Training and Pruning of Apple Trees According to the New System 'Cone'

S. Gandev
Fruit Growing Institute
12, Ostromila, 4000, Plovdiv
Bulgaria

Keywords: Malus domestica L., orchard system, yield, fruit size

Abstract

In the near past mainly spur apple cultivars, such as 'Starkrimson', 'Delicious', 'Yellowspur', etc., grafted on MM106 rootstock and trained to the free growing spindle-type bush system, were grown in Bulgaria. Nowadays, the spur cultivars are replaced by cultivars such as 'Jonagold', 'Melrose', 'Florina', etc., which do not belong to the group of the spur cultivars, they are of another fruiting type and they have more vigorous growth.

The aim of the experiment was to develop and study a new apple training system suitable for growing non-spur cultivars on MM106 rootstock in intensive orchards.

The experiment was carried out in the period 2000-2007 with the 'Jonagold' apple cultivar grafted on MM106 rootstock, planted at a distance of 4.5 x 2.5 m. The free growing spindly-type bush training system was used as a control. On the basis of the large number of pruning variants applied, the one leading to the best results was selected. The developed new training system was called 'Cone' system.

Data showed that higher and better quality yields were obtained from the trees trained to the cone system compared to the yields harvested from trees trained to the free growing spindle-type bush system. The total yield reported from the cone system was 160.6 t/ha and from the free growing spindle-type bush training system it was 111.6 t/ha. In the years of the experiment, the percentage of fruits of a size over 80 mm from the trees trained to the cone system surpassed that of the trees of the free growing spindle-type bush training system.

INTRODUCTION

It is known (Barritt, 1987) that there is not an apple training system optimal for all the cultivar-rootstock combinations, climatic conditions and economic situations. Out of that reason, different systems were established and studied worldwide in accordance with the specific characteristics of the fruit-growing countries and regions (Wertheim, 1978; Lespinasse and Delort, 1986; Van Den Ende et al., 1987; Sansavini and Corelli, 1990; Robinson et al., 1991; Clayton-Greene, 1993; Djouvinov et al., 2002).

In Bulgaria, the cultivars grafted on MM106 rootstock were usually trained to the free growing spindle-type bush system (Djouvinov et al., 2002). That system was used in all the cultivars regardless of their growth vigor and fruiting type. That system was acceptable in the near past when mainly the spur cultivars 'Starkrimson' and 'Yellowspur' were grown. Nowadays, non-spur cultivars, having more vigorous growth and another fruiting type, are predominantly used. Disturbance of the balance between growth and fruiting was observed with them when the trees were on MM106 rootstocks and trained to the free growing spindle-type bush system (Gande, 2006).

Unfortunately, substituting the free growing spindle-type bush system with the vertical axis system (Lespinasse and Delort, 1986), which was suitable for the cultivars of moderate and vigorous growth when grafted on MM106 rootstocks, faced some difficulties in Bulgaria, due to which its popularization was hampered. In cultivars having soft wood (such as 'Jonagold'), the young trees lose their leader due to the fruit weight,
because fruit sets are localized mainly on it. Out of that reason, it is necessary to set the
leader straight up by single stakes or trellis structures, which is in principle not constructed
for trees on the MM106 rootstock. What is more, on weaker soils and at an insufficient
agrotechnical level that is still observed in the country, the trees trained to the vertical
axis system stop their growth quite early.

The aim of the experiment was to establish a training system suitable for growing
apple cultivars of moderate and vigorous growth, grafted on MM106 rootstock under the
soil and climatic conditions of the country.

MATERIALS AND METHODS

The experiment was carried out in the period 2000-2007 with the 'Jonagold' apple
cultivar grafted on MM106 rootstock, planted at a distance of 4.5 x 2.5 m. Planting
material without premature shoots was used. In the third year after planting, the fruit sets
were thinned by chemical substances.

The trees were trained to the following systems: 1) Free growing spindle-type
bush system (control) and 2) Cone system.

Free Growing Spindle-Type Bush System

The trees had a leader with scaffold branches along its whole length, which were
not bended to a horizontal position. Pruning for fruit setting consisted of thinning and
reducing the fruit structures grown on the scaffold branches (Djouvinov et al., 2002),
(Fig. 1).

Cone System

In contrast to the already known training systems, the 'cone system' goes through
two training types, conventionally called a 'whorl (layered) cone' and a 'step-like cone'.
The choice of that decision was dictated by our aims to: 1) reduce the trees growth vigor
in their period of vigorous growth and in the period of their initial rapidly increasing
fruiting, and 2) to maintain a balance between tree growth and fruiting in the full fruiting
period. The common thing between the whorl cone and the step-like one is the conical
shape of the tree crowns and the difference is in the number and position of the scaffold
branches. The transition from one system into the other was realized by pruning for
fruiting according to the branch thickness.

1. Whorl (Layered) Cone. After the final training of the trees to a whorl (layered) cone
they consisted of a leader and three whorls (layers) located at a 70-80 cm distance. The
first whorl had 4-5 permanent scaffold branches and the upper two layers 3-4 temporary
branches each (Fig. 2).

After planting, the trees were cut to 90-100 cm height above the soil surface. In
August the strongest branches with the widest growth angle (most often 2-3 in number)
were bended by fastening in a horizontal position. They formed the future permanent
scaffold branches of the first whorl.

At the second winter pruning, the leader was cut at about 80 cm above the
branches forming the first whorl and its competitors were removed. In August other
strong branches having a wide growth angle were bended in a horizontal position for
forming the first whorl. The total number of branches bended in the current and the
previous year was 4-5 per tree.

In the third year, the leader pruning was similar to that in the second winter
pruning. The competitors of the leader were cut and only 3-4 shoots of a wide growth
angle were left for forming the second whorl.

During the fourth winter pruning, the leader was not cut. The competitors were
removed and 3-4 shoots were left for forming the third whorl. Some shoots sprouting
between the whorls were left on the stem. In the next years they gradually replaced the
branches of the second and the third whorls that had been removed and they turned into
new temporary scaffold branches located stepwise up along the leader above the
permanent first whorl.
2. Step-Like Cone. After the final tree training to a step-like cone they consisted of a leader, on which 4-5 horizontal permanent scaffold branches were located at 70-100 cm height above the soil surface and young temporary branches stepwise located above them at 30-50 cm distance (Fig. 3).

The transfer from a whorl into a step-like cone was carried out from the fourth until the eighth year of the trees by pruning for fruiting, described below.

During the pruning for fruiting, the tree scaffold branches from the first whorl were shortened by cutting when they started tangling with the crowns of the adjacent trees. We proceeded in the following three ways with the temporary branches of the second and the third whorls, depending on the growth vigor and branch thickness:

a) The scaffold branches of a vigorous growth and thickness at the basal part, close to that of the leader at the place of branch shooting, or, dominating over that of the adjacent scaffold branches, were annually removed.

That was the basic principle and it determined the transfer from a whorl cone to a step-like one. Thus, the crown whorls, typical for the first years of the tree development, were gradually replaced by stepwise located temporary branches.

b) The scaffold branches of a moderate growth were cut down to a fruit bud when possible, leaving on them young fruiting wood oriented vertically upwards or horizontally. After the natural bending of the branch under the weight of its own fruits, the winter pruning was carried out by cutting down to a fruit bud at the curve, i.e., the already bended fruiting wood was removed. Thus the horizontal position of the temporary fruiting branches of the second and the third whorls was maintained. In case the scaffold branch was not bended by the fruit weight then it was cut down in such a way as not to distort the conical crown shape.

c) The scaffold branches of a poorer growth were not pruned. Those of them having bended strongly by the fruits and not being able to be recovered in the above-described way, were removed.

Shoots that had sprouted directly from the leader were preserved for future temporary fruiting branches.

When the trees reached the height of 3.4-3.6 m, they were cut to old wood.

The following characteristics were reported: yield per tree, yield per hectare, and fruit size. After the inter-row space was filled in and the trees were finally trained – at the end of the eighth vegetation – the crown volume, the stem cross-section area and the average tree increment were measured.

The reported data were collected from ten trees randomly selected within the plantation, each tree being a replication. Data were statistically processed by Duncan's test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Data presented in Table 1 showed that the pruning activities characterizing the new cone system had a positive effect on tree growth. The trees of the "Jonagold" cultivar grafted on MM106 rootstock and trained to the cone system had an average increment of 39 cm, while the average increment of those trained to the free growing spindle-type bush system was bigger – 62.8 cm. According to Djouvinov et al. (2002) a good balance between growth and fruiting in apple was maintained when the average annual increment was 30-50 cm. The same table showed that in the two systems the crown volume was also different. In the cone system it was 6.8 m³ versus 8.3 m³ in the free growing spindle-type bush system. The stem cross section area was 101.5 cm² in the cone system and 136.8 cm² in the free growing spindle-type bush system.

The trees of both systems started fruiting in the third year after planting but the first significant yield was harvested after the fourth year – 12.9 t/ha from the trees trained to free growing spindle-type bush and 13.7 t/ha from those trained to the cone system. The difference between both systems was insignificant (Table 2). In the fifth year, the yield was in favour of the cone system – 31.5 t/ha versus 20.4 t/ha, respectively. In the sixth year after planting 46.2 t/ha were harvested from the trees trained to the cone
training system and 32.7 t/ha from the trees trained to the free growing spindle-type bush system. In the seventh year the yields from both variants were poorer compared to the previous year, from the free growing spindle-type training system being 12.4 t/ha and from the cone system 27.7 t/ha. The yield in the eighth year was 32.3 t/ha from the free growing spindle-type bush training system and 40.4 t/ha from the cone system. The total yield reported from the cone system was 160.6 t/ha and it was higher than that from the free growing spindle-type bush training system, which was 111.6 t/ha. Table 2 showed that in the separate years the percentage of fruits of a size over 80 mm from the trees trained to the cone system surpassed that of the trees of the free growing spindle-type bush training system.

The presented results showed that the cone training system, and its whorl and step-like forms in particular, led to the provision of a balance between tree growth and fruiting. That was proved by their moderate growth and the obtained high yields of good quality fruit. Obviously the whorl cone system with its well-developed scaffold branches grouped in three whors, maintains the vigorous tree growth during the unproductive and poorly productive periods and leads to regular flower setting and fruiting supported by the chemical fruit set thinning. Another interesting thing is that the transfer of the whorl into a step-like cone by gradual pruning of the branches from the second and the third whorl of the layered cone did not disturb the established balance between growth and fruiting, despite the fact that the pruning was quite severe. In that case, good loading with fruit did not allow growth acceleration and disturbance of the balance between growth and fruiting.

CONCLUSION

The cone system is a new way of training and growing non-spur apple cultivars grafted on MM106 rootstock in intensive orchards. It consists of pruning activities, which, applied consecutively, lead to the formation of a crown conical in shape and having different numbers of scaffold branches according to the age of the trees, their growth vigor and loading with fruit.

Higher and better quality yields are obtained from the trees trained to the cone system compared to the yields harvested from trees trained to the free growing spindle-type bush system.

Literature Cited


Table 1. Vegetative habits of apple ‘Jonagold’ grafted on MM106 rootstock and trained to free growing spindle-type bush and cone systems after the end of the eighth vegetation.

<table>
<thead>
<tr>
<th>Training system</th>
<th>Crown volume (m³)</th>
<th>Stem cross-section area (cm²)</th>
<th>Average increment (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free growing spindle-type bush</td>
<td>8.3 a</td>
<td>136.8 a</td>
<td>62.8 a</td>
</tr>
<tr>
<td>Cone</td>
<td>6.8 b</td>
<td>101.5 b</td>
<td>39.0 b</td>
</tr>
</tbody>
</table>

Table 2. Yield of the apple ‘Jonagold’ on MM106 rootstock trained to free growing spindle-type bush and cone systems.

<table>
<thead>
<tr>
<th>Variants</th>
<th>Calendar year and year after planting / yield per tree and ha (kg)</th>
<th>Cumulative yield (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2002</td>
<td>2003</td>
</tr>
<tr>
<td>3 rd</td>
<td>2.1 a</td>
<td>14.6 a</td>
</tr>
<tr>
<td>Cone system</td>
<td>80.0</td>
<td>72.0</td>
</tr>
<tr>
<td>Free growing spindle-type bush system</td>
<td>0.9 a</td>
<td>12.9 a</td>
</tr>
<tr>
<td>Cone system</td>
<td>82.0</td>
<td>75.2</td>
</tr>
<tr>
<td></td>
<td>1.1 a</td>
<td>13.7 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figures

Fig. 1. Free growing spindle-type bush system.

Fig. 2. Whorl (layered) cone.

Fig. 3. Step-like cone.