Ministry of Agriculture, Irrigation and Livestock
Department of Horticulture

THE FRUIT TREE NURSERY INDUSTRY OF AFGHANISTAN

TRAINING SERIES 1

THE FRUIT TREE PRODUCTION NURSERY

3

MANUAL

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Training Series 1: The Fruit Tree Nursery Industry

Volumes in this Series:

- Manual 1 The fruit tree nursery growers' associations
- Manual 2 The mother stock nursery
- Manual 3 The fruit tree production nursery

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Introduction

This is the third manual in a series of three. This manual provides a guide for the establishment and management of registered fruit tree nurseries and advises on practical steps to improve the quality of the saplings produced in the nurseries. At the same time, this manual intends to facilitate the development of standard operating procedures for the production of certified fruit trees.

Manual 1 of this Series contains information related to organisation of the nursery industry. We describe the steps to create horticulture associations, and in particular, nursery growers' associations.

Manual 2 of this Series explains the correct use of mother trees for producing certified fruit tree propagation materials: high quality scion materials (graftwood and budwood), cuttings, and seeds for rootstocks.

Manual 3 provides information useful in understanding (a) the certification scheme standards to produce certified saplings; (b) which species are available in Afghanistan to produce rootstocks; (c) how to produce certified saplings and finally, (d) how to manage a commercial registered nursery. The manual concentrates on the most important fruit tree species for commercial production in Afghanistan.

This manual has been designed for extension personnel to train nursery growers. However, it is also suitable for a wide range of users as a reference manual, including university students, teachers, and development organisations working in the perennial horticulture sector. Simple, practical language is used to reach the broadest audience possible.

Content of the manual

The manual is divided into four parts:

- Part 1 discusses the standards for producing certified saplings under the fruit tree certification scheme being developed for Afghanistan.
- Part 2 describes the main characteristics of the rootstocks available in Afghanistan. It further summarises technical information about propagation techniques for rootstocks.
- Part 3 provides technical guidelines for the propagation of varieties using budding and grafting techniques.
- Part 4 provides practical guidelines for establishing and managing a commercial fruit tree nursery, using improved horticulture techniques currently available in Afghanistan. This section also includes an outline of the traceability guidelines proposed for the nursery certification system. This is the "*Field training*" section.

Part 1

Development of an improved nursery industry in Afghanistan: Certified nursery production

After reading Part 1 you will:

- Understand the importance of producing high quality fruit trees in order to improve the nursery industry in Afghanistan
- Learn about the certification scheme procedures for fruit saplings

1. Production of improved fruit trees

The perennial horticulture sector of Afghanistan offers promising development opportunities for high value horticulture products due to excellent agroclimatic conditions for fruit production and significant export market potential.

Nursery growers can improve their nursery businesses by helping their customers, the fruit growers, to develop more profitable orchards. Fruit growers can increase profitability of their orchards by:

- *Increasing orchard yields, especially during the earlier years of the orchard's life.*
- *Growing varieties that mature earlier or later than the main season of supply, in order to achieve higher prices.*
- *Growing varieties that produce fruit with special features consumers are willing to pay more for. These features may relate to colour, size, flavour, fragrance, texture, shape, absence of seeds, ease of peeling, thickness of shells, and others.*
- *Growing varieties that have features desired by traders, such as long shelf-life and ability to withstand rough handling.*
- *Growing varieties that cost less to produce; for example varieties that are less susceptible to pests and diseases and therefore suffer lower losses and require fewer control measures; or varieties that produce smaller sized trees requiring less labour to manage.*

Improvements in technical and managerial capacities, as well as improved access to agricultural inputs are also required for the development of the nursery industry. This is especially important for an export-oriented horticulture sector.

The strategies for achieving these objectives have been described in more detail in Manual 1 of this series *The fruit tree nursery industry of Afghanistan*. Here, we summarize briefly:

1. Development of reliable fruit tree suppliers: organize nursery growers in nursery growers' associations (NGAs), registered as members of the

Afghanistan National Nursery Growers' Organization (ANNGO) (see Manual 1 *Series 1*).

2. Implementation of a system of inspection and certification of fruit tree nursery products to produce certified budwood, cuttings (see Manual 2 *Series 1*), and rootstocks (see Manuals 2 and 3 *Series 1*).
3. Building the nursery growers knowledge and skills in improved horticulture techniques. The propagation of modern, valuable varieties and suitable rootstocks (see Manual 3 *Series 1*) is one of the most important aspects to be considered in training.

A registered production nursery can participate in the fruit tree certification scheme that aims to provide commercial fruit growers with sufficient certified true-to-type fruit tree saplings, proven in terms of health and vigour.

2. The fruit tree certification scheme

The Afghanistan National Nursery Growers' Organization (ANNGO) and its members lead the implementation of a fruit tree certification scheme which aims to provide commercial fruit growers with certified true-to-type fruit tree saplings of proven health and vigour.

2.1. How does the certification scheme work?

Material entered into the scheme must be of known lineage. All materials must be grown under specific conditions with regard to site and isolation from other crops. During the course of the growing season, the crop will be inspected at least once by the PHDP project or PHDP-authorized inspectors. Until an in-country laboratory becomes available, assessments will normally be made on the basis of visual examinations.

2.2. Certification

If plants submitted for certification are found to meet all required criteria, a numbered certificate will be issued. This certificate is a label that will be attached to the fruit tree. The certificate will have a specific period of validity.

2.3. What are the advantages of buying certified material?

The certification authority cannot guarantee that every plant certified under the scheme will be completely free of pests or diseases. However, certified plants are grown under strict conditions that provide valuable plant health assurances.

Participation in the certification scheme affords nursery growers with opportunities to increase their profitability by supplying to the market high value saplings that are:

- Budded with scion varieties suited to the requirements of growers, traders and consumers
- True-to-type
- Free of harmful pests and diseases
- Grown on appropriate rootstocks
- Grown in the correct manner

2.4. What are the requirements for registration and certification?

Nursery growers wishing to participate in the certification scheme should be members of an officially registered Nursery Growers' Association (NGA). In turn, their NGA should be a member of the Afghanistan National Nursery Growers' Organization (ANNGO). The nursery should submit an application form to register their nursery (refer to Manual 1 of this *Series*). Then, after receiving a nursery registration code, the nursery grower should submit an application to certify planting materials produced in his nursery. Not all material produced in the nursery has to be submitted for certification, but all material that is submitted must meet all the scheme's standards and be clearly identifiable, i.e. differentiated from material that is not part of the certification scheme.

For further details about the registration and certification requirements, refer to the ANNGO certification scheme, in Annex 3 of Manual 1 The fruit tree nursery growers association.

3. The certified fruit sapling

A certified fruit sapling is a sapling or tree that has been produced using certified true to type propagation materials. "True-to-type propagation materials" refers to materials coming from registered mother stock trees. A certified fruit sapling has been checked and identified by inspectors as true-to-type. This certification protects the orchard growers against planting unwanted or unknown varieties.

3.1. Budwood and cutting materials

Certified mother stock propagation materials, budwood (or scion material) and cuttings carry the commercially valuable characteristics for the orchard grower.

For the production of a certified sapling, certified propagation materials have to be purchased from a registered mother stock nursery. Please refer to Manual 2 *The mother stock nursery* of this Series for more details about the characteristics of the certified propagation materials, and how to produce them.

3.2. Rootstocks

Rootstocks are the part of the grafted or budded tree that will become the root system of the plant. There are several propagation methods to produce rootstocks. Some of these methods require specific skills and knowledge of plant function to improve the success of multiplication. For producing a certified sapling, certified rootstocks have to be produced by a registered nursery.

Rootstocks can be produced from seeds (sexual reproduction) or from other parts of the plants (asexual reproduction or vegetative propagation). The most common multiplication technique to obtain rootstocks on which to graft or bud varieties is from seed. Accordingly, they are known as "seedling rootstocks". This technique is easier and more economical than clonal propagation. The rootstocks produced by vegetative techniques are called "clonal rootstocks". Clonal rootstocks have characteristics identical to the mother plant. The methods of propagation will be explained in detail in Part 2 of this manual.

3.3. Standards for certified fruit saplings

A fruit sapling can be certified if the following characteristics are observed:

- True-to-type: known varieties
- Healthy, disease free plants
- Certification scheme procedures carefully followed
- Certification documents carefully completed

Part 4 of this manual presents a comprehensive description of the standards to produce certified fruit saplings.

Figure 1: *PHDC nursery in Kunduz province (E. Vernon)*

Part 2

Production of certified fruit saplings: Fruit tree rootstocks

After reading Part 2 you will understand:

- The role of fruit rootstocks in the production of high quality fruit saplings
- Rootstock selection in Afghanistan
- The different techniques available to propagate rootstocks: Seed and clonal propagation

Fruit tree propagation is an important activity for enhancing plant quality in the nursery industry. Most of the fruit trees produced in Afghanistan yield much less than the average potential of the species. This situation is the result of poor orchard management (this topic will be further discussed); however, it is also the result of poor quality of the nursery plants produced. This section focuses on the importance of production of appropriate saplings of known genetic origin and proven good health status.

In order to grow trees that are true-to-type, most commercial fruit trees are propagated by budding or grafting sections of known varieties (scions) onto special rootstocks. For many species, there are different possible scion/rootstock combinations suitable for different needs or site conditions.

In this section, we will describe the methods for producing seedling and clonal rootstocks. In part 3 you will learn how to propagate the chosen variety by budding on selected rootstocks.

Photo L. Imburgia

1. Certified fruit tree rootstocks

1.1. Selection of rootstocks

The choice of rootstock should consider the conditions imposed by local climate and soils. Compatibility with the common local varieties used must be also considered.

The performance of the scion (i.e., the variety expression) is affected by the rootstock in important ways. Rootstocks are responsible for the water and nutrient uptake, and give anchorage to the tree. Rootstocks also affect tree vigour and determine the final size of the tree. Some rootstocks are more susceptible to diseases or insects than others. Rootstocks also provide different degrees of tolerance to soils that are sometimes too wet or too dry, too salty or too alkaline. Thus, the selection of the rootstock has to be made very carefully.

The influence of the rootstock on the variety can be mostly observed in the quantity of fruits per tree (yield efficiency), and some influences in fruit texture and flavour (fruit quality). Both attributes are of major importance in fruit production, given that they ultimately define the orchard profit (For further description of fruit production and quality, refer to Manual 4 of *The Orchard Management Series*).

When selecting rootstocks, there are important traits to consider. A suitable rootstock should be compatible with the scion variety, and should provide adequate fruit quality and quantity of production. Further important criteria guiding rootstock selection include growth control, adaptation to local soil and climatic variables, resistance to insects and diseases, precocity and yield efficiency, anchorage and ease of propagation.

1.2. Types of rootstocks

Currently, the trend in perennial fruit production is to increase plant density in orchards. Higher fruit tree densities lead to precocious (early) production and to higher productivity per unit of land (higher crop efficiency). This management is made possible by the introduction of so-called “dwarfing” rootstocks. This kind of rootstock produces smaller trees, which have additional advantages such as allowing better light distribution, improved yield efficiency and fruit quality. Further, these orchards are cheaper to manage, due to reduced labour demand for pruning, harvesting and other management tasks.

Rootstocks also differ in the frequency of occurrence of root initials (burrknots) on the above-ground stem. Burrknots are unwanted because they form points of entry for serious diseases, such as fire blight and fruit-tree canker. They also facilitate the damage caused by harmful insects. Moreover, burrknots are spots of lower winter hardiness and, if they occur near the union between the rootstock and the scion, they increase the incidence of scion rooting. Burrknots lead to heterogeneity of the orchard. Burrknots on the rootstock stem actively compete for nutrients, and reduce tree growth.

Each variety of fruit will have a rootstock that gives the best performance in any specific circumstances. Generally, the rootstock should be of the same genus as the variety to produce a successful graft. Table 1 describes the main rootstocks under evaluation at MAIL - PHD Centres.

Table 1: *Main fruit tree rootstocks available in Afghanistan*

Crop Species	Rootstock type	Rootstock characteristic
Apple	Apple seedling *(Malus domestica)*	If apple is grafted onto an apple seedling, the resulting tree is very large and comes late into production. Pruning, harvesting and pest management of these vigorous trees is difficult and expensive. A wide range of clonal rootstock choices have been developed so apple seedling rootstocks should not be used.
	Clonal apple *(Malus domestica)*	A large number of clonal rootstocks are available for apple. They will produce trees of varying sizes (including dwarfing rootstocks), winter hardiness, resistance to certain insects and diseases, and performance in a wide range of soils types. Most of the dwarf rootstocks offer precocity (fruit production early in the tree's life) as an additional benefit. Dwarfing rootstocks must be propagated asexually since they will not come true to type from seed. Apple cuttings are also difficult to root. Layering is the most common propagation technique used. Several of these apple rootstocks are available in Afghanistan. Since the labour cost in Afghanistan is not the main cost constraint, small tree size is not as important a concern as other rootstock attributes such as adaptation to poor soil conditions, hardiness and high soil temperatures in summer. Rootstocks are mostly affected by the same pests and diseases that affect scion varieties. Among the most important are: the woolly apple aphid *(Eriosoma lanigerum)*, bacterial fireblight *(Erwinia amylovora)*, and fungal crown rot *(Phytophthora)*. **Clonal apple rootstocks available in Afghanistan** M9: Dwarf tree. It roots well in stoolbeds but production per bed is low. Very precocious; fruit colours and sizes well. Poor anchorage; must have support throughout the tree's life. This is the major rootstock used for high-density plantings. It should be planted on sites that have deep, fertile, well-drained soils. M7: Semi-dwarfing rootstock. It is moderately vigorous. It has a high cropping efficiency, high adaptability to a range of soils and climates. The main drawback is its tendency to sucker. M26: Vigour is in between M9 and MM 106. It produces well in stoolbeds. Mildly susceptible to collar rot. Susceptible to woolly aphid and fireblight. Prone to burrknots. It is the most winter hardy of all M rootstocks. It is drought susceptible. Dwarf rootstock for high-density plantings. May need support under some soil conditions (poor drainage). Suitable for precocious varieties. MM106: Medium vigour, precocity, high productivity, good anchorage, no root suckers, and easy propagation by layering in stoolbeds. It is woolly aphid resistant. Drawbacks are susceptible to fireblight and crown rot. This is the most popular apple rootstock for well drained soils. It is not recommended for heavy or poorly drained soils. Suitable for semi-intensive plantings. MM111: Medium vigour (but more vigorous than MM 106). It is adapted to heavy soils with few losses from collar rot. Good anchorage. It is used for spur-type varieties, and in replant land (i.e. land where apple trees have been grown before). Very productive. Collar rot and woolly aphid resistant. It can be used with precocious varieties and compact spur-type varieties, on shallow, less fertile soils. B9: Similar in vigour and performance to M9, with better frost tolerance, plus better resistance to crown rot disease. Can be identified in the nursery by its red leaves.
Pear	Pear seedling *(Pyrus communis)*	Wild pear varieties are used to produce seedling rootstock for budding commercial pear varieties. Pear seedling rootstocks produce trees that are vigorous and productive, and reasonably winter hardy. They can adapt to a wide range of soils. The most problematic diseases are fireblight *(Erwinia amylovora)*, and pear decline (caused by a phytoplasm).
	Clonal pear (*P. communis)*	**Clonal pear rootstocks available in Afghanistan** Clonal *pyrodwarf* has low vigour. It has high precocity (2 to 3 years), good yield efficiency, uniform fruit size, good anchorage, winter hardiness, no sucker production, and no lime-induced chlorosis in high pH soils. It has medium susceptibility to fireblight. Its susceptibility to pear decline is unknown. It is easily propagated by cuttings. *Pyrodwarf* is suitable for high density planting.

Pear	Clonal quince (*Cydonia oblonga)*	Quince is the standard dwarf rootstock for pear. Quince and pear are often incompatible and must be double-worked with a compatible interstem. In hot climates there are more compatibility problems than in cooler areas. Quince has limited winter hardiness and is susceptible to lime-induced iron chlorosis in the case of calcareous soils. Propagation is easily done by hard cuttings, and it is highly productive on stool beds. It has high tolerance to woolly aphid, resistance to root lesion nematode, mildew and crown gall. It is susceptible to quince fleck and fireblight. The main quince rootstocks in Afghanistan are A 332 and B29.
Almond	Bitter almond seedling *(Prunus dulcis)*	The almond seedling rootstock has deep root system, and tolerance to calcareous and drought soil. However, this seedling rootstock is sensitive to salinity and water logged soil. It requires well drained soils. The almond seedling rootstock is sensitive to crown gall, *Armillaria*, crown rot and verticillium wilt *(Verticilium)*. It is the standard rootstock for almond in Afghanistan.
	GF 677 (*P. persicae x P. amygdalus)*	GF677 is a vigorous, precocious and high yielding rootstock, with good fruit size. It has excellent compatibility with most *Prunus sp*. It is suitable for planting on well drained, high pH, sandy soils. Very fertile soils should be avoided. It is not susceptible to re-plant disorders where continuous cropping of *Prunus* is practiced. It is sensitive to nematodes, and susceptible to crown gall. It does not sucker. Its main drawback is the difficulty for propagation. It does not root readily from cuttings or layers. It is propagated by micropropagation. However, it is the rootstock most widely used for almond worldwide. PHDP will experiment this rootstock in demonstration orchards.
Peach	Peach seedling (*Prunus persica*)	Peach seedling is a good rootstock for peach, and widely used. Sensitive to calcareous and drought soils. PSB2 and the local Urdu Khan 1 are clonal peach rootstocks under evaluation by PHDP.
Apricot	Bitter apricot seedling (*Prunus armeniaca*)	Bitter apricot seeds are used as seedling rootstocks. This rootstock is well adapted to drought and light soils. Plum is also budded on apricot.
Cherry	Mazzard (*Prunus avium)*	Mazzard is vigorous, with variable sucker production. It is moderately cold hardy, and compatible to most sweet varieties. It is fairly tolerant to *Phytophthora*. Mahaleb seedling is tolerant to drought and calcareous soils and compatible with all varieties of sweet and sour cherry. This rootstock produces few suckers; it is cold hardy, and more precocious than *P. avium*. Mahaleb is propagated from seed. It is susceptible to *Phytophthora*, and *Armillaria*.
	Mahaleb (*P.mahaleb*)	**Clonal cherry rootstocks available in Afghanistan** Clonal Mahaleb SL 64 is less vigorous than the seedling rootstock, precocious, productive with high quality fruit production. It is compatible with all varieties of sweet and sour cherries. It produces fewer suckers and it behaves well in dry conditions, sandy and calcareous soils. It is less tolerant to wet soils. It is tolerant to *Agrobacterium tumefaciens* and *Pseudomonas*, but sensitive to A. mellea and *Phytophthora*. Mahaleb SL 64 is propagated by semi-hard cuttings.
	Colt (P. avium x P.pseudocerasus)	Colt *(P. aviumxP.pseudocerasus)* is a rather vigorous rootstock, but very easy to manage since the angle branches are excellent and the trees are rather compact. Fruit quality is good, which can be due to moderate cropping per unit of growth. It does not perform well under dry or calcareous conditions.
Plum	European plum (*Prunus domestica*)	For many plum varieties, rootstocks are not needed. For those varieties that do not perform well on their own roots, most plum rootstocks belong to the common plum *(P. domestica)* and myrobalan. These rootstocks induce vigorous or semi-vigorous growth, leading to rather large trees. Incompatibilities between scion and cultivar may occur. Plum rootstocks have moderate tolerance to wet soils. Myrobalan and Mariana rootstocks

Plum		show resistance to *Phytophthora* (often related to wet soil conditions). Plums are susceptible to verticillium wilt *(Verticillium ssp.)*. Nematodes can be serious pests in warmer areas. There are great differences in susceptibility among different rootstocks. *Meloidogyne* species or root knot nematodes are among the most damaging. Propagation is easy through hard cuttings of myrobalan and Mariana.
	Myrobalan (*P. ceracifera*)	Myrobalan is a very important and widely used rootstock for plum. It is cheap, easily obtained and it crops well. It has good anchorage. It is tolerant to drought and relatively tolerant to *Phytophthora*. Myrobalan 29C is the most common rootstock used. Drawbacks are quite many: too vigorous growth, there can be much tree variability, thus it is difficult to obtain uniform plantings. Trees start to crop late, and the roots freeze easily in climates with harsh winters. Myrabolan seedlings are incompatible with some cultivars. They have low resistance to crown gall, are less resistant to root asphyxia than Mariana, and tend to produce shoots at the rootstock stem. Myrobalan has great adaptability to different climatic conditions and soils. This is one of the most used rootstocks for budding plum and apricot.
	Mariana (*P. cerasus* x *P munsoniana*)	Mariana GF 8-1 (open pollinated seeding of Mariana) is a very vigorous rootstock that can be used on many soil types. It suits calcareous soils (with less than 10% active calcium), and also heavy soils, since it is resistant to root asphyxia. On sandy soils suckering can be abundant. It is resistant to *Armillaria* and *Meloidogyne* nematodes. Mariana 2624 tolerates heavy soils.
Citrus		*Poncirus trifoliata* is generally a good rootstock for oranges, satisfactory for grapefruit (although small fruit size is sometimes reported), most mandarins and lemons with the exception of Eureka lemon. Trees on *P. trifoliata* grow well on fertile clays to loams but are intolerant of highly acid or highly alkaline soils. They also react to saline conditions. It is one of the preferred rootstocks for replant sites. It has poor drought tolerance. It is highly resistant to *Phytophthora* root and collar rots caused by the fungus *Phytophthora citrophthora* and to the citrus nematode *Tylenchulus semipenetrans*. It is tolerant of citrus tristeza virus. A major drawback in the use of *P. trifoliata* is the slow initial establishment of new plantings. Cropping efficiency and fruit quality is good. Trees propagated on *P. trifoliata* are suitable for planting at high density. In the nursery, the rootstocks are slow growing.
	Trifoliate orange seedlings *(Poncirus trifoliata)*	
	Sour orange seedlings *(Citrus aurantus)*	Sour orange is somewhat tolerant to salinity, alkalinity and less than optimal drainage; it is relatively tolerant to cold, cotton root rot and *Phytophthora*. It is susceptible to citrus nematode and citrus tristeza virus. There is a serious danger that tristeza may soon become a problem in Afghanistan because citrus saplings are being imported from Pakistan where tristeza is present. For this reason, sour orange is not recommended for rootstock in Afghanistan.
	Volkamer lemon seedlings *(C. volkameriana)*	*Volkameriana:* This rootstock is moderately tolerant to salinity and suitable for alkaline soil conditions. It produces vigorous and large trees capable of carrying heavy crop loads. Fruit quality is poor. In the nursery it is a very vigorous and fast-growing rootstock that is easily budded and rapidly available for field planting. *Volkameriana* is highly susceptible to *Phytophthora*, a deadly disease that is widely found in Afghanistan. It requires a high level of nursery hygiene, not currently practiced by nurseries in Afghanistan. Tolerant of citrus tristeza virus, exocortis and xyloporosis viroids.
	Citrange seedlings (X Citroncirus = *Citrus sinensis x Poncirus trifoliata*)	Carrizo and Troyer citange are citrus rootstocks suggested to be worthy of trial in Afghanistan. They are tolerant to tristeza but susceptible to soil alkalinity. PHDP has established registered seed production orchards of Volkamer lemon (South African clone introduced by Roots of Peace), Trifoliate orange (clone Shishembaghi), Citranges Troyer and Carrizo at the PHDC Jalalabad for testing and further introduction in Eastern Afghanistan.

2. Rootstock propagation

Rootstocks can be produced from seeds, called seedling rootstocks, or from other parts of the plants, called clonal rootstocks. Clonal rootstocks are produced by vegetative techniques, and have identical characteristics to the mother plant.

2.1. Seedling rootstocks

The seed of a plant is formed when pollen from a flower fertilises this flower or another flower of the same species, stimulating the development of a fruit. This fruit contains a seed or seeds which, when germinated, will become a new plant. The new tree will inherit many of the characteristics of both parents, and it will not grow "true" to the variety from which it came. In addition, it will develop many unpredictable characteristics of its own. In some cases, the seedling tends to revert to a wild-like state of the species. However, a large number of rootstocks for many temperate and subtropical fruit and nut species are raised by seeds. These species include almond, peach, nectarine, apricot, and citrus. Other species in contrast, require clonal rootstocks for the successful development of the sapling, such as apple.

Most fruit trees are propagated on seedling rootstocks. Seedling rootstocks have important advantages for the nurseryman: They are simple and cheap to produce; they have potential for avoiding transmission of root-borne diseases such as crown gall (*Agrobacterium tumefasciens*).

The main drawback of some seedling rootstocks is the high variability in performance, growth and cropping of many fruit species. In addition, most species multiplied by seeds produce large and late fruit bearing trees. In this Series we mainly describe seed propagation in the context of stone fruit saplings.

2.1.1. Fruit and seed collection

The seeds have to be collected from reliable sources. Seeds may also come from a true-to-type, registered mother tree (see Manual 2 of this Series).

The fruits selected for seed extraction should possess good fruit quality. In most cases, the seeds have to be extracted from ripe fruits. In the case of fleshy fruits (e.g. peaches), they must be kept cool and out of direct sunlight during collection and handling. If the fruits get too warm, the seeds can be damaged. The collection of fleshy fruits must be carried out in white plastic bags or buckets and stored in a cool place or a refrigerator until they are cleaned. The seeds have to be uniform in size, and should be of good quality – there should be no signs of disease or damage.

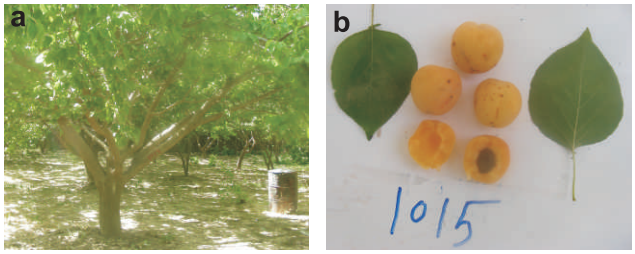

Figure 2: *Mother tree for seed production (a) and variety identification (b) (J.I.Trives)*

2.1.2. Seed extraction

Extracting seeds is necessary for proper storage and sowing. Sometimes seeds will not germinate if they are not removed from fruits. The seed cleaning area should be well ventilated. It is also important to wear gloves and dust masks during cleaning.

The seeds from fleshy fruits must be extracted soon after collection to avoid fermentation, and fungal or bacterial damage. Just before extraction, the fruits should be soaked in water for a few hours to soften the pulp. Flesh can be removed by squeezing fruits off with hands, or mashing the fruits. Seeds can also be extracted by rubbing the soaked fruits against a screen while a stream of water washes the pulp away. Floating seeds are empty and should be removed. Extracted peach stones can be easily cleaned by placing the seed in a cement mixer with some water. Once extracted and washed the seed must be dried in shade and stored in a cool dry place.

Figure 3: *Seed extraction equipment (Source: Infojardin.com)*

2.1.3. Seed germination

Seeds germinate when the proper conditions are provided regarding water, air (oxygen), and temperature. Additionally, some species require exposure to light, and others absence of light.

Mature seeds of most temperate fruit trees will not germinate until they are chilled above freezing point, under moist conditions. Such conditions release seed embryos from rest or dormancy. Seed dormancy is an adaptation that ensures seeds will germinate only during the time period that is favourable for survival. Seed dormancy is highly variable among species or among seed sources of the same species. Seeds can be non-dormant or dormant. Non-dormant seeds can germinate immediately upon maturation and release from the parent plant without any special conditions. Dormant seeds cannot do that, even when proper environmental conditions exist.

Box1: Seed dormancy

Seed dormancy can be caused by:

- *External factors:* the seed has characteristics that create a barrier for water to enter the seed, such as a hard, thick seed coat. *Scarification* is a summary term for any process used in nurseries that modifies seed coats to enable water to enter the seeds. Mechanical scarification and hot water scarification are common methods. The efficacy of those methods depends on the species and the thickness of the seed coats. It is very important to avoid damaging the tissue inside the seeds, the embryo, when performing mechanical scarification.
- *Internal factors:* the seed embryo is still underdeveloped or the seed needs a particular metabolic process. Internal factors can be also a combination of both conditions. After extraction, the seeds of some of the common deciduous fruit trees such as apples, pear, peach, plum and cherries, still need a period of rest under certain conditions before they will germinate. Such seeds have to be stored with alternate layers of moist sand, at a cool temperature (chilling), and must also have suitable moisture conditions before sowing. This process is called stratification, and it helps the embryo (future plant) of the seed to complete development, and remove dormancy. The optimum temperature and duration of chilling varies widely with the species. Usually it is below 7ºC.

Two methods are used to after-ripen dormant fruit tree seeds: *stratification* and *autumn seeding*.

Stratification is a practice that tries to imitate the natural winter conditions that most dormant seeds need to break or alleviate dormancy. Traditionally, stratification is understood as layering seeds between moist strata of soil and exposing them to cold temperatures below 7ºC. Some species require only a few days or weeks of stratification, while others such as *Prunus* require several months. Stratification is also useful to increase vigour (how fast seeds germinate) and uniformity. Before stratification seeds must be soaked in water for 24 to 48 hours.

Sowing seeds in autumn in seedbeds and allowing them to be exposed to winter conditions is a form of stratification. Although easier to perform, this practice has several disadvantages. Seeds can be eaten by birds and rodents, or be washed by rain. Seeds can also be lost if the conditions in early winter are warm enough to cause seeds to germinate and then are killed by the low winter temperatures. It can also happen that the warm weather of early spring stimulates germination that a late frost can kill.

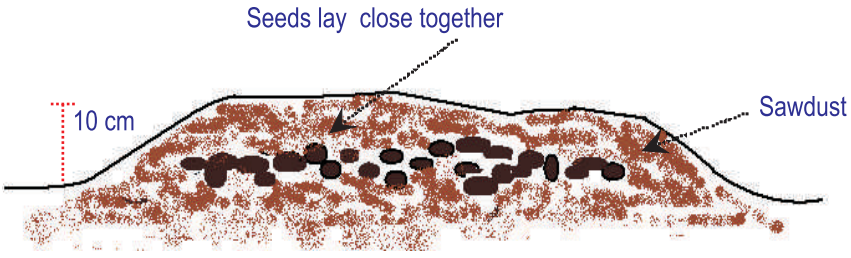

Figure 4: *Sawdust seed germination bed (Adapted from Jackson and Looney, 1999)*

2.1.4. Sowing method

The sowing of fruit seeds can be done directly in soil beds in the nursery rows. Containers can be also used such as pots, trays or plastic bags.

Direct sowing is cheaper and mostly used for plants that do not tolerate transplanting. In this case, seeds are sown at a certain distance from plant to plant, and the seedlings are budded *in-situ*. Many nurseries in Afghanistan sow rootstock seeds very close together to maximise the use of their land; however, in order to produce saplings with good feathers (side branches) it is recommended that the seeds be spaced 20 cm apart. A good sowing depth is generally two to three times the size of the seed. After sowing, the seeds have to be covered with sand or leaf mould, and water. Nutrients, especially phosphate fertiliser, should be incorporated in the seed bed, and the ground levelled to receive the seeds.

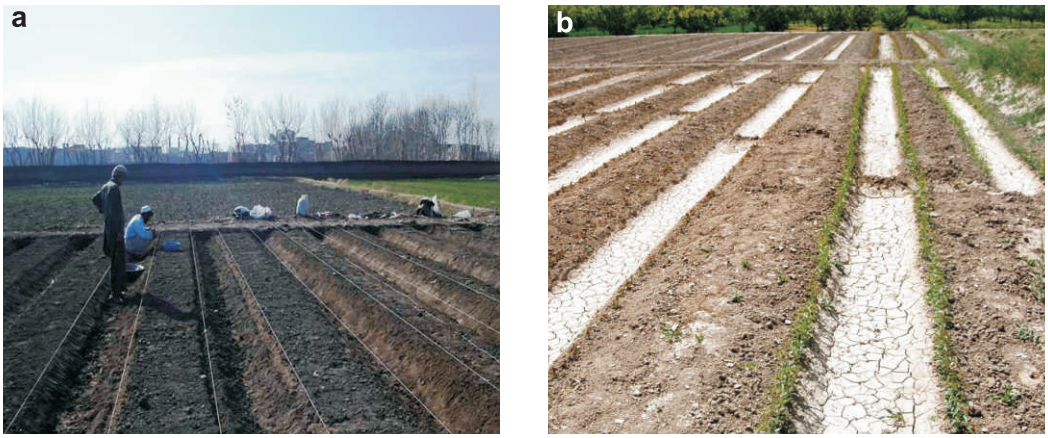

Figure 5: *Direct sowing of stone fruits. Nursery layout (a); Stone fruit germination (b) (Source: GPFA)*

To break dormancy in stone fruits, seeds must undergo a period of moist chilling (stratification). Seeds can be chilled naturally in a cool shaded place or in a cold store or refrigerator.

The stones are packed in plastic bags mixed with moist sawdust. After two to three months the seeds will start germinating and cracking out of the stones. The seeds should be sown immediately after germination.

2.2. Clonal rootstocks

Clonal rootstocks are propagated asexually or vegetatively. Clonal rootstocks are now very popular in commercial nurseries due to certain advantages:

- Desirable characteristics of the parent plants are retained
- Saplings using clonal rootstocks bear fruit earlier than using seedling rootstocks
- One of the main characteristics offered by clonal rootstocks is dwarfing ability. Dwarfing leads to reduced height and vigour of the trees, which in turn reduces labour costs for orchard management. More dwarf trees can be planted per unit area. An advantage for nursery growers is that they will have an opportunity to sell more trees.
- There is a uniform appearance of the trees and harvesting time.

Figure 6: *Apple demonstration orchard on dwarfing rootstock M9 (L. Imburgia)*

There are several methods of clonal propagation. They mostly use rooting parts of plants. The most common methods of vegetative propagation in commercial nurseries are the use of rooted cuttings and division techniques (layering). Tissue culture and micropropagation are techniques regularly used for some species.

Generally, a clonal rootstock is selected for economic benefit. Therefore, the clonal rootstock must be easy to propagate: techniques of layering or stooling are often used (refer to Manual 2 of this Series). The clonal rootstock should bear fruit early and abundantly. They should confer benefits to the scion, such as reducing vigour of growth, inducing early and abundant cropping, or conferring resistance to soil-borne pests and diseases, or tolerance of adverse soil conditions.

2.2.1. Rootstock multiplication by cuttings

Cuttings are portions of the plants (stems, leaves, or roots) that can be developed into new intact plants, genetically identical to the mother or donor plant. A good cutting for rootstock multiplication consists of healthy stem tissue with some intact buds or leaves. It must also have sufficient stored nutrient reserves to sustain it until new roots are formed, and the plant starts the uptake of minerals and water from the soil. When planted, roots grow from the buried portion of the cutting and it becomes a complete plant.

Dormant hardwood cuttings (stem cuttings taken during the dormant season) are the easiest type of stem cuttings to grow. These cuttings are collected during late autumn through late winter, after trees drop their leaves and when stems are firm. Artificial rooting hormones are sometimes used to ensure rooting success (see Box 2). The cutting must be placed in an environment that helps them to stay alive, and that facilitates root initiation, and/or root development.

Figure 7: *Mahaleb cuttings are immersed in IBA solution prior to planting (M. Khademi)*

Cutting techniques are used to propagate rootstocks difficult to root by other methods, or to avoid certain soil diseases.

Box 2: ***Plant hormones and growth regulators***

Rooting is stimulated by the action of plant hormones and the use of synthetic growth regulators. Plant hormones are organic substances produced in one part of the plant and transported to another part where, at very low concentrations, they provoke a physiological response. The physiological response can be either a promotion or inhibition of growth. These effects of hormonal growth regulators also depend on the hormone concentration, and on the physiological state of the plant. The groups of natural plant hormones are: Auxins, cytokinins, gibberellins, abscisic acid, and ethylene. There are also a number of these growth regulators that have been produced synthetically. Some of the most important factors in successful rooting include:

1. Proper balance of plant hormones. Auxins stimulate rooting (auxins move from top to base) and cytokinins stimulate budding (cytokinins move from base to top). They must be in balance.
2. Juvenile tissues contain more rooting promoters than adult tissues. Juvenile cuttings also lack flower buds, which are known to inhibit rooting in some species.
3. Gibberelins and cytokinins often inhibit rooting, while ethylene and abscisic acid may improve rooting.
4. There are other compounds called co-factors involved in rooting that interact with hormones and growth regulators, phenolic compounds are one example. Both environment and genetic controls affect the kind and amount of rooting co-factors.

Typically, for rooting hardwood cuttings of fruit trees, Indol Butyric Acid (IBA), is used for 2-3 weeks at 15-20°C, and when roots begin to show at the basal end, they are placed in cool storage at 3°C to await spring planting.

2.2.2. Rootstock multiplication by stoolbeds

Stoolbed propagation is when a part of the rootstock stem is induced to produce roots while still attached to the mother plant. Rooting is stimulated by different methods, such as excluding light from the part of the stem that is intended to be rooted. This is usually done by covering the stems with soil or another medium (e.g. sawdust, peat or a mixture of both). It is very important to provide adequate rooting conditions, including enough moisture and oxygen, in the area of root growth. For a complete description of the layering process, refer to Manual 2: The Mother Stock Nursery, Part 3.

Figure 8: *M111 apple rootstock stoolbed in Pul-e-Khumri. The stoolbed was established in 2005 and cut back in 2006. The first rootstocks were harvested in 2007 (Source: AKF, Afghanistan)*

2.2.3. Micropropagation

In recent years, micropropagation has been increasingly used for propagation of rootstocks which are difficult to root or for rapid multiplication of rootstocks which are in short supply. Tissue culture requires the use of aseptic methods for clonal reproduction. A completely sterilized environment inside a laboratory is needed, by disinfecting the meristem sections, usually shoot tips, or micro-cuttings prior to explanting them into sterile culture media. Use of plant hormones, cytokinins and auxins is necessary for shoot initiation and proliferation.

An acclimation period in a clean soil and decreasing humidity conditions are necessary. This involves a certain protocol to avoid rapid water loss from leaves while their anatomy becomes functional. These methods are not currently used in commercial fruit tree production in Afghanistan.

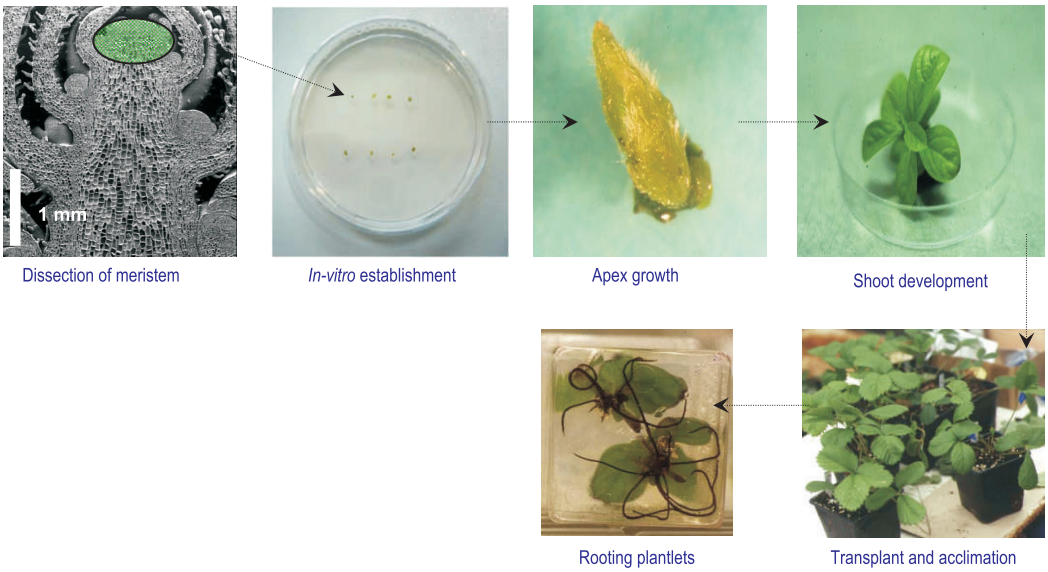

Figure 9: *Production of clonal plants by micropropagation techniques (adapted by E. Giordani)*

Part 3

Production of certified fruit saplings: Budding and grafting commercial varieties

After reading this section you will:

- Learn about the most common methods of propagating varieties by budding and grafting
- Understand the importance of well trained farm personnel to develop propagation using budding and grafting techniques

The seedling and clonal rootstock saplings can be converted into finished nursery trees or vines by budding or grafting a commercial scion variety. The bud or graft becomes the cropping part of the tree or vine and the fruit produced is identical to that of the mother tree from which the bud or graft wood was obtained. These varieties are selected for valuable market attributes, such as consumer preference, yield, fruit quality, size, colour, flavour, etc. Peaches, apricots, almonds, plums, apples, pears, and citrus are propagated by budding on suitable rootstocks.

The propagation of grape, pomegranate, quince and fig is achieved by cuttings. Cuttings are planted for rooting in the soil and transplanted after one year during the dormant season. Variety propagation by cuttings works in the same way as the rootstock cutting propagation (see Part 2 of this manual). Stem cuttings are taken from healthy stems or hardwood cuttings are obtained from pieces of dormant woody stem containing a number of buds, which will grow out into shoots when dormancy is broken in spring. For species that propagate easily by cuttings, this is the preferred method. For species or varieties very difficult to root, grafting or budding techniques must be used.

1. Variety propagation by budding and grafting

Budding and grafting are asexual or vegetative methods of variety propagation. The resulting plant will be identical to the mother plant that provided the bud or graft..

Both techniques use the principle of connecting two pieces of living plant tissues together so that they unite and continue to grow as one plant. With budding, a single vegetative bud is placed on a rootstock plant; with grafting, a larger portion of the stem is used as the scion.

These methods are used on most fruit trees where a specific rootstock is desired, or when cuttings do not root satisfactorily or do not develop a root system sufficiently large to support a tree of the desired size. Budding and grafting can transfer to the final plant certain characteristics of the rootstock, i.e. hardiness, drought tolerance, or disease resistance.

Figure 10: *Certified budded trees in PHDC (E.Vernon).*

For any successful grafting operation, producing a plant requires (at least) five important elements:

1. The rootstock and scion must be compatible. They must be capable of uniting. Usually, but not always, closely related plants, such as two apple varieties, can be grafted together.

2. The vascular cambium of the budwood must be placed in intimate contact with that of the rootstock. In woody plants the cambium is a very thin layer of actively dividing cells located just below the bark. The cambium produces conductive tissue for the actively growing plant (Figure 11).The cut surfaces should be held together tightly by wrapping, nailing, wedging, or some similar method. In grafting, as well as budding, the vascular cambium of the scion or bud must be aligned with the vascular cambium of the rootstock. Rapid development of the graft union is necessary so that the scion can be supplied with water and nutrients from the rootstock by the time the bud starts to open.

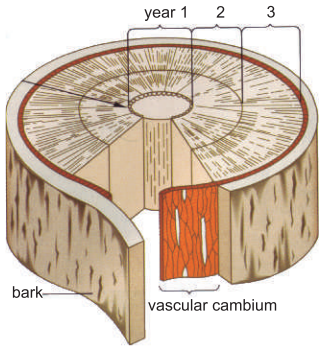

Figure 11: *Cross section of a woody stem (Source: Rost et al. 2003)*

3. The grafting operation must be done at a time when the rootstock and scion are at the proper physiological stage. Usually this means that the scion buds should be dormant. For deciduous plants, dormant scion wood is collected during the winter and kept inactive at low temperatures. However, in the case of budding, the buds can be collected and used in the summer, though the buds are usually dormant due to the apical dominance of the shoot terminal (the shoot terminal and also the leaves produce auxin that suppresses lateral bud growth). The rootstock plant may be dormant or in active growth, depending upon the grafting method used.

4. Immediately after the grafting operation is completed, all cut surfaces must be protected from desiccation. The grafting union is covered with tape, grafting wax, or parafilm tape. Electrician's tape can be also used. Alternatively, the graft can be placed in a moist substrate.

5. Proper care must be given to the grafts for a period of time after grafting. Shoots coming from the rootstock below the graft will often choke out the desired growth from the scion. In some cases, shoots from the scion will grow so vigorously that they break off unless staked and tied or cut back.

Figure 12: *Proper care of grafted rootstocks (L. Imburgia)*

1.1. Budding

The majority of fruit trees are propagated by budding. This method is usually performed in late summer but may be done at any time the scion buds are mature and dormant and when the bark on the stock is active (i.e., when the bark peels easily from the stock). When it is performed at the beginning of the growing season, e.g. June budding, it is possible to save one year. The risk is that the new shoot will not be sufficiently strong and mature to survive freezing conditions during the winter. The other and more common option is budding in late summer or in the beginning of the dormant stage. This means that the bud will remain dormant until the following spring.

Figure 13: *Budded pear saplings in PHDC Herat, 2009. (L. Imburgia)*

This method is only applicable for young rootstock plants or smaller branches of large plants. The stem or branch to bud may not be thicker than 2 cm diameter.

1.2. Grafting

In grafting, a short piece of stem with one or more buds is inserted into the rootstock. It is normally done in late winter or early spring. It is used for grapes, apples, cherries, walnuts, and other fruit and nut trees. As with budding, it is essential that the cambial layers of the two parts make good contact.

Figure 14: *Grafted tree in Jalalabad (E.Vernon)*

Unlike budding, which can be performed before or during the growing season, most grafting is done during winter and early spring while both scion and rootstock are still dormant. Nurserymen can choose from a number of different types of grafts. This section describes only the basic types of grafts used on fruit tree nursery plants.

All grafts should be covered with a protective coating immediately after completing the graft. Electrician's tape is an excellent material that will bind and protect graft unions. Choose a brand that is elastic and amply adhesive. A good tape for the purpose will stick well to itself. Do not stretch this tape too tightly or it may crack or weather. Good quality tape will last throughout the first summer, after which the tape is no longer needed.

Refer to Part 4 of this manual for a practical description of the most commonly used methods of budding and grafting.

Part 4

Registered fruit tree nursery management

After reading Part 4 you will be able to explain:

- How to plan and establish a commercial nursery to be registered with the ANNGO
- How to correctly apply propagation techniques for producing high quality saplings
- How to take care of the trees until they are ready to harvest and sell
- How to carefully apply the traceability instructions

Field training

The following section will be “hands-on” training. A PHD Centre, a demonstration orchard, or a farm of one of the nursery association members would be suitable for this activity.

To conduct this field activity you should divide the participants into groups of 4 or 5 persons, in order to give everyone an opportunity to perform the practical tasks.

Photo L. Imburgia

Field training 1

Preparation and establishment of the fruit tree nursery

The most important considerations for preparing and establishing the fruit tree nursery include:

- Planning the fruit tree production at least two years ahead of time
- Planting only certified materials from registered mother stock nurseries
- Proper site selection
- Carefully following the traceability instructions

1. Ordering and purchasing certified propagation material

For the establishment of a registered fruit tree nursery, certified propagation materials, rootstocks, budwood, and cuttings will be available from the mother stock nurseries registered with the Afghanistan National Nursery Growers' Organization (ANNGO).

ANNGO has the main function of obtaining market information on tree sales and, based on this predicted demand, estimating the number of trees for production the following year. Most of the nursery production planning falls into the following general production cycle:

Winter (year 1)	Sow rootstock seeds; plant rootstocks in the nursery; graft planted rootstocks
Summer (year 1)	Receive budwood from mother stock nursery, bud onto rootstocks
End of winter (year 2)	Cut back trees at bud level Lift and sell certified trees (from grafting in year 1)
End of winter (year 3)	Lift and sell certified trees (from budding in year 1)

Propagation material should be ordered well in advance for timely delivery; winter and early spring delivery (March), in the case of graftwood and hardwood cuttings, or summer delivery in the case of budwood and softwood cuttings. Remember that there are a limited number of registered mother stock nurseries and the nursery grower must ensure sufficient mother stock materials are available for his desired production. Any material received from a registered mother stock nursery has to be accompanied by a certification label (Figure 15).

Figure 15: *Certified graftwood (E.Vernon)*

Rootstocks should be delivered in early spring. On delivery, the nursery grower should verify their material condition. Dehydrated, infested or injured materials should not be accepted. If the materials received are not planted immediately, they should be stored in cool, moist conditions to avoid drying out.

2. Fruit tree nursery establishment

2.1. Materials needed

This section refers to growing rootstock seedlings. The nursery techniques for planting clonal rootstocks, rooted cuttings and layering are the same as the techniques used for planting seedlings.

- ❑ Certified propagation materials: budwood, cuttings, rootstocks, etc.
- ❑ Tape measure
- ❑ Thin rope for aligning plant rows
- ❑ Planting board
- ❑ Sticks for marking planting holes
- ❑ Manure
- ❑ DAP fertilizer
- ❑ Spades for digging
- ❑ Wooden signs for identifying rows
- ❑ Indelible marker pens
- ❑ Damp hessian sacking to protect sapling roots during planting
- ❑ Buckets of water

2.2. Nursery site selection

You want to make sure that the participants understand that the selection of an appropriate site is one of the most important aspects of nursery production. Use the following check-list in your field training:

- ❑ The location for the nursery should not have been previously used for growing fruit trees (saplings or mature trees) in the previous two years, unless the soil is treated (e.g. solarisation).
- ❑ The site should not be subject to flooding, and it must be protected from livestock.
- ❑ The site must have easy access to irrigation water all year round.
- ❑ Ideally, the soil for the nursery should be deep, loamy sand, intermediate texture, and it should have good drainage.
- ❑ Soils that become sticky in wet weather or hard, caked, and cracked when dry, should be avoided (Figure 16).
- ❑ It is important to consider elevation of the sites. Freezing air flows from higher slopes down to flat lands at lower elevations to form “frost pockets”. This effect can also occur if a physical obstruction such as a topographical barrier (e.g. impermeable windbreak) creates an “air dam” (Figure 17).
- ❑ The size of the nursery will depend on how many seedlings are to be grown, what species are grown, and how long those seedlings will be in the nursery.
- ❑ The site should be of sufficient area to accommodate the required number of trees planted in blocks of the same variety, 20 cm apart in rows 80-100 cm wide. A minimum distance of 5 m should be allowed between the nursery trees and any other fruit trees.

Figure 16: *Heavy clay soils crack when become dry (L. Imburgia)*

Figure 17: *Slope areas in Shomali plain (L. Imburgia)*

Figure 18: *Nursery in Kohkaran, 2008 (J.I.Trives)*

2.3. Nursery site preparation

Explain to the participants the main land preparation considerations:

- *Soil structure and fertility:* If the soil has a high clay content, sand should be added to loosen the soil (create a lighter soil texture) for good aeration. If soil structure is very poor, explain that it could be modified with large amounts of aged sawdust, or well-composted animal manure. These practices improve water retention, tilth, and fertility.
- *Tillage:* The soil should be thoroughly tilled at least 25 cm deep (preferably before the winter), and then must be left to sun-dry for a few days. This practice will help reduce the weed and soil pathogen population, as well as improve soil aeration. Thorough tillage should be followed by a fine cultivation just before planting.
- *Levelling:* Level the nursery land, and correct if necessary any drainage problem by ditching, levelling, or raising the beds at least 45 cm above the maximum height of the water table.

Figure 19: *Thorough soil tillage (a) followed by levelling (b, c) (L. Imburgia)*

2.4. Direct sown seedbeds

Explain to the participants that those species that do not tolerate transplanting well are sown directly in nursery rows, at the defined nursery distance. These seedlings will be budded or grafted *in-situ.*

- Incorporate 200 kg of DAP fertilizer per hectare into the soil. Up to 20 tons per hectare of well rotted farm yard manure may also be applied, if available.
- Smooth and level the nursery bed. Seedbeds should be 1 m wide and raised 8 to 15 cm.
- At sowing time, soil should be moist but not wet to avoid damping-off and root diseases.
- Before sowing, make a plan (map) on paper of the layout of the nursery to show what will be planted where.
- Prepare wooden signs and insert at the end of each row to show what will be planted in that row.
- Using a marking board, sow seeds in double rows, 40 cm apart with 20 cm between the seeds.

- For some species such as peaches, seeds can be sown in autumn, allowing them to stratify under natural conditions. These seeds must be protected from vermin, especially mice.
- After sowing, cover the seeds with a thin (3 to 5 mm) layer of fine mulch, sand or sawdust. Be careful not to sow seeds too deep. Two to three times the size of the seed is a standard sowing depth.
- Once seeds germinate, seedbed soils should be kept evenly moist. When irrigating, water deeply and infrequently to encourage deep root growth.

Figure 20: *Seedbed preparation for seedling rootstocks (E. Vernon)*

2.5. Transplanting seedlings

For some citrus rootstock seedlings, it is common to lift the seedlings and grade for size before transplanting back into the nursery bed. Planting bareroot seedlings must be done during the dormant season. For rootstock seedlings that are purchased from mother stock nurseries, to be grafted and grown in the nursery, the same steps should be followed. Explain to the participants the detailed steps of marking out the plantation site:

- Incorporate 200 kg of DAP fertilizer per hectare into the soil. Up to 20 tons per hectare of well rotted farm yard manure may also be applied, if available.
- Smooth and level the nursery bed. Beds should be 1 m wide and raised to at least 15 cm.
- The nursery will be planted in single rows.
- Before transplanting, make a plan (map) on paper of the layout of the nursery to show what will be planted where.
- Measure and mark planting positions in straight rows: 20 cm along the row x 1 m between rows for stone fruits and 80 cm for pome fruits.
- Prepare wooden signs and insert at the beginning of each row to show what will be planted in that row.
- Dig a narrow trench wide and deep enough to allow the roots to be buried without them bending upwards. If the soil is loose enough, it may be possible to simply insert the spade and pull it back to create a narrow “V”-shaped slot in which to insert the roots and then tread the soil back around the roots.
- Water immediately after planting.

2.6. Procedures for planting cuttings

Explain to the participants step by step how to organise and perform a proper plantation of certified cuttings. In this section we refer to the rootstock cutting plantation. As explained elsewhere in this Series the same procedures are used for several species.

- Hardwood cuttings are usually planted in the nursery after leaf fall in the autumn.
- Incorporate 200 kg of DAP fertiliser per hectare into the soil. Up to 20 tons per hectare of well rotted farm yard manure may also be applied, if available.
- Smooth and level the nursery bed. Beds should be 1 m wide and raised to at least 15 cm.
- The nursery will be planted in single rows.
- Before planting, make a plan (map) on paper of the layout of the nursery to show what will be planted where.
- An important fact to remember and reinforce is that there is a **"top"** and **"bottom"** to each cutting. It is the "bottom" portion that you will put into the soil and that will produce roots. The bottom part will have a straight cut and the top part an angle of 45 degrees.
- The cuttings must not be allowed to dry out, especially in spring.
- Rootstock cuttings must be planted as soon as possible after they are received in the nursery.
- If not all the cuttings can be planted the same day, the remaining cuttings must be kept in the bags, inside a cool room.
- Prepare wooden signs and insert at the end of each row to show what will be transplanted in that row.

Figure 21: *Planting certified grape cuttings. Herat, 2007 (M. Khademi)*

2.6.1. Apple, pear, pomegranate, and fig cuttings

- Get the bags containing the cuttings of one variety. Plant only one rootstock type or variety at a time.
- Hand over the cuttings to the planter only at the labelled row. Fill in the number of rootstocks planted in the nursery book.
- Hardwood cuttings are commonly 25-40 cm long. They are usually planted to a depth equal to half their length. If there is a risk of drying out or late frosts, they should be planted with three-quarters of their length under the soil (Figure 22).

- If the soil has been properly prepared, it should be possible to insert the cuttings directly into the soil without the need to use a spade.
- When the planter finishes planting one bag, go to the row, count the number of cuttings planted, and sign the nursery book. Only then can another labelled rootstock or variety bag be given to the planter.
- Water as soon as possible after planting.

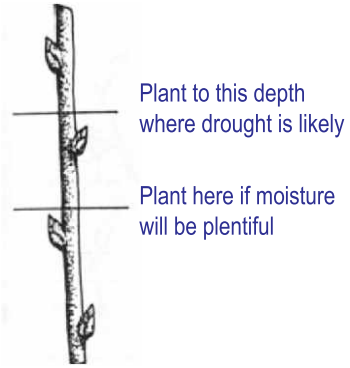

Figure 22: *Hardwood cutting (Jackson and Looney, 1999)*

2.6.2. *Vine cuttings*

- Take the bags containing the cuttings for one variety/clone to the planting area. Plant only one variety/clone at a time.
- Hand over the cuttings to the planter only at the labelled row. Fill in the number of cuttings planted in the nursery book.
- Plant the cuttings to a depth that allows the second bud (counting from top to bottom) to be at soil level (Figure 23). If there is still a risk of frost, cover the cuttings with loose soil.
- When the planter has finished planting one variety/clone, go to the row, count the number of cuttings planted, check the plant labels and register all relevant data in the nursery book.
- Next, another clone/variety is given to the planter.
- Water as soon as possible after planting
- As soon as the nursery area enters the frost-free period, carefully earth up the cuttings, avoiding damage to the buds.

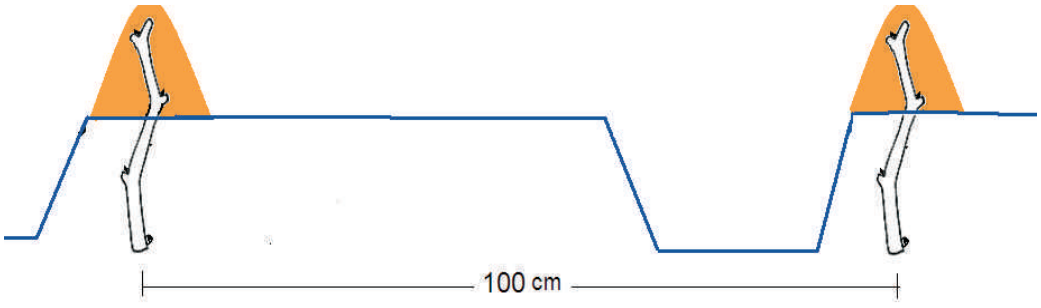

Figure 23: *Diagram of grape cutting plantation (J.I. Trives)*

2.7. Signage for fruit tree rows

This part of the training is very important. You should emphasize very strongly that well organized and focused work is required when managing varieties, labelling and registering in the nursery book. **Insist on the importance of following the instructions exactly!**

- All rows for each plot of the registered nursery must be labelled in ascending order before planting.
- The location of each variety/rootstock in the nursery must be marked with wooden signs before planting commences. Signs should be inserted at the beginning of each row and also in front of each group of plants of a variety in a row. Every sign identifies the row number, rootstock and the name or number of the variety to be budded (Figures 24 and 25).
- Signs should be marked with black indelible markers or paint.

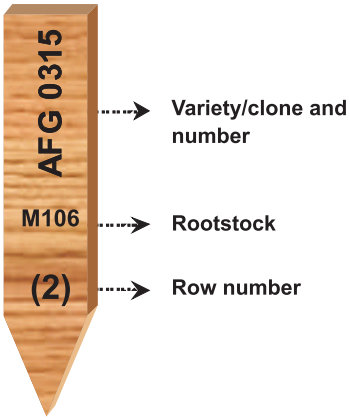

Figure 24: *Wooden sign for nursery tree rows*

Figure 25: *Budded pear rootstocks, Herat, 2009 (L. Imburgia)*

Very important!
Plants of the same variety must be kept in the same row.

2.8. Handling certified documentation of mother stock materials

- When the nursery growers receive the certified propagation materials they have to:
  - Open each parcel and ensure that the traceability documents (e.g. commercial invoice, packing list or delivery note) correspond with the contents of the parcel
  - Check the certification labels
  - Check if any of the materials listed in the documents are missing
- Next, bags have to be closed and kept in a cool, shady place until use.

Field training 2

Production of certified fruit tree saplings

During this field training you have to make sure the participants understand that:

- The usual nursery production cycle of budded saplings needs to be planned at least two years in advance. Budding and grafting is performed a year before saplings are sold to orchard growers.
- Budwood and graftwood should be ordered from the mother stock nursery well in advance to avoid shortage of planting materials at budding time.
- Budding and grafting are very precise techniques. They demand thorough practice and training.

1. Field preparation for budding and grafting

1.1. Rootstock selection and counting

Figure 26: *Labelled rows of cherry Colt rootstock (E. Vernon)*

- ❑ All the rootstock retained to be budded should show homogeneous development.
- ❑ Uproot all inadequate rootstocks showing weak growth, poor health or are double stemmed. **Although many nurserymen are unwilling to do this, this operation is essential for a registered nursery.**
- ❑ Count the remaining rootstocks available after rootstock selection. This data is very important to design the nursery layout.
- ❑ The field should be already marked with the wooded signs. Label all the rootstocks with the number of the variety to be budded.

1.2. Materials needed

- ❑ Cold box for budwood conservation
- ❑ Certified budwood/graftwood
- ❑ Grafting and budding tools: sharp knives, sharpening stones, saws, pruning shears (Figure 28)
- ❑ Alcohol or other disinfectant
- ❑ Sprayers
- ❑ Budding tape
- ❑ List of rootstocks to be budded, nursery book and certification labels: Use a plastic folder to keep the documents clean and dry.
- ❑ Nursery map: Include it in the plastic folder.

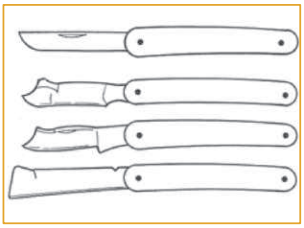

Figure 27: *Budding knives (Adapted from Hartman et al., 1997)*

2. Procedures for budding and grafting

When budwood is taken to the field, precautions should be taken against drying out. Storing budwood in a cold box with ice will help keep it cool and moist. Ice should be available the same morning of the budding. Ice should always be kept inside a closed container such as a plastic bag to avoid free water inside the cold box (this would make the ink on the labels run). Individual bundles of scions carried by budders can be wrapped in moist burlap or kept in dark plastic.

The nursery owner will probably be the budder supervisor. Explain that he has to hire the most skilled budders available in the area. Budding is a very skilled technique. **Successful budding is key to producing high quality planting materials.**

Check-list for the budding and grafting operations:

- ❑ Check the mother stock material order at least 2 weeks before starting budding operations to confirm delivery date.
- ❑ Generally, budwood stored for more than a few days should be discarded.
- ❑ Make sure that appropriate soil moisture is maintained before and after budding. Irrigate the nursery three days before the planned starting date of budding.
- ❑ Budsticks must remain in the cold box in a shaded place during budding operations.
- ❑ Hand over one bundle bag of budsticks at a time from the cold box to the budder to avoid confusion.
- ❑ Wrap the bundles in a wet cloth with the original labelled bag.
- ❑ Go with the budder to the corresponding tree in the nursery (the variety number on the nursery sign has to be the same as the variety number on the bundle bag certification label).
- ❑ Use very sharp knives.
- ❑ Disinfect hands and tools.
- ❑ Once the bundle bag is finished, the budder requests another bundle of the same variety from the supervisor, and so on.
- ❑ It is important that the nursery supervisor performs random checking of the proficiency of the hired budders to make sure the budding is being done properly:
  - ❑ *Cambium layers (vascular tissues) of scion bud and rootstock are in close contact*
  - ❑ *Budding tape is properly tied*
  - ❑ *Budding tape is note covering the bud*
  - ❑ *Height of budding is 20 to 25 cm from ground level*
- ❑ Irrigate immediately after budding.
- ❑ One month later, register the number of successful buds in the nursery book.

2.1. Procedures for T-budding

Explain to participants that in Afghanistan T-budding is the most common budding technique used to propagate all stone fruit species, citrus, apple, and many ornamental trees and shrubs (in some other countries, chip budding is often used). T-budding is performed during late summer (July through September. In some areas of the country, July is too hot for budding), when rootstocks have achieved the thickness of a pencil, the bark separates readily from the wood, and the high summer temperatures start decreasing.

- *Preparing the rootstock:*
  - When the rootstock is about 30 cm tall, the leaves and lateral branches within 15 cm of the ground have to be removed.
  - Towards late summer, the rootstock should have achieved the thickness of a pencil.
  - Before the budding operation, irrigate rootstocks well so bark will slip (separate from the wood) easily.
  - At the budding time, make a "T" cut about 20-25 cm above the surface, of about 3-4 cm vertically and 1.5-2 cm horizontally.
  - With a knife blade or bark separator, lift the corners of the cut and carefully loosen the bark.
- *Preparing the bud:*
  - Make a shallow cut starting below the bud and a light cut through the bark above the bud.
  - Peel the bud away.
- *The T-budding operation:*
  - Insert the bud under the two flaps of bark on the rootstock by pushing downward.
  - Tie the bud with rubber strips, electrician's tape, or adhesive tape tightly around the stem, avoiding covering the bud.
  - If the petiole falls off or can be removed with a touch, within 2 weeks of budding, a successful union has probably been achieved.
  - After 5-6 weeks, the tape should be removed. The bud should remain dormant until the following spring.
  - In late winter the rootstock is cut off about 4 cm above the inserted bud.
  - In spring the inserted bud will grow and other buds from the rootstock that burst should be removed.
  - During the summer, the 4 cm stub can be cut back closer to the new scion stem.
  - The budded plant is normally grown in the nursery for one season, sold and planted in the orchard the next winter.

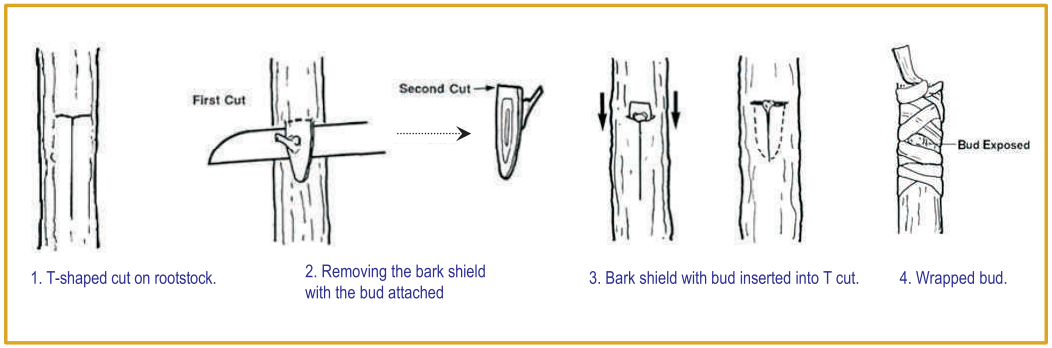

Figure 28: *Steps to perform T-budding (Adapted from Hartman et al., 1997)*

2.2. Procedures for chip budding

Participants should understand that chip budding does not use the protective bark flaps as T-budding does, and it does not require slipping the bark, either. Accordingly, it can be performed during spring or autumn (it is also possible to do it in summer unless it is too hot and the buds dry out). The budstick and rootstock must be of the same diameter. You can also explain that although chip budding is not popular in Afghanistan, it is one of the primary budding methods used for the asexual propagation of varieties or clones of many fruit and nut trees. This is the only budding system that can be employed on rootstocks that have either active or dormant vascular cambiums. It can be performed in spring through autumn.

- *Preparing the rootstock:*
  - First, at least 15 cm above ground level, make a horizontal cut at an angle of about 45 degrees into the rootstock stem.
  - Then starting about 3 cm above the first cut make a downward cut in the rootstock through the bark and slightly into the wood. The cut should meet with the first cut and a piece of wood is removed.
- *Preparing the bud:*
  - The aim is to prepare a piece of wood of similar size and shape to the piece of wood removed from the rootstock and containing one bud.
  - The petioles should already have been removed by cutting them off close to the top of the dormant bud immediately after collecting from the mother plant in the mother stock nursery.
  - Holding the base of the budstick near your body and the top pointing away from you, first cut off the end of the budstick about 1 cm below the bud using a sloping cut with angle about 45 degrees (to match the horizontal cut in the rootstock).
  - Make a second cut above the bud coming downward behind the bud and connecting with the first cut (this cut should be similar to the one performed on the rootstock).
  - It should be possible to remove the bud easily.
- *The chip budding operation:*
  - Place the rootstock and the chip bud together matching the cambia of bud and rootstock. If necessary cut the top of the chip bud so that it aligns with the top of the cut in the rootstock.
  - Tie tightly with grafting tape to avoid desiccation. The bud can be left uncovered.

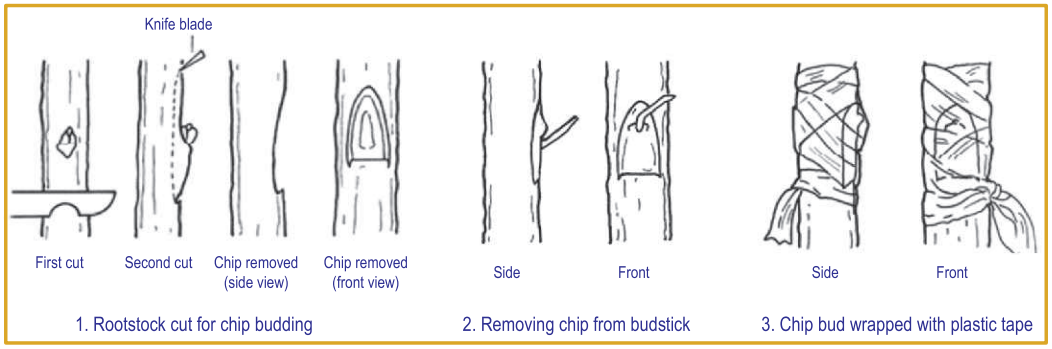

Figure 29: *Steps to perform chip budding (Adapted from Hartman et al., 1997)*

2.3. Procedures for whip and tongue graft

The whip graft is used mostly on nursery trees, commonly for apple and pear trees when the branches are relatively small (not more than 1.5 cm in diameter) and the rootstock is about the same diameter as the scion of the variety. Seedling or clonal rootstocks are grafted while still dormant (February or early March).

This type of graft consists of performing similar cuts on both the rootstock and the scion. These cuts should be made with a single draw of the knife and should have a smooth surface so that the two pieces can develop a good graft union.

Figure 30: *Whip and tongue graft in persimmon (J.I.Trives)*

- *Preparing the rootstock and scion:*
  - Cut off the rootstock using a diagonal sloping cut (as shown in Figure 31). The cut should be four to five times longer than the diameter of the stock to be grafted. Make the same kind of cut at the base of the scion.
  - Start the "tongue cut" at a point one third of the way down from the pointed end to the base of the first cut. Prepare the scion in the same way as the rootstock: make a sloping cut with a sharp knife on the scion (as shown in Figure 31).
- *The graft operation:*
  - Fit the scion into the rootstock so that they interlock whip and tongue. Be certain that the cambium layers are aligned.
  - Secure the graft: wrap the junction with a grafting strip or twine, and seal it with grafting wax or grafting paint. Never allow the binding material to girdle the stem.

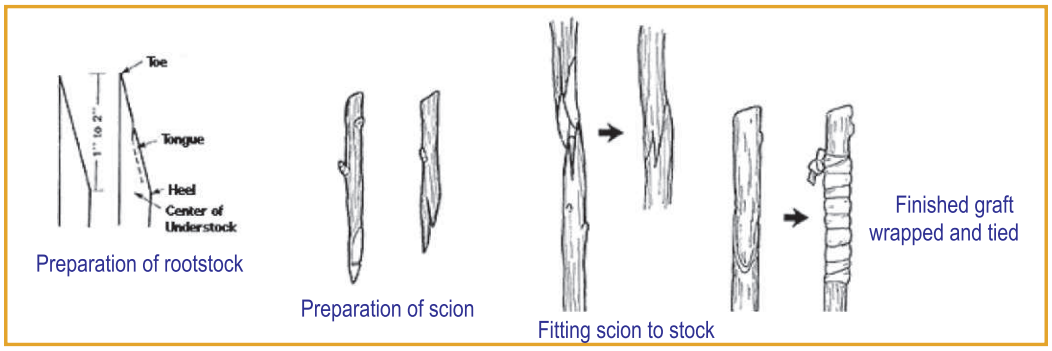

Figure 31: *Steps to perform whip and tongue graft (Adapted from Hartmann et al., 1997)*

Figure 32: *Whip and tongue graft on persimmon in Jalalabad, 2009 (E. Vernon)*

2.4. Procedures for cutting grafts (bench grafting)

2.4.1. Bench grafting for vines

Explain that bench grafts are produced in the nursery by grafting onto an unrooted cutting. We will use this grafting technique for grafting vines. The grafting is done in mid to late winter.

- *Preparing rootstock and scion:*
  - Make a cutting of the rootstock approximately 30 cm long.
  - Cut off all buds with a cut parallel to the stem.
  - Cut a one-bud scion
- *The graft operation:*
  - Graft to the rootstock using the whip-and-tongue graft as explained above. (This can also be done very quickly and accurately using an omega-grafting machine as introduced to Afghanistan by AKF in 2008).
  - Tie the graft with plastic tape and dip the whole scion area in melted grafting wax.
  - Place 50 or 100 grafted cuttings in bucket of water, tie them together, and place in polythene bag and seal with a rubber band. The bag must be airtight.
  - Place the cuttings in a room at 25-30°C until callus forms between the rootstock and scion. Buds will be beginning to swell and new roots will be seen.
  - Remove from the high temperature and from the bag. Insert the apical grafted portion for one second in grafting wax at a temperature just about melting point, below 70°C, and immediately quench in cold water.
  - Place the cutting base in growing media inside a cool greenhouse.
  - When the roots are well established, and the danger of spring frost has passed, the plants can be planted directly in the vineyard. If vegetative growth is excessive, trim back to two leaves.

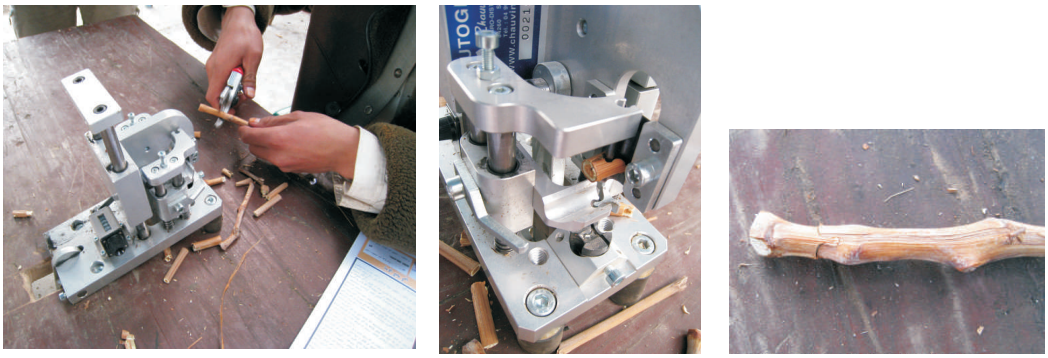

Figure 33: *Steps to perform bench graft using and omega-grafting machine (E. Vernon)*

2.4.2. Bench grafting for apple and pear

We will use this grafting technique for grafting apples and pears. The grafting is done on uprooted rootstocks in mid to late winter.

- *Preparing rootstock and scion:*
  - Uproot a rootstock from the stoolbed
  - Cut a two or three bud scion, of similar diameter to the rootstock
- *The graft operation:*
  - Graft to the rootstock using the whip-and-tongue graft as explained above.
  - Tie the graft with plastic tape and dip the whole scion area in melted grafting wax.
  - Place the grafted plants in pots in a warm, sunny room,
  - When the plants are well established in the pots, the scion shoots growing, and the danger of spring frost has passed, the plants can be planted directly in the orchard. If vegetative growth is excessive, trim back.

2.5. Procedures for top grafting in citrus

PHDP has implemented the top working technique for grafting young citrus rootstocks in Jalalabad. The technique has proven highly successful and is recommended as the standard propagation technique for citrus in the area. This method can be performed from spring to autumn. For the climatic conditions of Jalalabad, the best results have been obtained in October.

Figure 34: *Top grafting in citrus, Jalalabad, 2009 (E.Vernon)*

- *Preparing rootstock:*
  - Select a pencil-size rootstock of 1 cm diameter
  - Cut off the rootstock with a straight horizontal cut at 20 to 25 cm from the soil
  - Make a 2 cm vertical cut from the top, opening a slit.
- *Preparing the scion:*
  - Cut a two to four bud scion, of a 1-year-old shoot, hardened for 6 months (Figure 35 a, b)
  - Make a diagonal cut in the base of the scion of about 2.5 cm (Figure 35 c, d)
- *The graft operation:*
  - Graft to the rootstock inserting the scion in the opened slit, ensuring close contact of the cambium layers. (Figure 35 e, f)
  - Tie the graft with plastic tape. (Figure 35 g,h)
  - Cover the grafted plants first with a plastic bag, and then with a paper bag to protect from desiccation. (Figure 35 i,j)
  - Close the base of the bags with tape or wire.
  - When the bud shows signs of sprouting, remove the plastic bag and keep the paper bag for one more week.
  - The grafted tree can be transplanted to the orchard one year earlier than trees grafted by other methods.

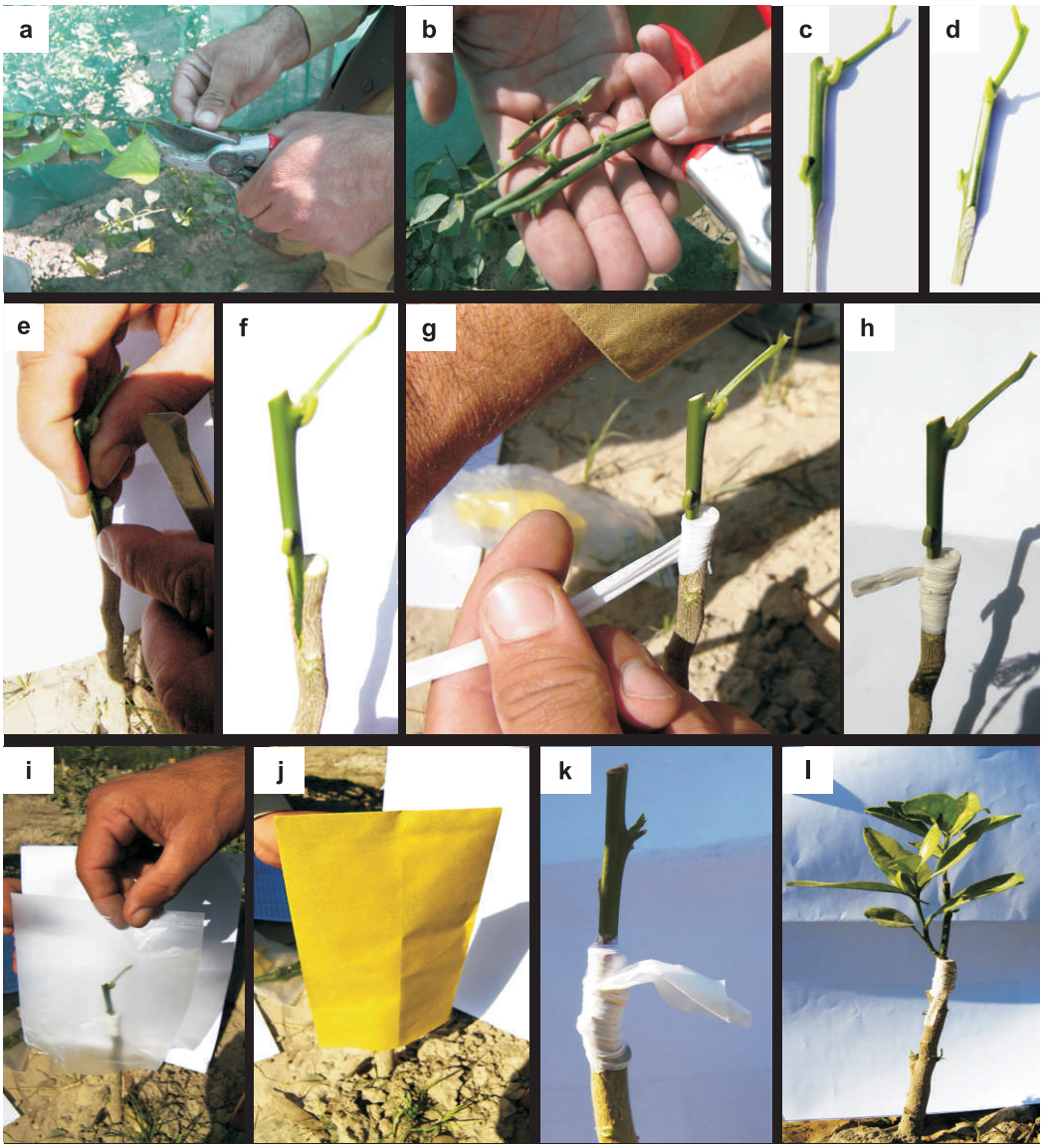

Figure 35: *Procedures to perform citrus top grafting. This technique was introduced in PHDC Jalalabad by Dr. Santo Recupero in 2008 (a-d) Rootstock and scion preparation; (e-h) Grafting operation; (i-j) Protection of the graft; (k-l) Final plant (J.I. Trives)*

Field training 3

Cultural activities in the nursery

The most important considerations in the management of a nursery include:

- Timely cultural activities including an integrated farming approach
- Nursery trees deplete soil nutrients Therefore a proper fertilisation regime should be adopted

1. Training saplings

- Cut back rootstock tops in the spring following budding, as soon as the buds begin to swell. This cut should be clean and 4 cm above the bud.
- Remove any growth in the rootstock from buds other than that budded from the scion.
- Nursery growers can remove the lower branches up to 30 cm maximum.

Figure 36: *Removal of lower branches in the nursery (E. Vernon)*

2. Irrigation

For proper irrigation management of the nursery, explain to the participants the following steps:

- As a general guide, when watering, moisten the entire seedling root zone. Water that penetrates below the root zone cannot be used by roots and is therefore, wasted.
- Especially in summer, it is usually best to irrigate early in the day (when evapotranspiration is less than during the heat of the day).
- If seedlings are watered with a furrow system, allow the water to run until it has infiltrated into the nursery bed to the correct depth. You can monitor infiltration using a trowel.

Figure 37: *Irrigation management in nursery (E. Vernon)*

- Proper scheduling of irrigation is critical for nursery trees since their root system is very small when planted. Frequencies and length of each watering will vary with soil type and climatic conditions.

- Avoid excessive irrigation, especially when soil drainage is poor. Waterlogging limits normal root growth, promotes root-rot organisms and leaches nutrients from the soil.
- As leaf and top growth develop and increase in length, increase the irrigation frequency. In the second year longer irrigation cycles can be employed.

3. Weed control

Weeds compete with fruit trees for water and soil nutrients, and also interfere with farming operations. Weeds can be annual (growing each year from seed), or perennial (growing from underground roots that survive drought and winter). Perennial weeds are particularly difficult to control, specifically on land which has not been previously used as an orchard and which may be infested with a wide range of perennial weeds. Such weeds should be controlled before planting; if not, subsequent control can be very difficult and time-consuming. Suckers arising from the rootstock are also considered unwanted nursery vegetation and may prove particularly difficult to control. It is important to keep the area surrounding the tree weed-free for a distance of at least 40 cm.

Weeds can be controlled by hand weeding and shallow hoeing. Do not dig the soil deeply within 40 cm of the tree because this will damage the feeder roots that grow close to the surface.


Figure 38: *Hand weeding in nursery. Weeds have to be removed complete with roots (L.Imburgia)*

4. Pest and disease management

In this part of the training, you will explain to nursery growers the basic principles of pest and disease management in the nursery. Nursery growers in Afghanistan generally have little knowledge of the common pests and diseases affecting their crops. Therefore, a good extension service is especially important in helping growers detect major pests and disease problems early.

- Highlight the distinction between pests and diseases. A horticulture pest can be a mammal, bird, insect, mite or nematode that is damaging the plants. A horticulture disease is an unhealthy condition of the plant caused by a fungus, bacterium, virus or virus-like organism.
- Pests provoke different types of damage, largely dependant on the anatomical structure of their feeding apparatus and their feeding habits.
  - *Chewing damage:* Leaf tissue is consumed by those insects with chewing mouth parts (Figure 39)
  - *Piercing and sucking damage:* Many insects and mites have piercing and sucking mouth parts. Chloroplasts are damaged and leaves take on a mottled appearance. Some insects also infest branches and twigs, sucking nutrients from the phloem.

During the feeding process, enzymes may be injected which induce a reaction in the plant. This is manifested by galls on branches such as those caused by the feeding of woolly apple aphid. Diseases, particularly viral diseases, may be transmitted by sucking insects.

- Nursery growers can apply many different types of control measures during a plant or crop cycle in order to achieve an efficient pest and disease control. In almost all cases, a combination of measures will provide the most efficient and long-lasting effect.
- A programme of control against a pest or disease should consider non-pesticide controls first before relying on chemicals. The main reasons include; high costs of chemicals, harm to beneficial insects, and induction of chemical resistance in the pest or disease.
- There are many ways to manage pests and diseases other than using chemical pesticides. They include:
  - *Cultural control: Using the right pruning, fertilisation irrigation regime, or selecting pest-resistant varieties or species*
  - *Physical control, for example, using mulch to keep weeds from growing, or the use of solarisation against soil-borne pathogens or weed seeds*
  - *Mechanical control, for example hoeing weeds; the use of traps and barriers to capture and exclude pests*
  - *Biological control: Using beneficial organisms such as insects that prey on pests or parasitise other insects*
  - *Replant: In extreme cases, where a plant requires repeated pesticide treatment, consider replanting with a more pest-resistant species or variety*
- Hygiene measures such as sanitising tools, machinery and shoes have been shown to be very effective measure in preventing diseases from spreading from plant to plant.
- Predators and parasites can be effectively used against pests in orchards. However, in combating diseases, selecting disease resistant genetic material is the most effective control method minimising the need for pesticides.

Figure 39: *Integrated pest management strategies. (a, b) Monitoring pests in the fruit tree nursery (GPFA); (c) Tool disinfection (J.I.Trives); Common pest natural enemies: (d) Ladybird beetles; (e)Lacewing (Adams et al., 2008).*

- The main pest and diseases that can affect the nursery include:

- **Aphids**

Figure 40: *Adult aphid (PAN, 2001).*

This is a widespread pest that has sucking mouthparts. Aphid nymphs and adults may cause three types of damage: (1) Using its sucking stylet, this insect may inject a digestive juice into the plant phloem, causing distortion. (2) the aphid excretes a sticky substance called honey-dew, which may reduce photosynthesis when covering the leaf blade, and dark-coloured fungi (e.g. sooty mould) may grow over the honey-dew; and (3) the aphid stylet may transmit viruses. The most important species in fruit tree nurseries include: Woolly apple aphid (*Aphis pomi);* rosy apple aphid (*Dysaphis plantaginea*), this also feeds on shoots and leaves, but injects a salivary toxin which causes leaf deformation; green peach aphid (*Myzus persicae*) is an important pest of peaches, in particular for its ability to transmit viruses. It has a high number of host plants including vegetables and greenhouse crops. Most aphids (other than *A. pomi*) have an alternative summer host plant, for example certain weeds. Heavy infestations damage plant growth and reduce vigour. Aphids have many natural predators including Lacewings (*Chrysopa & Henerobius*), Ladybirds (*Coccinellids*) and various parasitic wasps.

Pest management: Avoid using broad spectrum pesticides which are toxic to one or more natural predators. There are a number of apple rootstocks resistant to woolly apple aphid, such as MM106 & MM111.

- **Two Spotted Spider Mite (*Tetranchyus urticae*)**

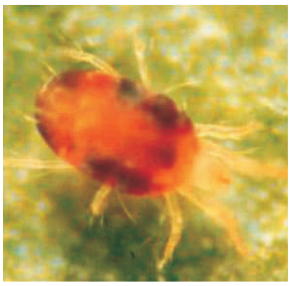

Figure 41: *Adult mite (PAN., 2001).*

This pest feeds on the cellular contents (including chlorophyll) by penetrating the leaf surface (often from the underside), killing only one or a group of cells at each feeding site. The damage appears as yellow speckling or bronzing (where larger numbers of mite are present). Under these conditions, reduction in photosynthesis may occur. Since several predatory mite species useful as biological control agents may occur in Afghanistan, care must be exercised to protect beneficial mite species while controlling pest mites.

Pest management: Two Spotted Spider Mite infestations can be treated with some pesticides. However, pesticides can be detrimental to predatory mite populations.

- **Damping-off (*Pythium* and *Phytophthora* species)**

This disease is caused by a complex comprised of two fungi. This is the first disease that may be found in a newly established nursery, particularly seedbeds. Damping-off affects germinating seeds and very young seedlings. Both fungi occur naturally in soils, but under damp conditions they produce the asexual spores that cause infection.

Symptoms: Damped-off seedlings fall over at the ground line and dry out.

Disease management: damping-off can be prevented mainly by using a disease-free nursery soil. This can be achieved by partial sterilisation by solar heat (solarisation). It can also help to irrigate sparingly when seedlings are small, and by prompt removal of dead and dying seedlings.

❑ Phytophthora Root Rot (*Phytophthora spp*)

This disease can become a problem when seedlings are larger. The disease is more likely to occur when the soil remains wet for extended periods and temperatures are warm. It affects pome and stone fruits.

Symptoms: During summer, foliage of plants may appear light green in colour. As the season progresses, leaves of infected rootstocks turn to a reddish brown colour. Infected plants are stunted in growth with smaller leaves and less annual growth. Exposed roots show infected reddish brown tissue which easily parts from the woody tissue of the root.

Disease management: Prevention is the best approach because once *Phytophthora* is in the soil it is virtually impossible to eradicate. Practice good crop rotation; do not plant fruit planting materials on land that has previously grown fruit trees or saplings in the past 4 years. Do not over-irrigate and make sure drainage is good. Grow plants on raised beds. Avoid bringing contaminated soil into the nursery, for example on shoes, plants or livestock. If *Phytophthora* is found in the nursery, immediately stop irrigation of the infected area because irrigation water can spread the disease. Pull up the infected plants and other plants in the vicinity, including all plants downstream of the irrigation channel and place them into bags. Take them away to a remote site and burn them. Do not carry the plants away without placing them in bags because soil or leaves may fall off the plants and infect other plants in the nursery. Remove all suspect plants. In orchards it is also possible to use a systemic fungicide such as metalaxyl (e.g. Ridomil Gold) applied as soil drench (if sprayed on the leaves it will not travel down to the roots) to prevent further spread or infection of healthy material. However, the fungus can quickly develop resistance to this chemical. Fungicide should not be used to cure infected plants. In nurseries, fungicide should not be used because it may mask disease symptoms without eradicating the disease. Plants in that area of the nursery will not be certified due to the risk that they may be infected.

❑ Powdery mildew (*Podosphaera leucotricha*)

This disease is caused by the fungus *Podosphaera leucotricha.* It is distinguished by its dry powdery appearance, most commonly found on the upper surface of leaves. Hot, dry weather provides ideal conditions for the development of this disease. It has a broad range of hosts among temperate fruit trees.

Symptoms: The foliage of new terminal shoot growth is highly susceptible to infection by Powdery Mildew. Initial infection appears as grey/white felt-like patches on the undersides of leaves. These patches are comprised of masses of fungal mycelia and spores (conidia). As the disease spreads it also infects the upper side of the leaves. Infected leaves may curl and blister and eventually become brittle and necrotic.

Figure 42: *Powdery mildew on apple shoot (Source: UCIPM, 2009)*

Disease management: Temperature is the most important factor affecting disease spread. Conidia spores develop between 10 and 25° C – the optimum temperature for development is 20 - 22° C. Epidemics are favoured by high humidity; therefore problems can often be avoided by good cultural practices that promote air movement and light penetration (nurseries and stoolbeds should not be over-crowded). Pruning of silvered shoots can eliminate a good proportion of the primary mildew. A systemic fungicide for spring and summer sprays can be applied.

5. Fertilisation

Fertiliser applications required to produce the desired plant growth vary according to the type of plant, climate, season of growth, other sources of nutrients applied and the nutrient status of the soil. Here you will find general advice to assist participants in developing an appropriate fertilisation schedule for their fruit tree nursery:

- Incorporate 200 kg DAP per hectare prior to planting.
- If well rotted manure is available, also apply during soil preparation; up to 20 tons/hectare can be applied.
- Apply small amounts of N (approximately 150-200 kg of urea per hectare in total) broadcasting throughout the growing season, with an application peak in the middle to end of June. Apply immediately before irrigation.
- Increase fertiliser rates in the second year to maintain vigorous growth.

6. Tree harvesting and tree preparation for market

By spring of the third year, saplings should be ready for sale.

- Attach certification labels to trees before lifting in order to avoid loss of identity during harvesting. This operation needs to be supervised by accredited personnel.
- Before lifting, make sure the soil is not too wet or dry; if necessary irrigate 2 or 3 days before.
- Lift trees with shovel. This requires two persons –one on each side of the sapling- to make two cuts and then lift the tree.
- Immediately after lifting, keep the roots of the lifted saplings covered with damp material to avoid drying out of the roots.
- Top the tallest trees to 1.8 m before sale.
- Neatly trim any broken roots or branches.
- Reject trees showing root infection. Incinerate them later, and avoid the plot for growing nursery plants in coming years.
- The trees should be delivered as soon as possible to the orchard growers. In case trees have to be stored for a few days, they can be heeled into a trench in a shady place, the roots covered with sawdust or soil and watered.

In the future, development of the nursery industry in Afghanistan will require trees to be graded for the market. The commercial value of a fruit tree is related to specific features including:

- Stem diameter range (measured 2.5 cm above the bud union): 1.3 – 2 cm
- Height range: 0.9 – 1.8 m
- Number of feathers: a minimum of 3 up to more than 9
- Strong and straight union between the rootstock and scion.

Figure 43: *Nursery tree preparation for sale. Lifting trees (a); Saplings graded and prepared for transportation (b, c) (E.Vernon)*

Field training 4

Fruit tree certification scheme

1. The ANNGO Fruit Tree Certification Scheme

In March 2009, the Afghan National Nursery Growers' Organization (ANNGO) and its members began the implementation of a fruit tree certification scheme that aims to provide commercial fruit growers with certified true to type fruit tree saplings. In the future, when the necessary phytosanitary facilities become available, the fruit tree saplings will also be certified in terms of health and vigour.

All of the local nursery growers associations (NGAs) that are members of ANNGO have one or more mother stock nurseries amongst their members. These mother stock nurseries play an important role in the certification scheme because they provide the certified propagation materials, such as budwood, cuttings, rootstocks or seeds that the other nurseries need in order to produce certified fruit tree saplings.

Each NGA should have its own technical officer to ensure that the certification scheme operates successfully.

2. Standards for production of certified fruit trees

1. Each nursery location shall be subject to approval by PHDP and shall be in an area suitable for healthy growth with minimal risks for spread of infectious pests and diseases.
2. Water supply should be uncontaminated (recycled water should not be used unless it has been efficiently decontaminated). Fields where drainage water from other fruit tree nurseries or orchards may enter should be avoided.
3. In order to reduce the risk of soil-borne infection, previous cropping should not have included fruit plants of the same genus.
4. Plants entered in the Scheme shall be kept in a good growing condition and pests shall be effectively managed. Suitable precautions shall be taken in cultivation, irrigation and in other farming practices to guard against spread of disease.
5. Materials and tools should be disinfected, and used only for the crop concerned.
6. No off-types should be present (if off-types are seen, they should be removed).
7. Certified saplings shall be planted sufficiently apart to maintain their identity. There should be a distinct gap (of at least 80cm) between saplings of different clones in the same row.
8. All certified saplings shall be designated according to scion and rootstock sources. This information should be shown on the nursery map and signage.
9. There may be no rebudding or regrafting of rootstocks unless the rootstock is reworked from the same certified mother tree sources as used originally.
10. Fruit tree saplings being grown for certification shall be on rootstocks approved by PHDP. In the future, the rootstocks will originate from registered seed trees or

from registered stool beds; until then, fruit tree saplings being grown for certification may be grown on non-certified rootstocks.

11. Scion material (buds/graftwood) and rootstocks shall originate from registered Mother Stock Nurseries.
12. There should be no weeds or intercrops growing in the nursery. The ground in a certified sapling block up to a distance of 5 meters surrounding it shall be kept either kept clear of vegetation by cultivation, or under an approved, properly controlled, ground cover.
13. All certified saplings meeting the requirements of the scheme are to be sold bundled in accordance with commercial practice and shall be identified by the certification label that indicates the clone, rootstock and certification number.

3. Traceability

If the procedure and standards of the certification scheme are carefully followed by the registered nursery, then it will be possible to trace the fruit tree saplings through the nursery system to the original source of the genetic material.

The most important advantages of a traceability system include:
- Ability to trace the origin of the saplings and assure that the plant is true to type (known variety and rootstock)
- Quantification of production
- Assurance of production and management quality

4. Record keeping

In this last part of the field training, you will emphasise the importance of maintaining two types of records:

1. Nursery management information

It is useful to keep a record of observations and treatments performed on the plants while growing in the fruit tree nursery. These include:
- Weather condition observations
- Growing behaviour of the plants
- Pests and diseases
- Any management treatments including input costs (materials such as pesticides, fertilisers and labour)

These records are useful to analyse the performance of the varieties for future considerations and to support decision making for good business management.

2. Traceability information

The following documents should be retained:

(a) Records concerning the origin of the mother stock plants: The record document may be the certification label. In the case of imported materials, an invoice, packing list or delivery note.
(b) Registration book (the nursery book) of sapling production, including information pertaining to budding and grafting operations.

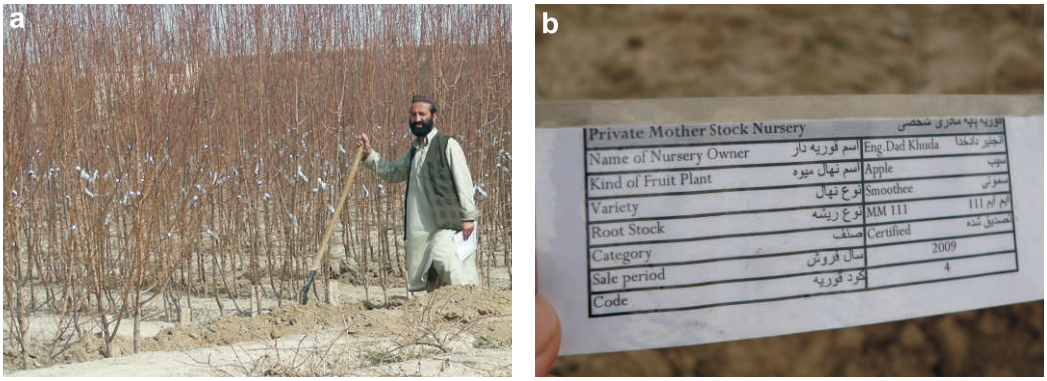

Figure 44: *Certified fruit trees in a registered nursery. Certified saplings with label (a); Certification label describing mother stock material origin (b) (M. Athar)*

If you have access to a computer and projector, you may like to show the following presentation during the growers' association meeting (click below or open the CD accompanying your manual):

PRESENTATION No. 3: "The fruit tree production nursery".

Annexes

Annex 1: List of registered mother stock nurseries in Afghanistan (2009)

Nursery Code	MSN Name	Owner's name	Province	District	Settlement	Phone #
HER06229	Guzara MSN	Abdul Aziz	Herat	Guzara	Dehzaq	
HER06233	Injil MSN	Haji Naim	Herat	Injil	Naw Badam	0700401971
JAL06221	Kunar MSN	Rohollah	Kunarha	Asadabad	Dandona	0700583396
JAL06251	Nangarhar MSN	Agha Shirin Abdul	Nangarhar	Behsud	Jamali	0799320203
JAL06252	Laghman MSN	Masoud	Laghman	Mehterlam		0799670660
JAL06253	Gardez MSN	Noor Agha	Paktya	Gardez	Bala Deh	0700583396
KAB06157	Bagram MSN	Abdul Majid	Parwan	Bagram	Deh-e Harzara Qalai Bashir	0799434198
KAB06369	Maidan MSN	Taus	Wardak	Nirkh	Ahmad Khair Bagh	0775181237
KAB06610	Paghman MSN	Haji Noor Mohammad	Kabul	Paghman	Arghandi Paian	070081519
KAB06809	Shakardara MSN	Abdul Khalil	Kabul	Shakar Dara	Dowlana	0700583396
KAB06898	Lugar MSN	Shah Mahmood	Logar	Pul-i-Alam	Tator Khana	0700205621
KAB06912	Sayedkhel MSN	Abdul Manan	Parwan	Jabalsuraj	Khowaja Mohammad Khyel	0700495884
KAB06932	Dr. Wakili Association	Hedayatullah	Wardak	Nirkh	Tashleq	0799618683
KAN06095	Kandahar MSN (Mohammad Shafi)	Mohammad Shafi	Kandahar	Kandahar	Deh Kochi	0700305406
KAN06169	Zabul MSN	Haji Amanullah	Zabul	Qalat	Jalal Khan Kalay	0700382817
KAN06188	Kandahar MSN (Qasim)	Mohammad Qasim	Kandahar	Daman	Mahmmadzo Qalacho	0708322905
KAN06189	Kandahar MSN (Asadullah)	Asadullah	Kandahar	Kandahar	Mirza Mohammad Khan Qalacha	0700389151
KUN06065	Imam Qutiba Baghlani MSN	Shah Mohammad (Muhaqiq)	Baghlan	Baghlan-i-Jadeed	Logarian	0700616400
KUN06109	Kunduz MSN	Noor Hazrat	Kunduz	Kunduz	Za Khel (1)	0799828271
KUN06175	Chonghar MSN	Haji Mohammad Sarawar	Baghlan	Pul-i-Khumri	Niazullah Dand Ghoori	0799038462
KUN06210	Andarabha MSN	Haji Abdul Rahman	Baghlan	Andarab	Sayad	0707510651
KUN06267	Takhar MSN	Rahimullah	Takhar	Taluqan	Sari Sang	0772343770
MAZ06441	Khulm MSN	Fazel Ahmad	Balkh	Khulm	Charsoq	0799881030
MAZ06441	Khulum Fazel Ahmad MSN	Fazel Ahmad	Balkh	Khulm	Charsoq	0799881030
MAZ06570	Um-ul-bilad MSN	Mohammad Akram	Balkh	Dehadadi	Shikabad	0700049952
MAZ06571	Aibak MSN	Haji Noor Ahmad	Samargan	Aybak	Khowaja Ismail	0799102397

Perennial Horticulture Development Project

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