# Ultra High-density Sweet Cherry Plantings

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*Presented at the 53rd Annual IFTA Conference, Feb. 27-March 10, 2010, Grand Rapids, Michigan, USA*
***Keywords: sweet cherries, ultra high-density plantings, training systems, Italy***

For several years now sweet cherry plantations have been going toward higher and higher densities. This trend goes somewhat against the grain given that certain issues long linked to cultivation at such high-densities, like the natural tendency of trees to develop big canopies of notable acrotony with upright habit and a relatively long period prior to initial cropping, have had to be resolved to a great extent. A distinct number of factors have combined to open the path to higher density cherry orchards, including, in order of importance, new dwarfing rootstocks to control and achieve the desired vigor and the canopy management practices to go with them. Perhaps the most widely used dwarfing and semi-dwarfing stocks today are the GiSelA series developed at Justus Liebig University Giessen, Germany.(1) These stocks can reduce tree vigor and induce early cropping, and many industry experts and observers rate GiSelA5 as the most promising for use in high-density plantings in Italy's main sweet cherry growing districts.

## DEVELOPMENTS OF TRAINING SYSTEMS

Unlike traditionally extensive cherry orchard systems that view each tree as an isolated, individual architectural element, today's more advanced plantations, especially those of increasingly higher densities, see the tree as part of a continuous fruiting row. The idea is to achieve a mature orchard by establishing a kind of seamless 'cropping hedge wall.' This requires, among other practices, a pruning regime essentially aimed at cutting away any elements of a given tree that do not conform structurally to the overall system in order to ensure balanced spring and season-long shoot growth. Pruning is thus geared to preventing rapid fruit-bud aging and the shoot loss in the mid-to-basal canopy areas that often causes cropping to shift towards the upper zone of the orchard canopy.

A look at the data in Table 1 *infra* regarding the types of orchard most widely adopted today clearly indicates that plantings below 300 trees/ha are considered too low for economic viability mainly because they are incompatible with the potentialities offered by modern management techniques. At the other extreme, we see that planting densities of more than 2,000 trees/ha are, by and large, of a purely experimental interest, although we shall look at the few commercial orchards of this kind in operation.

It is thus the middle density in the 500-800 trees per ha range that is the general planting rule of thumb for cherry orchards today.(2, 3, 4, 5) Yet the planting models in this system usually employ very hardy, traditionally vigorous stocks and volumi-

**Table 1 – Sweet cherry orchard models**

| Density (Indicative) | Training System | Spacing (m) | Rootstock |
|---|---|---|---|
| Low | Vase | 6-5.5 x 4-5 | Vigorous |
| (up to 500) | Palmette | 5.5-5 x 4-5 | |
| LDP | Flag | 5.5-5 x 3.5-4.5 | |
| Medium | Open Vase | 5-5.5 x 4.5-3.5 | Vigorous |
| (500-800) | Multi-leader Vase | 5-5.5 x 4.5-3.5 | Semi-dwarfing |
| MDP | Palmette | 5-5.5 x 4.5-3.5 | |
| | Flag | 5-5.5 x 4.5-3.5 | |
| High | Open Vase | 4,5-5,0 x 4,0-3,0 | Semi-dwarfing |
| (800-1200) | Slender Spindle | 4.5-5 x 3.5-2.5 | Dwarfing |
| HDP | Solaxe | 4.5-5 x 3.5-2.5 | |
| Very High | Slender Spindle | 4-3.5 x 2.5-1.5 | Dwarfing |
| (over 1,200) | V | 4-3.5 x 1.5-0.5-0.3 | |
| VHDP | Vertical Axe | 4-3.5 x 1.5-0.5 | |

nous canopies like the low Spanish bush or multi-axis vase (open vase) and hedgerow training systems like palmette or bandiera (Drapeau Marchand or flag).(6) In effect, all of these orchard models are commonly found throughout Mediterranean cherry districts because they are a better fit with the soil and climate conditions, grower management skills and energy input requirements than other systems.

## TRAINING SYSTEM

What is perhaps most notable about the considerable changes cherry training systems have undergone over the years is the flexibility they have shown in adapting to the differing demands of growers and the socio-economic conditions of the districts in which they work. Current trends indicate a continuing, steady shift towards orchard systems that facilitate, as far as possible, management operations like pruning and picking. The flexibility, or plasticity, of cherry is clearly reflected in the many different planting systems it affords. Indeed, these systems in turn reflect the notable variability in the size of holdings, extent of mechanization, labor demand and even the end-market of the fruit itself. Here are the most widely employed today:

a) **Flat shapes** are marked by a relatively thin canopy featuring a vertical growth habit that develops into a continuous hedge wall that is usually harvested by carts with side-mounted platforms. Palmette and flag, or Drapeau Marchand, are good examples.
b) **Volume shapes** feature a canopy with a relatively contained growth upwards, width-wise in depth. The idea here is to achieve a tree that can be governed as near as possible from the ground, the distance depending on compatibility with under-canopy management practices. These systems include vase, Catalan vase and open vase with multiple leaders and its variants and are picked from the ground.
c) **Hybrid shapes**, though originally designed as volume systems, now feature canopies that are continuous fruiting walls that let the plant grow more freely upwards. Depending on vigor, trees are picked from the ground, with stepladders or even carts with lateral platforms. Good examples include free spindle, slender spindle and solaxe.
d) **Shapes**, adapted to high and very high-density plantings with dwarfing stocks that establish fruiting walls fully governable from the ground, are the so-called 'pedestrian' orchards. These systems include single-wall shapes like central leader or cordon and inclined double-wall canopies like the Tatura trellis V.

FIGURE 1 – THE USE OF HIGH-DENSITY PLANTINGS SHOWS GREAT PROMISE IN ITALY'S MAIN SWEET CHERRY GROWING DISTRICTS.

## TOWARDS HIGH-DENSITY – PLUSSES AND MINUSES

As we've noted, the trend today is toward a planting that combines crop quality, yield and standard size in the most economically viable and competitive management package possible. This in effect means performing a neat balancing act between the advantages and the drawbacks one risks encountering eventually with orchards at high planting densities.

*Advantges.* Putting into practice the criteria needed to manage HDP and VHDP orchards makes it possible to reduce tree size and time to initial bearing while increasing per unit yield. It is, in short, a recipe for better ground governance of trees and more efficient use of energy inputs, machinery and packing operations. HDP helps to reduce overhead by cutting labor costs for pruning and, above all, picking, cutting the time to break-even point and optimizing treatment scheduling.

*Drawbacks.* The most obvious in this connection is the increase in initial outlay for orchard establishment, the difficulties involved in retaining high yield efficiency and crop quality over time and, inevitably, the shorter orchard life compared to orchards of lower densities.

## THE LADDERLESS ORCHARD

The features that distinguish a UHDP from other intensive orchard systems that have been tested and employed in cherry are instructive.

*Density.* The foremost distinguishing mark usually ranges from 5 to nearly 7 thousand plants per hectare. Past trials have tested HDP plantings up to, but not more than, 1500-2000 trees per hectare.

*Management.* UHDP plantings can, for all intents and purposes, be pruned and picked from the ground.

*Training system.* Trees are grafted to dwarfing rootstocks and feature a permanent vertical axe and short, young, bearing feathers that are periodically renewed.

*Rootstock.* The only stock so far that best fits this kind of planting is Gisela5. A notably dwarfing stock, it demands high water and nutrient inputs and adapts to a narrow range of soil and climate conditions. When these prerequisites are not fully met, it will not perform to potential and, hence, will adversely affect the UHDP.

*Cultivar.* The profile of those that best fit UHDP's features good vigor, expansive (not upright) canopy habit, good feathering, capable of cropping on spurs and, especially, on basal buds of year-old shoots. The cultivars that best fit this description are Ferrovia, Kordia and Regina, all self-incompatible but inter-fertile among them.(7)

## A CLOSER LOOK AT A UHDP

*Start-up material.* Unlike other high-density orchards that require feathered or knip plants with slender spindle or solaxe training systems, our UHDP needs no such kind of plant. Its vertical axe training system needs a year-old plant of 100-120 cm in height from the graft point with short, preferably smooth internodes, mature buds in the median and especially in the scion's apical area. Plants of 6-8 months that have been bench grafted are also suitable so long as they are at least 80-100 cm tall.

*Pruning regime for training and cropping.* Setting the cropping points is the key to UHDPs. In traditional volume or hedge wall orchards, and even in the new hybrid systems, most of the cropping occurs on permanent wood like short shoots with spurs that is at least two years old and more or less severely pruned to renew bearing spurs. By contrast, cropping in a

**Table 2 – Planting 1 – Vertical axe**
**Planting distance 4.0 x 0.5m – Planting density 5,000 tree/ha**
**Year of plantation 2004 – Productive data 2006-2008**

| | 2006 (year 3) | | | 2007 (year 4) | | | 2008 (year 5) | | |
|---|---|---|---|---|---|---|---|---|---|
| Cultivar | Weight/Tree (kg) | Fruit Weight (g) | Calc. Yield (t/ha) | Weight/Tree (kg) | Fruit Weight (g) | Calc. Yield (t/ha) | Weight/Tree (kg) | Fruit Weight (g) | Calc. Yield (t/ha) |
| KORDIA | 1.05 | 11.24 | 5.3 | 3.60 | 10.21 | 18.0 | 1.64 | 14.7 | 8.2 |
| FERROVIA | 1.64 | 11.32 | 8.2 | 4.70 | 9.30 | 23.5 | 2.97 | 13.6 | 14.9 |

| Cultivar | Cum. Yield 2006-08 (kg/tree) | Cum. Yield 2006-08 (t/ha) | Trunk Area Section 2008 ($cm^2$) | Yield Eff. ($kg/cm^2$) |
|---|---|---|---|---|
| KORDIA | 6.3 | 31.4 | 21.2 | 0.30 |
| FERROVIA | 9.3 | 46.6 | 23.5 | 0.40 |

**Table 3 – Planting 2 – Vertical axe**
**Planting distance 4.0 x 0.5 m – Planting density 6,666 tree/ha**
**Year of plantation 2005 – Productive data 2006-2008**

| | 2006 (year 3) | | | 2007 (year 4) | | | 2008 (year 5) | | |
|---|---|---|---|---|---|---|---|---|---|
| Cultivar | Weight/Tree (kg) | Fruit Weight (g) | Calc. Yield (t/ha) | Weight/Tree (kg) | Fruit Weight (g) | Calc. Yield (t/ha) | Weight/Tree (kg) | Fruit Weight (g) | Calc. Yield (t/ha) |
| KORDIA | 0.84 | 10.42 | 5.6 | 1.52 | 11.51 | 10.1 | 1.38 | 14.5 | 9.2 |
| FERROVIA | 1.33 | 9.34 | 8.9 | 1.67 | 11.83 | 11.1 | 1.87 | 12.6 | 12.5 |

| Cultivar | Cum. Yield 2006-08 (kg/tree) | Cum. Yield 2006-08 (t/ha) | Trunk Area Section 2008 ($cm^2$) | Yield Eff. ($kg/cm^2$) |
|---|---|---|---|---|
| KORDIA | 3.7 | 24.9 | 16.5 | 0.23 |
| FERROVIA | 4.9 | 32.4 | 21.1 | 0.23 |

UHDP with vertical axe trees should take place as far as possible on basal buds of year-old shoots. This is why the tree needs a certain number of cropping feathers – future branches – that are uniformly arrayed along the central leader and have, as far as is possible, uniform vigor. These 'fruiting feathers' are cut back every year so as to later induce spring renewal via short winter pruning that leaves 2-3 vegetative buds, with length slightly decreasing from tree base to apex. Unlike those plantings and training systems that cut for yield, a UHDP achieves a high fruit quality standard at an average cropping level of 10-15, and never more than 20, metric tons per hectare. This is another reason why such a planting needs cultivars combining a pronounced aptitude for good feathering with flower buds on the basal parts of shoots. Girdling and notching can help to induce proper feathering in the former case and pre-pruning in summer/autumn can improve or even accelerate bud maturity.

*Energy inputs* and *plant and orchard protection* are the last items on the list. Water and nutritional inputs in a UHDP should be handled through fertigation, and trees must be protected against fungal diseases, especially those from *Monilia* that can strike from pre-bloom to picking. In effect, damage to flowers and fruitlets can, in severe infections, spread to shoots and young wood, thereby compromising the entire central-leader system. For orchards in humid lowland districts or have heavy spring rainfall, as many as 6-7 treatments against rot may be needed. A UHPD orchard must also be protected against environmental adversities. This usually means double covering, the top one being a permanent hail net and underneath it a rain sheet that is opened at the onset of ripening and closed after picking. A third perimeter net of wider mesh can also be used to protect the crop against birds.

## UHDP TRIAL

This is an ongoing trial at the commercial Beltrami Farms orchards in Italy's Ferrara Province, a humid lowland area. It involves two plantings, each of which was set up with year-old plants of cvs. Ferrovia and Kordia grafted to Gisela5 and trained to vertical axe. Planting 1 was established in February 2004 at a spacing of 4 x 0.5 m for a density of 5,000 per hectare.(Table 2) Planting 2 was established in February 2005 at the same 0.5 intra-row but a narrower 3 m inter-row spacing, for a density of 6,660 trees per hectare.(Table 3)

The data that follows is for the parameters being monitored in both orchards from 2006-2008: trunk area section; yields in repeated plots of 10 uniform; orchard-representative trees each; fruit size per size grade over entire crop; average fruit weight; and fruit quality determined only in 2008 on 100 representative fruits per plot by measuring for each fruit weight; firmness (Durofel 25 and Effegi ∅ 6mm penetrometer); soluble solids (Atago digital refractometer); malic acid content; and skin color (Minolta colorimeter). Yield efficiency and per hectare yield indices were calculated for both orchards in 2008.

The **cropping data** are shown in Tables 2 and 3. For Planting 1, we see that bearing began in year 3 (2006) with yields slightly over 1 kilo per tree in Kordia and 1.6 kg/tree in Regina, figures that respectively correspond to 5.3 and 8.2 metric tons/ha. The next year, the average crop for Kordia was 3.6 kg/tree, or 18.0 MT/ha, and for Ferrovia 4.7 kg/tree, or more than 23 MT/ha. By year 5, yields dropped to an inter-

**Figure 1 – Planting 1 – Vertical axe. Planting distance 4.0 x 0.5 m – Planting density 5,000 alb./ha. Year of plantation 2004**

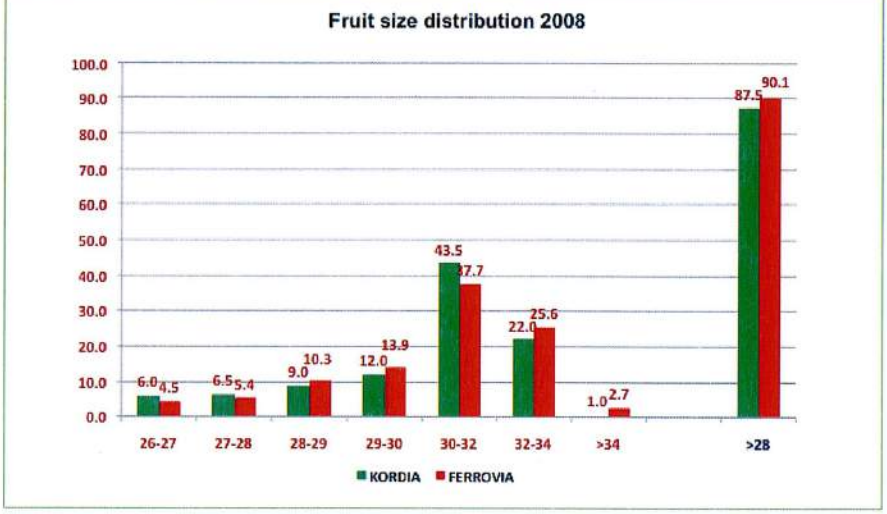
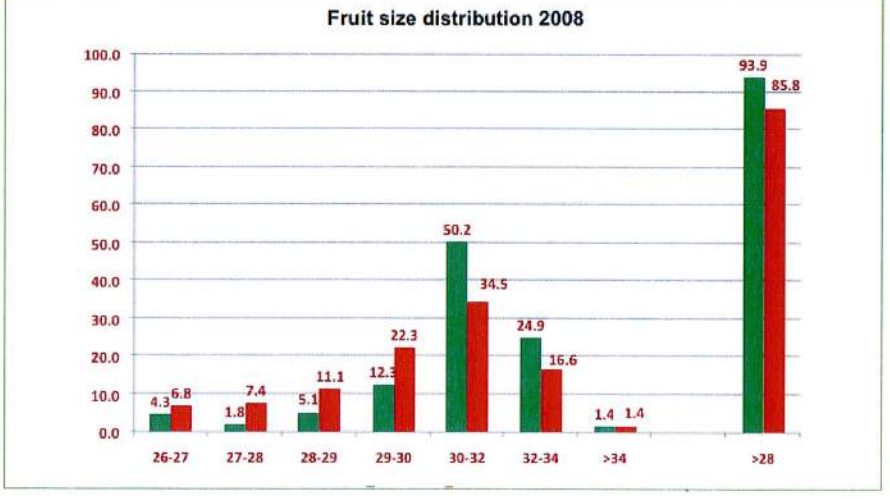



**Figure 2 – Planting 2 – Vertical axe. Planting distance 3.0 x 0.5 m – Planting density 6,666 tree/ha. Year of plantation 2005 – Productive data 2006-2008 Fruit size distribution 2008**



mediate level compared to the previous two years, with Kordia registering 1.64 kg/tree, or 8.2 MT/ha, and Ferrovia 2.97 kg/tree, or 14.9 MT/ha.(Table 2)

Planting 2 began cropping in year 2 (2006), registering 0.84 kg/tree in Kordia, or 5.6 MT/ha, and 1.33 kg/tree in Ferrovia, or 8.9 MT/ha. The following year's crop was 1.52 kg/tree (10.1 MT/ha) and 1.67 kg/tree (11.1 MT/ha) for the respective cultivars. By 2008, yields were 1.3 kg/tree for Kordia, or 9.2 MT/ha, and 1.8 kg/tree for Ferrovia, or 12.5 MT/ha.(Table 3)

**Average fruit weight** always registered high values in both plantings, both cultivars and over the three-year data set, ranging from 10 to 14 g. Generally speaking, Kordia produced slightly larger fruit than Ferrovia; minimum differences in fruit weight were also found for both densities. Perhaps the most noteworthy finding in this connection is the breakdown by **size class**, which we report for both plantings only in 2008 for brevity's sake. Figure 1 shows that in Planting 1 Kordia had more than 87% and Ferrovia 90% of fruits larger than 28 mm, with nearly 40% in 30-32 mm class for 23% of Kordia's and with 28% of Ferrovia's fruit in class 32 and over. The rates were even higher for Planting 2, with peaks of 94% for Kordia fruits and 86% of Ferrovia's larger than 28 mm.(Fig. 2)

Fruit quality was also noteworthy in all parameters measured.(Table 4) For example, the Durofel and penetrometer data show good firmness values for Kordia and Ferrovia, roughly 60 measured by the former and 600 by the latter, with Kordia fruit being slightly firmer. Soluble solids also proved to be at average values, with Ferrovia's 14.6 °Brix slightly higher than Kordia's 13.4 °Brix in Planting 1 and higher again, both averaging about 16 °Brix, in Planting 2; acidity was also slightly higher in Planting 2. The colorimeter data show that the fruit in Planting 2 ripen faster, with registering saturation values for red color in both a* and b* parameters and lower brightness L* values for fruits picked on the same day in both plantings.

## CONCLUSIONS

The Gisela5 dwarfing stock and cultivar graft combination is capable of controlling vigor and enabling ground-based manual crop management for all operations. Second, the data show that yields in both plantings are now between 10 and 15 MT/ha. Thus, while it would not be unreasonable to expect that they might stay there in the upcoming years, we simply do not know how long such UHDPs can maintain yield and cropping efficiency at the levels registered so far. If, however, we assume proper crop management and exclude damage from unforeseeable severe weather events, it would not be amiss to expect that these plantings could remain productive at current levels for about 10 years.

The real achievement these systems have recorded to date has been their high crop quality. As we've seen, proper crop management practices have yielded a fruit size of 28-30/30 mm and more at amount rates close to 90%.

At this point, striking a cautionary note may be in order for anyone thinking about establishing a UHDP of sweet cherry. It must be kept in mind that the results we have reported here for what is still an ongoing trial cannot be taken as a general rule in measuring outcome of such a planting in other soil-climate and market conditions. Another item that needs to be factored into any UHDP equation is the complexity of the system itself and the skill levels a grower needs to successfully manage it. Indeed, there is no room here for mistakes or second thoughts either in the orchard or even in the planning stages that come before establishing it.

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**Table 4a – Planting 2 – Vertical axe. Planting distance 4.0 x 0.5 m – Planting density 5.000 alb/ha Year of plantation 2004 – Quality traits 2008**

| Cultivar | Weight (g) | Durofel | Penetr. | °Brix | Acidy | pH | L | a | b |
|---|---|---|---|---|---|---|---|---|---|
| KORDIA | 12.5 | 57 | 0.48 | 13.4 | 4.76 | 3.87 | 28.28 | 24.20 | 4.92 |
| FERROVIA | 13.7 | 67 | 0.59 | 14.4 | 4.32 | 3.88 | 26.61 | 19.92 | 2.55 |

**Table 4b – Planting 2 – Vertical axe. Planting distance 3.0 x 0.5 m – Planting density 6.666 tree/ha Year of plantation 2005 – Quality traits 2008**

| Cultivar | Weight (g) | Durofel | Penetr. | °Brix | Acidy | pH | L | a | b |
|---|---|---|---|---|---|---|---|---|---|
| KORDIA | 12.8 | 58 | 0.46 | 16.01 | 4.99 | 3.92 | 25.94 | 16.96 | 2.03 |
| FERROVIA | 13.3 | 67 | 0.62 | 15.96 | 5.20 | 3.91 | 26.10 | 18.21 | 2.12 |