# Cultivar and rootstock response to drip irrigation in sweet cherry tree vigour and start of bearing during the first three years after planting

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**ABSTRACT**: Fifteen sweet cherry cultivars and three rootstocks were evaluated within three years in two experimental orchards established in the same location in the autumn 2004. In one of them drip irrigation was applied in the periods of insufficient rainfall, i.e. from mid-April to mid-August. This irrigation distinctly increased the vigour of trees that was jointly expressed by trunk-cross-section area, total length of shoots and canopy volume. An increase of tree vigour was the greatest in trees on Mazzard, medium on P-HL-C and the lowest on Gisela 5 rootstocks. The trees on P-HL-C that grew without irrigation similarly as the trees on Gisela 5 grew significantly more vigorously when irrigation was applied. Considerable differences in the response to irrigation were also found among cultivars; it increased the vigour of Halka, Sylvana, Aranka and Burlat more distinctly, whereas the least response to irrigation was recorded in the Horka, Jacinta and Justyna cultivars. The vigour of Regina, Tim and Vanda cultivars grown on P-HL-C rootstock was more extensively increased by irrigation than if they grew on Gisela 5. Flower and fruit sets of irrigated trees were with a few exceptions significantly lower than those of trees without irrigation. Tamara, Sandra and Regina were the most vigorous cultivars in this study, whereas Tim and Skeena had the weakest tree growth. Practical aspects of these findings are briefly discussed.

**Keywords**: sweet cherry; rootstocks; cultivars; drip irrigation; tree vigour; bearing; flower set; fruit set

The development of sweet cherry growing in the Czech Republic has departed during the last 10 years from traditional large tree forms towards much smaller trees planted in higher densities and trained like spindles with short stems. These new growing systems are mainly based on using new clonal rootstocks that significantly restrict the vigour of trees. Furthermore, these trees are frequently more vulnerable to various stressors and especially to the dryness of soil. In such situations, the growth of trees is often poor and the size of fruits is too small (Edin et al. 1998; Modl 2000; Blažková 2001; Bujdosó et al. 2004; Blažková, Hlušičková 2004, 2007a,b). For these reasons, many cherry growers have focused on the construction of irrigation, which was not necessary for the crop in this country before. Drip irrigation seems to be the best solution based upon previous experience from abroad (Möhler 2005).

The aim of this paper was to study the impact of drip irrigation in domestic climatic and soil conditions on tree vigour and cropping of the sweet cherry in the first 3 years after planting in an orchard with a special focus, i.e. to observe the response of a larger number of newly bread cultivars growing on three different rootstocks.

## MATERIAL AND METHODS

For this study, 15 sweet cherry cultivars (Aranka, Burlat, Fabiola, Halka, Horka, Jacinta, Justyna, Kordia, Regina, Sandra, Skeena, Sylvana, Tamara, Tim and Vanda) and 3 rootstocks (Gisela 5, P-HL-C and Mazzard P-TU-2) were used. From these genotypes, Burlat, Kordia, Regina and Vanda, as well as the rootstock P-TU-2, are commonly grown in the Czech Republic and can be considered as standard (control varieties), whereas the others are still in the stage of introduction or testing there.

Two experimental sweet cherry orchards were established close to each other in the autumn of 2004 at Holovousy in similar site and soil (sandy loam) conditions using the same cultivars and rootstocks.

Supported by the Ministry of Agriculture of the Czech Republic, Project No. QF3225.

Table 1. Survey of rainfall and mean temperatures during irrigated periods of 2005–2007

| Characteristics | Year | April | May | June | July | August | Mean |
|---|---|---|---|---|---|---|---|
| Rainfall (mm) | 2005 | 49.2 | 92.8 | 16.6 | 152.7 | 46.8 | 71.6 |
| | 2006 | 54.4 | 55.5 | 68.8 | 21.6 | 111.0 | 62.3 |
| | 2007 | 4.5 | 109.4 | 90.7 | 122.9 | 68.4 | 79.2 |
| Mean temperature (°C) | 2005 | 10.9 | 14.7 | 17.1 | 19.1 | 17.2 | 1.8 |
| | 2006 | 9.3 | 13.7 | 17.9 | 22.6 | 16.0 | 15.9 |
| | 2007 | 12.2 | 15.7 | 19.1 | 18.7 | 19.1 | 17.0 |

Both orchards were located at the altitude of about 300 m a.s.l. and they were situated on a gentle slope facing south. One of the orchard was equipped with drip irrigation system whereas the other was left without this facility. As planting material, one-year-old trees obtained by budding were used. Usually, six trees were planted from each cultivar-rootstock combination but only those variants remained in the study where at least three well growing trees were available throughout the whole evaluation period. In the non-irrigated orchard the spacing of 5 × 1.5 m was applied, while in the irrigated orchard trees on the Gisela 5 rootstock were planted in the spacing of 4.2 × 2 m and the rest of the trees were planted in the spacing of 4.2 × 1.5 m. The latter spacing should be increased in the next few years to 4.2 × 3 m by tree thinning, if necessary.

Experimental trees were trained as spindles using strong wooden stakes as supports rather than shoot binding and pegging but minimal pruning was applied to achieve more horizontal positions of side branches and their regular spacing within the canopy. Clean strips were kept under the trees by hand hacking in the first growing season and then by contact herbicides, and frequently cut sod was kept in alleys between tree rows. Fertilizers were applied according to soil analyses. Spraying treatments against pests and diseases were conducted according to the recommendations for commercial orchards.

Irrigation was regularly applied from mid April till mid August in single dosages of 36 l per one meter of tree row per week, only if the rainfall was less than 10 mm the previous week. During periods of dry weather and higher temperatures, the irrigation was applied twice a week. The survey of the rainfall and mean temperatures during the irrigated periods between 2005 and 2007 is given in Table 1.

Since the time of planting in 2004, stem circumference of each tree was repetitively measured after the growing season till 2007, the length of all shoots was recorded in 2006 and tree size characteristics in 2007. In 2006 and 2007, flower set and fruit set were rated for each tree using 1–9 rating scales (1 = no set). All gathered data were processed by ANOVA analyses using records from individual trees as replications. Intervals of least significant difference were calculated to separate the cultivar and irrigation treatment means for each rootstock.

## RESULTS

### Trunk-cross-sectional area

The survey regarding an increase of trunk-cross-sectional area (TCSA) for all the evaluated cultivar-rootstock combinations from the time of planting in 2004 till the end of the growing season 2007 is presented in Table 2. No significant differences were found between non-irrigated and irrigated variants at the starting point in 2004, however, six significantly larger TCSAs due to irrigation were noticed after the first growing season in 2005. Three of them were on the rootstock P-HL-C (Horka, Regina and Vanda) and the other three on the Mazzard rootstock P-TU-2 (Sandra, Skeena and Tamara). Most of the irrigated cultivar-rootstock combinations had significantly greater values of trunk cross-sectional area after the next growing season (in 2006) and nearly all after the 2007 growing season.

### Total shoot length

Values of the total shoot length measured in the orchard without irrigation after the second growing season in 2006 presented in Table 3 fluctuated between 3.72 m (Halka on P-HL-C) and 11.30 m (Regina on Gisela 5). In the irrigated orchard the span of shoot length ranged from 4.25 m (Skeena on Gisela 5) to 18.12 m (Sandra on P-TU-2). In comparison with the mean for all cultivars, the total shoot lengths were the greatest on the P-TU-2 rootstock both in the orchard with and without irrigation (Table 5). Trees on Gisela 5 had, on average, greater total shoot length than trees on P-HL-C in the orchard without irrigation but much smaller shoot length in the irrigated one.

Table 2. Increase of trunk-cross-section area ($cm^2$) of tested cultivars and rootstocks until 2007 with and without irrigation

| Cultivar | Year | Non-irrigated trees on the rootstock | | | | Irrigated trees on the rootstock | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Gisela 5 | P-HL-C | P-TU-2 | mean | Gisela 5 | P-HL-C | P-TU-2 | mean |
| Aranka | 2004 | | 1.4a* | 1.0a | 1.2 | | 1.5a | 1.2a | 1.4 |
| | 2005 | | 2.2a | 1.5a | 1.8 | | 3.9a | 3.5a | 3.7 |
| | 2006 | | 6.8a | 6.3a | 6.6 | | 12.2b | 13.6b | 12.9 |
| | 2007 | | 13.3 a | 17.4a | 15.4 | | 26.3b | 32.8b | 29.6 |
| Burlat | 2004 | 1.1a | 1.8a | | 1.4 | 1.7a | 1.6a | | 1.6 |
| | 2005 | 2.5a | 2.8a | | 2.7 | 4.3b | 4.1a | | 4.2 |
| | 2006 | 7.3a | 7.4a | | 7.4 | 12.3b | 11.7b | | 12.0 |
| | 2007 | 12.1a | 15.3a | | 13.7 | 24.1b | 26.6b | | 25.4 |
| Fabiola | 2004 | 0.9a | 1.1a | | 1.0 | 1.6a | 1.5a | | 1.5 |
| | 2005 | 2.6a | 2.3a | | 2.4 | 3.4a | 3.6a | | 3.5 |
| | 2006 | 7.6a | 6.6a | | 7.1 | 9.8a | 9.7b | | 9.7 |
| | 2007 | 13.3a | 15.0a | | 14.2 | 21.2b | 22.0b | | 21.6 |
| Halka | 2004 | | 1.2a | | 1.2 | | 1.6a | | 1.6 |
| | 2005 | | 2.8a | | 2.8 | | 3.8a | | 3.8 |
| | 2006 | | 7.4a | | 7.4 | | 10.8b | | 10.8 |
| | 2007 | | 14.7a | | 14.6 | | 26.0b | | 26.0 |
| Horka | 2004 | | 1.5a | | 1.5 | | 2.3a | | 2.2 |
| | 2005 | | 2.6a | | 2.6 | | 5.3b | | 5.3 |
| | 2006 | | 8.0a | | 7.9 | | 14.6b | | 14.6 |
| | 2007 | | 16.3a | | 16.3 | | 24.7b | | 24.7 |
| Jacinta | 2004 | 1.2a | 1.0a | | 1.1 | 1.2a | 1.5a | | 1.4 |
| | 2005 | 2.6a | 3.2a | | 2.9 | 1.6a | 3.3a | | 2.4 |
| | 2006 | 7.7a | 8.4a | | 8.1 | 5.8a | 8.9a | | 7.4 |
| | 2007 | 14.7a | 15.4a | | 15.0 | 16.0a | 19.4b | | 17.7 |
| Justyna | 2004 | 0.7a | 1.1a | | 0.9 | 1.4a | 1.2a | | 1.1 |
| | 2005 | 1.9a | 2.3a | | 2.1 | 1.7a | 2.9a | | 2.0 |
| | 2006 | 6.0a | 6.0a | | 6.0 | 5.2a | 7.6a | | 6.4 |
| | 2007 | 10.7a | 11.6a | | 11.1 | 12.9a | 16.6b | | 14.7 |
| Kordia | 2004 | 1.2a | 2.1a | | 1.6 | 1.9a | 1.0a | | 1.5 |
| | 2005 | 2.7a | 2.4a | | 2.6 | 2.7a | 2.5a | | 2.6 |
| | 2006 | 6.0a | 7.2a | | 6.6 | 8.6b | 8.5a | | 8.5 |
| | 2007 | 11.6a | 16.2a | | 13.9 | 18.1b | 19.6b | | 18.8 |
| Regina | 2004 | 1.0a | 1.5a | | 1.3 | 1.1a | 1.4a | | 1.3 |
| | 2005 | 2.7a | 2.1a | | 2.4 | 3.3a | 4.0b | | 3.7 |
| | 2006 | 10.0a | 6.4a | | 8.2 | 12.0a | 11.7b | | 11.9 |
| | 2007 | 16.6a | 12.7a | | 14.7 | 22.3b | 22.8b | | 22.6 |
| Sandra | 2004 | 1.9a | 1.3a | 1.0a | 1.4 | 1.3a | 1.7a | 1.5a | 1.5 |
| | 2005 | 3.7a | 2.4a | 2.7a | 3.0 | 2.8a | 4.3a | 5.7b | 4.3 |
| | 2006 | 10.0a | 6.8a | 11.2a | 9.4 | 12.2a | 12.3b | 18.0b | 14.2 |
| | 2007 | 16.5a | 13.5a | 25.9a | 18.6 | 24.6b | 23.4b | 40.2b | 29.4 |
| Skeena | 2004 | 1.3a | | 1.0a | 1.2 | 1.2a | | 1.8a | 1.5 |
| | 2005 | 1.8a | | 2.6a | 2.2 | 3.3a | | 5.2b | 4.3 |
| | 2006 | 6.1a | | 8.9a | 7.5 | 9.9b | | 14.3b | 12.1 |
| | 2007 | 11.9a | | 14.8a | 13.4 | 20.3b | | 26.8b | 23.5 |

Table 2 to be continued

| Cultivar | Year | Non-irrigated trees on the rootstock | | | | Irrigated trees on the rootstock | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Gisela 5 | P-HL-C | P-TU-2 | mean | Gisela 5 | P-HL-C | P-TU-2 | mean |
| Sylvana | 2004 | 1.3a | 1.3a | | 1.3 | 1.3a | 1.2a | | 1.3 |
| | 2005 | 3.2a | 2.3a | | 2.7 | 2.8a | 3.5a | | 3.1 |
| | 2006 | 6.9a | 6.5a | | 6.7 | 10.4b | 9.9b | | 9.9 |
| | 2007 | 21.0a | 10.4a | | 15.7 | 23.2a | 19.4b | | 21.3 |
| Tamara | 2004 | | 0.7a | 1.1a | 0.9 | | 1.3a | 2.0a | 1.6 |
| | 2005 | | 2.4a | 3.1a | 2.8 | | 3.7a | 6.7b | 5.2 |
| | 2006 | | 6.6a | 11.9a | 9.2 | | 13.6b | 16.2b | 14.9 |
| | 2007 | | 19.0a | 20.5a | 19.8 | | 25.1b | 33.2b | 29.2 |
| Tim | 2004 | 1.2a | 1.2a | | 1.2 | 0.8a | 0.8a | | 0.8 |
| | 2005 | 3.0a | 1.9a | | 1.9 | 1.5a | 2.3a | | 1.9 |
| | 2006 | 5.7a | 5.8a | | 5.8 | 7.8b | 7.1a | | 7.5 |
| | 2007 | 10.2a | 10.4a | | 10.3 | 12.6b | 16.1b | | 14.4 |
| Vanda | 2004 | 1.1a | 1.5a | | 1.3 | 1.4a | 1.7a | | 1.6 |
| | 2005 | 2.6a | 2.3a | | 2.5 | 3.3a | 4.0b | | 3.6 |
| | 2006 | 9.2a | 6.7a | | 8.0 | 11.5b | 11.8b | | 11.7 |
| | 2007 | 17.5a | 13.6a | | 15.5 | 23.2b | 27.4b | | 25.3 |

*For each cultivar and rootstock combination (in a row) values followed by the same letter are not statistically different at $P = 0.05$ for the irrigation treatment

Table 3. Total shoot length (m) of tested cultivars and rootstocks in 2006 with and without irrigation

| Cultivar | Non-irrigated trees on the rootstock | | | | Irrigated trees on the rootstock | | | |
|---|---|---|---|---|---|---|---|---|
| | Gisela 5 | P-HL-C | P-TU-2 | mean | Gisela 5 | P-HL-C | P-TU-2 | mean |
| Aranka | | 6.34a* | 6.65a | 6.49 | | 10.82b | 13.03b | 11.93 |
| Burlat | 5.84a | 5.82a | | 5.83 | 7.43b | 8.97b | | 8.20 |
| Fabiola | 8.68a | 7.10a | | 7.89 | 9.91a | 8.36b | | 9.13 |
| Halka | | 3.72a | | 3.72 | | 10.00b | | 10.00 |
| Horka | | 9.68b | | 9.68 | | 6.89a | | 6.89 |
| Jacinta | 8.08a | 9.04a | | 8.56 | 6.72a | 11.28b | | 9.00 |
| Justyna | 7.55a | 7.21a | | 7.38 | 6.41a | 8.02a | | 7.21 |
| Kordia | 5.54a | 8.96a | | 7.25 | 7.04b | 10.89b | | 8.97 |
| Regina | 11.30a | 6.56a | | 8.92 | 13.48b | 12.11b | | 12.79 |
| Sandra | 10.72a | 7.59a | 11.11a | 9.81 | 11.34a | 11.38b | 18.27b | 13.66 |
| Skeena | 3.88a | | 5.48a | 4.68 | 4.25a | | 8.99b | 6.62 |
| Sylvana | 6.92a | 5.50a | | 6.21 | 7.36a | 11.36b | | 9.36 |
| Tamara | | 8.99a | 10.16a | 9.58 | | 13.78b | 19.12b | 16.45 |
| Tim | 4.17a | 5.20a | | 4.69 | 4.76a | 6.41b | | 5.58 |
| Vanda | 10.57a | 7.44a | | 9.01 | 12.62b | 12.68b | | 12.65 |
| LSD ($P = 0.05$) | 2.67 | 1.50 | 3.19 | | 2.88 | 2.29 | 4.02 | |

*For each cultivar and rootstock combination (in a row) values followed by the same letter are not statistically different at $P = 0.05$ for the irrigation treatment

Table 4. Canopy volume ($m^3$) of tested cultivars and rootstocks in 2007 with and without irrigation

| Cultivar | Non-irrigated trees on the rootstock | | | | Irrigated trees on the rootstock | | | |
|---|---|---|---|---|---|---|---|---|
| | Gisela 5 | P-HL-C | P-TU-2 | mean | Gisela 5 | P-HL-C | P-TU-2 | mean |
| Aranka | | 2.07a* | 2.30a | 2.19 | | 3.25b | 5.03b | 4.14 |
| Burlat | 1.55a | 2.77a | | 2.16 | 3.80b | 5.26b | | 4.53 |
| Fabiola | 2.21a | 2.29a | | 2.25 | 3.72b | 4.56b | | 4.14 |
| Halka | | 2.83a | | 2.83 | | 6.91b | | 6.91 |
| Horka | | 3.40a | | 3.40 | | 4.83b | | 4.83 |
| Jacinta | 3.48a | 3.53a | | 3.51 | 4.07a | 5.35b | | 4.71 |
| Justyna | 2.32a | 3.44a | | 2.88 | 3.64b | 4.51b | | 4.07 |
| Kordia | 2.15a | 2.59a | | 2.37 | 3.44b | 4.25b | | 3.84 |
| Regina | 3.05a | 2.38a | | 2.72 | 4.04b | 4.25b | | 4.15 |
| Sandra | 2.31a | 2.50a | 4.03a | 2.94 | 4.16b | 5.34b | 6.23b | 5.25 |
| Skeena | 1.29a | | 2.31a | 1.81 | 2.28b | | 3.88b | 3.08 |
| Sylvana | 2.01a | 2.17a | | 2.09 | 4.55b | 5.18b | | 4.86 |
| Tamara | | 2.83a | 3.71a | 3.27 | | 5.34b | 6.42b | 5.88 |
| Tim | 1.51a | 1.94 | | 1.72 | 2.51 | 4.17 | | 3.34 |
| Vanda | 2.73 | 2.32a | | 2.52 | 3.98b | 4.60b | | 4.29 |
| LSD ($P$ = 0.05) | 0.76 | 0.65 | 1.10 | | 0.58 | 0.73 | 1.26 | |

*For each cultivar and rootstock combination (in a row) values followed by the same letter are not statistically different at $P$ = 0.05 for the irrigation treatment

### Canopy volume

The final canopy volumes calculated upon measuring trees after the 2007 season for all evaluated cultivar-rootstock combinations are presented in Table 4. In the orchard without irrigation, this characteristic varied between 1.29 $m^3$ for Skeena on Gisela 5 and 4.03 $m^3$ for Sandra on P-TU-2. In the irrigated orchard, the smallest canopy was found in Skeena on Gisela 5 (2.28 $m^3$) and the biggest one in Tamara on P-TU-2 (6.23 $m^3$). Regarding the mean values of the canopy volume for the rootstocks, Gisela 5 had the smallest canopy, followed by P-HL-C, whereas the P-TU-2 had the largest (Table 5).

### Tree vigour

In comparison of tree vigour based on the mean of all three characteristics described above, Gisela 5 and

Table 5. Influence of the rootstock and irrigation on tree vigour

| Tree vigour | Parameters of the vigour | Gisela 5 | | P-HL-C | | P-TU-2 | |
|---|---|---|---|---|---|---|---|
| | | non-irrigated | irrigated | non-irrigated | irrigated | non-irrigated | irrigated |
| In absolute values | TCSA ($cm^2$) 2007 | 14.2 | 19.9 | 14.1 | 22.5 | 19.7 | 33.3 |
| | shoot length 2006 (m) | 7.6 | 8.3 | 7.1 | 10.2 | 8.4 | 14.9 |
| | canopy volume ($m^3$) 2007 | 2.2 | 3.8 | 2.6 | 4.8 | 3.1 | 5.4 |
| In percentage of P-TU-2 | TCSA ($cm^2$) 2007 | 72 | 60 | 72 | 68 | 100 | 100 |
| | shoot length 2006 (m) | 91 | 56 | 85 | 69 | 100 | 100 |
| | canopy volume ($m^3$) 2007 | 73 | 68 | 86 | 90 | 100 | 100 |
| | mean | 79 | 61 | 81 | 76 | 100 | 100 |

Table 6. Impact of irrigation on the increase of tree vigour (%) of tested cultivars and rootstocks expressed by means of 3 parameters

| Cultivar | Gisela 5 | P-HL-C | P-TU-2 | Mean |
|---|---|---|---|---|
| Aranka | | 75 | 101 | 88 |
| Burlat | 90 | 73 | | 78 |
| Fabiola | 47 | 54 | | 51 |
| Halka | | 130 | | 130 |
| Horka | | 22 | | 22 |
| Jacinta | 3 | 34 | | 19 |
| Justyna | 21 | 28 | | 24 |
| Kordia | 48 | 36 | | 41 |
| Regina | 28 | 81 | | 50 |
| Sandra | 45 | 79 | 58 | 58 |
| Skeena | 52 | | 71 | 63 |
| Sylvana | 48 | 110 | | 73 |
| Tamara | | 58 | 74 | 66 |
| Tim | 34 | 65 | | 51 |
| Vanda | 33 | 90 | | 58 |
| Mean | 41 | 67 | 76 | 58 |

P-HL-C ranged into the same vigour category in the orchard without irrigation, whereas trees on P-HL-C in the irrigated orchard were more vigorous than trees on Gisela 5 (Table 5). Irrigation increased the vigour of trees on Gisela 5 on average by 41%, on P-HL-C by 57% and on P-TU-2 by 76% (Table 6). Regarding cultivars, tree vigour was most increased by irrigation in Halka, Sylvana, Aranka and Burlat; on the other hand, the least response to irrigation was recorded in Horka, Jacinta and Justyna. Among other cultivars this increase was much more obvious on P-HL-C rootstock than on Gisela 5. That was also the case of Regina, Tim and Vanda.

**Flower set**

In the first year after planting (2005) flower set was very rare. Only a few flowers were observed on Sylvana, Tim and Vanda. In 2006 nearly all trees on Gisela 5 and P-HL-C developed almost a normal flower set (Table 7); however, the trees on P-TU-2 still had a very low flower set. The flower set of trees in the irrigated orchard was generally significantly lower than those in the orchard without irrigation (Fig. 4). The phenomenon was practically the same on all three rootstocks but relatively lowest on P-HL-C.

The flowering of trees in 2007 was negatively influenced by late spring frosts that occurred just at the beginning of blossom time. It damaged majority of the flowers, which did not develop properly, and therefore flower densities were rated distinctly lower than in 2006. Beyond this reduction, the figures were generally similar to those from the previous year, including a negative effect of irrigation on the flower set (Fig. 4).

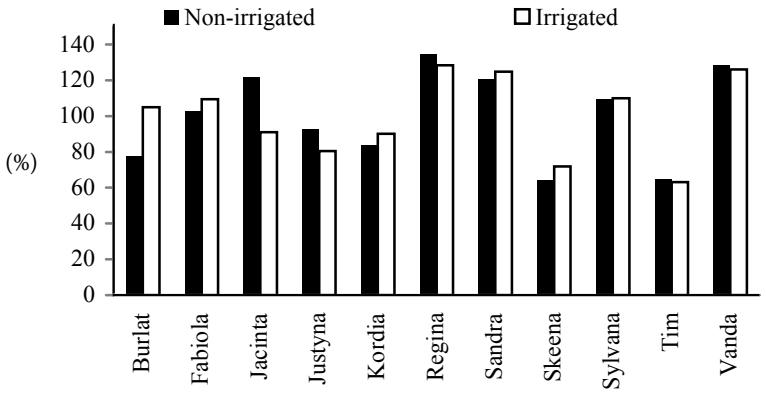


Fig. 1. Tree vigour of cultivars on Gisela 5 rootstock as a percentage of the mean

Table 7. Flower set of tested cultivars and rootstocks in 2006 and 2007 with and without irrigation

| Cultivar | Year | Non-irrigated trees on the rootstock | | | | Irrigated trees on the rootstock | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Gisela 5 | P-HL-C | P-TU-2 | mean | Gisela 5 | P-HL-C | P-TU-2 | mean |
| Aranka | 2006 | | 4.8b* | 2.5b | 3.7 | | 3.0a | 1.0a | 2.0 |
| | 2007 | | 4.7b | 3.0b | 3.8 | | 3.0a | 1.0a | 2.0 |
| Burlat | 2006 | 5.0a | 5.0a | | 5.0 | 5.3a | 6.0b | | 5.7 |
| | 2007 | 5.0b | 4.8b | | 4.9 | 3.0a | 3.7a | | 3.3 |
| Fabiola | 2006 | 7.0a | 6.0a | | 6.5 | 8.0b | 6.5a | | 7.2 |
| | 2007 | 7.0b | 7.3b | | 7.1 | 6.0a | 3.8a | | 4.9 |
| Halka | 2006 | | 5.0a | | 5.0 | | 6.5b | | 6.5 |
| | 2007 | | 7.5b | | 7.5 | | 4.5a | | 4.5 |
| Horka | 2006 | | 6.0a | | 6.0 | | 7.0b | | 7.0 |
| | 2007 | | 6.0b | | 6.0 | | 4.5a | | 4.5 |
| Jacinta | 2006 | 7.0b | 6.0b | | 6.5 | 5.5a | 5.0a | | 5.2 |
| | 2007 | 6.3b | 5.0b | | 5.7 | 2.5a | 3.8a | | 3.2 |
| Justyna | 2006 | 5.8b | 6.3b | | 6.0 | 2.0a | 5.0a | | 3.5 |
| | 2007 | 6.2b | 5.5b | | 5.8 | 3.0a | 4.5a | | 3.8 |
| Kordia | 2006 | 7.3b | 6.0a | | 6.7 | 3.5a | 6.7a | | 5.1 |
| | 2007 | 7.0b | 6.0b | | 6.5 | 5.5a | 4.8a | | 5.2 |
| Regina | 2006 | 7.7a | 6.7a | | 7.2 | 6.5a | 6.0a | | 6.2 |
| | 2007 | 7.3b | 6.7b | | 7.0 | 5.5a | 4.7a | | 5.1 |
| Sandra | 2006 | 7.0a | 5.5b | 2.5a | 5.1 | 7.0a | 4.5a | 4.0b | 5.2 |
| | 2007 | 7.2b | 5.8a | 3.5a | 5.5 | 5.3a | 6.5a | 3.5a | 5.1 |
| Skeena | 2006 | 6.5a | | 2.7a | 4.6 | 6.0a | | 2.0a | 4.0 |
| | 2007 | 5.5b | | 2.0a | 3.7 | 3.8a | | 1.3a | 2.5 |
| Sylvana | 2006 | 6.0b | 7.0a | | 6.5 | 4.5a | 6.3a | | 5.4 |
| | 2007 | 7.0b | 8.0b | | 7.5 | 3.5a | 4.5a | | 4.0 |
| Tamara | 2006 | | 5.0a | 3.5a | 4.2 | | 4.5a | 3.3a | 3.9 |
| | 2007 | | 4.0a | 4.5b | 4.2 | | 4.5a | 2.8a | 3.7 |
| Tim | 2006 | 5.3a | 4.8a | | 5.1 | 6.0b | 6.0b | | 6.0 |
| | 2007 | 7.0b | 6.0b | | 6.5 | 6.0a | 3.8a | | 4.9 |
| Vanda | 2006 | 6.7b | 5.7b | | 6.2 | 4.8a | 4.5a | | 4.6 |
| | 2007 | 6.0b | 5.8b | | 5.9 | 4.6a | 5.0a | | 4.8 |
| LSD ($P$ = 0.05) | 2006 | 0.5 | 0.9 | 0.8 | | 1.0 | 0.7 | 1.5 | |
| | 2007 | 0.7 | 0.7 | 1.1 | | 0.6 | 0.7 | 1.2 | |

*For each cultivar and rootstock combination (in a row) values followed by the same letter are not statistically different at $P$ = 0.05 for the irrigation treatment

### Fruit set

The fruit set, despite having a similar course as the flower set, was clearly lower than the flower set in majority of cultivar-rootstock combinations in both orchards (Table 8). In 2007, it was mainly because of the damage of the flowers by the late spring frosts. Very poor bearing was recorded mainly with trees on the Mazzard rootstock. On average, trees on Gisela 5 had a fruit set somewhat higher than those on P-HL-C (Fig. 4) but in some cultivars this pattern was different. Sylvana was generally the most precocious in bearing among all the evaluated cultivars. Very good and early cropping was observed also on Kordia and Vanda. Trees of Fabiola and Regina were more precocious on Gisela 5 rootstock than on P-HL-C. On the other hand, the least productive at the time of this study were cultivars Tamara, Aranka and Horka. Actual yields

Table 8. Fruit set of tested cultivars and rootstocks in 2006 and 2007 with and without irrigation

| Cultivar | Year | Non-irrigated trees on the rootstock | | | | Irrigated trees on the rootstock | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Gisela 5 | P-HL-C | P-TU-2 | mean | Gisela 5 | P-HL-C | P-TU-2 | mean |
| Aranka | 2006 | | 3.3b* | 1.0a | 2.2 | | 1.0a | 1.0a | 1.0 |
| | 2007 | | 3.3b | 1.0a | 2.2 | | 1.5a | 1.0a | 1.3 |
| Burlat | 2006 | 4.0a | 2.7a | | 3.4 | 4.0a | 3.3a | | 3.7 |
| | 2007 | 4.0a | 3.0a | | 3.5 | 3.7a | 2.3a | | 3.0 |
| Fabiola | 2006 | 4.5a | 4.0a | | 4.2 | 6.0b | 3.5a | | 4.8 |
| | 2007 | 7.0b | 4.7b | | 5.9 | 4.7a | 2.0a | | 3.0 |
| Halka | 2006 | | 4.0a | | 4.0 | | 3.5a | | 3.5 |
| | 2007 | | 6.0b | | 6.0 | | 3.0a | | 3.0 |
| Horka | 2006 | | 2.0a | | 2.0 | | 2.5a | | 2.5 |
| | 2007 | | 3.0a | | 3.0 | | 2.5a | | 2.5 |
| Jacinta | 2006 | 5.3b | 3.0a | | 4.2 | 2.3a | 4.0b | | 3.2 |
| | 2007 | 4.3b | 3.3a | | 3.2 | 2.7a | 3.0a | | 2.8 |
| Justyna | 2006 | 4.2b | 3.8b | | 4.0 | 1.3a | 2.0a | | 1.6 |
| | 2007 | 5.4b | 4.2b | | 4.8 | 2.0a | 2.5a | | 2.3 |
| Kordia | 2006 | 5.3b | 5.0b | | 5.1 | 2.3a | 3.0a | | 2.7 |
| | 2007 | 5.7b | 4.3b | | 5.0 | 3.5a | 2.7a | | 3.1 |
| Regina | 2006 | 4.0b | 4.7b | | 4.4 | 3.0a | 2.0a | | 2.5 |
| | 2007 | 6.3b | 4.3b | | 5.3 | 4.0a | 3.0a | | 3.5 |
| Sandra | 2006 | 4.8b | 4.4b | 1.5a | 3.5 | 3.3a | 1.5a | 2.0a | 2.3 |
| | 2007 | 5.0b | 4.0a | 2.0a | 3.7 | 3.7a | 4.0a | 2.0a | 3.2 |
| Skeena | 2006 | 5.0b | | 1.7a | 3.3 | 4.0a | | 1.3a | 2.7 |
| | 2007 | 3.5b | | 1.3a | 2.4 | 2.5a | | 1a | 1.8 |
| Sylvana | 2006 | 5.0b | 6.0b | | 5.5 | 3.0a | 4.0a | | 3.5 |
| | 2007 | 7.0b | 7.0b | | 7.0 | 3.0a | 3.5a | | 3.2 |
| Tamara | 2006 | | 3.3b | 3.0b | 3.2 | | 1.5a | 1.3a | 1.4 |
| | 2007 | | 2.3a | 2.5a | 2.4 | | 3.0a | 1.3a | 2.2 |
| Tim | 2006 | 4.0b | 3.6a | | 3.8 | 3.0a | 4.0a | | 3.5 |
| | 2007 | 3.0b | 2.0a | | 2.5 | 2.0a | 1.6a | | 1.8 |
| Vanda | 2006 | 5.3b | 4.0b | | 4.7 | 3.0a | 2.5a | | 2.8 |
| | 2007 | 5.7b | 5.0b | | 5.3 | 4.0a | 3.5a | | 3.8 |
| LSD ($P$ = 0.05) | 2006 | 0.4 | 0.6 | 0.7 | | 0.7 | 0.5 | 1.0 | |
| | 2007 | 0.8 | 0.9 | 1.4 | | 0.8 | 0.8 | 0.5 | |

*For each cultivar and rootstock combination (in a row) values followed by the same letter are not statistically different at $P$ = 0.05 for the irrigation treatment

in the irrigated orchard were roughly similar to those in the non-irrigated one despite a significantly lower fruit set. This was because the lower fruit set was more or less compensated by bigger canopy volumes of trees there.

### Cultivars

There were particular differences in tree vigour among the evaluated cultivars according to the rootstock used. On Gisela 5, the most vigorous cultivars in both orchards were Regina, Vanda and Sandra (Fig. 1). On the contrary, the weakest growth on this rootstock was found with Tim and Skeena. Trees of Jacinta were quite vigorous without irrigation but relatively less vigorous with irrigation. The opposite was the case of Burlat, which was less vigorous without irrigation but more vigorous with it.

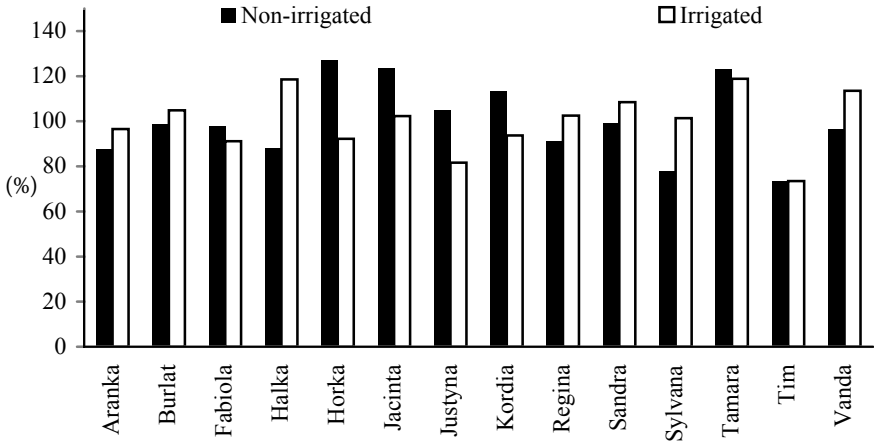


Fig. 2. Tree vigour of cultivars on P-HL-C rootstock as a percentage of the mean

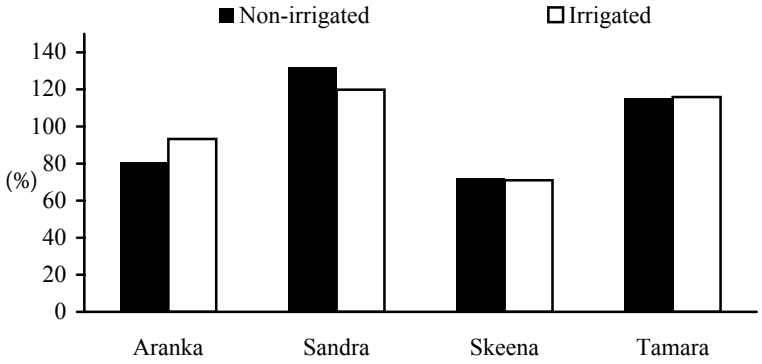


Fig. 3. Tree vigour of cultivars on P-TU-2 rootstock as a percentage of the mean

With trees on P-HL-C, the most vigorous in both orchards was Tamara and least vigorous was Tim (Fig. 2). Trees of Horka and Jacinta grew vigorously in the orchard without irrigation but relatively less when irrigated. The opposite behaviour was observed on the case of Halka and Vanda.

Trees of the cultivar Sandra were the most vigorous in both orchards on P-TU-2 rootstock, followed by trees of Tamara (Fig. 3). Trees of Aranka grew much less on the rootstock P-TU-2, and Skeena had the smallest trees of all. Irrigation of trees on P-TU-2 had no significant influence on the ranking of cultivar vigour.

## DISCUSSION

Irrigation of sweet cherry orchards is recommended, mainly for improvement of fruit quality (Neilsen et al. 2004; Möhler 2005; Kügerl 2006). For this purpose, the most important timeframe is irrigation just before the harvest. The size of sweet cherry fruits is closely related to the content of wa-

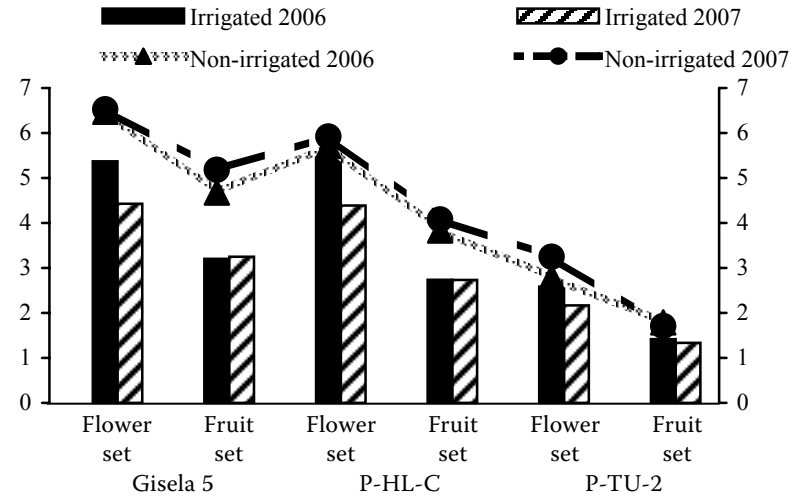


Fig. 4. Influence of irrigation on flower and fruit set in 2006 and 2007

ter in the soil during the last week before harvest (Blažková et al. 2002).

The results of this study show that generally, permanent drip irrigation of a sweet cherry orchard during the growing season in the first years after its establishment very significantly improves the growth of trees; they build up adequate canopy volume required for obtaining high yields much faster. The irrigation has an additional effect on the rootstock and cultivar; trees are able to achieve their final size faster. This is vital mainly in new orchards planted with trees on dwarf rootstocks, where the trees without irrigation often grow too slowly and require more pruning.

The effect of irrigation on improvement of tree vigour is significantly related to the rootstocks and cultivars used. The increase of vigour of trees on P-HL-C rootstock was greater than in the case of trees on Gisela 5. This is in agreement with our previous findings from a study on the effects of irrigation in the nursery (Blažková, Hlušičková 2007b). Similarly, some cultivars (e.g. Halka, Sylvana, Aranka and Burlat) had a stronger response to irrigation than the others did. In the orchards where slow-growing cultivars such as Tim, Skeena or Burlat are used, irrigation should be definitely applied.

Besides, irrigation had a reducing effect on flower and fruit sets of grown trees. With a few exceptions, this seemed to be a regular phenomenon in this study; it was probably related to prolonged shoot growth, which had an inverse effect on flower bud differentiation. In the case of abundantly cropping cultivars, a diminishing of excessive flower and fruit densities should be considered as positive since it enhances cropping volumes of trees and contributes to a better fruit quality. With poor cropping cultivars, however, a cessation of watering at the time of harvest should eliminate the negative impact of irrigation.

## CONCLUSIONS

According to the present study, the following conclusions can be drawn:

- Permanent drip irrigation of a sweet cherry orchard during the growing seasons in the first years after its establishment distinctly increased the vigour of trees. This increase was the greatest with trees on the Mazzard rootstock (76%), followed by trees on P-HL-C (57%) and on Gisela 5 (41%).
- Trees on P-HL-C as well as on Gisela 5 grew significantly more vigorously when irrigation was applied.
- With respect to the cultivar, irrigation increased the vigour of Halka, Sylvana, Aranka and Burlat more distinctly, whereas the least response to irrigation was recorded in Horka, Jacinta and Justyna cultivars.
- The vigour of Regina, Tim and Vanda cultivars grown on P-HL-C rootstock was enhanced by irrigation more than on Gisela 5.
- Flower and fruit sets of irrigated trees were, with a few exceptions, significantly lower than those of trees without irrigation.
- Tamara, Sandra and Regina were the most vigorous cultivars in this study, whereas Tim and Skeena had the weakest tree growth.

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Received for publication November 23, 2007
Accepted after corrections December 19, 2007

# Odrůdové a podnožové rozdíly ve vzrůstnosti a nástupu do plodnosti u třešní po použití kapkové závlahy v prvních třech letech po výsadbě

**ABSTRAKT**: Patnáct odrůd třešní a tři podnože byly po tři roky hodnoceny ve dvou pokusných výsadbách, které byly na podzim roku 2004 založeny ve stejné lokalitě. V jedné z nich byla aplikována v době nedostatku srážek kapková závlaha v období od poloviny dubna do poloviny srpna. Tato závlaha výrazně zvýšila vzrůstnost stromů, která byla vyjádřena plochou průřezu kmene, celkovou délkou přírůstků a objemem koruny. Toto zvýšení intenzity růstu bylo největší u stromů na podnoži ptáčnice, střední u podnože P-HL-C a relativně nejmenší u podnože Gisela 5. Stromy na podnoži P-HL-C, které bez závlahy měly stejnou intenzitu růstu jako stromy na podnoži Gisela 5, rostly při použití závlahy mnohem silněji. Významné rozdíly v účinku závlahy byly také zjištěny mezi odrůdami. Závlaha nejvíce zvýšila růst u odrůd Halka, Sylvana, Aranka a Burlat, zatímco méně výrazně na ni reagovaly Horka, Jacinta a Justyna. Růst stromů odrůd Regina, Tim a Vanda naštěpovaných na podnoži P-HL-C byl při použití závlahy mnohem intenzivnější, než když tyto odrůdy rostly na podnoži Gisela 5. Násady květů a plodů však byly kromě několika výjimek při použití závlahy významně nižší než u nezavlažovaných stromů. Stromy odrůd Tamara, Sandra a Regina rostly v tomto hodnocení nejsilněji, zatímco odrůdy Tim a Skeena měly růst stromů nejslabší.

**Klíčová slova**: třešeň; podnože; odrůdy; kapková závlaha; růst stromů; plodnost; násada květů; násada plodů

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