High Density Planting for Sweet Cherry Orchards

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Abstract

While a number of training systems are suitable for increasing sweet cherry planting density, the V and vertical axis systems are perhaps best suited to the task. New ideas regarding tree shape include short trees grown using dwarfing rootstocks like the Gisela® series. Research now needs to discover ways to improve tree efficiency under dwarfing or semi-dwarfing rootstocks. We report two ongoing cherry training system trials. The first trial, now in year 3, compares the vertical axis, spindle and V training systems, the dwarfing rootstocks Gisela® 5 and Gisela® 6 in planting densities of 1,905 and 5,714 trees ha^{-1}, and the cultivars (11) Early Bigi, Sweet Early, Early Star, Giorgia, Grace Star, Black Star, Summit, Sylvia, Ferrovia, Kordia and Regina. The second trial involves trees trained to vertical axis with 'Kordia' and 'Ferrovia' at ultra-high densities of 5,000 (4.0 x 0.5 m) and 6,666 (3.0 x 0.5 m) trees ha^{-1} in two orchards, both at year 6. Cumulative yield of 'Ferrovia' in the second trial at year 6 was 46.6 t ha^{-1}. Cherry quality was very high: 88.8% of the fruit at the density of 5,000 trees ha^{-1} and 89.8% at 6,666 trees ha^{-1} were over 28 mm in diameter.

INTRODUCTION

The sweet cherry (*Prunus avium* L.) industry has seen a radical transformation in certain growing areas over the last decade with the advent of dwarfing rootstocks and the high-density plantings (HDPs) they make possible (Long, 1997; Hrotko et al., 1998; Green, 2005; Lauri, 2005; Long 2007; Long et al., 2005; Robinson, 2005). New training systems coupled to a short pruning regime and the development of earlier bearing cultivars have also played a role in the spread of these highly intensive plantings. The GiSelA® stock series developed at Justus Liebig University in Giessen, Germany, is one of the main driving forces behind HDPs and ultra-high density plantings (UHDPs) (Gruppe, 1985; Lang, 1998; Weber, 2003; Bassi, 2005). These genotypes can reduce tree vigour and induce early bearing. Perhaps the most important of the series for sweet cherry HDPs is GiSelA® 5 because the shorter tree it induces lets growers govern the orchard either directly from the ground or using low platforms and, hence, enables savings on overhead, especially picking outlays. Other advantages that shorter trees facilitate include the use of netting to protect the crop against birds, hail and rain, a better distribution of sunlight within the canopy that improves fruit colour and quality, and upgraded efficiency of chemical sprays that helps to reduce environmental impact. We tested the performance of GiSelA® 5 in an HDP and a UHDP sweet cherry planting in the Ferrara area. This rootstock was chosen for the trial because it not only reduces tree height, but provides a marketable cropping volume by year 2 of orchard life.

MATERIALS AND METHODS

Trial 1

In a sweet cherry orchard planted in 2007 at Salvi Farms in Runco, Ferrara Province, one plot was testing GiSelA® 5 grafted to cvs. 'Sweet Early', 'Black Star', 'Grace Star',

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‘Sylvia’, ‘Early Star’, ‘Regina’, ‘Kordia’, ‘Early Bigi’, ‘Ferrovia’ and ‘Summit’. While the row spacing is 3.5, the tree spacing depends on training system: 1.0 m for slender spindle and 0.5 m for V and central leader systems, with each cultivar being tested on each training system. A second plot has GiSelA® 6 with ‘Grace Star’, ‘Giorgia’ and ‘Sweet Early’. The row spacing is 3.5 m and the tree spacing in 0.7 m for V, 0.8 m for the central leader and 1.5 m for slender spindle, with each cultivar being tested on each training system. Fertigation is used in both plots with the drip irrigation line strung along the ground.

Trial 2

This is being conducted at Beltrami Farms in Albarea, Ferrara Province in two orchards. One orchard was planted in 2004 with ‘Kordia’ and ‘Ferrovia’ grafted on GiSelA® 5 and trained to central leader at a spacing of 4 m x 0.5 m, for a density of 5,000 trees/ha. The other was planted in 2005 at 3 m row spacing and 0.5 m tree spacing, for a density of 6,666 trees ha^{-1}. All data for growth, cropping and fruit quality parameters were processed using SAS for analysis of variance and means separation by SNK test.

RESULTS AND DISCUSSION

Trial 1

1. Pruning Weight and Trunk Cross-Sectional Area (TCSA). For these two growth parameters, the values for the V and central leader systems were lower than those for slender spindle in year 1 for trees on Gisela® 5. The winter-pruned wood weight for the slender spindle was 0.57 kg $tree^{-1}$, whereas both V and central leader were 0.37 kg $tree^{-1}$ (Fig. 1). However, accounting for planting density and wood per hectare, the central leader had the most (2.16 t ha^{-1}), followed closely by V (2.10 t ha^{-1}) and, a distant third, slender spindle (1.62 t ha^{-1}) (Fig. 1).

Given the high vigour induced by Gisela® 6 compared to Gisela® 5, Gisela® 6 had the greatest weight of pruned wood (Fig. 1). While there was no significant difference in pruned wood between the V and the central leader (0.66 vs. 0.69 kg $tree^{-1}$, respectively), the spindle on Gisela® 6 had the most wood, almost double that on Gisela® 5 (1.07 kg $tree^{-1}$). Thus far, for each Gisela® 5-grafted cultivar vis à vis training system, slender spindle is the most vigorous, with more pruning wood weight; the V and central leader systems did not differ statistically except for ‘Kordia’ (2008 data).

‘Black Star’ had the highest 2008 values for pruned wood weight at 0.66 kg $tree^{-1}$ with V, 0.51 kg $tree^{-1}$ with central leader and 0.95 kg $tree^{-1}$ with slender spindle; ‘Grace Star’ followed at 0.58 kg $tree^{-1}$ with V and central leader and 0.92 kg $tree^{-1}$ with slender spindle. Overall so far, slender spindle with both stocks had the lowest amount of pruned wood per ha, despite the highest weights per tree (Fig. 1). This is undoubtedly due to the effect exerted by the lower planting density per hectare of this system in comparison to central leader and V (see spacing in Table 1).

The lower growth by central leader trees to date are likely due to greater root competition among adjacent plants resulting from its narrower tree spacing compared to slender spindle. V-system trees have also shown a lower growth rate because they are trained at an angle that induces less plant growth (Fig. 2). Our preliminary data so far indicate that Gisela® 6 is inducing greater trunk cross-sectional area (TCSA) growth than Gisela® 5 (Fig. 2). We can see this not only in the 2009 data but even in the values recorded since orchard establishment in 2007. On the other hand, Gisela® 5 with slender spindle has always registered higher TCSA growth since 2007 (Fig. 2). In effect, while slender spindle trees on Gisela® 6 evinced greater TCSA growth than central leader and V trees through 2008, the TCSA for all three training systems was very similar by 2009, with slender spindle at 34 cm^2, central leader at 32.2 cm^2 and V at 31.5 cm^2 (Fig. 2).

2. Yield and Yield Efficiency. Our preliminary data through 2009 indicate that Gisela® 5 was slightly more yield efficient than Gisela® 6, the only exception being their equal performance with slender spindle (0.16 kg cm^{-2}).The V- and central leader-trained trees with GiSelA® 5 were more efficient than slender spindle. Indeed, higher efficiency was shown by both of the former systems compared to the latter with both stocks. Although slender spindle has been less efficient so far, differences have been significant only with ‘Grace Star’ and ‘Kordia’. Comparing cultivars only, ‘Ferrovia’ grafted to Gisela® 5 has been the most efficient in all three training systems: 0.79 kg $tree^{-1}$ for V, 1.06 kg $tree^{-1}$ for central leader and 0.43 kg $tree^{-1}$ for slender spindle.

Some of the cultivars have begun cropping well by virtue of the precocious bearing typical of the tested stocks. Comparing the three training systems with both stocks, slender spindle was the highest yielding per tree (Figs. 3-4). Annual average yield for Gisela® 5 was 0.38 kg $tree^{-1}$ for V, 0.41 for central leader and 0.60 for slender spindle (Fig. 3). Cropping for all trees on Gisela® 6 in all three training systems was clearly higher, 1.17 kg $tree^{-1}$ for V, 1.06 for central leader and 1.74 for slender spindle (Fig. 4). On Gisela® 5, ‘Ferrovia’ in all three systems has cropped the most of all cultivars so far: 1.90 kg $tree^{-1}$ for slender spindle, 1.20 for central leader and 0.94 for V. Other noteworthy cultivar cropping data include 0.87 kg $tree^{-1}$ for ‘Grace Star’ on slender spindle, 0.41 for ‘Black Star’ on V and 0.83 for ‘Early Bigi’ on slender spindle. Yet, it was ‘Giorgia’ on Gisela® 6 that had the best overall cropping combination on either stock at 2.58 kg $tree^{-1}$, followed by ‘Grace Star’ on slender spindle at 1.66 kg $tree^{-1}$.

Yield per hectare was significantly different between stocks, with the V and central leader systems cropping more than slender spindle (Figs. 3 and 4). Thus, despite the fact that slender spindle is the training system with the highest yield per tree, the trend for yield per hectare is exactly opposite due to a higher planting density (Figs. 3 and 4). The highest yielding cultivar grafted on Gisela® 5 was ‘Ferrovia’ trained to central leader at 6.3 t ha^{-1} in year 2 and 6.9 t ha^{-1} in year 3. Again, however, it is Gisela® 6 that had the highest cropping rates, with ‘Giorgia’ at 12.0 t ha^{-1} trained to central leader, followed by 7.4 t ha^{-1} with V and 4.9 t ha^{-1} on slender spindle. Notably, ‘Grace Star’ had 6.3 t ha^{-1} with central leader. ‘Giorgia’ on GiSelA® 6 with slender spindle was the best yielding cultivar by training system. These yields achieved so early in the development of the orchard, i.e., in years 2 and 3, offer returns that help to offset the initial high capital outlays for HDPs.

3. Fruit Weight. While average fruit weight was unaffected by training system with Gisela® 5, it was higher with Gisela® 6 trees trained to slender spindle than to the other two systems (Fig. 5). Fruit weight under all training systems was highest with Gisela® 5, averaging 11.0 g for V, 10.5 g for central leader and 10.8 g for slender spindle. With Gisela® 6, it was highest with slender spindle at 10.5 g.

‘Ferrovia’ had the largest-sized fruit at over 30 mm and slender spindle had the highest rate with 37% in the extra-large grade, followed by V with 29% and central leader with 18%. Noteworthy here, also, is the 11% under central leader and 19% under the other two systems with the early-season ‘Early Bigi’. This cultivar also had 68% of its fruit in the 26 and 28 mm classes under central leader.

The cultivar on Gisela® 5 with the highest rate of small (22 mm diameter) fruit was ‘Black Star’, with 24% on central leader, 16% on V and 13% on slender spindle. ‘Grace Star’ had the most fruit at 28 mm with both Gisela® 5 and 6, the best training system being slender spindle. ‘Giorgia’ had small fruit, the largest size being 24 mm, but this is linked to its high cropping and self-fertility.

Trial 2

The UHDP orchard at 6,666 trees ha^{-1} established in 2005 began cropping in year two with yields of 5.6 t ha^{-1} for ‘Kordia’ and 8.9 t/ha for ‘Ferrovia’; the three-year cumulative yields at year four (2008) were 24.9 and 32.4 t ha^{-1}, respectively (Fig. 6a). The average fruit weight of these two varieties ranged from 9.2 to 14.5 g for ‘Kordia’ and 9.3 to 12.5 for ‘Ferrovia’. The HDP orchard at 5,000 trees ha^{-1} had a cumulative three-year yield of 31.4 t ha^{-1} for ‘Kordia’ and 46.6 for ‘Ferrovia’ (Fig. 6b); each hit a yield peak in 2007, with 18.0 t/ha for ‘Kordia’ and 23.5 t ha^{-1} for ‘Ferrovia’.

Over the first three years of orchard life, for both cultivars almost the entire crop was larger than 24/26 mm, with a peak in 2008 of 85% of the fruit being 28/29 mm. The calculated market value, so far, of the two plantings was € 35,215 ha^{-1} for 'Kordia' and € 45,988 ha^{-1} for 'Ferrovia' in the UHDP orchard and € 34,157 ha^{-1} and € 62,050 ha^{-1} for the HDP orchard.

CONCLUSIONS

The slender spindle averaged higher pruned wood weights and TCSA growth rate than did the other two training systems. The lower values for central leader trees are presumed to be due to greater root competition between adjacent trees, due in turn to a narrower in-row spacing compared to slender spindle. The lower values for the V system can be attributable to the fact that the trees are trained at an angle that induces a lower growth rate.

The most yield-efficient trees were grafted to Gisela® 5 and trained to V and central leader. In effect, this stock and training combination induced rapid bearing of 'Ferrovia' and 'Black Star'. The highest yielding cultivar under slender spindle has been 'Giorgia' grafted to Gisela® 6. 'Ferrovia' fruit size and yield were very high, indicating the suitability of this cultivar to HDP.

Noteworthy, too, was the high early bearing of 'Ferrovia' and 'Black Star', which yielded 6.3 t ha^{-1} and 4.1 t ha^{-1}, respectively, by 2008 (year 2), clearly indicating their suitability to HDPs which need to deliver rapid returns on capital outlays. However, 'Black Star' did not repeat these yield levels in 2009, cropping at only 2.3 t ha^{-1}. The best performing of the early-season cultivars so far has been 'Early Bigi', which cropped at nearly 2 t ha^{-1} in year two and 4.1 t ha^{-1} in year three. It is also worth keeping in mind that these are preliminary data recorded through year three and will need another two years, at least, for information that can be applied to commercial plantings at such densities.

ACKNOWLEDGEMENTS

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Literature Cited

Bassi, G., 2005. Influenza dei portinnesti sulla produzione del ciliegio. L'Informatore Agrario, Edagricole 24:55-59.

Green, K. 2005. High density cherry systems in Australia. Acta Hort. 667:319-324.

Gruppe, W. 1985. Characteristics of some dwarfing cherry hybrid rootstocks. Acta Hort. 169:103-112.

Hrotko, K., Simon, G. and Magyar, L. 1998. Modified Brunner-Spindle as a training system for semi-intensive sweet cherry orchard. Acta Hort. 468:459-464.

Lang, G.A. 1998. Going With Gisela, American Fruit Grower. 118 (4): 16-17.

Lauri, P.E. 2005. Developments in high density cherries in France: integration of tree architecture and manipulation. Acta Hort. 667:285-291.

Long, L.E. 1997. Spanish Bush increases worker productivity. Good Fruit Grower, February 1:27-33.

Long, L.E. 2007. Worldwide trends in cherry orchard systems. The Compact Fruit Tree 40(2):16-18.

Long, L.E., Facteau, T., Nunez-Elisea, R. and Cahn, H. 2005. Developments in high density cherries in the USA. Acta Hort. 667:303-309.

Robinson, T.L. 2005. Developments in high density sweet cherry pruning and training systems around the world. Acta Hort. 667:269-272.

Weber, M.S. 2003. I portinnesti semi-nanizzanti nella cerasicoltura tedesca. Frutticoltura, Edagricole 6:22-27.

Tables

Table 1. Sweet cherry training system planting distances and densities.

Training system	GiSelA® 5		GiSelA® 6	
	Planting distance (m)	Planting density (trees ha^{-1})	Planting distance (m)	Planting density (trees ha^{-1})
V system	3.5 x 0.5	5,714	3.5 x 0.8	3,571
Vertical axis	3.5 x 0.5	5,714	3.5 x 0.7	4,082
Spindle	3.5 x 1.0	2,857	3.5 x 1.5	1,905

Figures

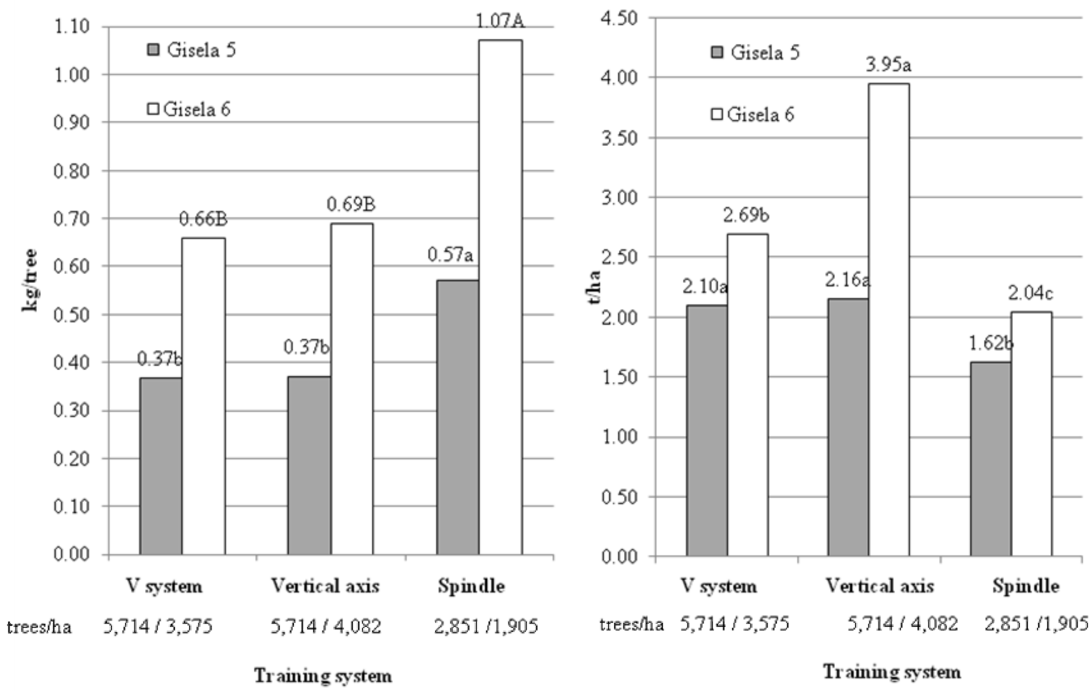

Fig. 1. Pruning weight (2008) per tree (kg tree^{-1}) and per hectare (t ha^{-1}). Mean values followed by same small letters do not differ significantly according to SNK test (p=0.05).

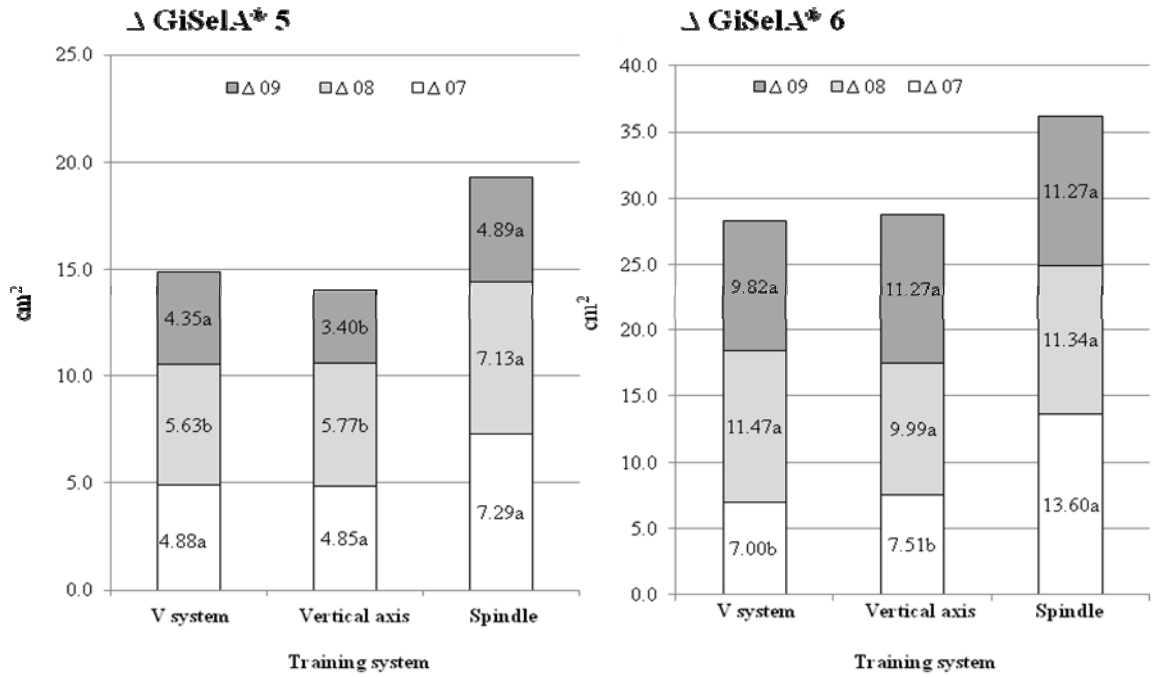

Fig. 2. Trunk cross-sectional area (TCSA) growth in three years for both the rootstocks. Mean values followed by same small letters do not differ significantly according to SNK test (p=0.05).

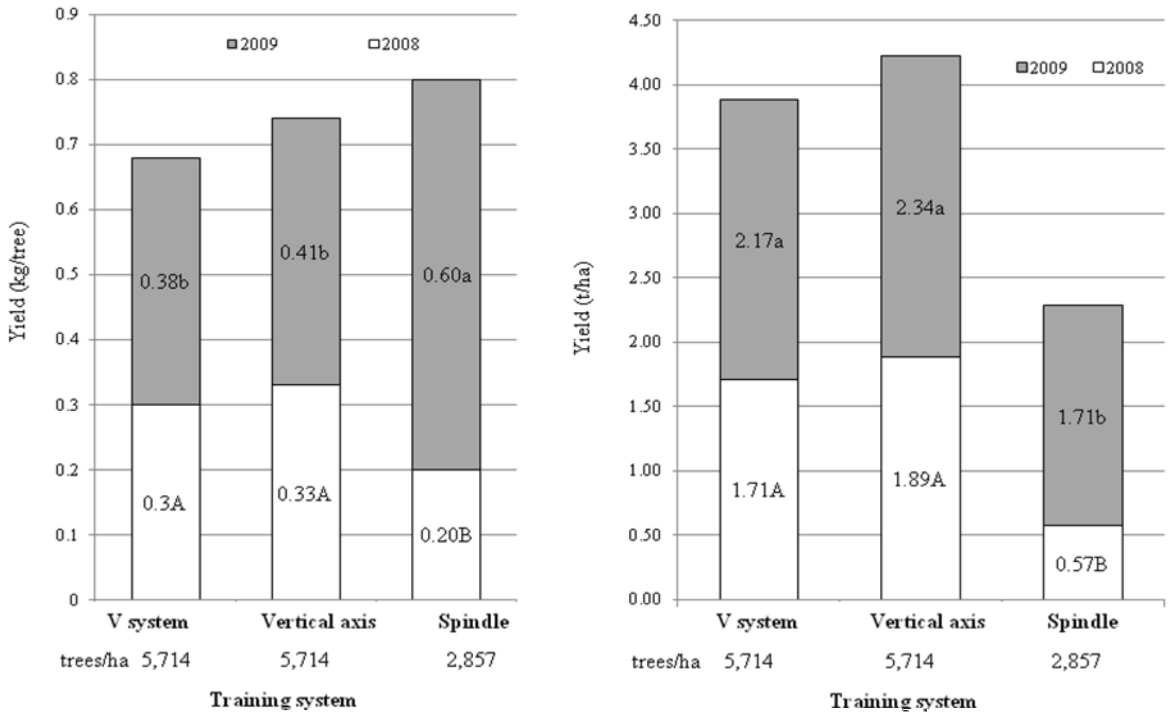

Fig. 3. Cumulated yields for the combinations with Gisela® 5 (2008-09). Mean values followed by same small letters do not differ significantly according to SNK test (p=0.05).

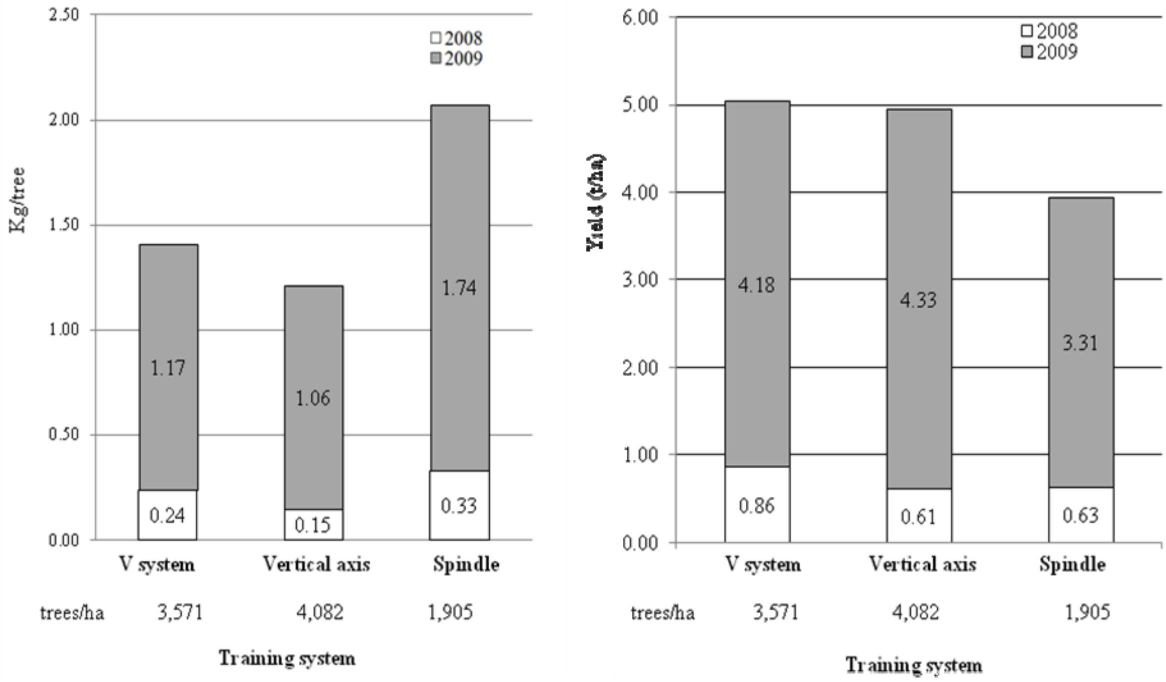

Fig. 4. Cumulated yields for the combinations with Gisela® 6 (2008-09).

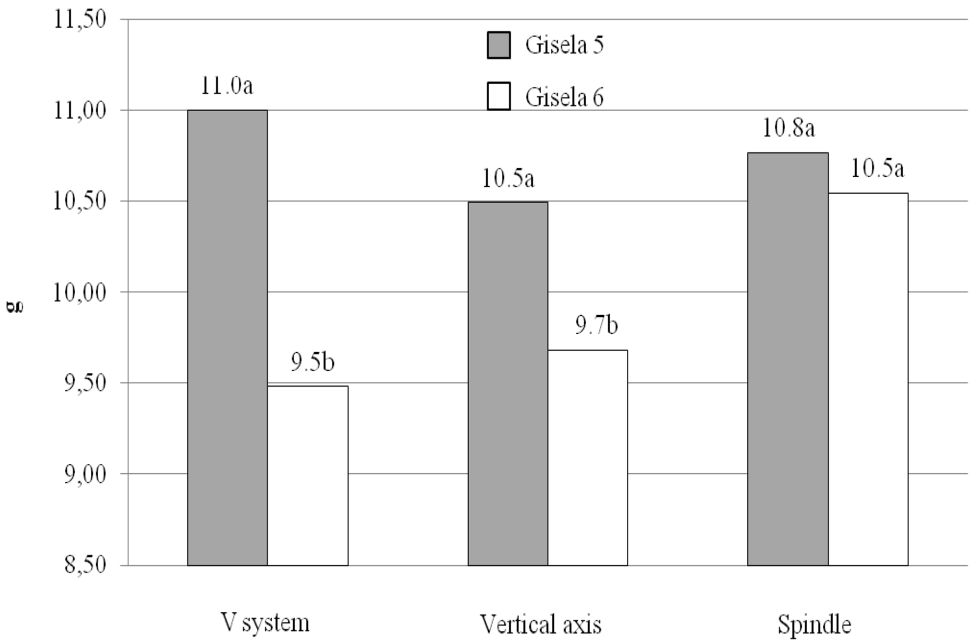

Fig. 5. Average fruit weight (g) on different training systems (2009).

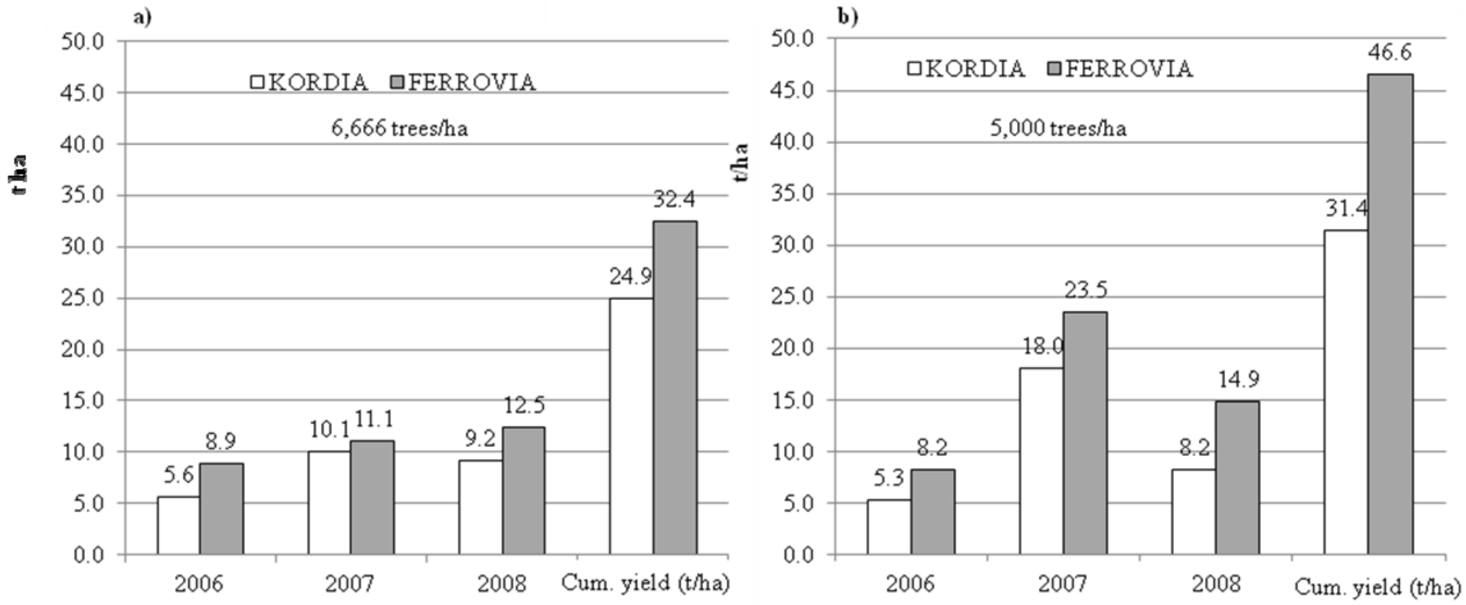

Fig. 6. Vertical axis in the second trial (Beltrami farm), yield 2006-2008: a) Planting distances 3.0 x 0.5 m (6,666 trees ha^{-1}), year of plantation 2005 and b) Planting distances 4.0 x 0.5 m – Planting density 5,000 trees ha^{-1}, year of plantation 2004.