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Development in intensive orchard systems of cherries in Hungary

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Summary: High density central leader systems, the so called "spindle trees" are spreading in intensive stone fruit orchards established for hand picking in Hungary. Results of *Brunner* (1972, 1990) and *Zahn* (1967, 1996) inspired the researchers to implement their theories into practice under our climate and special soil conditions. For sweet cherry it is essential to apply an orchard system appropriate for hand picking because of the European market requirements. In intensive sweet cherry orchards two new training and orchard systems are developed and adapted to environmental conditions in Hungary based on previous inventions. The first step of the development is represented by modified Brunner-spindle, which applies the delayed heading of the central leader and the sectorial-double-pruning system from Brunner (1972), resulting intensive orchard of 600-800 trees/ha density, planted on standard vigour rootstocks. Modified Brunner-spindle trees are developed with a central leader and wide-angled branches on it. Light bearing wood is positioned on the central leader and wide-angled branches. During training, shoots for branches are bent or a sectorial double pruning is used. The growth of central leader is reduced by delayed heading, and the strong upright shoots are pinched in summer. Based upon tree size spacing of 5 m between row and 2.5–3 m between trees is recommended, tree height is around 3.5–4 m. This training system is useful for hand-picking; 60–70% of the crop can be harvested from ground. Modified Brunner-spindle is suitable for either standard or moderate vigorous rootstocks. The cherry spindle is an intensive orchard planted with 1250–2300 trees per hectare and it is recommended for sweet and sour cherries on semi dwarf to vigorous rootstocks, depending on soil fertility and quality. Trees are 2.5–3.5 m high, 75–80% of the crop can be harvested from the ground. Permanent basal scaffolds are developed on the basis of the canopy to counteract the stronger terminal growth. The tree is headed only once, after planting, from the following year the central leader grows from the terminal bud. The central leader developed from the terminal bud results moderated growth in the upper parts of the tree head. The strong upright shoots that may develop below the terminal bud are pinched to 3–4 leaves in the summer or removed entirely. The weaker, almost horizontal shoots growing from the central leader form fruiting twigs in the following year if their terminal bud is not removed. Brunner's double pruning is used only once or twice on the permanent basal branches because of its good branching effect. Trials on various rootstocks are running to find optimum spacing and fruiting wood management. The training and pruning guidelines are discussed in the paper. The average crop of bearing years is around 20–30 t/ha depending on site and cultivars. This new system is spreading in Hungary, around 70 ha sweet and sour cherry orchards are trained according to our guidelines.

Key words: training, pruning, spindle

Introduction

For the last 35 years considerable progress has been achieved in the intensive sweet cherry orchard systems in Hungary. Due to the application of research and development results in the field of training and pruning, as well as rootstocks, the tree number has increased from 250–280 trees/hectare to 1250–2300 trees/ha. This means a 6–7 folds increase in orchard density, earlier turning to bearing, increased cropping and fruit quality, and easier hand picking.

In Europe, two main streams are known in high density systems; in Southern-European countries researchers and growers developed their intensive systems based on the traditional Mediterranean open-center canopy, which after certain modifications resulted in the Spanish-bush (*Negrón* et al. 2005, *Negueroles* 2005, *Bujdosó* 2006, *Iglesias* 2007). In Central- and Northern-Europe various spindle training systems are more popular (*Zahn* 1986, 1996, *Vogel* 1994, 1995, *Long* 1997, *Lauri* 1998, *Lang and Ophardt,* 1998). The term spindle represents a central leader type tree architecture, where on the central leader no strong limbs but subordinated scaffolds and light fruiting branches are developed.

The Hungarian research in this field can be traced back to the early 70-es of last century when *Brunner* (1972) reported his invention, the so called sectorial double pruning. His spindle (*Brunner* 1991) represents the first step forward with 660 trees/ha, which is followed by the modified Brunner-spindle (*Hrotkó* et al. 1998a) in a density of 600–800 trees/ha. The present recommendations of the Hungarian cherry spindle (*Hrotkó* 1998b) are around 1250–2300 trees/ha combined with appropriate training and pruning protocols and rootstock usage.

Inventions in Europe in sweet cherry orchard systems

There are numerous experiments all over the world to produce dwarf cherry trees for intensive orchards. In Northern-European countries the central leader versions are

preferred while in Southern-Europe the open center canopy is still traditional. The developed training and orchard systems in both directions involve rootstock usage, spacing, training and pruning practices, treatment of fruiting branches and consider the environmental conditions. The rootstock research in Northern-Europe produced more series of dwarfing rootstocks which contributed to establishing and spreading of spindle trees (*Scimmelpfeng & Liebster* 1979, *Trefois* 1981, *Blazek* 1983, *Sansavini* 1984, *Gruppe* 1984, *Franken-Bambenek* 2005, *Callesen* 1998). However, the growth reducing rootstocks allow plantation density up to 1500 – 2500 trees/ha (*Vogel* 1994, 1995, *Zahn* 1990, 1996), growers in dry regions like Hungary prefer medium vigorous or vigorous rootstocks and also train their trees to central leader. On the other hand the growth control is managed in Spanish bush orchard using frequent summer pruning, water restriction and application of growth regulators (cultar, paclobutrazol) (*Negrón* et al. 2005, *Negueroles* 2005, *Bujdosó* 2006, *Iglesias* 2007). The type and treatment of fruiting branches differ essentially in the two training system groups. Due to the multiple summer pruning short shoots, one-year-old shoots and burse shoots produce the fruits on Spanish bush. On central leader type the majority of fruits are formed on burse shoots, which are developed on long fruiting branches subordinated to the central leader.

Development in spindle trees

The Brunner's upright-bud-spindle training system (*Brunner* 1972, 1990) was developed for sweet cherry trees but scarsely used in practice. Brunner's concept (1972) of forming spindle cherry trees is based on application of sectorial double pruning onto upper buds. In Italy (Verona) *Bargioni* (1990) succesfully applied Brunner's pruning method to a high density sweet cherry orchard. *Zahn* (1967, 1973, 1986, 1992, 1996) also developed spindle trees but with pruning techniques different from those of Brunner's. However certain elements of his training system seem to be related to Brunner's theory on sectorial material-transport disturbance (*Brunner* 1972). In his latest publications, *Zahn* (1992, 1996) reported about the formation of spindle trees without permanent basal scaffolds with a spacing of 3 to 4 m between row and 2 to 3 m between trees.

Nevertheless the first determining person who achieved a considerable progress in this field was F.G. Zahn, whose method and recommendations got through into practice mainly in NW- and Central-Europe. Working in extension service in Altes Land (Germany) he recognized the rule: a side branch will function as fruiting branch when it is subordinated to the central leader and its thickness never exceeds the half of the central leader. Applying his theory in the renewal pruning of old cherry trees he developed a complex theory of pruning (*Zahn* 1967, 1973, 1986, 1990, 1992, 1996) which involves his rules on thickness rates, and correctional pruning in summer leaving a stub. His theories have been successfully applied to intensive cherry orchards on a wide range of vigour from dwarf to standard rootstocks.

Another intensive spindle system is developed by *Vogel* (1994, 1995) in Fränkische Schweiz, this system is based on less vigorous rootstocks (Weiroot series and Gisela® 5, allows longer fruiting branches than Zahn's system and applies less pruning (*Long* 1997, 1998).

Both systems can be planted on standard and dwarfing rootstocks, although there are certain advantages on dwarfing rootstocks, which is precocity and less pruning requirement.

The French Solax system is also a type of central leader, which is based on long fruiting branches bent down under horizontal level (*Laurie* 1998) (*Figure 1*). On the long fruiting branches the crop regulation can be achieved by partial removal of burse-shoots (extinction of shoots). This system is planted mainly on dwarfing rootstocks, like Tabel® Edabriz.

Developments in Hungary

Upright-bud-spindle (Brunner 1990)

The first attempts in Hungary to train the cherry trees for intensive orchards can be traced back to early '70-s. *Brunner* (1972, 1990) published his theory on sectorial transport-disturbances caused by pruning wound, and developed the sectorial double pruning method. *Brunner* (1991) developed a central leader-type training system for sweet cherry, on mahaleb seedling planted on 5x3 m planting distance. The main element of this training system is the shoot bending to 60° crotch angle and the sectorial double pruning (*Brunner* 1972, 1990) on scaffolds. This practice results in wide angled scaffolds which produce the fruiting wood. However, the biggest shortcomings of this practice was the fact that the central leader loses dominance often, heading the tree above the third set of scaffolds. Because of the missing dominance of central leader, scaffolds developed into strong limbs. The fruiting wood formed on them shaded the scaffolds as well as the canopy center, which lead to barewood formation. In practice these trees slowly developed to a modifyed central leader. This system because of its shortcomings did not get through in the practice.

Studying the spindle-systems (in tree architecture they are different versions of central leader) like the Zahn's methods (*Zahn* 1990, 1996) or the Vogel-system (*Vogel* 1994, 1995), their difficulties in adaptation to our environmental conditions are discovered (uncertain growth responses in planting year because of dry and hot summer). On the other hand, considerable differences are found among cultivars in the development of fruiting shoots (*Gonda* et al. 2007.) Based on our experiences we decided to combine the advantages of the Zahn–system with Brunner's upright-bud-spindle, which resulted in the modified-Brunner spindle (*Hrotkó* et al. 1998a, b). Later on it turned out that our modified Brunner-spindle also involves shortcomings, due to frequent sectorial double pruning and the strung stub-pruning. In order to avoid them, we developed the so called

"Hungarian cherry spindle", which is central-leader tree architecture with moderate strong flat angled basal scaffolds

Modified Brunner-spindle

During the development of modified Brunner-spindle the following changes were made as compared to the theoretical description of original Brunner's upright-bud spindle:

a/ Keeping dominance of central leader and each set of scaffolds are subordinated (shorter and weeker scaffolds towards the top, larger crotch angle).
b/ Delayed heading and pinching upright shoots around the terminal one.
c/ Brunner's sectorial double pruning is applied on scaffolds only in the early years.
d/ The strong upright shoots on the flat branches should be pinched or pruned back.
e/ Zahn's method of using a stump or a longer stub as a form of corrective pruning is used for the removal of large branches during corrective pruning.

Modified Brunner-spindle trees (*Figure 1, Table 1*) are developed with a dominant central leader and four sets of wide-angled scaffolds on it (*Hrotkó* et al. 1998 a). Light bearing wood is positioned on the central leader and wide-angled scaffolds. During training, shoots for branches are bent or a sectorial double pruning (*Figure 2*) is used. The terminal growth of central leader is reduced by delayed heading, and the strong upright shoots are pinched in summer. Based upon tree size spacing of 5 m between row and 2.5 to 3.0 m between trees appears appropriate. This training system is useful for hand-picking, 60–70% of the crop can be harvested from the ground. The sectorial double pruning results a good branching in the lower canopy sector reached from ground and the delayed sectorial double pruning in bearing stage improves the renewal of fruiting wood (*Figure 3*).

Table 1. Main characteristics of modified Brunner-spindle

Spacing	5 x 2.5–3 m
Tree/ha	600-800 tree/ha
Tree height	3.5–4m
Plant material	both whips and feathered trees
Treatment after planting	heading
Pruning methods	forming wide-angled scaffolds by sectorial double pruning
Fruiting twig location	on scaffolds and on central leader

Training and pruning guidelines to modified Brunner-spindle

a/ Establish four sets of wide angled scaffolds at about 80, 160 and 230 and 300 cm above the ground (*Figure 1*). Above the last set of branches let the central leader grow and branch freely at least two years longer and than remove. The central leader is removed above the fourth set of branches leaving a 20–30 cm stub, from which the buds and shoots are removed in the spring after removal.
b/ Use delayed heading (*Figure 4*) on the central leader (*Hrotkó* et al. 1997, 1998a). Strong upright shoots from the top of the headed central leader are removed in late July when the wide crotch angle of the lower shoots is fixed. The shoot with weaker growth after delayed heading should be chosen for central leader as it would moderate the terminal growth. Shoots arising from the central leader that are too strong or in narrow crotch-angle are either have to be pinched during summer pruning or removed.
c/ Select the shoots to form the wide-angled branches at the time of summer pruning and if their crotch angle is not suitable, bend them to 70–80° crotch angle. The need for bending can be decreased if the strong upright shoots with narrow crotch-angles are pinched to 3–4 leaves. These pinched shoots may form a fruiting branch in the same year or when they form more shoots use sectorial double pruning leaving an almost horizontal shoot in the following year.
d/ Use Brunner's double pruning (*Figure 2*) on the terminal shoot of flat scaffolds until fourth or fifth year (*Hrotkó* et al. 1997, 1998a). Heading of shoots contributes to branching but strengthens the scaffolds and the regular removal of the terminal bud delays the formation of burse shoots. When upright shoots whould develop later on scaffolds' tip, they may be removed by a delayed sectorial double pruning (*Brunner* 1990).
e/ The strong upright shoots on the flat scaffolds should be pinched or pruned back to 3–4 leaves in summer. From these short shoots fruiting wood will form in the same year. After cutting back the stronger shoots, long and fine shoots will develop. These shoots may be useful by using sectorial double pruning next year.
f/ Zahn's method of stub-pruning as a form of corrective pruning to remove of large branches is recommended (*Zahn* 1986, 1990, 1992). The stump will gradually dry and die back, thus reducing the danger of gummosis or infection by bacteria and fungi causing branch decay.

The training of modified Brunner-spindle cherry trees in steps, see in *Table 2*.

Rootstocks and planting material

Modified Brunner-spindle are suitable for trees on standard and moderate vigorous rootstocks, but not recommended on dwarfing rootstocks because of their insufficient growth response. However, when defining the spacing, the rootstock's effect on growth has to be taken into account. *Table 2* shows the spacing recommendations for the rootstocks studied (*Hrotkó* et al. 1999, *Hrotkó & Magyar* 2004).

One-year-old trees with or without laterals can be used. Laterals with narrow-crotch-angles should be bent at least to 80 ° but no double pruning on these laterals is recommended. On trees without laterals the above bending procedure should be carried out on the growing shoots.

Orchard experiences with modified Brunner-spindle

Our experiences confirmed most of the recommendation for spindle trees by *Brunner* (1990) and *Zahn* (1986, 1990,

Table 2. Training of Modified Brunner-spindle trees in steps

Year	Season	Training
Planting year	Spring, after budbreak	Whip is headed at 80 cm. Central leader of nursery trees with laterals is headed to half. Three or four wide angled laterals are pruned to half.
	Summer	When whip is planted, three or four laterals are to bend to 70–80° crotch-angle using clothpins, toothpicks, clamps or strings. When branched tree is planted, bending the laterals, delayed heading on central leader. Only wide angled (70–80 °) shoots may remain.
2nd year	Spring, after budbreak	Heading the central leader to 90–100 cm. pruning on 3–4 lower flat (70–80° crotch-angle) shoots onto upright buds.
	Summer	Delayed heading, 3-4 wide-angled shoots (70–80°) are left on the second set of branches. If necessery, bending shoots, pinching competing upright shoots to 3-4 leaves. Removal of shoots formed from upright upright buds (sectorial double pruning) on lower set of branches.
3rd year	Spring, after budbreak	Heading the central leader to 80–90 cm, sectorial double pruning on 3–4 lower shoots onto upright buds
	Summer	See 2nd years summer pruning. Pinching the upright shoots from basal branches.
4th year	Spring, after budbreak	Heading the central leader to 70–80 cm, sectorial double pruning on 3–4 lower shoots onto upright buds.
	Summer	See 2nd years summer pruning. Pinching the upright shoots from basal branches. The tree turns to bearing.
5th year	Spring, after budbreak	The central leader is grown unpruned, no more sectorial double pruning is needed.
	Summer	Pinching the competing upright shoots to 3–4 leaves on central leader. Only wide angled (80–90 °) fine shoots may remain to form fruiting wood. Pinching the upright shoots from basal branches. Delayed sectorial double pruning (Brunner 1990) on scaffolds and fruiting branches if needed.
6th year	Summer	See 5th years summer pruning. If needed corrective pruning is done on bearing trees: branches thicker than half of the central leader are cut back to 20–30 cm stumps (Zahn's pruning). In the 6th year the central leader may be headed to a fruiting twig at a height of 3.5–4 m.

1992, 1996). The modified Brunner-spindle is more suitable for semi-intensive orchards with 600–800 trees/ha (*Table 3*). It is easier to keep the trees within their space if moderate vigorous rootstocks are used, but trees on dwarfing rootstocks do not grow strong enough to give satisfying pruning responses. The trees with wide-angled branches started cropping in the 4th year and their yield was greater than the average yield for sweet cherries in Hungary (*Table 4*). An important advantage is the possibility of hand picking from the ground or from low picking stands. Thus picking is more efficient, costs are lower and the danger of accidents are also reduced. As the fruiting branches on the trees are young, the fruit size is excellent, and the higher exposure to sunlight results better fruit colour and taste. Spraying a smaller tree canopy can be carried out more precisely, economically, and with reduced emmission of chemicals into environment. It is possible to use a net above the small-size trees to protect them from hail or birds and a protective cover is possible to prevent rain-induced cracking.

To maintain the fruiting branches regular summer pruning is needed, which takes 8-10 minutes per tree. On bearing trees no dormant pruning is recommended thus summer pruning reduces the tree growth.

Table 3. Suggested spacing of sweet cherry trees trained to modified Brunner-spindle on different rootstocks

Rootstock vigour	Rootstocks	Spacing
Standard vigour	Mahaleb seedling Cema (C500), Cemany (C 2753), Mahaleb 'SL 64', 'Bogdány'	5 x 3 m
Moderate vigorous	Mahaleb 'Magyar', 'Brokforest' (MaxMa 14), 'Brokgrow' (MaxMa 97), Pi-Ku-1.	5 x 2.5 m

Modified Brunner-spindle is suitable for growers on poor soil, where vigorous mahaleb rootstocks are most efficient even without irrigation. However, when defining the spacing, the rootstock's effect on growth should be taken into account.

Hungarian cherry spindle

The Hungarian Cherry Spindle (*Figure 5*) as orchard system partly follows the original concept of slender spindle (*Hrotko* 1998b). This system represents a considerable high level of intensity and is recommended in cherry orchards planned for hand picking. It involves a special training and pruning protocol (*Table 5*), spacing and rootstocks matched

Table 4. Growth and yield of cherry trees trained to modified Brunner-spindle (Szigetcsép Station 1993–2004)

	Cumulated yield kg/tree	Cumulative yield efficiency by canopy volume	Yield kg/tree*	Cropping capacity t/ha/year *
Germersdorfi óriás				
MxM 97	65.7 a	5.82 a	12.86 a	8.56 a
MxM 14	83.2 ab	6.46 ab	14.82 ab	9.87 ab
Colt	95.2 bc	4.92 a	16.85 bc	11.23 bc
SL 64	117.3 c	8.56 b	20.11 c	13.39 c
'Van'				
MxM 97	101.3 a	6.55 a	14.31 a	9.53 a
MxM 14	128.2 b	8.92 b	17.71 b	11.79 b
Colt	128.1 b	6.69 ab	18.12 bc	12.07 bc
SL 64	163.2 c	8.90 b	20.52 c	13.67 c

- * in average of best four years from among nine at 5 x 3 m spacing
- means are separated by Duncans multiple range test at p = 0,05

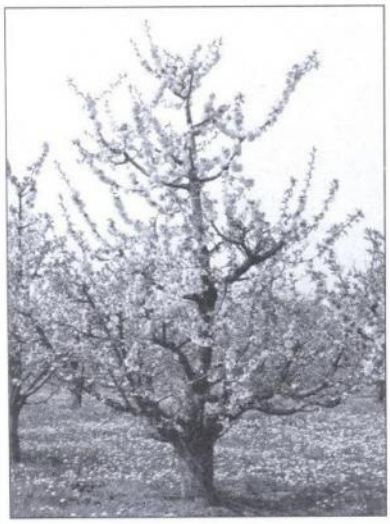

Fig. 1. Modifyed Brunner-Spindle 'Van' on SL 64 rootstock

Fig. 2. Bending effect of upright shoot when using Brunner's double pruning

Fig. 3. Fruiting branches on central leader

with site and cultivar vigour, as well as special orchard management practices. The tree is central leader type with permanent basal branches, which counteract the terminal growth. The fine fruiting branches are positioned on the central leader, which is 3–4 m high, depending on the rootstock. Compared to other spindle types (*Zahn, Vogel*) this system is characterized by subordinated basal scaffolds that contributes to the well balanced growth on the central leader. Bending and branching of the permanent basal branches can be achieved by application of Brunners' double pruning (*Brunner* 1972, 1990).

The tree is headed only once, after planting; from the following year the central leader grows from the terminal bud. The central leader developed from the terminal bud results moderated growth in the upper parts of the tree head. The strong upright shoots that may develop below the terminal bud are pinched to 3–4 leaves in the summer or removed entirely. As the tree reached the planned height, on the dominant and well illuminated leader regularly wide angled light shoots are formed. The weaker, almost horizontal shoots growing from the central leader form burse shoots in the following years if their terminal bud is not removed. Double sectorial pruning (*Figure 2*) is used only once or twice on the permanent basal branches in order to use its good branching effect. The use of spindle trees is appropriate in intensive high density cherry orchards in spacing 3.5–4 m between rows and 1.2 to 2.0 m between trees with 800–2300 tree/ha.

Table 5. Training and pruning protocol of cherry spindle recommended in Hungary

Year	Season	Training and pruning practice
Planting year	Spring (dormant)	Whips are headed at 90–100 cm. Heading the leader and laterals of feathered trees to half or 1/3. Three to five wide angled laterals (70–90°) are left, if needed, should be bent by using clothspins, strings or clamps.
	Summer	Whip: shoot selection, shoot bending, only those of 80–90 ° crotch angle may remain. Feathered tree: bending the leader of feathers, only those of 70–80 ° crotch angle may remain. Bending laterals on central leader to 80–90 o crotch angle.
2nd year	Spring	No heading on central leader, only if its stability is not enough. Bud removal under the terminal one to 25–30 cm (if not, pinching of competing shoots in late spring). Selection of shoots for permanent basal branches, and pruning back them onto upper position bud. On low vigour rootstocks all the shoots are to be pruned back to 1/3, onto upper position bud to achieve better branching. Late spring: bending lateral shoots on central leader using clamps or cloth-spins to 80–90 ° crotch angle (Figure 6).
	Summer	Removal of all upright shoots. Pruning back the upright, strong shoots to 3–4 leaves onto upper positioned summer bud. BA application on terminal shoot of central leader if needed.
3rd year	Spring	No heading on central leader. Bud removal under the terminal one *(Fig. 7)* to 25–30 cm or pinching of competing shoots in late spring. All upright and too strong shoots are to be pruned back to 3–5 bud, the terminal one should be in upper position. Flat angled shoots on permanent basal branches and central leader not longer than 80–90 cm are left without pruning to grow from terminal bud. Late spring: bending lateral shoots on central leader using clamps or cloth-spins to 80–90 ° crotch angle.
	Summer	Removal of all upright shoots. Pruning back the upright, strong shoots to 3–4 leaves onto upper positioned summer bud.
4th and	Spring	No dormant pruning. If needed, root pruning when trees are on vigorous mahaleb rootstocks.
5th year	Summer	Pruning after harvest. Removal of all upper positioned shoots. Pruning back the upright, strong shoots to 3–4 leaves onto upper positioned summer bud. Lightning out of fruiting branches, those that are stronger than half of the central leader should be removed.
6th year	Summer	Heading back when the top to be removed is already bearing.

Fig. 4. Delayed heading of central leader

Fig. 5. Cherry spindle

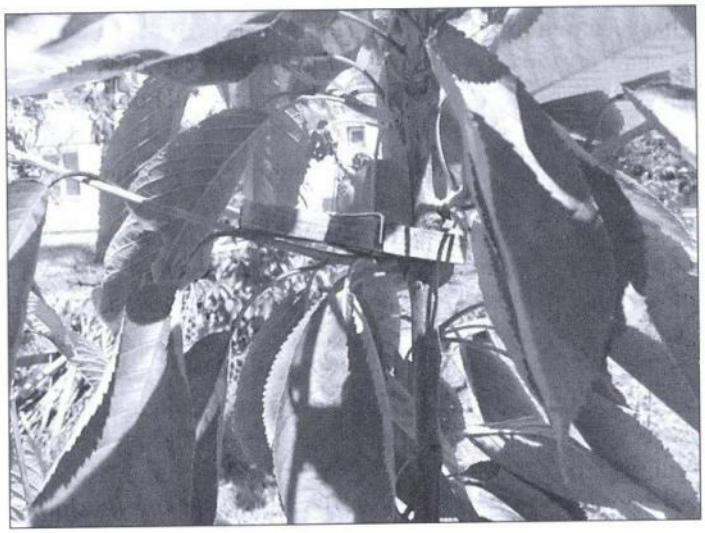

Fig. 6. Shoot bending using clothspins

Fig. 8. Axel spindle trees on Bogdány (background) and Gisela 5 (right) rootstocks

Fig. 7. Effect of bud and shoot selection on branching of central leader

In order to improve branching on the central leader, on the terminal shoot at length of 1 m BA (0.05%) application is recommended (*Hrotkó* et al. 1999, *Magyar & Hrotkó* 2005), or in dormant stage BA containing painting (*Csiszár & Bubán* 2004) may help. As the tree reached the planned height at 4th year age on vigorous mahaleb seedling rootstocks root pruning is recommended in order to slow dawn the growth and improve burse shoot formation. Heading is recommended not earlier than at 6th year, when the top (to be removed) is already bearing. In this stage the branches left under the heading cut will form less vigorous shoots. Mown grass in alleyways is essential element of this orchard system, which also contributes to the growth control. Regular nutrition is recommended only after trees turned to bearing. Exceed nutrient supply before bearing leads to such an exceed vegetative growth which is complicated to keep under control.

The recommended training and pruning protocol see in *Table 5*.

Rootstocks and spacing for spindle trees

According to Zahn's experinces (*Zahn* 1996) even trees on vigorous rootstocks can be planted for slender spindle training system. Our data support this opinion, but the training and mantaining is easier if the trees are on medium vigorous or dwarfing rootstocks (*Bujdosó* et al. 2004, *Bujdosó & Hrotkó* 2005). Rootstocks causing wide-angled branching are especially advantageous.

The tested moderate vigorous and dwarfing rootstocks provide a proper anchorage, there is no need of support while for semi dwarf and dwarf rootstocks support system is recommended.

Following rootstocks seem to be usable for slender spindle based on our experiences (*Hrotkó & Magyar* 2004, *Hrotkó* et al 1998):

Standard rootstocks: Mahaleb Sainte Lucie 64, Bogdány.

Moderate vigorous: Mahaleb Magyar, PiKu 1 (both provide wide-angled branching), MaxMa 14, MaxMa 97 (both cause narrow crotch-angle on scion).

Semi-dwarfing: Weiroot 158, Weiroot 154.

Dwarfing rootstocks: Tabel® Edabriz, Gisela® 5 (trees on both rootstock need pruning to achive good branching in the early years).

Advantages of the Hungarian cherry spindle trees in intensive orchard

Based on our experience and assesment the technology development in high density cherry orchards provides the following advantages:

- High fruit quality
- Increased percentage of crop picked from the ground (70 – 100%)
- Turning to bearing earlier (3 or 4 year-old trees)
- Increased yield and picking efficiency

Table 6. Suggested spacing of sweet cherry trees trained to modified Brunner-spindle on different rootstocks

Rootstock vigour	Rootstocks	Spacing
Standard vigour	Mahaleb seedling Cema (C500), Cemany (C 2753), Mahaleb 'SL 64', 'Bogdány'	4 x 2 m
Moderate vigorous	Mahaleb 'Magyar', 'Brokforest' (MaxMa 14), 'Brokgrow' (MaxMa 97), Pi-Ku-1.	4 x 1.5-2 m
Semi dwarf	Weiroot 154, Weiroot 158	3.6–4 x 1.3–1.8 m
Dwarf	Tabel® Edabriz, Gisela® 5	3.6–4 x 1.2–1.4 m

Table 7. Cropping of Hungarian spindle cherry trees ('Axel' and 'Vera') on different rootstocks planted in Szigetcsép Station between 2004–2008.

Roostock	Cumulated yield (kg/tree)	Cumulative yield efficiency by canopy volume (kg/m^2)	Yield (kg/tree)*	Cropping capacity t/ha*
'Axel'				
Gisela 5	40,36 b	8,41 c	10,07 b	13.4
Edabriz	25,90 ab	2,90 a	6,46 ab	8.1
Cema	81,69 c	8,94 c	20,40 c	25.5
Bogdány	85,19 c	7,59 c	21,27 c	26.6
'Vera'				
Gisela 5	66,17, ab	9,03 d	16,5 ab	20.6
Edabriz	51,10 a	5,17 ab	12,8 a	16.0
Piku 1	89,14 c	7,14 c	22,3 d	27.9
Cema	88,99 c	6,68 bc	22,2 cd	27.8
SL 64	91,62 c	7,31 c	22,9 d	28.6
Bogdány	83,58 bc	6,05 abc	20,9 bcd	26.1

- * in average of four years 4 x 2 m spacing
- means are separated by Duncans multiple range test at p = 0,05

- When applying yearly summer pruning, pruning labour request is not higher
- Appropriate tree size for IFP or organic farming – reduced emission of chemicals.

Using of spindle trees is recommended in intensive high density cherry orchards at spacing 3.6–4 m between rows and 1.2 to 2.0 m between trees with 1250–2300 trees6ha. The central leader developed from the terminal bud results moderated growth in the upper parts of the tree head. The slender spindle provides the advantage in the possibility of hand picking from the ground and from low picking stands. In the high density orchard picking is more cost efficient, and the danger of accidents are reduced.

One of the points is the improved fruit quality from spindle trees. As the fruiting branches on the trees are young, rate of one-year-old fruiting wood is higher, the fruit size is excellent, which supports statements of *Looney* et al. (1996). The conical tree shape and the young, fine fruiting wood allow better light penetration into the canopy thus the higher exposure to sunlight results better fruit color and taste (*Lang and Ophardt,* 1998). Spraying a smaller tree canopy is more precise and economical, and reduces the emmission of chemicals into environment. It is possible to use a birdnet or raincovercover above the small-size trees.

To maintain the fruiting branches regular summer pruning is needed. In comparison to modified Brunner-spindle much less pruning is needed for the slender spindle trees as the fruiting branches are less thick. This means much less wounds on the central leader which remain healthy.

The advantages of spindle trees can be used in high-density orchards. The trees begin cropping early and can be planted on standard rootstocks too. Our results with C 500 (*Figure 8*) mahaleb seedling or moderate vigorous mahaleb rootstocks support this opinion (*Table 7*). The expected cropping capacity of 1 ha orchard is between 25–30 tons, although orchards on dwarfing rootstocks with the larger tree number may reach a yearly crop up to 35 tons too. But theese high yields might be linked with smaller fruit size, which is a considerable shortcoming of dwarfing rootstocks (*Bujdosó* et al. 2004, *Simon* et al. 2004, *Bujdosó* 2005). This fact should be considered in the goals of cherry-rootstock research. Besides dwarfing and precocity rootstocks should provide an acceptable renewal capacity of fruiting branches together with an excellent yield potential, good fruit quality and wide angled branching. On the other hand, thinning out practices (so far mechanical) or chemical methods of fruit thinning should be developed. Suitable tree size for intensive orchards can be obtained when using both appropriate rootstocks and training system.

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