POMOTECHNICAL TREATMENTS IN THE BROADLEAVE CLONAL SEED ORCHARDS

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Abstract

For several decades management of most economically important forest tree species has faced problems of natural regeneration, repair planting on partially naturally regenerated areas and afforestation of open sites. Over these decades, the periodicity of seed crops has not been regular, which has limited natural regeneration and artificial planting. In order to increase genetic quality and reduce seed crop irregularity, it was decided to establish clonal seed orchards. Pedunculate oak (*Quercus robur* L.) and narrow leaf ash *(Fraxinus angustifolia* Vahl) are two of the most important and the most valuable forest tree species. Three clonal seed orchards of pedunculate oak were established between 1996 and 2001 in three seed regions (total area from 15 to 26 ha). The grafts were formed by the oval spindle training system and with spacing 10 × 8 m. The clonal seed orchard of narrow leaf ash was established in 2005 in the area of 3.5 ha. The grafts were planted with 4 × 4 m spacing and formed by the spindle pyramid training system. The clonal seed orchard of wild cherry was established in 2001 in the area of 2 ha and it contains 27 clones. Grafts were planted with 6 × 3 m spacing and formed by the spindle bush training system. The orchard is further supplemented by new grafts. In one of the earlier experimental clonal seed orchards of pedunculate oak root cutting was used to produce higher yield. All clonal seed orchards have been regularly maintained by pruning and other agrotechnical treatments.

Background

Highly disturbed natural balance of forest stands and lack of their regular natural regeneration have called for special measures in seed and nursery production in Croatia with application of expert forest knowledge about restoration, preservation and enhancement of forest resources.

In the last decades management of most economically important forest tree species has faced problems of natural regeneration, repair planting on partially naturally regenerated areas and afforestation of open sites. There is no regular periodicity of seed crops in stands and the time period between mast yield years is prolonged. The seed is collected from natural and seed stands as well as seed orchards (clonal seed orchards).

Even though the Croatian forests are supposed to be naturally regenerated it cannot be fully conducted. The most common reason is lack of yield in those stands that should be naturally reforested. The seed amount of important forest tree species required in a year is higher than its yearly production. To reduce or annul this negative difference between the required and the collected seed and to organize the production of genetically improved seed clonal seed orchards were established.

Seed stands and clonal seed orchards in Croatia

The total area of 17 612 ha (Table 1), managed by Hrvatske Sume limited liability company, has been selected as registered seed stands in the category of special purpose forests. Their main purpose is the production of seed needed for the production of seedlings and stands underseeding. The seed yield of every species produced in seed stands is not always sufficient for the underseeding of stands (as a way of enhancement of natural regeneration) or for open sites afforestation. Only in a year of mast crop there is sufficient productivity on the above stated area of seed stands. However, the yield periodicity for almost all tree species is between two and five years or even more. The clonal seed orchards were establish to reduce the lack of seed in the years when there is either no crop or low and insufficient seed crop (Table 2).

Table 1 Seed stands in Croatia

Species	Type	No.	Total area (ha)
Conifers			
Abies alba	PSS/ISS	14	418
Larix decidua	PSS	1	15
Picea abies	PSS	13	280
Pinus brutia	PSS	3	21
Pinus halepensis	PSS/ISS	5	185
Pinus nigra	PSS/ISS	15	302
Pinus nigra ssp. *dalmatica*	PSS	1	57
Pinus nigra ssp. *laricio*	PSS	2	29
Pinus pinaster	PSS	4	50
Pinus pinea	PSS/ISS	3	9
Pinus sylvestris	PSS	5	69
Taxodium distichum	PSS	1	1
Total	PSS/ISS	76	1 436
Social Broadleaved species			
Fagus sylvatica	PSS/ISS	25	1 603
Quercus ilex	PSS	3	85
Quercus petraea	PSS/ISS	35	2 044
Quercus pubescens	PSS/ISS	3	129
Quercus robur	PSS/ISS	106	10 094
Quercus robur var. *tardissima*	PSS	5	99
Total	PSS/ISS	180	14 054
Noble Hardwoods species			
Acer pseudoplatanus	PSS	1	22
Alnus glutinosa	PSS/ISS	4	50
Carpinus betulus	PSS/ISS	4	132
Castanea sativa	PSS	1	23
Fraxinus angustifolia	PSS/ISS	25	1 603
Fraxinus excelsior	PSS	1	22
Juglans nigra	PSS/ISS	3	56
Tilia tomentosa	PSS	2	42
Tilia platyphyllos	PSS	3	172
Ulmus minor	PSS	3	GS
Total		47	2 122
Subtotal		303	17 612

PSS = registered seed stands
ISS = selected seed stands
GS = group of trees

To supplement natural regeneration of forest stands every year certain amounts of forest tree seed should be ensured. The need for the seed of important large seed producing broadleaved trees such as pedunculate oak, sessile oak, narrow leaf ash, beech tree, etc. is evident not only because of their yield periodicity but also because their seed cannot be stored. For example, on average around 900 tonnes of pedunculate oak and 170 tones of sessile oak is harvested in a year.

It is especially important to provide enough forest seed necessary for the nurseries managed by Hrvatske sume that lately have to grow and deliver large amounts of forest seedlings. Seed production in seed orchards should provide better solutions for regular yield of high quality and genetically improved seed as production of forest seedlings in nurseries (an average year production is between 18 and 26 million seedlings).

Table 2: Clonal seed orchards in Croatia

Species	No. of orchards	Total area (ha)	No. of clones
Pinus sylvestris	2	3,00	30
Pinus nigra	2	1,50	41
Larix europea	2	2,50	28
Quercus robur	4	47,00	150
Tilia cordata	1	0,72	13
Alnus glutinosa	2	1,70	61
Fraxinus angustifolia	1	3,50	56
Prunus avium	1	3,00	26
Total	15	62,92	

First clonal seed orchards in Croatia were established a few decades ago. Those orchards had scientific purpose and were used for practical training (Kajba et al 2006). They were experimental seed orchards on small areas mostly of coniferous and only few of broadleaved species. Newer clonal seed orchards were established on more productive sites in larger areas (from 15 ha up to 26 ha) in the period between 1996 and 2006 (pedunculate oak, narrow leaf ash, wild cherry). The establishment of clonal seed orchards of late flushing pedunculate oak (*Quercus robur* var. *tardissima*) and sessile oak (*Quercus petraea*) is in process. Three clonal seed orchards of pedunculate oak have been established in three provenance regions: “Central Sava river“, established in 1996 in the area of 15 ha including 40 clones, “Upper Sava river“

established in 2000 in the area of 26 ha including 53 clones and a “Lower Posavina“ established in 2001 in the area of 25 ha including 57 clones. The clonal seed orchard of narrow leaf ash was established in 2005 in the area of 3.5 ha and it includes 56 clones. The grafts were planted with 4 × 4 m spacing.

The clonal seed orchard of wild cherry was established in 2001 in the area of 3 ha. The orchard includes 27 clones with 517 grafts and it is further supplemented by new grafts.

Along with the above stated clonal seed orchards of pedunculate oak and narrow leaf ash the progeny trials of selected plus trees were established to test their genetic quality (Bogdan et al 2004).

Training shapes and forms

The purpose of successful fruit techniques is maintaining the balance between the vegetative and generative activity. These techniques are also being applied on forest tree grafts in clonal seed orchards.

The forming pruning is used to bring the grafts into the required training shape whereas pruning for higher yield maintains the adequate balance between the growth and the seed production.

Tree pruning and training started right after the planting with a goal to gain desired canopy shape with well-deployed scaffold branches in the next 7 or 8 years.

Grafts were reduced to the desired canopy height. Some of the branches were pruned for inducing further branching from the side buds.

The main function of pruning is the removal of competing shoots to enforce the growth of remaining desired ones. Pruning intensity, i.e. the relation between vegetative and generative buds in the canopy determines the tree’s condition, density and yield. The balance between vegetative and generative buds can only be achieved by appropriate underground and aboveground tree parts pruning.

Knowing the production morphology of each tree species is very important (oak, ash and cherry). For instance, oak- the fruit called acorn are on long stem of terminal buds on one-year branches. Ash flowers in dense clusters inflorescences. Cherry fruits on one-year branches of various length, long shoots or short bearing branches.

Characteristics of training systems

Training systems should produce a strong framework and good light penetration in canopy. Different training system is applied to each tree species.

Pedunculate oak – oval spindle training system (Figure 1).
The spacing is 10 × 8 m. The total height of the training shape is up to 7 m with six scaffold whorls (figures of trunk height and branch angle within every scaffold whorl): 0.90 m/45°, 1.30m/30°, 1.20m/25°, 1.00m/20°, 1.00m/10°.

Narrow leaf ash – spindle pyramid training system (Figure 2).
The spacing is 4 × 4 m. The total height of training shape and form is 4.00 m with five scaffold whorls (the trunk height and branch angle: 1.20m/45°, 1.00m/60°, 0.90m/70°, 0.50m/80°, 0.40m/90°).

Wild cherry – spindle bush training system.
This training system ensures a strong framework and a good light penetration. The spacing is 6 × 3 m. The trunk height is 90 cm and the central leader ends with the upright terminal shoot. There are four to eight lateral skeleton branches spirally shaped 20 to 40 centimetres apart in height. The unneccesery shoots that are competing with scaffolds are cut off. Skeleton shoots are spirally spreaded out around the central leader and are two times thiner than the leader.

Fig. 1 Pedunculate oak (*Quercus robur*) – oval spindle training system

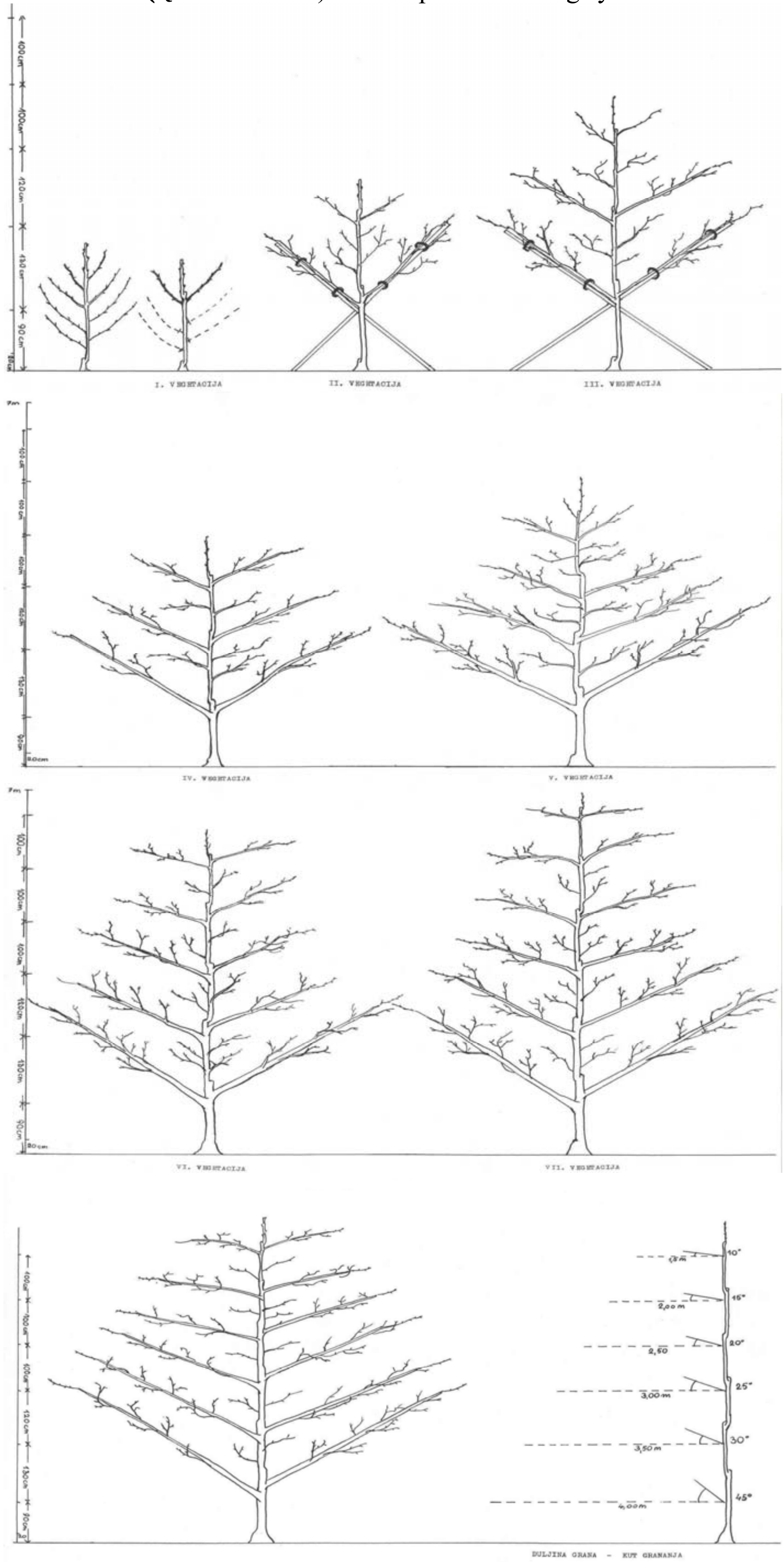
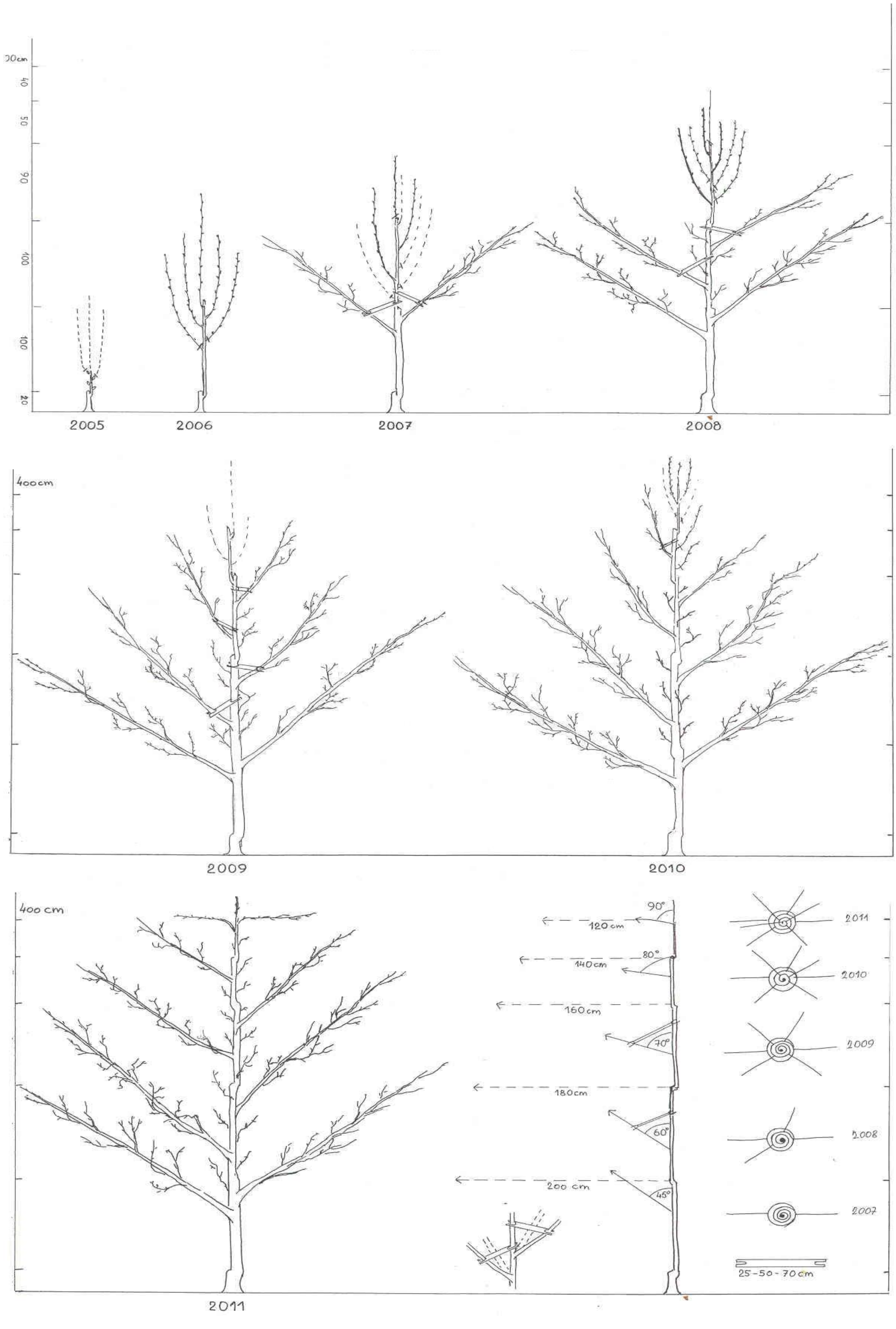


Fig. 2 Narrow leaf ash (*Fraxinus angustifolia*) – spindle pyramid training system



In the vegetative growing season of the second year shoots should be headed at the height of 25 cm to increase the yield.

On grown scaffold shoots only the best lateral branches are left whereas all the rest branches in the scaffold are cut off. In the third year there is a selection of branches in a scaffold and side shoots are cut down to 25 cm. When trees are older and have been shaped and formed the only method used is that of heading to thin and clean the canopy.

Root cutting

The first experimental clonal seed orchard of pedunculate oak was established in 1991. It consisted of 36 clones in the area of 1.00 ha. The spacing in that orchard was 6 × 6 m, which was too close and it was increased to 10 × 8 m in newly established production orchards (situated in the area of 14 to 26 ha). There were some clones that started blooming in the first and the second year upon planting.

Practical training and experience in training systems and pruning methods affecting the yield were gained in this experimental seed orchard. It also served as a mother plantation for grafts and as a site where flowering phenophases and various methods for soil treatment and protection were studied.

Root cutting in one line in the orchard was done on 13 May, 2006 on fifteen years old trees. The roots were cut at 120 cm from the grafts trunk and to a depth of 90 to 100 cm.

Root cutting can annul the negative effect of yields to flower buds differentiation and can also increase yield efficiency. Root cutting for some fruit-trees proved to be efficient method for the shortening of vegetative growth, but for some trees it had a negative effect on yield size and harvest. It has also been established that the effect of root cutting done once a year is not the same every year.

Root cutting increases the activity of cytokinin thus annulling a negative effect of giberelin**.** Knowledge gained so far shows that root cutting or other methods of limiting vegetative growth can affect fruit and higher yield and can increase the canopy of vigorous tree species.

References

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