ACHIEVEMENTS IN HIGH DENSITY CHERRY ORCHARD SYSTEMS
IN HUNGARY

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Abstract: 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, resulting semi-intensive orchard of 600-800 trees/ha density, planted on standard vigour rootstocks. 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. 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.

INTRODUCTION

During 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 [14]. In Central- and Northern-Europe various spindle training systems are more popular [22, 24, 19, 20, 16, 15]. 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.
DEVELOPMENT IN CHERRY SPINDLE TREES

The Brunner’s upright-bud-spindle training system [1,2] was developed for sweet cherry trees but scarcely used in practice. Brunner’s concept (1972) of forming spindle cherry trees is based on application of sectorial double pruning onto upper buds. 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. Another intensive spindle system is developed by Vogel [20,21] in Fränkische Schweiz, this system is based on less vigorous rootstocks (Weirroot series and Gisela 5, allows longer fruiting branches than Zahn’s system and applies less pruning [16]. The French Solax system is also a type of central leader, which is based on long fruiting branches bent down under horizontal level [15]. On the long fruiting branches the crop regulation can be achieved by partially removed burse-shoots (extinction of shoots). This system is planted mainly on dwarfing rootstocks, like Tabel® Edabriz.

Table 1

<table>
<thead>
<tr>
<th>Main characteristics of modified Brunner-spindle</th>
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<tbody>
<tr>
<td>Spacing</td>
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<tr>
<td>Tree/ha</td>
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<tr>
<td>Tree height</td>
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<tr>
<td>Plant material</td>
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<td>Treatment after planting</td>
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<tr>
<td>Pruning methods</td>
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<td>Fruiting twig location</td>
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</table>

The first attempts in Hungary to train cherry trees for intensive orchards can be traced back to early ’70-s. Brunner [3] developed a central leader-type training system for sweet cherry, on mahaleb seedling planted on 5x3 m planting distance. Because of the missing dominance of central leader, scaffolds formed into strong limbs, and these trees slowly developed to a modified 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 [23,24] or the Vogel-system [19,20], their difficulties in adaptation to our environmental conditions are discovered (uncertain growth responses in planting year because of dry and hot summer). 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 [12,13]. 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, which is now spreading in Hungary.

EVALUATION OF 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/ Each set of scaffolds are subordinated to dominant central leader (shorter and weaker scaffolds towards the top, larger crotch angle).
b/ Delayed heading and pinching upright shoots around the terminal one is applied.
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. [11,12].

Modified Brunner-spindle is suitable for 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 [9,7]. 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.

Table 2

<table>
<thead>
<tr>
<th>Rootstock vigour</th>
<th>Rootstocks</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard vigour</td>
<td>Mahaleb seedling Cema (C500), Cemany (C 2753), Mahaleb ‘SL 64’, ‘Bogdány’</td>
<td>5 x 3 m</td>
</tr>
<tr>
<td>Moderate vigorous</td>
<td>Mahaleb ‘Magyar’, ‘Brokforest’ (MaxMa 14), ‘Brokgrow’ (MaxMa 97), Pi-Ku-1.</td>
<td>5 x 2.5 m</td>
</tr>
</tbody>
</table>

The modified Brunner-spindle is more suitable for semi-intensive orchards with 600-800 trees/ha. 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. An important advantage is the possibility of hand picking from the ground or from low picking stands. 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. 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 as orchard system partly follows the original concept of slender spindle [13]. 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, spacing and rootstocks matched 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 [1,3].
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. 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 1250-2300 tree\textperthousand.

In order to improve branching on the central leader, on the terminal shoot at length of 1 m \textit{BA (0.05\%)} application is recommended [10,17], or in dormant stage \textit{BA} containing painting [6] may help. As the tree reached the planned height at 4\textsuperscript{th} 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 6\textsuperscript{th} 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 grow 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.

According to Zahn's experiences [24] even trees on vigorous rootstocks can be planted for slender spindle training system. Our data support this opinion, but no doubt that the training and maintaining is easier if the trees are on medium vigorous or dwarfing rootstocks [4,5]. 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 [7,13]:

- **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, Gisela® 6 (trees need pruning to achive good branching in the early years).

Based on our experience and assessment 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
- 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 trees \textperthousand depending on site and rootstocks (Table 3). 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.
Table 3

<table>
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<th>Rootstock vigour</th>
<th>Rootstocks</th>
<th>Spacing</th>
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</thead>
<tbody>
<tr>
<td>Standard vigour</td>
<td>Mahaleb seedling Cema (CS00), Cemany (C 2753), Mahaleb ‘SL 64’, ‘Bogdány’</td>
<td>4 x 2 m</td>
</tr>
<tr>
<td>Moderate vigorous</td>
<td>Mahaleb ‘Magyar’, ‘Brokforest’ (MaxMa 14), ‘Brokgrow’ (MaxMa 97), Pi-Ku-1.</td>
<td>4 x 1.5-2 m</td>
</tr>
<tr>
<td>Semi dwarf</td>
<td>Weiroot 154, Weiroot 158, Gisela® 6</td>
<td>3.6 - 4 x 1.3-1.8 m</td>
</tr>
<tr>
<td>Dwarf</td>
<td>Tabel® Edabriz, Gisela® 5</td>
<td>3.6 - 4 x 1.2-1.4 m</td>
</tr>
</tbody>
</table>

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. 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. Spraying a smaller tree canopy is more precise and economical, and reduces the emission 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 mahaleb seedling or moderate vigorous mahaleb rootstocks support this opinion. 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 these high yields might be linked with smaller fruit size, which is a considerable shortcoming of dwarfing rootstocks [5,18]. 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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