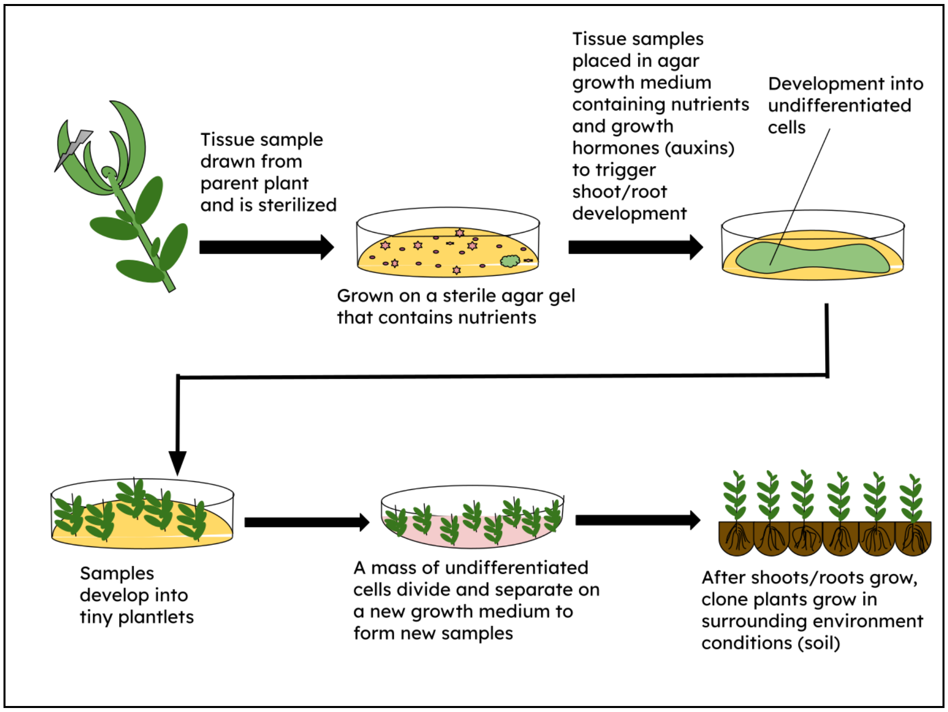


Figure 6: Micro-propagation stages.

1.3. Scientific basis of seedling production:

I.3.1. Technical basics of cuttings:

Cuttings can be a piece of stem, leaf or root. Cuttings follow certain rules:

a. Cuttings concern the most vigorous and floriferous plants.

b. The cuttings taken must come from the healthy parts (Table 1).

Depending on the form of the cutting, different cutting techniques exist (Table 2):

<u>a. The simple cutting:</u>

- Fragment of a young branch of 10 to 15 cm;
- Use the middle part of the branch;
- Eliminate the base that is too hard and the end that is too soft;
- The cutting must be below a bud;
- remove the leaves from two-thirds of the twig, starting from the base

<u>b. Heel cuttings:</u>

Detach the twig with a piece of bark (1 to 2 cm); technique used for evergreen plants such as Thuya and Cypress. This is a consequence of the flexible nature of their twig, where it is almost impossible to get a cutting without a stub (Figure 6).

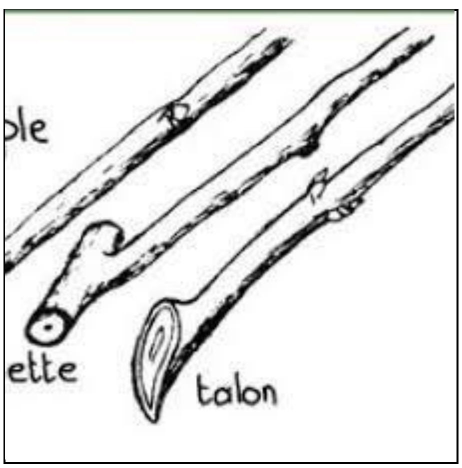


Figure 7: Heel and fine cutting.

<u>c. Root cuttings:</u>

- Take cuttings during periods of vegetation with young and very firm roots;
- Cut sections of 5cm in length;
- Lay the finest roots flat on the surface of the substrate;
- To avoid planting a root cutting upside down, always cut the upper part perpendicular and the lower part at an angle.

• Bury the cutting to a depth of 1cm in the substrate.

• Root cutting technique is used for trees or shrubs such as lilacs, raspberries, etc. (Figure 7).

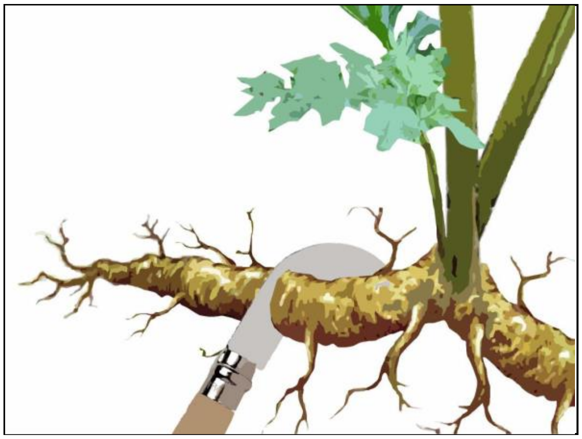


Figure 8: Root cutting.

d. Tuber cuttings:

• The tubers are swollen stems full of reserves,

• Burying them in the ground is called cuttings (figure 8).

Figure 9: Potato tubers that will serve as cuttings.

e. Stem cuttings:

• Cut a branch without leaves and cut it into pieces 4 to 5 cm long;

• Each piece must have at least 3 nodes (the marks of the location of the old leaves on which the new roots will form).

• Incise the bark and apply the hormone powder;

• Lay the lines flat on a damp substrate at a temperature of 25°C.

• The humidity must be very high.

1.3.1.2. The species concerned by the cuttings:

This type of vegetative reproduction applies to many woody plants but obviously not to herbaceous plants. Trees such as willows, poplars, some maples and even plane trees are affected. As for shrubs, the choice is even wider: old or botanical roses, spirea, buddleia, dogwood, deutzia, cotoneaster, forsythia, laburnum, privet, mock orange, knotweed, Japanese knotweed are just a few examples.

Climbing plants such as honeysuckle, clematis, bignone or Virginia creeper can also accommodate this method.

In the orchard, the fig tree, vine, raspberry, currant and blackcurrant will be easy to propagate by cuttings.

1.3.2. The technical bases of grafting:

Grafting is used to adapt a plant to a particular soil or climate: thanks to the intrinsic qualities of the rootstock, it gives the graft certain qualities that it did not have on its own roots (resistance to limestone, waterlogged soils, heat, etc.)

Conditions for successful grafting:

• The compatibility of the graft and the rootstock: same species or same family

• Take a healthy and vigorous graft: young shoots of the year taken from the end of the branches;

• Consider the right time: for each type of graft;

• Choose the varieties you prefer for their color, scent or taste.

Table1 : the technical bases of cutting.

Cutting out ligneous plants	When?	Which organ	How to get there	Which plants
Half-headed cuttings	In mid-August and late September	Young shoots that are in the process of hardening into a woody texture (wood)	Smothered in an unheated mini greenhouse	Evergreen shrubs, cedars, cypresses, etc.
Cutting with dry wood	After leaf fall	Young lignified shoots taken from the ends of stems	The cut and prepared branches are placed in gauges at the foot of a north-facing wall, to await transplanting in the following spring.	Deciduous trees and shrubs, poplar, willow, hydrangea, forsythia, etc.

Table 2: Technical bases of layering.

Type of grafting	period	Plants
In a crown **Fairly easy**	April-May	Repairing broken branches and grafting adult shrubs
Slotted **Easy**	Mid-April or between last august and mid-September	Ornamental plants and on grafting of a tree on a stem whose escutcheon has not regrown
English grafting method **Fairly easy**	In March : simple English. In January and February, under cover: complicated English.	Simple English grafting : apricot trees and clematis Complicated English grafting : vine
Inlay **Delicate**	In April after the spring frosts or in the first half of September	Stone fruit trees. Professionals use it to obtain plum, apricot or cherry trees on stems.
In veneer **Fairly easy**	In springer	Ornamental plants (many varieties of trees or conifers with colourful foliage or weeping habit)
Sideways under the bark **Delicate**	In February or March under heated cover	Trees and conifers (bluish foliage forms), small propagation plants. Reconstituting a branch on a fruit tree or to make certain branches fertile.

I.4. Multiplication of fruit trees and vines:

1.4.1. The propagation of fruit trees:

The vegetative propagation of fruit trees consists in producing fruit trees mainly by grafting. The main fruit trees studied are pome trees: apple and pear, and stone trees (apricot, peach and cherry).

1.4.1.1. Pome fruit trees:

a. The apple tree:

The apple tree, a member of the Rosaceae family, is the most widely cultivated fruit tree globally. It is native to Central Asia and the Caucasus and can thrive in a range of climates. It prefers rich, well-drained soil, including limestone, but should not be planted in soggy soil.

Apple varieties are always offered grafted, with rootstocks including the franc, doucin, and *Pommier paradis*.

The franc is often grafted at the base with an intermediate, which is then grafted at the top, as it is suitable for tall trees.

The doucin (*Malus sylvestris*) produces low-stemmed trees.

The paradis (*Malus pumila*), which has several types (Malling rootstock), is a dwarf apple tree obtained by selection and is the most widely used rootstock.

b. The pear tree: Pear trees are among the most classic of fruit trees, and the *Pyrus communis* can live to be 100 years old and 15 meters tall. Native to the temperate regions of Europe and western Asia. This ability to develop and grow uncontrollably, causing the fruit to fall and become damaged as it falls, has led to the pear tree being grafted onto smaller trees in order to reduce its size.

The rootstocks of the common pear tree are:

- Quince: Quince is used as common pear rootstock despite its high susceptibility to fire blight. The unsuitability of the pear tree for conventional cuttings, as well as the heterogeneity and excessive vigour of open pear trees (from seedlings) have led to grafting onto quince.

- Pear tree: Produced from seeds of the common pear tree *Pyrus communis*, it is susceptible to fire blight (a bacterial disease affecting rosaceous plants).

- Chinese pear (*Pyrus calleryana*): used as rootstock for several varieties of pear: Nashi (*Pyrus pyrifolia*), Comice and Bosc.

- Corm and Hawthorn can also be used as rootstocks in poor soils.

1.4.1.2. Stone-fruit trees:

a. Apricot tree:

The apricot tree is a member of the *Prunus* genus in the Rosaceae family. It is grown for its fruit and is native to the mountains of eastern Iran, northwest India, and Turkestan. It grows wild in Central Asia, including China, Korea, and Japan, and has been cultivated in China for over 2,000 years. The apricot is a vigorous species that can reach heights of up to 6 meters. It can reproduce by semi-sowing seeds, but growth is slow. Farmers use grafting to speed up growth and improve the quality and yield of their apricot trees.

Apricots can be grafted onto seedling apricot rootstocks, but not peach or plum rootstocks due to incompatibility issues that can compromise bud set. When choosing, consider three criteria, prioritizing the first two: adaptation to the soil (limestone, texture, humidity) and affinity with the variety, as well as vigour.

a.1. Main Characteristics of Apricot Rootstocks:

A- PG Apricot Franc: Is obtained from the seeds of Canino, Polish, Rouge de Roussillon varieties, among others. It provides great vigour to trees but is characterized by plant heterogeneity. It adapts well to poor, dry soils, but is not suitable for compact and wet soils. It is resistant to limestone and nematodes and ensures great longevity for trees.

B- Straight Mech-Mech PG: Derived from the seeds of certain populations of wild apricots, particularly found in certain areas of Eastern Algeria where it is often referred to as 'Fermés'. It promotes good tree growth and adapts well to various soil types, including poor and dry soils. It is resistant to drought, salt, and high concentrations of limestone (over 10-15% active limestone). One disadvantage is that it provides very heterogeneous seedlings and delays the fruiting of varieties.

C- Manicot Franc GF 1236: The vigorous rootstock was obtained by INRA de la Grande Ferrade (France) from a wild apricot seedling. It appears to produce uniform seedlings and is suitable for healthy, well-draining soils. It has a good affinity with apricot varieties, especially Canino, Bergeron, and Polish. It has an average speed to fruit and good productivity, with fruit of medium size. It does not produce suckers and is best grown in gravelly, non-compacting soils with average tolerance of limestone.

D- **Myrobolan GF.31** : This rootstock is a hybrid of the Japanese plum and the Myrobalan plum. It was developed by the INRA in France. It is well-suited for growing Canino, Rouge de Roussillon, and Luizet apricot varieties, providing trees with strong vigour and a moderate fruit set. It thrives in deep, fertile, and cool soils. However, it is important to note that varieties grafted onto this rootstock are more vulnerable to bacterial blight (*Pseudomonas syringae*) in soils with low water reserves.

E- **Myrobolan B** : This rootstock originates from a selection of Myrobolan plums (Prunus cerasifera) cultivated at the East Malling station. It is suitable for various soil types, including heavy, fertile, and cool soils, and is highly resistant to root asphyxia. However, it is often not recommended for grafting Canino, Polonais, Rouge de Roussillon, and Bergeron varieties due to poor compatibility, which can result in graft detachment, even in the orchard.

F- **Mariana GF.8.1** : The rootstock was chosen by INRA Bordeaux from a natural cross of (Plum Mariana x Plum Myrobolan). It has strong vigour and can be easily multiplied by woody cuttings. It can adapt to various soil types, but it thrives in rich, cool soils due to its high resistance to root asphyxia. It is highly incompatible with most apricot varieties, except for Canino, Luizet, Polonais, Bergeron, and Paviot, with which it is compatible. Please note that GF8.1 may not be compatible with certain apricot varieties, including Rouge du Roussillon, Hâtif Colomer, Canino, Moniqui, and Amal. Therefore, it is recommended to either graft them onto apricot stock or use intermediate grafts.

G- **Frank Almand tree:** The peach tree is suitable for growing in all types of soil, including poor and very chalky soils. However, it dislikes cold and impermeable soils. Although it has great vigour for growing trees in the open air, its growth is slow. Despite this, it has good productivity. It is often used as a grafting intermediate.

H- **Peach frank** : For loamy soils, good vigour and early fruiting.

I-Peach GF 305: Suitable for all well-drained, non-calcareous soils, this variety boasts high vigour and good productivity. It is available in both stem and half-stem forms. While it is fairly resistant to bacterial canker, it is incompatible with certain varieties of apricot.

Table 3 : Characteristics of apricot rootstocks used in Algeria (ITAF, 2010).

Portes greffes	**Origine**	**Avantages**	**Inconvénients**
Franc d'Abricotier	Semi de variétés Canino, polonais, Rouge de Roussillon etc.	Il donne de grandes vigueurs aux arbres, S'adapte aux sols pauvres et secs, Résiste aux calcaires et aux nématodes, Donne une longévité aux plants	Plants hétérogène, Crin les terrains compactes et humides
Franc Mech-Mech	issu de semis de certaines populations d'abricots de types sauvages,	Il permet un bon développement des arbres ; s'adapte aux différents types de sols y compris ceux pauvres et secs. Il résiste à la sécheresse, aux sels et aux concentrations élevées de calcaire (» 10 à 15 % de calcaire actif).	Fournit des semis très hétérogènes et retarde la mise à fruits des variétés.
Franc Manicot	obtenu par INRA de la grande Ferrade(France), à partir d'un semis d'abricot sauvage,	Vigoureux ; donner des semis homogènes ; convient aux sols sains et filtrants et présente une bonne affinité pour les variétés d'abricotier en particulier Canino, Bergeron et polonais. Mise à fruit moyennement rapide, Productivité bonne Fruits calibre moyen. Drageonnement nul, Adaptation au sol à réserver aux sols graveleux, non asphyxiants ; tolérance moyenne au calcaire	Pas d'inconvénients noté.
Myrobolan G31	hybride entre (prunier japonais x prunier Myrobolan) obtenu par l'INRA de France;	Convient très bien aux variétés d'abricotier Canino, Rouge de Roussillon et Luizet. Il confère une grande vigueur aux arbres et une mise à fruits assez lente. Il préfère les sols profonds, fertiles et frais	Les variétés greffées sur ce PG deviennent plus sensibles à la bactériose (Pseudomonas syringae) en terrains à faible réserve d'eau.
Myrobolan B	issu d'une sélection de prunier Myrobolan (*Prunus cerasiféra*) par	Il convient à plusieurs types de sols dont ceux lourds, fertiles et frais, et résiste bien à l'asphyxie racinaire. Il	Sa mauvaise compatibilité avec les variétés Canino, Polonais, Rouge de

	la station d'East Malling,	confère aux arbres une vigueur moyenne, une mise à fruits précoce et une bonne longévité	Roussillon et Bergeron, le rend souvent déconseillé pour le greffage des dites variétés à cause des décollements de greffes qui peuvent se produire même en verger.
Mariana GF.8.1	Sélectionné par l'INRA de Bordeaux à partir d'un croisement naturel de (prunier Mariana x prunier Myrobolan)	Il a une bonne vigueur et se multiplie facilement par bouturage ligneux. Il s'adapte à plusieurs types de sols mais, convient mieux aux sols riches et frais de par sa grande résistance à l'asphyxie racinaire. Il est conseillé de les greffer sur francs d'abricots ou bien procéder à des greffes intermédiaires.	Il est très incompatible avec la plupart des variétés d'abricotiers sauf Canino, Luizet, Polonais, Bergeron et Paviot avec lesquelles il se montre compatible. NB : le GF81 présente une mauvaise affinité avec certaines variétés d'abricotier, comme le rouge du Roussillon, Hâtif Colomer, Canino, Moniqui, Amal
Franc d'amandier		Pour tout type de sol, y compris les sols pauvres, les sols très calcaires. Redoute les terres froides et imperméables. Grande vigueur pour former des arbres de plein vent mais développement lent. Bonne productivité. On utilise souvent le pêcher franc comme intermédiaire de greffe.	
Franc de pêcher		Pour terres limoneuses. Bonne vigueur. Mise à fruits précoce	
Pêcher GF 305		Pour tout sol bien drainé, non calcaire. Grande vigueur. Formes tige et demi-tige. Bonne productivité.	Incompatibilité avec certaines variétés d'abricotier. Assez résistant au chancre bactérien.

b. Peach: Peach is a fruit tree in the Rosaceae family, scientifically known as *Prunus persica* L. Peaches are highly prized for their fruit. Although originally from China, it is now a cultivated species and does not exist in the wild. It can grow up to 7 metres in height. The peach tree is grafted onto:

b-1- Peach frank: This is the natural form of the peach tree. It originates from seedlings, preferably taken from wild plants, to produce more consistent plants.

b-2- Missour's frank: This homogeneous stand is obtained from seedlings of a variety of wild peach trees in Morocco. It is resistant to doses of active limestone of around 8%.

b-3- Almond frank: The almond tree is resistant to drought and limestone, and thrives in poor soil. This rootstock is particularly suitable for late varieties, as its sap is maintained late in the season. However, it is sensitive during the planting phase, so it is best to wait until after the first frosts. It can survive for over 30 years and can tolerate watering in light soil. Prolonged dampness in the soil is not tolerated. Other rootstocks can be used such as:

* Plum ;

* Saint Julien plum;

* Myrobolan plum;

* Black damask plum.

c. Cherry trees: Part of the Rosaceae family and genus *Prunus*, subgenus *Cerasus*, are native to East Asia where they are primarily used for ornamentation. However, in the rest of the world, they are grown for their fruit and there are over fifty different species. To ensure a good yield, cherry trees are often reproduced by grafting.

In particular, they are grafted onto French cherry rootstock.

For lower forms, use Saint Lucia cherry (*Prunus mahaleb*), and for higher stems, use cherry (*Prunus avium*), with a preference for white cherry due to its higher productivity.

1.4.2. vine propagation:

The vine is a woody shrub with sarmentose stems in the Vitaceae family. It produces bunches of very juicy fruit and can multiply through sexual or vegetative means. Vegetative propagation is mainly used to maintain its varietal characteristics, while sexual propagation is employed to create new grape varieties.

1.4.2.1. Sexual vine propagation:

Wild grapevines propagate through seeds and produce a rootstock that can be used for cultivated species. The cultivated vine is mainly hermaphroditic and has a long reproductive cycle, taking between 3 and 5 years for a new individual to produce new pips.

1.4.2.2. vegetative propagation:

In the wild, vines can multiply vegetatively through marcottes, where a buried shoot can take cuttings and regenerate a new root system (Levadoux, 1956).

In viticulture, vegetative reproduction is commonly used to multiply and conserve different varieties and selected grape varieties, ensuring uniformity of cultivation and maintaining the typicality of the grape variety. Some old grape varieties with unique characteristics have been preserved through this method. Examples of these include Muscat à petits grains, Sultanine, and Pinot.

a- **Vine cutting:** Vine propagation through cuttings is feasible in the absence of phylloxera. However, nurserymen usually plant rootstock cuttings, which take root after six months of cultivation. Nonetheless, it is possible to preserve the characteristics of a variety by taking cuttings. Cuttings should be taken after the leaves have completely fallen off, stored in sand until March, and then replanted directly in the soil. In this case, the first buds will be obtained in autumn.

b- **Vine grafting:** Grafting remains the most commonly used technique among poultry farmers. Rootstocks are typically produced through cuttings in nurseries and can be highly vigorous, sometimes exceeding 10 metres in length. Ultimately, only a fraction of the rootstock is retained, typically between 28 and 70 centimetres. The vines that have been grafted are fruit-bearing and have been established following a strict protocol designed to minimise health risks. This protocol includes using a plot of land that has not been planted with vines for at least 12 years, compulsory use of 'base' category plants, and isolation of at least 5 metres from all other vines The shoots, which must be well-seasoned and have a diameter of less than 14 mm, are harvested and packaged in bundles of 100 or 200 units. These bundles are labelled with regulation labels, with blue being used for certified material. The shoots are then cut into grafts, which consist of a fraction of a meristem a few centimetres long, topped by a bud (eye).

<u>Production conditions for vine rootstocks and grafts</u>:

When it comes to nursery cuttings, they must have a minimum diameter of 3.5 mm and a length of 55 cm. They should be packaged in bundles of 100 or multiples of 100. As for graftable cuttings, they must have a diameter at the small end of between 6.5 and 12 mm and at the large end of less than 15 mm. They should be heeled at 2 cm from the base of the lower eye and cut into metres or fractions of 28 to 30 cm.

c. Vine layering: Vine layering is a vegetative propagation technique for vines. It involves planting a vine shoot that is still attached to the mother plant, with the two-eyed end sticking out. Rooting occurs quickly, and a fruit harvest can be expected the following year. This technique is limited to small-scale operations due to the significant time and labour required.

1.5. Nursery production:

1.5.1. Definition and Purpose of a Nursery:

A nursery is a place where seedlings are grown for later replanting. In 1805, Bosc defined a nursery as an area of land devoted to sowing tree seeds of any species and educating the seedlings during their initial growth.

The purpose of a nursery is to cultivate young plants until they are ready for transplantation. Nurseries have been in existence since ancient times (Bosc, 1805) and are used to care for young plants from the time they are sown. This ensures that they are able to withstand the difficult conditions they will later encounter in the field.

Nursery plants, whether local or introduced species, have a higher survival rate than seeds sown directly in the field or through natural regeneration. As a result, they are commonly used as planting material for production, protection, or ornamental purposes.

Producing high-quality seedlings at a reasonable cost is crucial for successful afforestation. This involves ensuring objectivity in the evaluation of seedling quality, using clear and concise language with a logical flow of information, adhering to conventional academic structure and formatting, employing formal register and precise word choice, avoiding bias, and ensuring grammatical correctness. Additionally, any changes in content must be avoided. Therefore, it is important to master nursery techniques.

1.5.2. Open-ground nurseries:

Open-ground nurseries are defined as nurseries where plants are either planted directly in the soil or in pots or bags that are in direct contact with the soil.

 (a)  (b)

Figure 10: Open-ground nursery. A: plants are planted directly in the ground; b. plants are planted in pots and placed directly on the ground.

1.5.2.1. Open-ground nursery types: There are two type of open-ground nursery: temporary nurseries and permanent nurseries.

a. Temporary nurseries: This term refers to nurseries set up on or near the planting site. Once the plants intended for planting have reached the required size, the nursery is integrated into the planted site. These nurseries are also known as 'flying nurseries'.

b. Permanent nurseries: This category comprises production nurseries that are planted on a suitable site and remain there for a considerable number of years. The size of these nurseries varies depending on their purpose and the number of seedlings grown annually. Small nurseries contain fewer than 100,000 seedlings at any one time, while large nurseries contain more. In all cases, permanent nurseries should be well-designed and located in a suitable site with an adequate water supply.

1.5.2.2. Choosing a Nursery Site:

When establishing a nursery, it is best to select a location on a plain or at the bottom of a hill that is sheltered from north and north-east winds by a mountain range or a clump of tall trees. The soil should be deep, with average or below-average fertility, and neither too dry nor too wet (Bosc, 1805). When selecting a nursery site, it is important to answer four key questions:

- What type of nursery is planned?
- Will it be temporary or permanent?
- What is the size of the nursery?

Is it a large nursery that will produce 100,000 plants per year or more, or is it a small nursery with a capacity of 50,000 plants per year or less? What is the demand for seedlings? For instance, a nursery located near multiple development projects may require a significant annual yield of diverse seedlings, whereas a nursery catering to small community woodlands may be satisfied with a modest production of seedlings each year.

The distance between the nursery and the location where the plants are needed for transportation purposes.

* After answering the questions, the nursery will be set up in a location that meets the following criteria:

- Access to a reliable water source, such as a river or well, as water is essential for the nursery; - Availability of good quality soil, free from salinity and alkalinity, as large quantities of soil are required; - Adequate drainage to prevent waterlogging and protection against the risk of flooding.

- When selecting a site for the nursery, it is preferable to choose a location that is naturally protected by vegetation or other formations to shelter it from prevailing winds. If an exposed site is the only option, it must be artificially protected.

- Good access roads are necessary to transport the plants to their planting site in good condition. Poor roads and long journeys can greatly reduce the survival rate of the plants.

The nursery should be located where labour is readily available or easily accessible. Nursery work is labour-intensive, and if nurseries are located far from population centres, they will incur high costs.

1.5.2.3. Nursery design:

The design of the nursery must be well-planned. It should be divided into blocks, designated by letters or Roman numerals, and linked by suitable paths. The paths should be wide enough to allow for loading and unloading, with a minimum width of 5 metres for turning around (Figure 9).

Each block should be further divided into 4 to 8 sections, separated by aisles. The nursery is divided into sections, each designated by a letter or number followed by a small letter. For example, Section I.a is the first section from the left-hand corner of Block I. Each section is further divided into planks. For example, Section I.a is the first section from the left-hand corner of Block I. Each section is further divided into planks.

For example, Section I.a is the first section from the left-hand corner of Block I. Each section is further divided into planks. The smallest unit in the nursery is the bed, which is typically one-metre-wide and can vary in length from 6 to 10 metres. The beds can be sunk 30 to 35 centimetres below ground level and lined with cement, stones or bricks.

The planks can be raised slightly above ground level and surrounded by piles, bricks or stones. Proper drainage is crucial for plant growth and nursery hygiene.

The beds in the nursery are identified by the block and section code, followed by an Arabic numeral. For instance, Bed No. Ia1 is the first bed in section (a) of block I. The beds are separated by one-metre-wide paths to facilitate manual or wheelbarrow transportation of plants, watering, and maintenance.

The nursery must have adequate space for soil mixing, which should be at least 5 x 5 metres. Additionally, there should be a designated area for composting, which is best located away from the nursery beds.

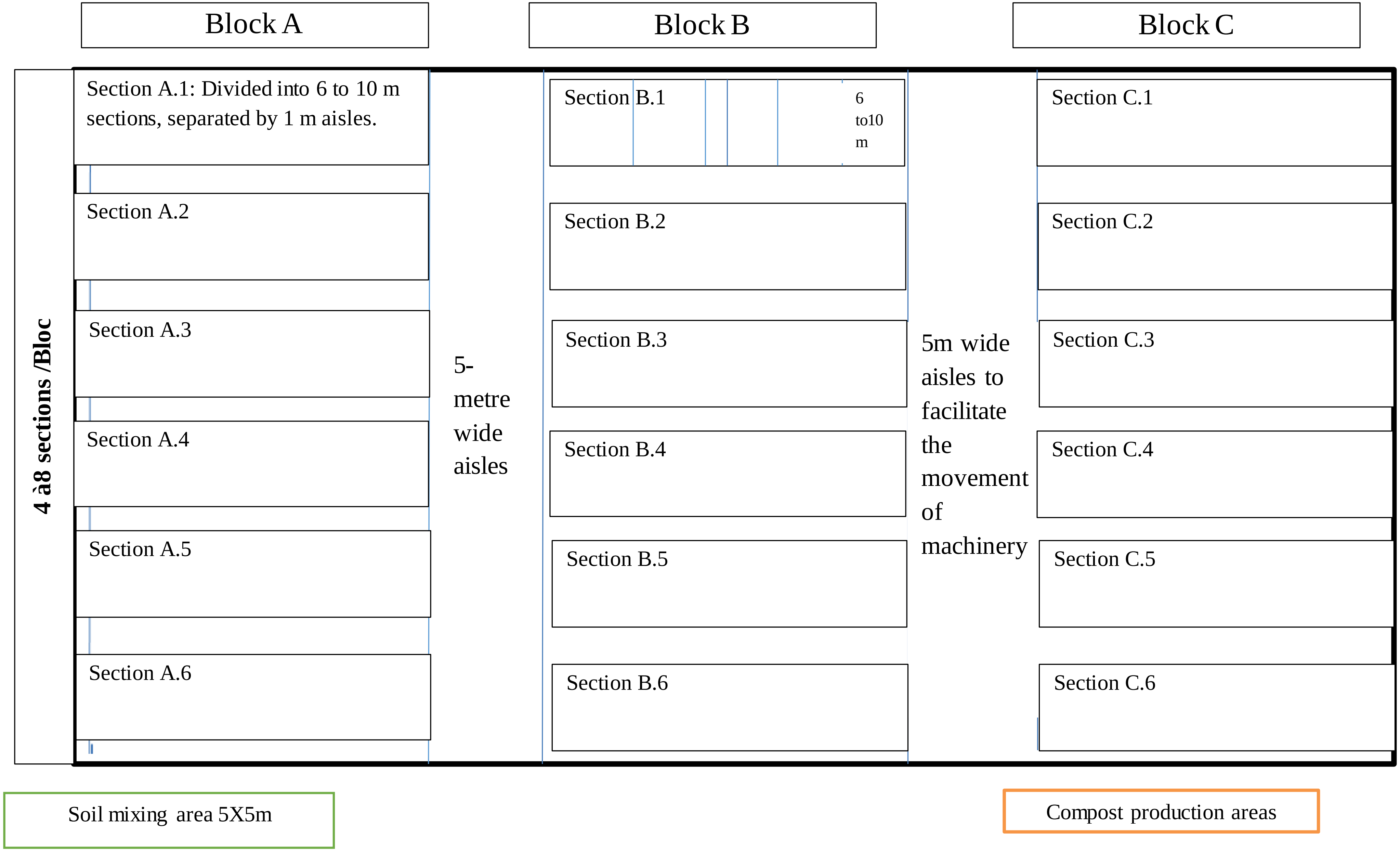


Figure 11: Nursery

1.5.2.4. Substrate preparation for Nurseries:

The potting soil used in nurseries must meet the following criteria:

it should be lightweight, cohesive, and have good water retention capacity.

- The substance must consist of a considerable amount of organic matter;

- It must possess adequate fertility, or it can be made fertile by adding 2 kg of NPK per cubic meter of soil.

(a)

(b)

(c)

Figure 12: Nursery in the ground, the plants are placed directly on the ground or even planted directly in the ground.

1.5.2.5 Example of a Permanent Nursery in Algeria

The Rural engineering group (REG) in French: Groupe de Génie Rurale (GGR), Horticultural and green space company (HGSC) in French known as: Entreprise Horticole et Espace Vert (EHEV) operates a permanent nursery in Staoueli, Algeria. The nursery covers an area of 52,318 m² and is part of a larger agricultural area of approximately 34 hectares, 91% of which is Utilised

Agricultural Area (UAA). The facility includes a 10,000 m^2 glazed complex that has been in operation for over 30 years. It has a production capacity of around 50,000 indoor plants per year.

Additionally, there are three production modules (greenhouse tunnels) for outdoor plants with a surface area of 380 m^2 and a production capacity of 100,000 plants per year. These modules are set to be installed in 2019. The facility also has a 7900 m^2 multi-chapel shade house, installed in 2018, which is used to store outdoor plants. It has an estimated storage capacity of 80,000 plants. The facility includes a storage area of 8,500 m^2 with a capacity of 340,000 outdoor plants, a cuttings area (sand trays) of 1120m^2 with a production capacity of 100,000 plants/year, which has been in place for over 15 years, a 10,000m^2 storage area for large trees and palms with a capacity of around 60,000 plants, and a 6,500 m^2 wood storage area for indoor plants located inside the glass complex and containing around 80,000 plants.

Figure 13: Multi-hood greenhouse at EHEV, Algiers.

In order to increase production capacity, EHEV has extended and modernised its production potential by creating a new multi-chapel greenhouse (05 chapels) (Figure 10) at its headquarters in Staouéli. The greenhouse has a total surface area of 1.200 m^2 and is used for the production and propagation of indoor and outdoor ornamental plants.

This greenhouse has been in operation since September 2021. Its design aims to intensify production and considerably improve nursery yields. Additionally, earlier sowing allows for earlier harvesting, enabling quicker crop rotation. This encourages crop diversity.

a. **<u>The objectives of the multi-chapel greenhouse:</u>** The multi-chapel greenhouse aimed to provide optimal growing conditions for ornamental plants during their juvenile stage, protect plants effectively against bad weather and insect pests, and allow for out-of-season plant production on heated layers in the Nebulisation room.

- Increased productivity and quality.

- Availability and success of crops throughout the year.

- Improved working comfort.

b. Water Resources:

The water supply is provided by a well with a capacity of 8 L/s and two basins with a total capacity of 400 m^3 and a flow rate of 50 m^3/ha. A water tank made of dosed reinforced concrete with a capacity of 24 m^3.

1.5.3 Production in Above-Ground Nurseries Under Cover:

The above-ground nursery cultivation technique involves planting the plant in a container and intervening from time to time until it is ready for sale. The pots are separated from the ground either by plastic wire (see figure 11) or placed on wooden boards raised off the ground.

This technique is based on the use of containers to prevent root deformation.

- Production beds are raised above ground to provide self-supporting roots. They are equipped with an automated irrigation/fertigation system and a shade canopy.

 **(a)**  **(b)**

Figure 14: A Soilless nursery. a: separation by plastic film; b. container raised on floors.

The container: The choice of container is a crucial factor in producing a quality plant. A good container should have the following characteristics:

- The angles must be less than 40°,
- The volume should be over 400CC on average,
- The height should be greater to allow deeper penetration of the lower roots into the soil after planting.
- The diameter at the collar increases primarily between 9 and 25 cm.

Growing medium: The quality of the growing medium used largely determines the success of forest plant production. A good substrate should have:

- A porosity of over 80% by volume,
- A high availability of easily usable water of over 20% for good water supply,
- And an air content at pF1 equal to or greater than 20% for good aeration.

- To ensure optimal mineral nutrition for plants, it is recommended that the substrate pH be maintained between 5 and 7.

Raising Seedlings in a Soilless Nursery:

The objective of this process is to raise seedlings with well-developed roots for successful transplantation. The following steps should be followed:

1. Fill the containers with moist soil, which is easy to handle.

2. Insert a maximum of two cuttings per container.

3. Store the containers in wooden boards.

4. Arrange the containers by species in beds, with the name of the species clearly labelled in front of each bed.

It is important to note that this process should be carried out in a soilless nursery.

The plants should be transplanted when the seedlings are around 6 to 8 cm high and fairly vigorous. The plants should be transplanted when the seedlings are around 6 to 8 cm high and fairly vigorous. It is important not to transplant them too late, as this can cause the roots of different plants to become too tangled. The plants should be transplanted when the seedlings are around 6 to 8 cm high and fairly vigorous. When transplanting, care should be taken not to damage the roots, as this can result in little or no recovery.

4. Nursery follow-up:

The logbook of the nursery is mandatory to record all the operations performed during the rearing of a species. The purpose is to have a history of the seedlings before planting them. This also enables the estimation of production costs and success rates, facilitating the improvement of techniques used.

Each bed must have recorded the species, planting dates, pre-treatments, dates of first buds, weekly bud burst rates, fungicide and insecticide treatments, soil loosening, seedling sorting and crenellations, height at nursery departure, and seedling to pot ratio.

I.6. Inspection and certification of nursery stock :

The Office of the Control and plants certification is responsible for controlling and certifying seedlings produced in nurseries. It is crucial to choose the right plant material to avoid catastrophic consequences. Therefore, phytotechnical control of seedlings is challenging and requires careful consideration. Standardising procedures and methods can help inspectors focus on qualitative assessments, which are the most delicate (Brague, 2023).

1.6.1. Inspection of fruit plants:

In accordance with Law No. 05-03 of 5 February 2005 on seeds, seedlings and plant production. The production and propagation of seedlings of species and varieties registered in the official catalogue is controlled.

Figure 15: Forest tree nursery (above-ground model).

1.6.1.1. Stages in the production of fruit plants:

Choice of vegetative propagation technique depending on:

-The species and variety to be produced;

-The production objective (to improve quality, taste, yield, etc.);

-Grafting is used to improve quality, taste and yield;

-To maintain the variety: use of cuttings;

-To maintain the variety produced by grafting, layering is used.

a. **First inspection**:

This inspection is carried out during the growing season and involves checking the production status of the declared plants.

It includes verifying varietal authenticity, determining varietal mixes, and estimating production. The following aspects are to be considered:

compliance with isolation standards, plant health, surface area planted, and assessment of varietal purity.

This control operation is authorised by a BCV: Brevet de Certificat Variétal (Varietal Certificate Certificate).

b. Second inspection:

After the leaves have fallen and the plants have been analysed by the phytosanitary services, a gauge is used to check the condition of the root system and the root ball (above-ground production). The phytosanitary status is confirmed by an analysis report. An analysis form must be provided to estimate marketable production. This stage is sanctioned by a Bulletin de Contrôle en Gauge (BCG) and the affixing of an official label, depending on the species.

c. **In the laboratory**: The third test focuses on propagation equipment, including the isolation hut, wood yard, and seed banks.

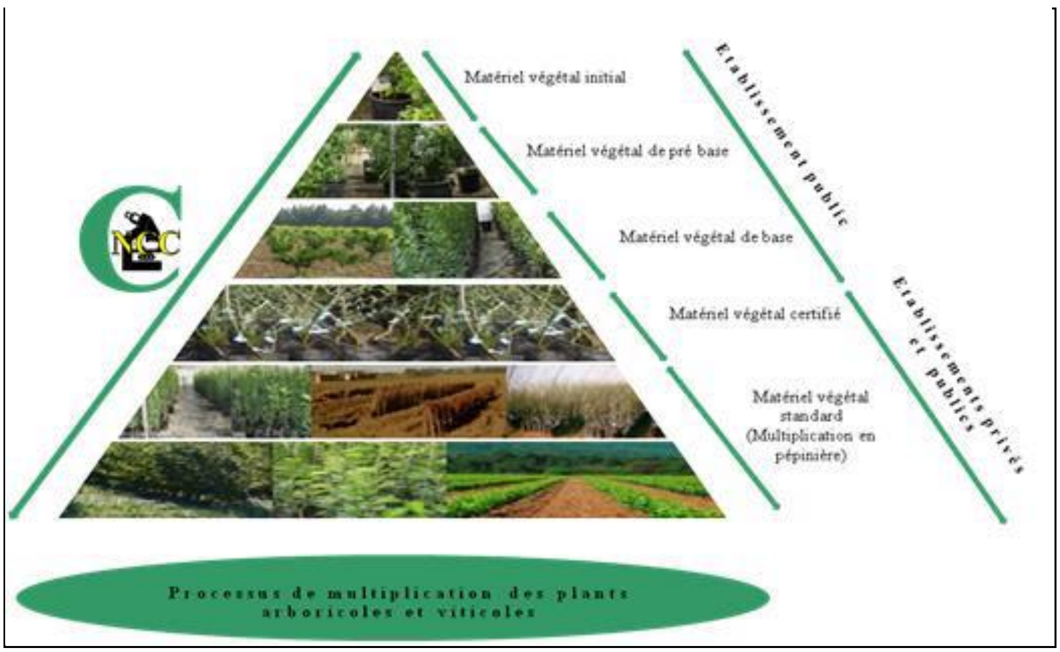


Figure 16: Multiplication processes for tree and variety plants

1.6.2. Control of forest seedlings:

1.6.2.1 Forest Seedling Production Stages:

The production of forest seedlings involves three stages:

- Installation of stock yards,
- Propagation phase,
- Control stages.

Propagation can be carried out by cuttings or by seed if stock plants have been produced.

1.6.2.2. Control of forest seedlings:

Produce high-quality and uniform seedlings that meet phytotechnical standards to increase the success rate of plantations. A significant proportion of losses are due to poor quality seedlings.
The control method must adhere to international standards for harvesting, management, production, transfer, and planting. To achieve this, seedling samples are randomly taken to cover each batch of each species in the same proportions and at regular intervals from the middle, edges, and ends of the production beds. The number of samples is proportional to the size of the batch to be approved.

a. Checks for plant health:

Control can eliminate unsuitable plants for reforestation. Seedling production in raised frames and rigid WM containers can solve the problem of root deformation, which is the main cause of rejection. Forestry seedlings undergo phytotechnical and phytosanitary inspection every September.

- A second check may be carried out in October of the same year, if necessary.
- The competent territorial forestry conservation authority will officially inform producers at least eight days before the commission's visit.
- Seedling producers must be present on the day of the phytotechnical and phytosanitary inspection.
- Each producer of forestry seedlings is required to maintain a register of stock accounts, which must be signed and initialled by the territorially competent Conservator of Forests.

- The phytotechnical inspection of forestry seedlings includes an assessment of the age, quality, and size of the seedlings.
- The phytotechnical inspection of forestry seedlings includes an assessment of the age, quality, and size of the seedlings. Please note that no changes were made to the content of the original text, as it already adheres to the desired characteristics of objectivity, comprehensibility and logical structure, conventional structure, clear and objective language, format, formal register, balanced writing, precise word choice, and grammatical correctness. The only changes made were to improve the clarity and flow of the text by rephrasing some sentences and adding appropriate punctuation.

This assessment takes into account the condition of the stem and roots, as well as the height of the stem and diameter at the collar.

b. Methodological approach:

To ensure accuracy, the following steps should be taken: first,

- Verify the number of plants declared by the nurseryman; second, determine the quantity of plants per box; third, decide on the number of plants to be checked; fourth, randomly select a sample of boxes; fifth, randomly select 2 to 3 plants per box; and finally, establish the parameters.
- To ensure accuracy, the following steps should be taken: first, verify the number of plants declared by the nurseryman; second, determine the quantity of plants per box; third, decide on the number of plants to be checked; fourth, randomly select a sample of boxes; fifth, randomly select 2 to 3 plants per box; and finally, establish the parameters. It is important to maintain objectivity throughout the process and avoid any biased language or subjective evaluations.

c. Phytotechnical and phytosanitary conditions and standards for forest seedlings (Algeria - Official Journal No. 2016-64):

- To encourage self-cultivation of the roots, containerised forestry seedlings should be grown on raised frames.

- Bare-root, tall-stemmed forestry seedlings, on the other hand, should be grown exclusively on the ground.

- The substrate used for the production of forestry seedlings must be well-aerated (with a total porosity of 60 to 80%) and have good water retention capacity. It must also be free of all pathogens.

- Forestry seedlings should be produced in non-cylindrical, rigid, bottomless WM containers.

- Polyethylene bags are not permitted.

- The shade canopy must be made of nylon fibre (polypropylene) and folded down on the sides to the ground. Irrigation should be done by misting, which is best suited for the production of raised seedlings.

- Plants must be hardened off as the planting season approaches. This involves reducing the frequency of watering and removing the combrières to prepare the plants for environmental conditions.

- **Aerial part control**:

- The plants in the bed should be uniform in terms of height and appearance, with all plants being healthy.
- For high-stemmed plants, the stem should be straight and have a calibre of at least 2 cm from the collar.
- The size of the stem above the collar must be between 10 and 15 cm for softwoods and over 35 cm for hardwoods, with a minimum height of 60 cm and two-thirds (2/3) of the stem in the case of high-stemmed plants.

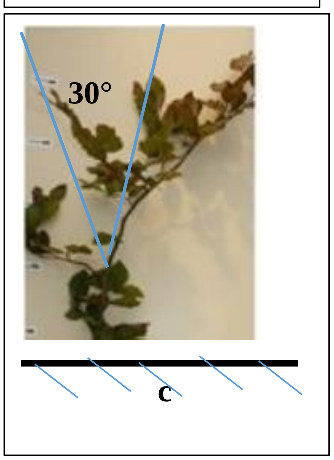
- **Root part control**:

  - Ensure that the pivot is straight;
  - Ensure that the secondary roots are abundant;
  - For high-stemmed plants, ensure that the main root is free of any deformities and is at least 20 cm long for seedlings;
  - Ensure that the root system is abundant and bushy, and at least 20 cm long for plants grown from cuttings.

- Redhibitory defects of the aerial part (Figure 17):

a. Presence of forcks on plants.

b. Stem sinuosity.



c. Inclined stem.

Figure 17: Schematic representation of the most common above-ground defects in nursery stock production.

d. Lateral hypertrophy.

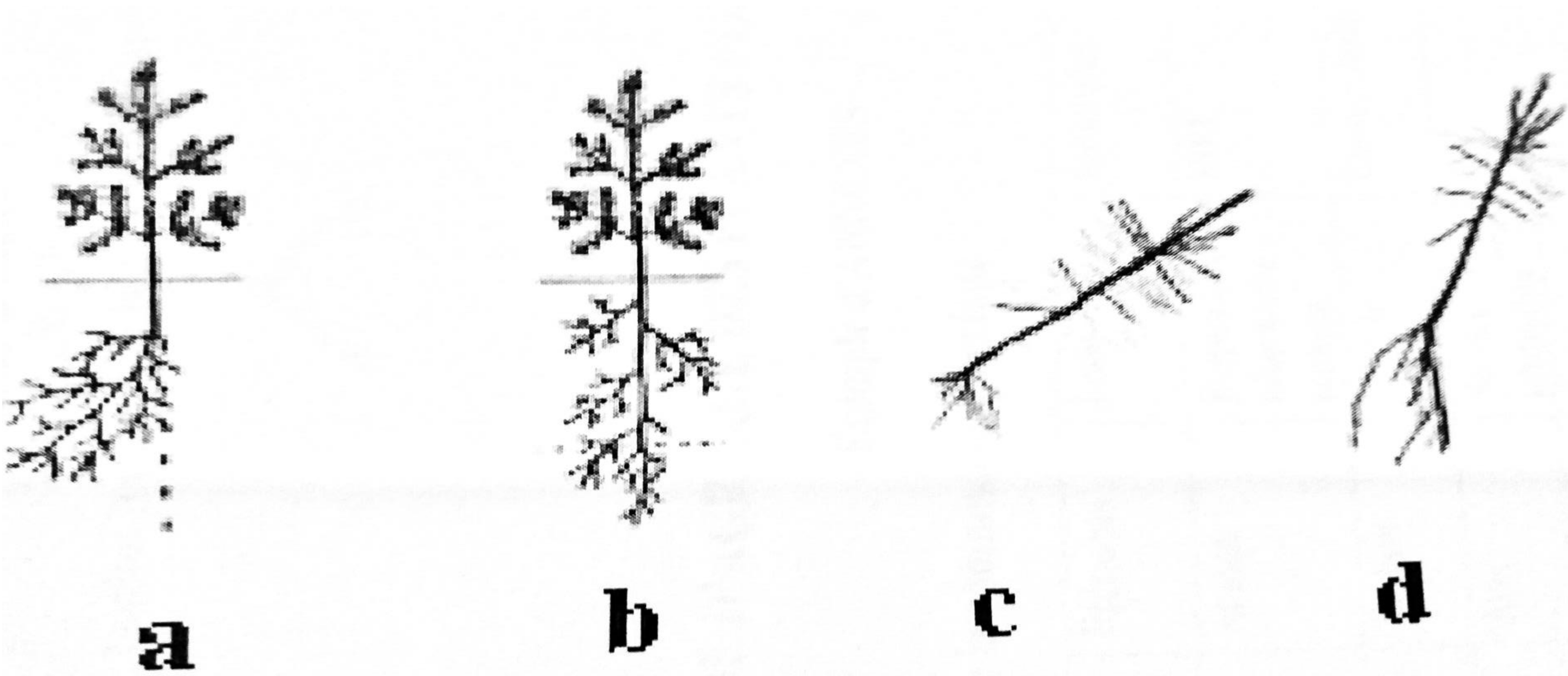
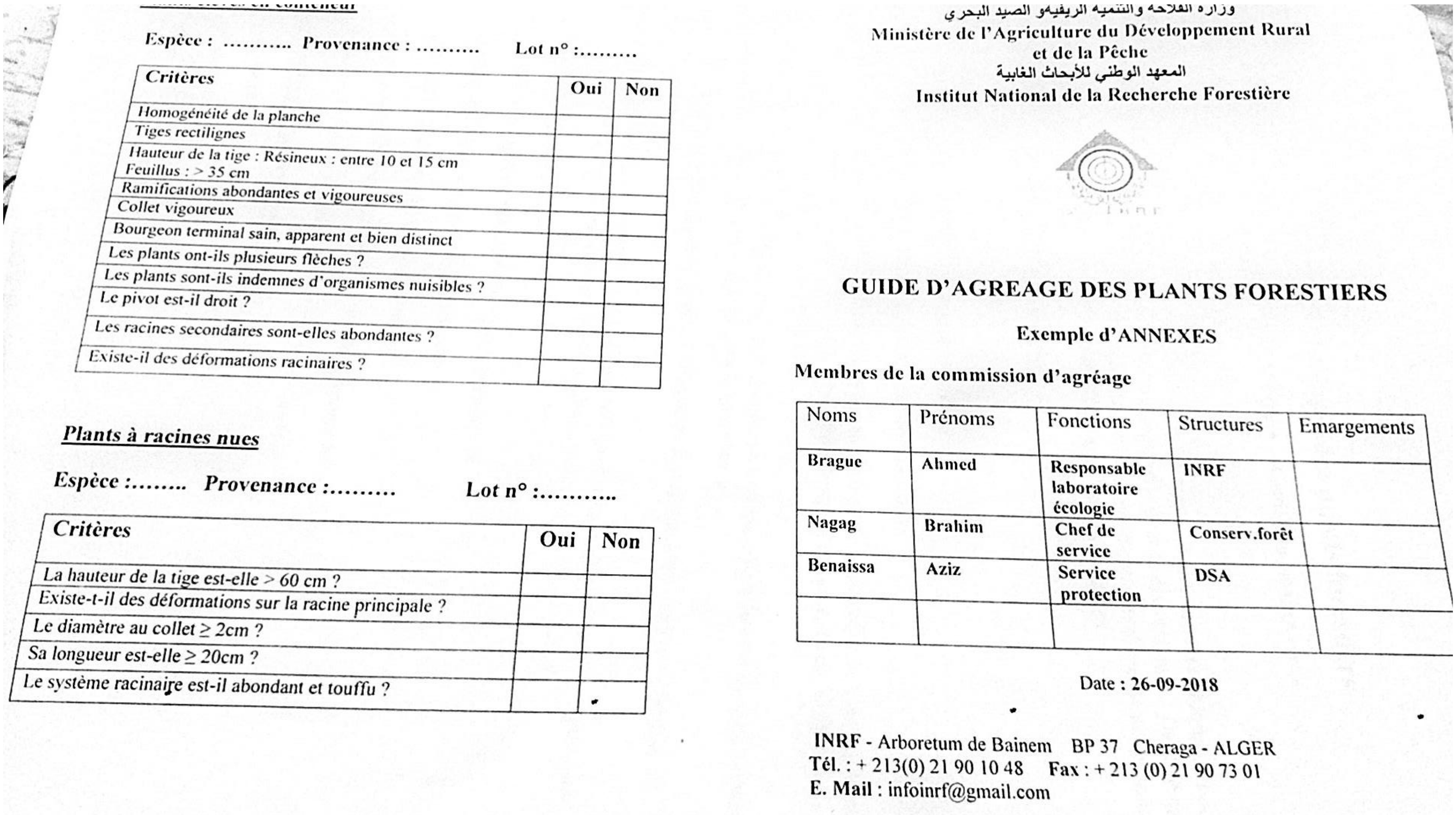


Figure 18 : Unacceptable root defects. A. Misaligned root system; b. Extended root system; superficial root system; d. Lateral root system



Espèce : ………. Provenance : ………. Lot n° :………

Critères	Oui	Non
Homogénéité de la planche		
Tiges rectilignes		
Hauteur de la tige : Résineux : entre 10 et 15 cm Feuillus : > 35 cm		
Ramifications abondantes et vigoureuses		
Collet vigoureux		
Bourgeon terminal sain, apparent et bien distinct		
Les plants ont-ils plusieurs flèches ?		
Les plants sont-ils indemnes d'organismes nuisibles ?		
Le pivot est-il droit ?		
Les racines secondaires sont-elles abondantes ?		
Existe-il des déformations racinaires ?		

Plants à racines nues

Espèce :…….. Provenance :……… Lot n° :………..

Critères	Oui	Non
La hauteur de la tige est-elle > 60 cm ?		
Existe-t-il des déformations sur la racine principale ?		
Le diamètre au collet ≥ 2cm ?		
Sa longueur est-elle ≥ 20cm ?		
Le système racinaire est-il abondant et touffu ?		

وزارة الفلاحة والتنمية الريفية و الصيد البحري

Ministère de l'Agriculture du Développement Rural et de la Pêche

المعهد الوطني للأبحاث الغابية

Institut National de la Recherche Forestière

GUIDE D'AGREAGE DES PLANTS FORESTIERS

Exemple d'ANNEXES

Membres de la commission d'agréage

Noms	Prénoms	Fonctions	Structures	Emargements
Brague	Ahmed	Responsable laboratoire écologie	INRF	
Nagag	Brahim	Chef de service	Conserv.forêt	
Benaissa	Aziz	Service protection	DSA	

Date : 26-09-2018

INRF - Arboretum de Bainem BP 37 Cheraga - ALGER
Tél. : + 213(0) 21 90 10 48 Fax : + 213 (0) 21 90 73 01
E. Mail : infoinrf@gmail.com

Figure 19 : Model control sheet for forestry seedlings (Brague, 2023).

ORGANISME ALGERIEN D'ACCREDITATION

ALGERAC

الهيئة الجزائرية للاعتماد

Organisme Algérien d'Accréditation

Essais 1-2-009

Certificat d'Accréditation

N°: 1-2-009

ALGERAC reconnu par le décret n° 05-466 du 06 décembre 2005, Atteste que le

Centre National de Contrôle et de Certification des semences et plants C.N.C.C

6 Bis, rue des frères OUADEK
Hassen Badi 16200 El Harrach, ALGER

est accrédité selon la norme ISO/CEI 17025:2005 et les règles d'application d'ALGERAC pour les activités d'essais suivantes :

- ✓ **Essai physique et physiologique des semences de céréales.**
- ✓ **Analyses virologiques sur matériel végétal de propagation.**

Les activités et les sites concernés, couverts par l'accréditation sont décrits dans l'annexe technique qui fait partie intégrante du présent certificat

Durant la validité du présent certificat, l'organisme s'engage à respecter les exigences de l'accréditation.

Le Directeur Général

Date d'octroi : 17/07/2014
Date de fin de validité : 17/07/2017

Noureddine BOUDISSA

FOR 16 Rev 03/22-04-2014

Figure 20 : Example of an Accreditation certificate.

1.6.2. Steps in the inspection application:

- To complete the inspection application, you must fill out two forms: the plant production declaration form and the propagation plant material production declaration form.
- Both forms must be approved by the Direction des Services Agricoles.
- Additionally, you must provide proof of the origin of the plant material.
- Plot plan of the nursery.
- The application must be submitted to the CNCC (Centre National de Certification des Semences et des Plants) between 2nd May and 31st July.

Part 2: Herbaceous plants: Part 2: Herbaceous plants are propagated by sexual reproduction through seed production.

II.1 Relationship between breeding and seed production:

II.1.1. Definition and importance of seeds: Seeds are the primary means of conserving and propagating over 95% of plant species.

They are either dry, indehiscent fruits known as achenes or dense, globular inflorescences called glomenules that produce several seeds.

In phytochemistry, the seed is responsible for reproducing the plant.

Seeds played a crucial role in the development of the first civilizations, and they continue to form the foundation of the world's food supply. The emergence of agriculture in the Middle Ages, around 10,000 years ago, is closely linked to the cultivation of primitive forms of wheat and barley, which are the ancestors of our modern varieties (Turner, 2013). Laboratory tests are used to assess and control the agricultural value of a seed. These tests relate to the purity of the species, which is measured by the quantity and quality of impurities per kilogram of seed, and the germination capacity, which is the number of grains capable of germinating out of 100 pure seeds (Maciejewski, 2013).

II.1.2. Seed production: Seed production depends on crop improvement, which in turn depends on plant breeding.

2.1.2.1. Definition of plant breeding: Plant breeding is the process of improving plants with the primary aim of increasing yields. This is achieved by creating new combinations of genes that provide greater benefits to farmers (Turner, 2013).

Plant breeding involves two distinct activities:

- Creative selection, which ensures the creation of new varieties,
- And conservation breeding, which ensures the maintenance of specific characteristics of the obtained varieties.

Selection techniques are constantly being renewed in practice, as they are involved in the process of creating and disseminating new varieties (Maciejewski, 2013).

Throughout history, farmers have unknowingly practised selection by cultivating wild species and adapting them to their region. They obtained seeds by setting aside a portion of their harvests (Turner, 2013). This selection technique, now known as massal selection, was the only method used until the mid-20th century (Maciejewski, 2013). Over time, some farmers were recognised as seed producers, and some traders began offering selected and improved seeds or seeds imported from other regions (Turner, 2013). The emergence of the green revolution and the prospect of feeding 9 billion people by 2050 transformed the vision of breeding. Breeding techniques have been used to modify the genetic material of plants, with the goal of developing new crop varieties that are more productive and better suited to the varying climatic conditions found throughout the world (Maciejewski, 2013).

2.1.2.2. Seed production stages:

Seed production corresponds to varietal creation, which aims to produce new and better-performing varieties based on the natural reservoir of genetic variability. Gene banks have been established to preserve the world's biological heritage. They study as many existing lines and populations as possible. Based on this material, the breeder creates new material to increase the initial genetic variability. This process involves several stages:

- Starting material can be created through simple crosses, recurrent selection, mutation, or gene transfer

- Creative selection can be achieved through genealogical selection, mass selection, or the 'single seed descent' (SSD) technique.

- Creative selection can be achieved through genealogical selection, mass selection, or the 'single seed descent' (SSD) technique. - It is important to maintain a clear and logical structure when presenting these methods.

a. First stage: Production of basic seeds: corresponds to the creation of starting material:

The purpose of starting material, also known as near-basic seed, is to maintain and multiply improved lines or clones. It is used by breeders for self-pollinating plants when the varieties are pure lines.

Cross-breeding requires the use of genitors and, for greater diversity, the breeder may use as many genitors as possible. Cross-breeding occurs naturally in cross-pollinating species, while in self-pollinating species, it is carried out by the breeder (see Figure ...).

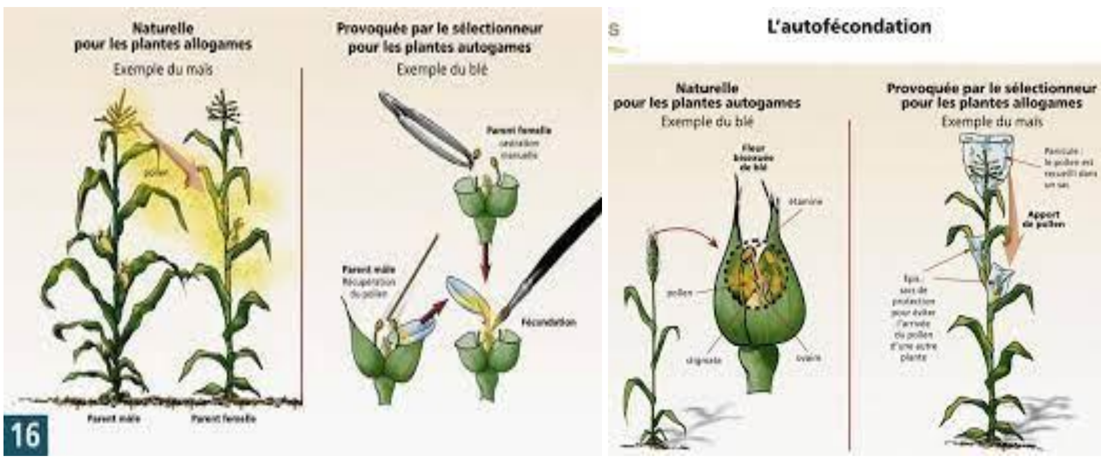


Figure 21: Crossing for the creation of starting material. Natural for cross-pollinated plants. And induced by the breeder for self-pollinating plants such as wheat.

Example: Creating starting material for wheat.

- Manual castration of a wheat ear: the female ear is castrated. This very long operation - 10 minutes to remove all the stamens from the flowers of a single ear of wheat - requires meticulous attention to detail. If any stamens are left out, the cross will be cancelled. The ear is then bagged. Male ears are then brought under the bag to allow pollination.

Recurrent selection: is the second stage in the creation of starting material. The aim of this selection method is to firmly introduce a trait, such as several disease resistance genes, to create a new population that will be used as starting material (Maciejewski, 2013).

- Other techniques for creating starting material include mutagenesis, which can occur naturally or be induced by the breeder. Genetic engineering is also a tool that can be used to directly manipulate genetic material by combining desirable genes from different individuals or species.

- Creative selection involves crossing two desirable parents, A and B, to produce an F1 hybrid.

This selection is based on Mendel's laws. The first law states that F1 seeds will be very homogeneous. Subsequently, self-fertilisation of the F1 products will produce the highly heterozygous F2, which will serve as the starting material for creative selection. Year 0:

Genitors A X B

Year 1: F1: Self-fertilisation

Year 2: F2: very highly heterozygous generation = material starting material for creative selection.

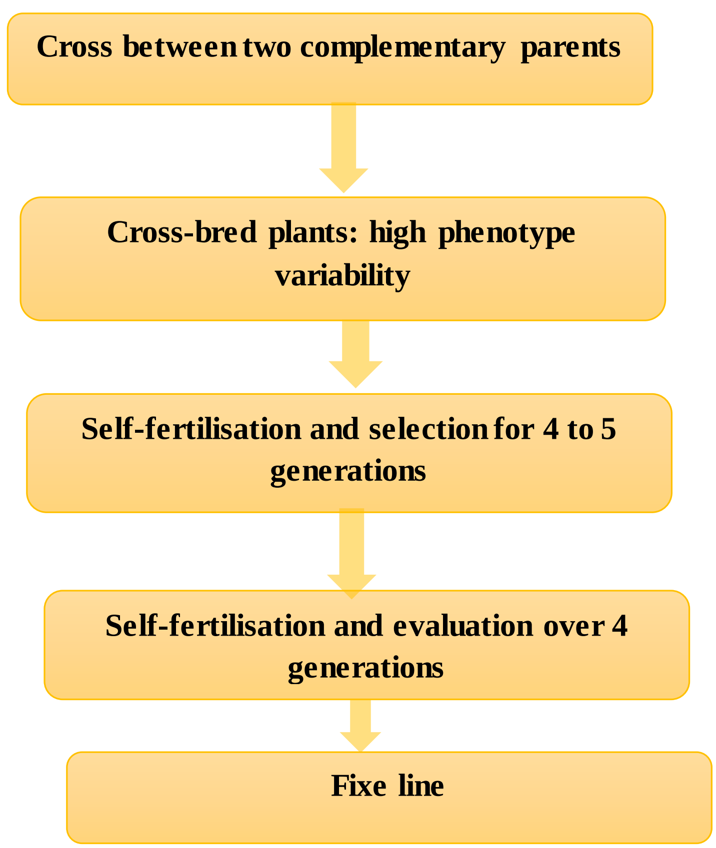


Figure 22: Principle of pedigree selection for the creation of basic seed.

The primary challenge at this stage is to maintain varietal purity. To achieve this, a conservative selection process is carried out using the genealogical method (refer to the genealogical selection chart). This selection and variety creation stage is time-consuming, taking between 8 and 10 years.

Varietal purity: is defined as: This section discusses the degree to which a seed lot conforms to a variety defined by a set of morphological and physiological characteristics, such as resistance to cold or disease.

c.The second stage: That involves seed multiplication and maintenance. To produce high-quality seed, it is essential to manage the seed production field and the seed batch from the harvest effectively (Turner, 2013).

To achieve the seed quality required by farmers, it is essential to maintain several cycles of multiplication.

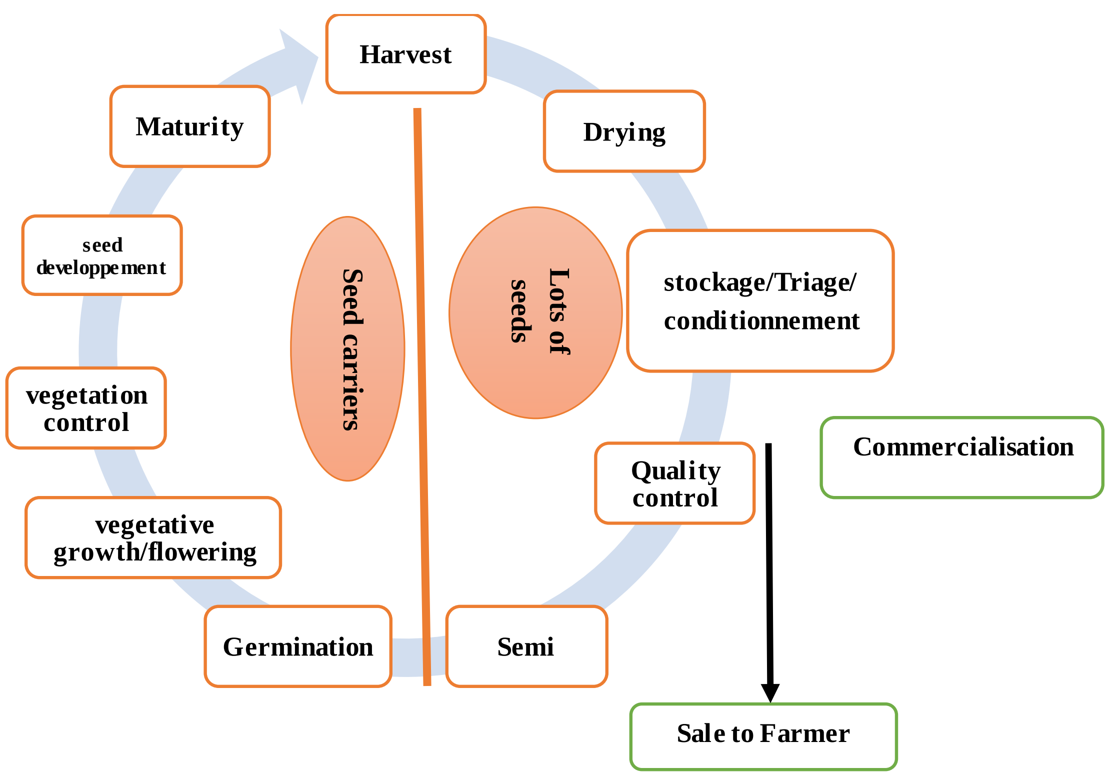


Figure 23: Seed production cycle.

Seeds intended for marketing are produced by multiplier producers. The farmer signs a multiplication contract with a plant breeder who supplies the basic seeds. Cultivation and harvesting are subject to precise technical rules.

For example, the production of hybrid seeds, such as tomatoes, requires the isolation of production fields.

Additionally, the layout of male and female

plants and castration are necessary to prevent pollination by foreign pollen.

The establishment verifies that the seed batch delivered by the farmer multiplier meets the approval standards outlined in the agreement.

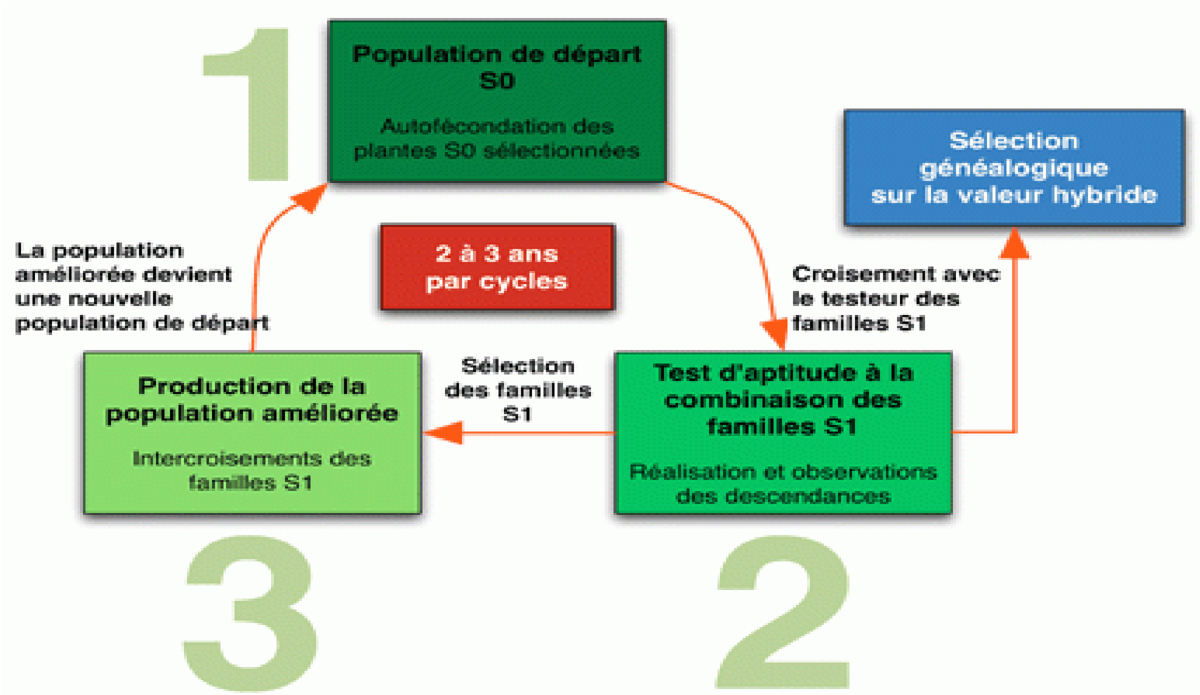


Figure 24: Purpose of selection - Creating a pure line for the basic seed.

II.2. Types of seeds:

Seeds are subdivided into three types according to the stages of production:

- Near-basic seeds

- Basic seeds: super elite and elite

- Certified seeds.

II.3 Seed Production Fields:

Production Schemes for Self-Pollinating Plants:

Year G0 seeds: Starter line (improved variety).

Year N+1: G1 seeds.

Year N+2: G2 seeds.

Year N+3: G3 seeds: Pre-bases.

Year N+4: basic seeds (Super-Elite and elite) will be used.

Year N+5: certified seeds will be used for cultivation.

Certified seeds and seedlings: Obtaining, preparing, and manufacturing seeds is the culmination of a long process that involves numerous manipulations and checks.

a. **The guarantee:** Seeds meeting the standards imposed by the official control and certification service (OCCS).

   Seeds are certified if they meet the standards set by SOCC, the official control and certification service.

- They must have a maximum water content of 14% and a minimum specific purity.
- The minimum varietal purity.
- Minimum germination capacity of 85% are required.

Specific purity: Sometimes propagated seeds are not pure enough, and are mixed with seeds of other species (weed seeds or seeds foreign to the species) and inert matter (fragments of bark that may contain pathogenic germs, flowers, sand, etc.).

Specific purity is expressed as a percentage, weight, or number of seeds conforming to the required standard. For example, if we have a batch of 10g with 8g of pure seeds, then the specific purity is calculated as follows: 8 x 100 / 10 = 80%.

Germination capacity: That refers to a seed's natural ability to sprout. This ability can diminish over time, but is stronger when seeds are harvested at full maturity and stored properly. There are various reasons why a seed may fail to germinate:

- Scalded seed (empty);

- Parasitized seed;

- Seed coat is very hard;

- Broken seed;

- Aged seed (lost germination capacity due to accelerated ageing caused by storage conditions).

- Seeds retain vitality better when stored at lower temperatures and humidity.

- Germination capacity is determined by the percentage of seeds that have successfully germinated and can produce healthy, viable seedlings in open ground. For example, if 50 out of 100 seeds have germinated, then the germination capacity is 50%.

During preparation, the seeds undergo rigorous sanitary controls to ensure they are free from viruses. Additionally, biochemical measurements are frequently conducted to study enzymatic, respiratory, and photosynthetic activity.

II.4. Harvesting and packaging:

2.4.1. Harvesting seeds in the field:

- Remove panicles with small, poorly formed, or aborted seeds. Also, remove panicles with a high number of mouldy or insect-attacked seeds.

2.4.2. Post-harvest treatment:

a. Drying: Drying takes 5 to 7 days in the sun.

- The humidity level acceptable for preservation is between 8% and 9%, 12% being the maximum.

- Clean the drying area thoroughly before placing another variety in it.

b. Harvesting conditions after drying:

- Do not break or damage the seed,

- Do not mix the seed with soil,

- Do not scatter the seeds,

- Sieve to separate seeds from husks and debris,

- Remove seeds with adherent glumes (glumes that do not detach from the seeds).

c. Calibration:

* The seeds should be calibrated to ensure even size.

* Any broken seeds, stones, dust, or other waste should be separated from the good seed.

* Grading can be done using a grader or a two-level sieve made of wire mesh to sieve the sand.

- Grading is crucial because during laboratory analysis, all contents in the seed samples are considered as seed, including impurities.

- If there are too many impurities, the certification may be rejected.

2.4.3 Seed Treatment and Conservation: Seeds may contain saprophytic or parasitic fungi in their integuments when disinfected with fungicides and insecticides. Treated seeds may become discoloured and unfit for consumption.

* Seeds are marketed either coated or film-coated: Pelleting involves adding neutral products to which fungicides, insecticides, and sometimes growth promoters have been added. The products used must only have a toxic effect on fungi and insect pests of the soil without causing damage to the embryo or young growing organs such as rootlets and tigelle. Additionally, some seeds are treated with products that repel birds.

How to treat and preserve seeds?

- Place the seeds in a container such as a bowl, basin or drum. Add the treatment product and mix thoroughly. Then, put the treated seeds back in a bag and sew or tie the opening. Remember to close the bag tightly after each use. Repeat the treatment every 6 months.

Additionally, it is recommended to place the seeds in new harvest bags, preferably in 50 kg bags per producer to facilitate sampling and increase the success rate at certification.

- Ensure that each batch of seeds is easily accessible to facilitate sampling and stock monitoring in well-ventilated shops. Create one-metre aisles between batches or shop walls. Store the bags in a room away from direct sunlight and humidity, avoiding inhabited houses. Do not place the bags on the ground, as moisture can damage the seeds. Instead, place them on wooden pallets. If the bags must be placed on the ground, treat them against insects. Storage areas must be clean and enclosed.

II.5 Seed production quality control:

How can I obtain certification from the national laboratory of seeds or by another approved laboratory?

"Only species or varieties listed in official catalogues may be used for certified seed production. Etc."

Article 9, Law N° 10-032/P-RM of 07.08.2010.

1. Registration as a seed producer with the relevant departments of the Ministry of Agriculture or representation in the regions/Directorates of Agricultural Services (DSA) is required.
2. Inspector visits: Three field inspections are required based on crop declarations supplied by seed producers to the inspection department. The first inspection is conducted before flowering to check installation conditions, including the origin of the seed, the history of the plot/previous crop, isolation, sowing dates, surface areas, crop condition, and purity.

- During the flowering stage, it is important to assess the crop's health and level of varietal purity. Any diseased plants, off-types, plants of other cultivated species, and weeds that could contaminate the seeds should be removed upon identification.
- After flowering, the varietal purity is re-checked and advice is provided on correct harvesting techniques. Laboratory analyses are conducted on samples taken from the production of accepted varieties following field inspections. Inspectors are responsible for sampling. Certification is authorized upon receiving satisfactory results.

II.6. Case studies: Seed production in leafy vegetables: Lettuce:

- In the case of lettuce, it takes 4 years to obtain the super elite.

<u>1st year:</u> A special selection field is set up just for the 1st cycle of seed production of a new variety.

During the apple phase, the most typical and deserving varieties are selected. According to the following characteristics:

- Earliness,
- The size of the apple
- Leaf colour,
- Length of vegetative growth until the young flowering shoots appear,
- Frost resistance.

In the second year: the selection process involves sowing each elite seed on a plot. During the apple phase, the lines that are most typical of the variety are chosen based on the same criteria. The seeds obtained from the selected lines are then mixed.

In the third year: the elite plants that are typical of the variety are selected and kept for sowing during the apple phase. Non-typical plants will be eliminated before flowering through repeated purification, which involves removing poorly developed and diseased plants, as well as plants that have produced young flowering shoots without forming normal apples.

In the fourth year: the field undergoes a purification process where all non-typical plants, including diseased, undeveloped, and those that have not formed a normal apple, are eliminated through repeated selection. It is important to maintain an isolation space of at least 300m between varieties.

III.1 Production scheme for certified seedlings:

3.1.1. Selection criteria for fruit trees:

- Tree vigour and silhouette;
- Disease resistance;
- Production: Time of ripening, appearance (size, colour, shape, etc.), taste (texture, juiciness, flavour, etc.).

3.1.2. Selection criteria for forest trees:

- Adaptation to climatic conditions,
- Growth (diameter or circumference of the trunk),
- Shape of trunk and branches,
- Wood quality: wood strength,
- vigour: growth in height and width.

3.1.3. Selection criteria for horticulture and ornamentation:

- Aesthetic qualities (shape, colour, stem length, foliage, etc).
- Life span.

- Resistance characteristics.

- Fragrance characteristics (rosé, fruity, lemony, spicy, honeyed, etc.).

3.2. Genetic criteria:

1. Biometric characteristics (in relation to morphological characteristics) : Morphological characteristics, inter and intra population :

- Vegetative development (biometric traits: leaf width, stem length, etc.)

- Reproductive development: roundness.

2. anatomical characteristics: use of electrophoresis to measure genetic variety at the enzymatic level.

3.3. Certified plan production scheme:

- Selection by genealogical hybridisation (10 years of selection and fixing of characteristics, or by micropropagation techniques);

- Multiplication of fixed varieties, respecting the criteria for isolation from production fields.

III.2 Control and certification of seedlings:

The CAC standard for citrus fruit plants. The CAC standard guarantees the varietal identity, health and physiological quality of the plants produced in compliance with the standard's specifications. As a result, 25,000 citrus seedlings with the CAC standard were produced by two approved nursery companies and put on the market at the end of 2008. Upstream of this sector, CIRAD Réunion is responsible for the production and distribution of disease-free grafts, in particular CTV (Citrus Tristeza Virus) and citrus canker (*Xanthomonas axonopodis* pv. Citrii), thanks to the conservation and amplification of varieties protected from all sources of contamination. Varietal identity is also ensured.

CIRAD has also contributed its know-how to the drafting of the Technical Regulations of the CAC Annex for citrus fruits and to the definition of sanitary standards.

There are plans to extend the CAC standard to other tropical species such as mango and lychee.

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