TECHNOLOIE PĚSTOVÁNÍ LISTNATÝCH POLOODROSTKŮ A ODROSTKŮ NOVÉ GENERACE V LESNÍCH ŠKOLKÁCH – souhrn certifikované metodiky

TECHNOLOGY FOR PRODUCTION OF NEW GENERATION SEMISAPLINGS AND SAPLINGS OF BROADLEAVES IN FOREST NURSERIES – summary of certified methodology

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Abstract

The document describes the technological process for production of large-sized bare-rooted planting stock of broad-leaved species with high-quality root systems, which do not require digging large planting holes at planting on forest sites. We termed this planting stock as "new generation semisaplings and saplings" (in abbrev. NGSS). As for the planting stock size, the new generation semisaplings belong to the 81–120 cm height class and new generation saplings belong to the 121–180 cm height class. The preconditions in terms of required nursery machinery and soil chemistry and physical characteristics of soil are specified and the particular operations within the NGSS production process are described in detail within this document. Chosen morphological parameters of the NGSS are summarized and confronted with the up-to-date version of the Czech standards (ČSN 48 2115 Forest reproductive material, Amendment Z2).

Keywords: *large-sized planting stock, broadleaves, bare-rooted planting stock; nursery operations*

Abstrakt

Příspěvek popisuje technologický postup produkce prostokořenných odrostků vybraných listnatých dřevin s vysoce kvalitním kořenovým systémem, který při následné výsadbě nevyžaduje kopání velkých sadebních jamek. Tento typ sadebního materiálu je nazýván „odrostky a poloodrostky nové generace" (ve zkratce PONG). Ohledně velikostních dimenzí, výška nadzemní části poloodrostků nové generace je v rozpětí 81–120 cm, u odrostků nové generace je rozpětí výšek 121–180 cm. V příspěvku je specifikováno nezbytné strojní vybavení lesní školky a požadované vlastnosti půd z hlediska chemismu a fyzikálních parametrů, aby bylo možné PONG pěstovat. Dále jsou popsány jednotlivé pěstební operace během produkce PONG. Shrnuty jsou vybrané morfologické parametry PONG a následně porovnány s aktuální českou normou (ČSN 48 2115 – Sadební materiál lesních dřevin, Změna Z2).

Klíčová slova: *odrostky, poloodrostky, listnaté dřeviny, prostokořenný sadební materiál, školkařské operace*

Introduction

The document describes the technological process, i.e. required machinery and nursery soil parameters, for production of large-sized bare-rooted planting stock of broad-leaved species with high-quality root systems.

Required machinery

A four-wheel drive tractor (motor power 60–75 kW) fitted with a creeping speed reducer enabling a very slow forward movement (140 $m.h^{-1}$) is necessary. The tractor must be equipped with a three point linkage (three point hitch) and free available hydraulic circuits.

A subsoiler (subsoil plough) must be able to conduct deep tillage down to 50 cm depths and to disrupt compacted layer of subsoil. A subsoiler can be towed behind tractors or mounted to the three point linkage.

It is necessary to use the quality ploughs or rotary cultivators for ploughing, loosening and homogenizing the plough layer of nursery fields.
Transplanter must be able to plough a furrow reaching a depth up to 35 cm below the surface of the nursery field. The width of the furrow should be up to 12 cm. The transplanter shoe must be equipped with a mechanism preventing compaction and/or smoothing of the furrow walls (e.g. ribs welded on the surface of the shoe disrupting the soil in the furrow walls). A transplanter should be equipped with a disc coulter mounted in front of the shoe. The disc coulter cuts the soil. The shoe opens the soil and makes a furrow to place the root systems of transplanted trees (see Fig. 1 for further details).
Side plant digger (side plant lifter) is used for row lifting of high-stemmed plants (saplings) over which the tractor cannot pass. Lifting depth must be up to 50 cm.

Soil parameters
Sandy loam (according to the world textural triangle) is the ideal soil texture for growing the NGSS in forest nurseries. The weight proportion of the soil particles 2–4 mm in diameter should be desirably less than 20%. As for soil texture, in the fine earth fraction (i.e. <2.0 mm in size), the weight proportion of the clay particles (less than 0.002 mm in size) should range between 3.5 and 6.5%. The weight proportion of the silt particles (i.e. 0.002–0.05 mm in size) should be 25–50%. The minimum depth of plough layer is 50 cm.
As for soil chemistry, soil reaction should be 5,5–6 pH (in $CaCl_2$). The cation exchange capacity (CEC; according to the Kappen procedure) of plough layer should be at least 15 meq/100 g of soil material (desirable CEC equals 18 meq/100 g or more). The concentration of soil organic matter (H_{ox}) should be at least 5%. Base saturation (BS) of plough layer should range between 75 and 90%. Recommendable concentrations of available nutrients (by the Mehlich III procedure) in the plough layer are as follows: P>81 $mg.kg^{-1}$, K>161 $mg.kg^{-1}$, Mg>136 $mg.kg^{-1}$, Ca>1 300 $mg.kg^{-1}$.

The principle nursery operations to grow NGSS
Initial planting stock selection
The two-year-old, bare-rooted, root-pruned plants (1–1) are used as the initial planting stock entering the further nursery process of NGSS production. The root pruning of these 1–1 plants is conducted in the spring of the second growing year. The plants belonging to the 70–90 cm height class constitute a group from which the first-quality individuals are selected for NGSS production. Apart from the above-ground parts, an important criterion for selection is root systems. Root systems of appropriate quality of European beech (*Fagus sylvatica*), English oak (*Quercus robur*) and small-leaved lime (*Tilia cordata*) are depicted on the Fig. 2, Fig. 3 and Fig. 4, respectively.

Manual root pruning
Manual reduction of root systems (second root pruning) is a major step in the process of NGSS production. The root biomass of the lifted two-year-old (1–1) plants (that were chosen as the initial planting stock for the NGSS production) is reduced by up to 50%. The aims are (1) to shorten the skeletal roots (and thus reduce the hazard of root system deformation during subsequent nursery and forestry operations), and (2) to achieve a more fibrous root system of the NGSS to be grown. The root pruning is conducted using garden shears (bypass pruners). This operation keeps an experienced worker occupied for ca 0.5 min per a tree. The cut end diameter of the

pruned roots should not exceed 6 mm. Some details of the manual root pruning of beech, oak and alder are depicted in figures Fig. 5, 6 and 7, respectively.

Transplanting
After root pruning, the plants are transplanted back into a nursery bed at a spacing of 80 × 30 cm (the drills with plants should be 80 cm apart). The used transplanter must meet requirements as defined above. The operational sequence is depicted in Fig. 8 and 9. The nursery stock must be transplanted in the upright position. The roots of the transplanted trees should be placed deep enough inside the furrow, however, the roots should not reach the bottom of the furrow.

Singling and formative pruning of the above-ground parts
The singling and/or formative pruning of the NGSS (Fig. 10, 11 and 12) are conducted to produce a single straight stem and to promote a dynamic height growth of the planting stock. Singling is the removal of a stem fork or multiple leaders, if these occur. Formative pruning should reduce the occurrence and growth of coarse lateral branches. Both operations are carried out on the transplanted trees during the vegetation period after the spring growth has terminated. The bypass pruners or sharp knives are used to conduct these nursery techniques. It is essential to avoid damaging the branch collar (the ridge of bark at the base of branch).

Production time
Propagating the NGSS from seed may require from three to six years depending on the species and target dimensions (semisaplings vs. saplings). As mentioned previously, the two-year-old, bare-rooted, root-pruned plants (1–1) are used as the initial planting stock entering the NGSS production. What differs is the production time in the nursery subsequent to transplanting that is required to achieve the finished planting stock. The following overview summarizes the recommended schemes for the NGSS production of chosen forest tree species.

- Oaks (*Quercus robur* and *Quercus petrea*): The bare-rooted transplants of oaks reach the dimension of NGSS most commonly at the age of four years. The recommendable way of production: two-year-old, root-pruned plants are transplanted and then grown for two years as transplants.
- Beech (*Fagus sylvatica*): The bare-rooted transplants of beech reach the dimension of NGSS most commonly at the age of four or five years. The recommendable way of production: two-year-old, root-pruned plants are transplanted and then grown for two or three years as transplants.
- Some other species – limes (*Tilia cordata* and *Tilia platyphyllos*), alder (*Alnus glutinosa*), bird cherry (*Prunus avium*), ash (*Fraxinus excelsior*), maples (*Acer pseudoplatanus* and *Acer platanoides*), birches (*Betula* ssp.) and rowan (*Sorbus aucuparia*): The bare-rooted transplants of the above-mentioned broadleaves reach the dimension of NGSS most commonly at the age of three years. The recommendable way of production: two-year-old, root-pruned plants are transplanted and then grown for one year as transplants.

Lifting of the NGSS
The lifting of the bare-rooted NGSS from the nursery bed is a crucial step that has an important influence on the physiological quality of the planting stock. The lifting must be well-timed to fit the phenology of trees. Tree dormancy is required. Since the lifted NGSS are bulky and sensitive, it is highly recommendable to lift this planting stock just before the term of expedition from the nursery and planting on a forest site.

In the temperate zone, it is advisable to lift the NGSS in autumn, usually in the second half of October, after the first night frosts occurred. The lifting from the nursery bed and planting on a forest site must be conducted when the outdoor temperature is above 0 °C. The soil must not be frozen or covered with snow. The spring term of lifting and planting the broad-leaved NGSS must be seen only as a fall-back solution. Tree dormancy is required.
The side plant digger able to lift the root systems of the NGSS from a depth of 30–50 cm must be used. The digger should be equipped with shaking grades separating the soil from roots of the lifted planting stock.

Grading, storing and expedition of NGSS
To keep the planting stock viable, respiration and transpiration must be held to a minimum so far the roots of plants are out of soil. Root systems of the lifted planting stock must not be exposed to sun radiation, desiccative air flow and freezing temperatures. It is best to reduce the time between lifting and planting the NGSS as much as possible. The manipulation with the lifted plants should be conducted in the air-conditioned facilities under cool and moist conditions.
Manual adjustment of root systems before expedition from the nursery includes shortening the roots to the required length. The length of roots should range between 25 and 35 cm, the diameter of the whole root system should be ca 20 cm. All pruning cuts must be less than 10 mm in diameter. Within this final adjustment, the roots systems of NGSS are also checked and some cuts made by the share of the lifter are eventually corrected (made smoother and perpendicular to root). The lifted plants are graded by the height of shoot and basal stem diameter in semisaplings and saplings.
The bundles of NGSS constructed before expedition from a forest nursery should consist of no more than 25 semisaplings and 10 saplings, respectively (Fig. 13). The application of antidessicants to roots is advisable. However, the antidessicants cannot be used if the planting stock is kept in air-conditioned stores with air humidifiers due the risk of fungi diseases of roots (moulding).
The expedition of NGSS from a forest nursery on forest site should be a component of a well-prepared flow of operations. The planting stock, when being transported, must be protected from high temperatures, frosts and desiccative conditions. Immediately after the NGSS arrive from the nursery on a forest site, they must be heeled in.

Morphological parameters of NGSS
The morphological parameters of NGSS and their confrontation with the requirements on semisaplings and saplings defined by the Czech standards (ČSN 48 2115, amendment Z2) are summarized in the Tab. 1 and Tab. 2 in Appendix. The NGSS meet all the requirements defined by the Czech national standards. Regarding the basal stem diameter as well as root-to-shoot volume ratio, the NGSS markedly exceeds the requirements defined by the national standards.

Acknowledgement
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Appendix

Table 1: Comparison of mean basal stem diameter of new generation semisaplings and saplings with the requirements defined by the Czech standard (ČSN 48 2115, amendment Z2) for the respective size classes of planting stock.

	Basal stem diameter [mm]			
Species	New generation semisaplings	Czech standard requirements	New generation saplings	Czech standard requirements
European beech *Fagus sylvatica*	16	11	18	14
English oak *Quercus robur*	17	11	17	14
small-leaved lime *Tilia cordata*	20	11	27	16
sycamore maple *Acer pseudoplatanus*	14	10	23	14
wild cherry *Prunus avium*	14	10	undefined	
rowan *Sorbus aucuparia*	14	10	16	14
black alder *Alnus glutinosa*	10	10	26	14

Table 2: Comparison of mean root-to-shoot volume ratio [-] of new generation semisaplings and saplings with the requirements defined by the Czech standard (ČSN 48 2115, amendment Z2) for the respective size classes of planting stock.

	Root-to-shoot volume ratio [g]			
Species	New generation semisaplings	Czech standard requirements	New generation saplings	Czech standard requirements
European beech *Fagus sylvatica*	0.8	0.5	0.8	0.3
English oak *Quercus robur*	1.2	0.5	1.0	0.3
small-leaved lime *Tilia cordata*	1.1	0.5	0.7	0.3
sycamore maple *Acer pseudoplatanus*	0.8	0.5	0.7	0.3
wild cherry *Prunus avium*	1.1	0.5	0.9	0.3
rowan *Sorbus aucuparia*	0.8	0.5	0.5	0.3
black alder *Alnus glutinosa*	1.0	0.5	0.7	0.3

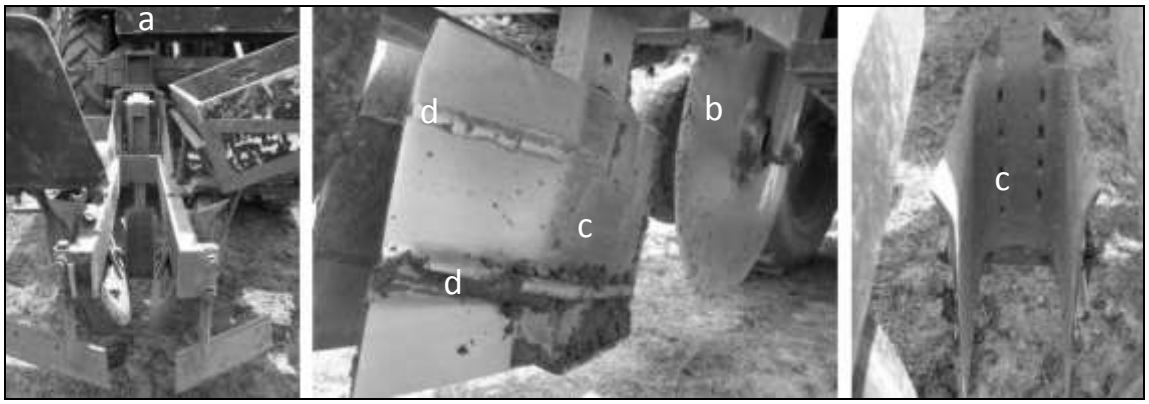

Fig. 1: The transplanter (a) is carried out on the three point hitch of a tractor.
A transplanter is equipped with a disc coulter (b) mounted in front of the shoe (c) that is equipped with ribs (d) preventing compaction of furrow walls.

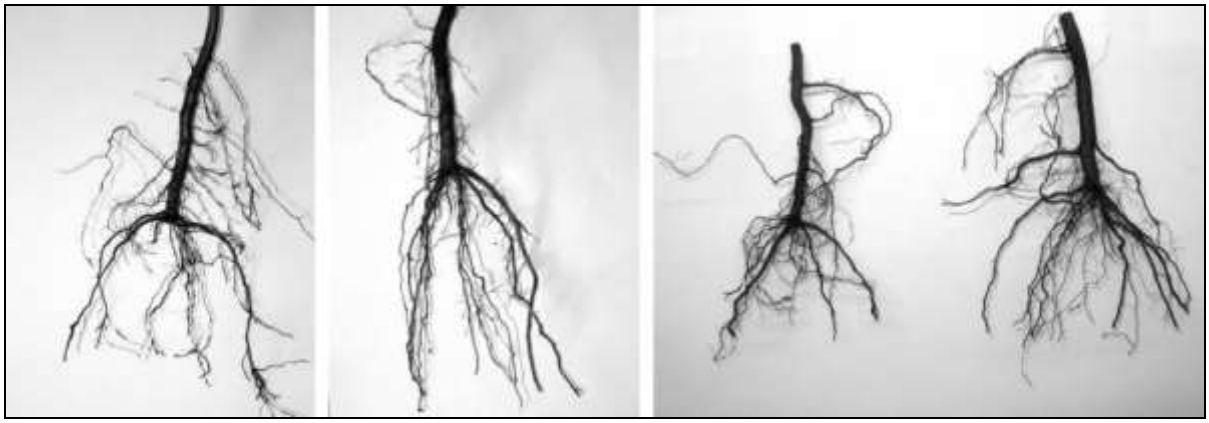
Fig. 2: Root systems of two-year-old, root-pruned plants of European beech (*Fagus sylvatica*).

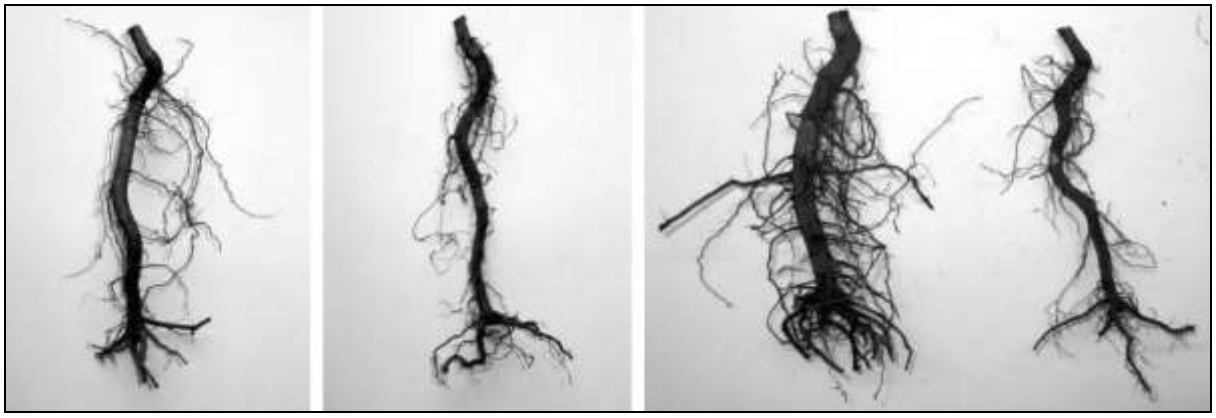
Fig. 3: Root systems of two-year-old, root-pruned plants of English oak (*Quercus robur*).

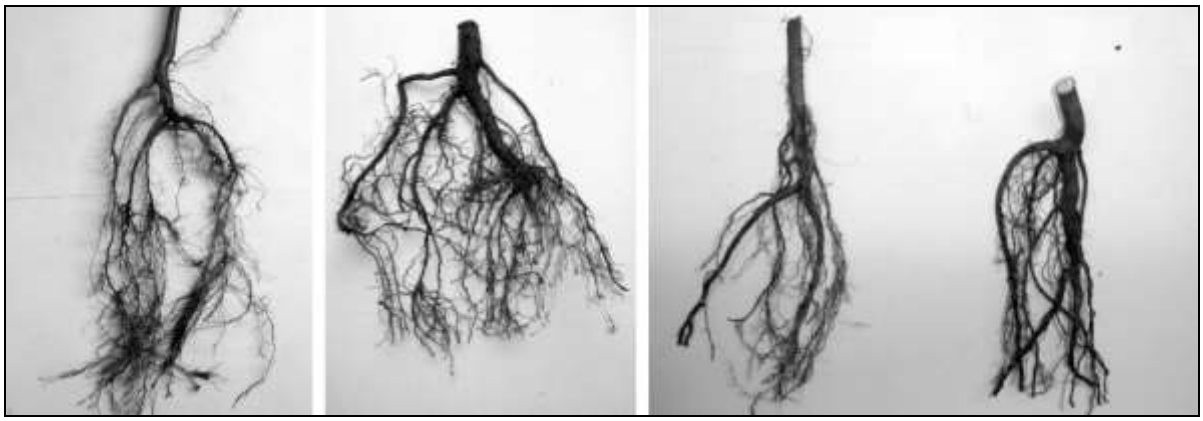

Fig. 4: Root systems of two-year-old, root-pruned plants of small-leaved lime (*Tilia cordata*).

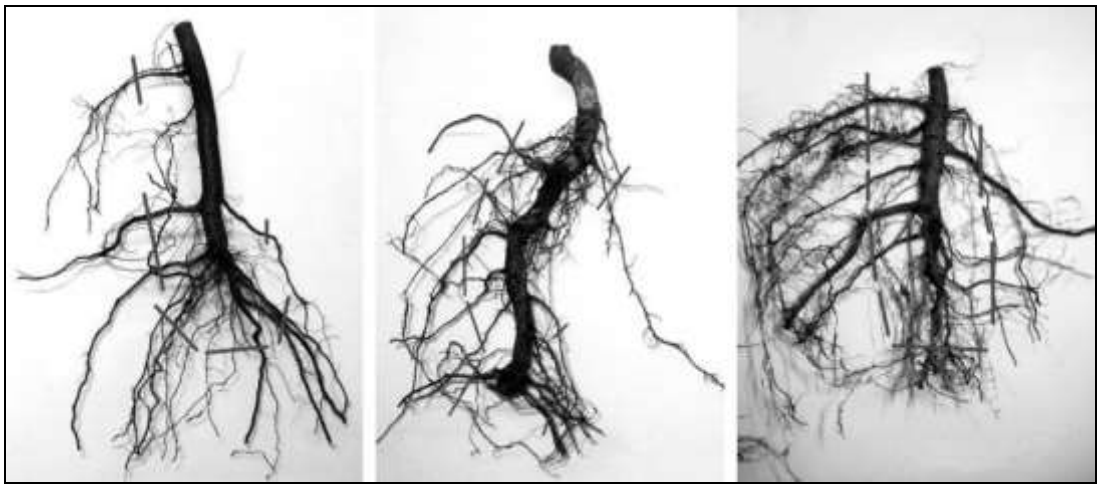

Fig. 5: Root systems of the two-year-old, root-pruned plants (1–1) of European beech (*Fagus sylvatica*) lifted from a nursery bed within the transplanting operation. The lines indicate the cuts to be done within second root pruning before (trans)planting the trees back to the nursery bed so that the growing of the NGSS could continue.

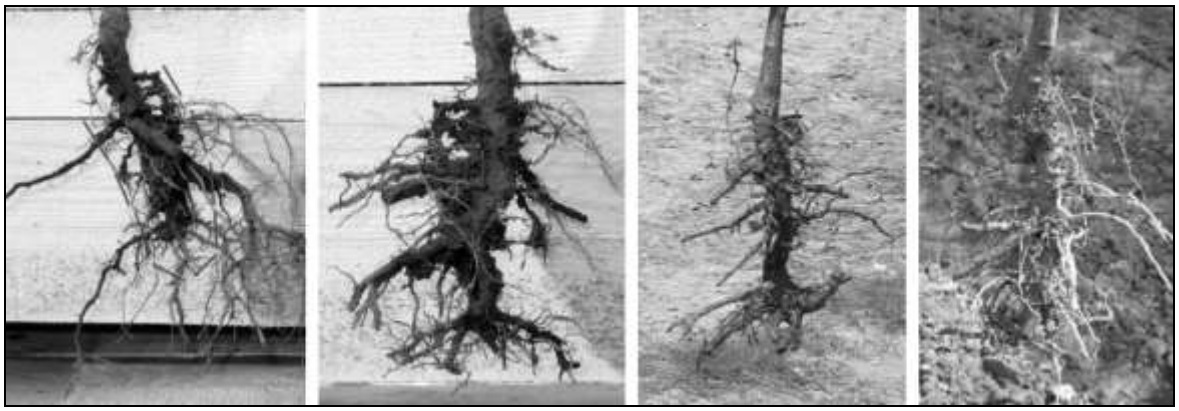

Fig. 6: Root systems of the two-year-old, root-pruned plants (1–1) of English oak (*Quercus robur*) lifted from a nursery bed within the transplanting operation. The lines indicate the cuts to be done within second root pruning before (trans)planting the trees back to the nursery bed so that the growing of the NGSS could continue. Where red lines are missing, the second root pruning has already been done.

Fig. 7: Root systems of the the two-year-old, root-pruned plants (1–1) of small-leaved lime (*Tilia cordata*) lifted from a nursery bed within the transplanting operation. The lines indicate the cuts to be done within second root pruning before (trans)planting the trees back to the nursery bed so that the growing of the NGSS could continue.

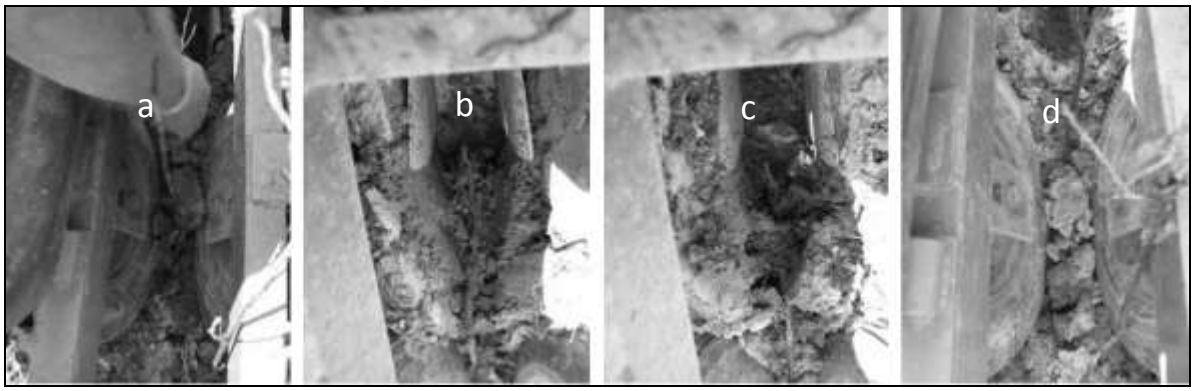

Fig. 8: Transplanting. Placing the roots of a two-year-old plant (after the second root pruning) in a furrow made by the transplanter (a). Covering the root system and filling the furrow with soil (b) and (c). Tamping the soil inside the furrow by the downwardly convergent packer wheels (d).

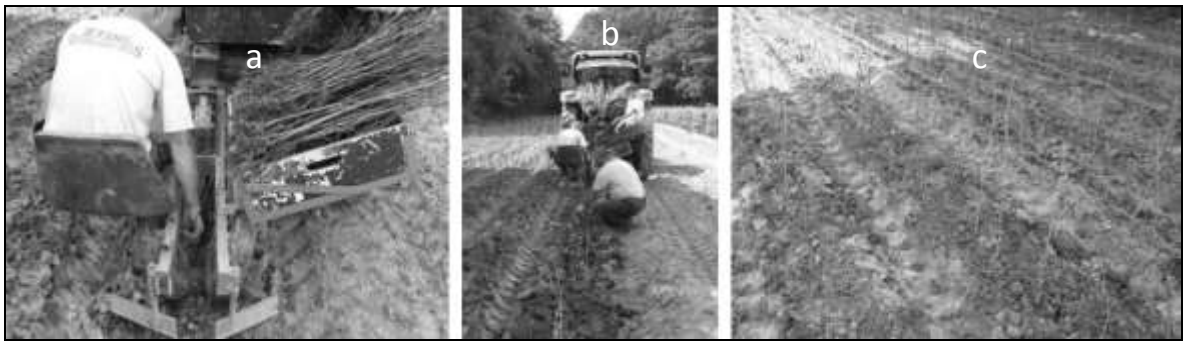

Fig. 9: Transplanting. The operator inserts the plants, whose roots have already been pruned for the second time, in the furrow made by the transplanter (a). Quality control of the transplanting (b). Nursery field with newly transplanted trees to be grown to the NGSS dimension (c).

Fig. 10: Formative (shoot) pruning of English oak (*Quercus robur*).

Fig. 11: Formative (shoot) pruning of European beech (*Fagus sylvatica*).

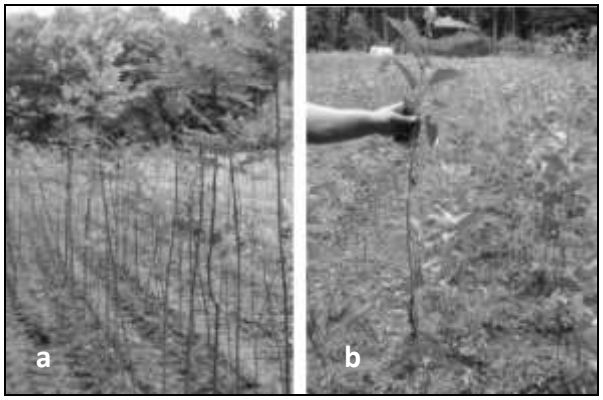

Fig. 12: Formative (shoot) pruning of European ash (*Fraxinus excelsior*) – (a), and wild cherry (*Prunus avium*) – (b).

Fig 13: Bundles of planting stock should consist of no more than 25 semisaplings (a) and (b) and of 10 saplings (c), respectively.

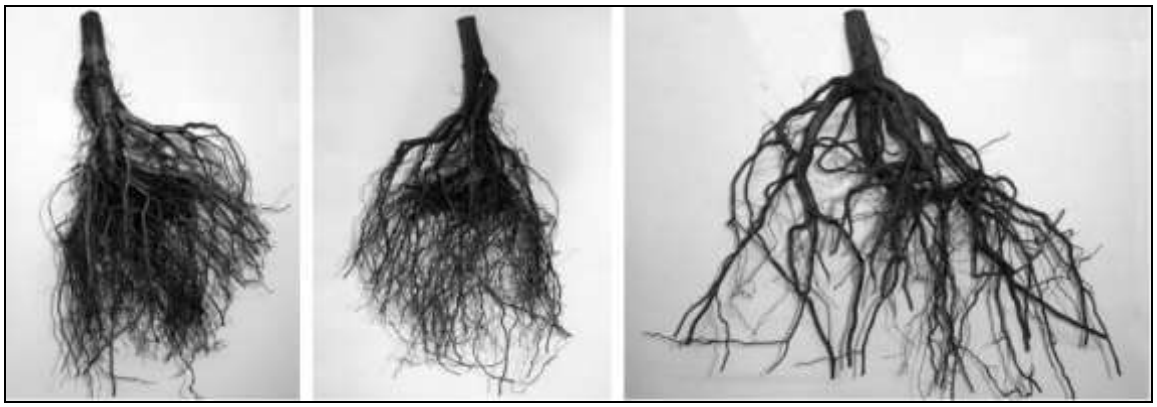

Fig. 14: Root systems of the NGSS of European beech (*Fagus sylvatica*).

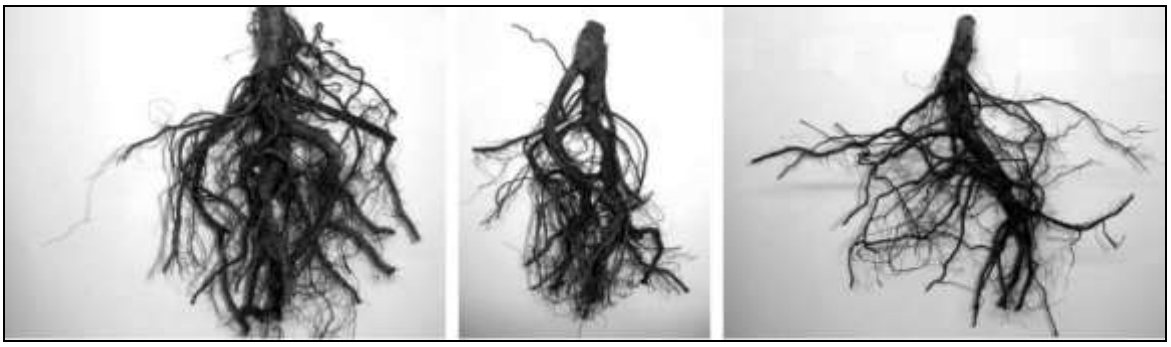

Fig. 15: Root systems of the NGSS of European beech (*Quercus robur*).

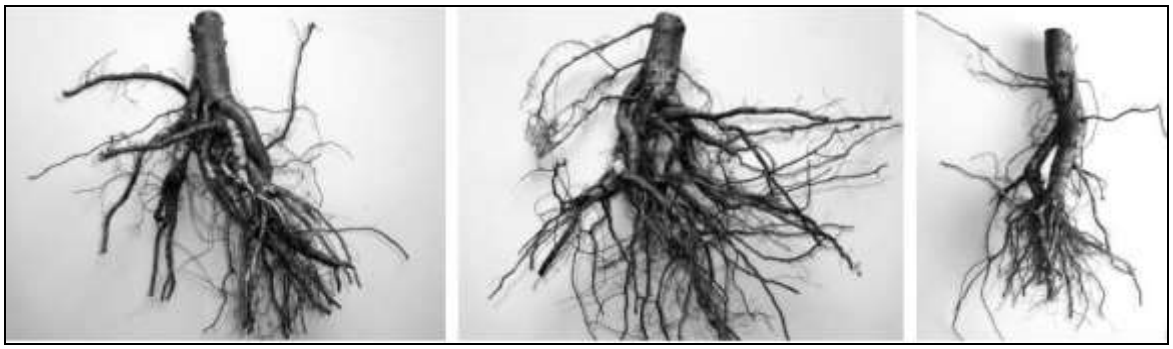

Fig. 16: Root systems of the NGSS of small-leaved lime (*Tilia cordata*).