

Effect of Weigi rootstocks on tree growth and fruit quality of sweet cherries

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Abstract

This study evaluated the growth performance and fruit characteristics of seven sweet cherry cultivars ('Burlat', 'Kasandra', 'Jacinta', 'Justyna', 'Early Korvik', 'Kordia' and 'Tamara') grafted on Weigi® rootstocks (Weigi® 1, Weigi® 2 and Weigi® 3) compared with Gisela 5 as a standard widely grown rootstock. The experiment was conducted in Holovousy, Czech Republic, under integrated production guidelines and non-irrigated conditions. Tree vigor was assessed as trunk cross-sectional area (TCSA) after seven growing seasons. Weigi® 3 (W3) generally induced the strongest vigor across cultivars, while Weigi® 2 (W2) consistently restricted growth with growth comparable to Gisela 5 (G5). Weigi® 1 (W1) promoted intermediate to strong increases in vigor. The highest TCSA increase was recorded in 'Early Korvik' on W3 (99.3 cm²), whereas the weakest growth occurred in 'Justyna' on W2 (35.4 cm²). Measurements of fruit quality traits (fruit size, firmness and soluble solids content (SSC)) were conducted over three growing seasons (2023–2025). W2 demonstrated the most consistent performance, often matching or surpassing G5 in fruit size and firmness. W1 also enhanced firmness and fruit weight in several cultivars. W3 exhibited the highest variability in cultivar–rootstock and year combinations. SSC was less affected by rootstock and more influenced by seasonal conditions. The clearest effect of rootstocks on fruit quality was seen in fruit firmness with higher values on W1 and W2 compared to G5.

Keywords: *Prunus avium* L., cherry production, rootstock, tree vigor, fruit quality

Introduction

Sweet cherry (*Prunus avium* L.) is an economically important temperate fruit crop with steadily increasing global production (Bujdosó & Hrotko, 2017). Gisela 5 is currently the most widely used cherry rootstock in Central European orchards (Franken-Bembenek, 2005), but climate change has shifted attention to finding alternatives better suited to specific conditions (Lanauskas et al., 2023). Rootstock selection is crucial as rootstocks strongly influence tree vigor, productivity and fruit quality through cultivar–rootstock interactions (Koc et al., 2013; Pal et al., 2017; Milić et al., 2019). Although growth control is one of the main advantages of Gisela® 5, several studies indicate that its low vegetative vigor may become a disadvantage under unfavorable environmental conditions or specific management conditions. Trees may develop weak shoots, limited canopy volume and reduced renewal growth, particularly when combined with high crop load. Climate change and soil heterogeneity emphasize the need for alternative rootstocks better adapted to local conditions (Lanauskas et al., 2023). Three Weigi® rootstocks were tested and compared with the standard rootstock Gisela 5 in this study. Weigi® rootstocks originating in Germany were finalized by breeder Peter Stoppel. Each rootstock differs slightly in vigor, adaptability and compatibility. A short description of rootstocks is given in Table 1 (Stoppel, 2015).

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Table 1: Characteristics of Weigi® rootstocks.

Weigi® 1	Trees grafted on Weigi® 1 are approximately 10% more vigorous than those on Gisela 5 producing larger fruits and higher yields. They perform well on less fertile soils and show strong drought tolerance due to a deep root system. Graft compatibility is excellent and trees exhibit very good anchorage. However, Weigi® 1 is not recommended for high-rainfall areas or fertile soils that may induce excessive vigor.
Weigi® 2	Growth on Weigi® 2 is comparable to Gisela 5 under fertile conditions but slightly stronger on poorer soils. Productivity and fruit size are consistently higher than on Gisela 5. The rootstock is suited for replanting sites and demonstrates very good anchorage and stability.
Weigi® 3	This rootstock induces about 30% greater vigor than Gisela 5 but 30% less than seedling <i>Prunus avium</i> . It performs well in drier and warmer regions and is well-suited for replanting or non-irrigated orchards. Trees exhibit strong anchorage, smooth graft unions and uniform yields of large fruit.

Material and Methods

The evaluation was conducted in an experimental orchard in Holovousy, Czech Republic (390 m a.s.l.). Cultivars ‘Burlat’, ‘Kasandra’, ‘Jacinta’, ‘Justyna’, ‘Early Korvik’, ‘Kordia’ and ‘Tamara’ grafted onto Weigi® 1 (W1), Weigi® 2 (W2), Weigi® 3 (W3) and Gisela 5 (G5) were planted in spring 2019 at a spacing of 4.5 × 2 m. Cultivars represented by a low number of trees on a specific rootstock were excluded from the evaluation (Table 2).

Table 2: Evaluated cultivars on specific Weigi rootstocks.

Cultivar / rootstock	G5	W1	W2	W3
Burlat	tested	NA	tested	NA
Early Korvik	tested	NA	tested	NA
Jacinta	NA	tested	tested	NA
Justyna	tested	tested	tested	tested
Kasandra	tested	NA	tested	tested
Kordia	tested	NA	tested	tested
Tamara	tested	NA	tested	tested

Legend: NA = not available

The location is characterized by a mild southern slope with an average annual temperature of 8.1 °C and mean annual precipitation of 655 mm. Randomized blocks design was implemented with three trees per cultivar and four replications. The soil was sandy loam with a shallow top layer. Irrigation was not applied. Trees didn’t exhibit stress by long periods of high temperature or drought in 2023, 2024 and 2025 when fruit quality was evaluated. Records of monthly weather from April to July during the vegetation period are given in Table 3. Precipitation was evenly distributed, and days with temperatures over 30 °C appeared only sporadically.

Table 3: Monthly weather in vegetation period in years 2023–2025.

Year	Month	Tmean (°C)	Tmax (°C)	Tmin (°C)	Air humidity (%)	Precipitation (mm)	Foliage wetness (hours)
2023	April	8.0	21.0	-5.8	74.4	68.5	204.8
	May	14.4	27.8	2.6	63.8	18.2	83.5
	June	18.8	33.7	4.5	64.5	20.5	83.7
	July	20.6	35.5	6.9	64.5	88	159.8
2024	April	11.3	30.1	-4.3	69.6	22.1	134.8
	May	16.4	26.3	2.5	68.5	34.2	200.3
	June	19.4	33.7	5.1	70.4	56.3	147.0
	July	21.1	35.5	8.5	68.7	71.7	198.2
2025	April	12.1	25.8	-3.7	65.7	10.9	72.0
	May	12.5	30.2	-0.5	69.3	43.9	218.2
	June	18.9	33.6	6.0	71.3	73.6	204.2
	July	19.2	34.6	8.0	73.0	59.5	244.2

Trees were trained as slender spindles with mechanical weed control of tree strips. Inter-rows were regularly mowed. Fertilization of N and Ca (ammonium nitrate with limestone, NPK fertilizer) was applied in springtime on soil. Leaf application of Zn, Mn and B was done during the vegetation period. Total dosage of N was 70 kg per ha each year. Pest and disease management followed integrated production guidelines with use of both biological agents (*Bacillus thuringiensis* ssp. *kurstaki*, Spinosad, copper, lime sulphur) and synthetic products (Steward, Horizon, Talent, Mospilan, Exirel, Movento, Delan, Luna Experience) in some years. Trunk diameters were measured 60 cm above the graft union and converted to trunk cross-sectional area (TCSA). Fruit quality measurements were performed in 2023, 2024 and 2025. Following traits were measured: 1. Fruit size (mm) as a mean of the equatorial diameter measured using a digital caliper; 2. Soluble solids content (SSC, °Brix) measured with a digital refractometer; 3. Fruit firmness (index 1–100) using a Durofel instrument (Agrosta, France) with measurements on opposite cheeks of each fruit. Data for fruit firmness are available only for 2023 and 2024. Relative values (% of G5) were calculated for comparison for each fruit quality trait. Statistical analyses were performed using STATISTICA 12 (StatSoft, USA) via ANOVA and Tukey's HSD test ($\alpha = 0.05$). Mean values followed by different letters differ significantly according to Tukey's test.

Results

Clear and consistent differences in tree vigor and fruit quality were observed among the tested rootstocks when averaged across cultivars and years.

Tree growth

Tree vigor was assessed as increase of trunk cross-sectional area (TCSA) after seven growing seasons from 2019–2025. Trees grafted on W3 induced the highest vegetative vigor as reflected by the greatest increases in TCSA than those on the standard G5 confirming its classification as a semi-vigorous rootstock (Table 4). W2 consistently reduced vegetative growth and produced TCSA increase values similar to or lower than G5 indicating a reliable dwarfing effect. W1 exhibited intermediate vigor generally promoting slightly stronger growth than G5 but clearly less than W3.

Table 4: TCA increase from 2019–2025.

Cultivar	Rootstock	TCSA increase 2019–2025 (in cm ²)	Relative growth to G5 (in %)
Burlat	G5	79.1 cdef	100,0
	W2	56.2 abce	71,0
Early Korvik	G5	74.2 cde	100,0
	W2	58.9 abce	79,4
	W3	99.3 def	133,8
Jacinta	W1	82.8 bcdf	ND
	W2	64.6 bce	ND
Justyna	G5	52,2 abc	100,0
	W1	65.6 abcde	125,7
	W2	35.4 abcde	67,8
	W3	66.8 abcde	128,0
Kasandra	G5	91.7 df	100,0
	W2	70.3 bcde	76,7
	W3	88.0 abcdef	96,0
Kordia	G5	72.9 bcde	100,0
	W2	64.9 bce	89,0
	W3	79.4 cdef	108,9
Tamara	G5	54.1 abce	100,0
	W1	70.5 bcde	130,3
	W2	45.9 ab	84,8

Legend: Different letters in rows indicate a statistically significant difference ($\alpha=0.05$)

These trends were stable across cultivars demonstrating that the rootstock genotype had a stronger influence on overall tree vigor than the scion/variety.

Fruit size

Fruit size on W1 and W2 was generally comparable to and in several cases slightly higher than that obtained on G5 (Table 5). W2 in particular showed stable performance maintaining fruit size close to the control G5 despite its growth-reducing effect. W3 showed greater variability and tended to produce fruit of similar or slightly smaller size than G5. Fruit size was influenced by crop load that was high in the year 2023 with records from 6–8 (scale 1–9; 1 – no fruits, 9 – extremely high) on most cultivars. Crop load on cultivar ‘Tamara’ was very high in the year 2023 with value 9. Crop load in years 2024 and 2025 was lower with records from 4–6 (scale 1–9; 1 – no fruits, 9 – extremely high). Fruit size in the year 2023 thus was lower in comparison with years 2024 and 2025.

Table 5: Effect of Weigi rootstocks on fruit size and comparison to G5.

Cultivar	Root-stock	2023		2024		2025	
		Size (mm)	Relative to G5 (in %)	Size (mm)	Relative to G5 (in %)	Size (mm)	Relative to G5 (in %)
Burlat	G5	22.9 c	100	22.0 bc	100	27.3 ab	100
	W2	22.3 bc	97.4	23.5 cd	97.4	27.2 a	99.6
	W3	20.2 a	88.2	NA	NA	NA	NA
Early Korvik	G5	22.0 bc	100	26.6 efg	100	28.7 c	100
	W2	21.0 ab	95.5	25.4 defg	97.4	29.1 cde	101.4
	W3	23.3 cd	105.9	25.8 defg	101.6	27.6 ab	96,2
Jacinta	W1	NA	NA	24.9 def	NA	28.5 bcd	NA
	W2	NA	NA	26.1 eg	NA	29.2 cde	NA
Justyna	G5	26.2 g	100	NA	NA	30.8 gh	100
	W1	26.4 fg	100.8	25.0 defg	NA	31.5 gh	102.3
	W2	24.3 de	92.7	NA	NA	30.7 gh	99.7
	W3	25.7 fg	98.1	NA	NA	30.7 fgh	99.7
Kasandra	G5	22.5 bc	100	19.7 a	100	26.9 a	100
	W2	20.3 a	90,2	23.7 cd	97.4	27.1 a	100.7
	W3	21.9 abc	97,3	21.6 b	91.3	27.3 ab	101.5
Kordia	G5	25.4 efg	100	26.5 eg	100	29.7 def	100
	W2	24.1 d	94,9	26.7 eg	97.4	29.8 ef	100.4
	W3	24.8 def	97,6	27.0 g	101.1	28.2 bc	94.9
Tamara	G5	26.7 g	100	31.3 h	100	30.7 fgh	100
	W1	26.5 g	99,3	31.0 h	97.4	30.3 fg	98.7
	W2	25.7 fg	96,3	32.1 h	103.5	31.3 h	102.0

Legend: NA = not available; different letters in rows indicate a statistically significant difference ($\alpha=0.05$)

Soluble solids content (SSC)

Rootstock effects on SSC were less pronounced than on growth or fruit size and firmness. Mean SSC values across cultivars remained close to those of G5 for all Weigi® rootstocks and year-to-year climatic variation had a stronger influence than rootstock type. W2 most frequently maintained or slightly increased SSC relative to G5 whereas W3 showed a tendency toward slightly lower SSC in some evaluated years (Table 6).

Table 6: Effect of Weigi rootstocks on fruit SSC.

Cultivar	Root-stock	2023		2024		2025	
		SSC (°Brix)	Relative to G5 (in %)	SSC (°Brix)	Relative to G5 (in %)	SSC (°Brix)	Relative to G5 (in %)
Burlat	G5	18.5 f	100	13.1 a	100	16.4 cd	100
	W2	18.4 f	99.5	14.2 ab	109.2	17.2 def	104.9
	W3	18.8 f	101.6	NA	NA	NA	NA
Early Korvik	G5	15.5 abc	100	18.5 def	100	20.2 j	100
	W2	14.6 ab	93.5	15.6 abcd	97.4	19.7 ij	97.5
	W3	14.7 ab	94.8	17.4 cde	105.5	18.1 defghi	89.6
Jacinta	W1	NA	NA	14.5 ab	NA	14.9 bc	NA
	W2	NA	NA	13.3 bc	NA	13.7 ab	NA
Justyna	G5	17.2 de	100	NA	NA	18.5 fghij	100
	W1	17.7 def	102.9	19.3 def	NA	18.0 defghi	97.3
	W2	15.8 bc	91.9	NA	NA	18.3 ghij	98.9
	W3	16.0 bc	93	NA	NA	19.1 fghij	103.2
Kasandra	G5	16.4 cd	100	13.6 ab	100	12.7 a	100
	W2	15,2 abc	92.7	14.6 ab	107.4	14.6 b	114
	W3	16,2 bcd	98.8	13.1 a	89.7	13.6 ab	107.1
Kordia	G5	18.2 ef	100	20.0 ef	100	17.3 defg	100
	W2	18.5 f	101.6	21.1 f	105.5	18.0 efgh	104
	W3	18.8 f	103.3	18.8 de	89.1	16.8 cde	97.1
Tamara	G5	14.4 ab	100	19.6 ef	100	19.1 fghij	100
	W1	15 ab	104.2	19.0 e	96.9	18.5 fghij	96.9
	W2	14.5 a	100.7	20.4 ef	107.4	19.1 hij	100

Legend: NA = not available; different letters in rows indicate a statistically significant difference ($\alpha=0.05$)

Fruit firmness

Firmness was the fruit quality trait most clearly affected by the rootstock. Across cultivars, both W1 and W2 consistently produced firmer fruit than G5 indicating a positive and stable rootstock effect on this parameter. In contrast W3 showed a more variable response and in several cases resulted in slightly reduced firmness compared with the control G5 (Table 7). W2 combined moderate vigor control with equal or improved firmness making it the most balanced rootstock with respect to vegetative growth and fruit quality.

Table 7: Effect of Weigi rootstocks on fruit firmness.

Cultivar	Rootstock	2023		2024	
		Firmness (Brix)	Relative to G5 (in %)	Firmness (Brix)	Relative to G5 (in %)
Burlat	G5	30.0 a	100	32.4 b	100
	W2	31.7 ab	105.7	32.0 b	98.8
	W3	29.4 ab	98	NA	NA
Early Korvik	G5	45.9 c	100	54.6 efg	100
	W2	51.7 cde	112.6	51.4 ef	94.1
	W3	51.8 cde	112.9	46.8 de	91.1
Jacinta	W1	NA	NA	34.9 bc	NA
	W2	NA	NA	31.3 b	NA
Justyna	G5	51.8 de	100	NA	100
	W1	53.5 de	103.3	60.2 fgh	NA
	W2	55.4 e	106.9	NA	NA
	W3	54.7 de	105.6	NA	NA
Kasandra	G5	35.2 b	100	39.1 cd	100
	W2	35.6 b	101.1	31.0 b	79.3
	W3	30.1 ab	85.5	23.8 a	76.8
Kordia	G5	49.3 cd	100	62.6 gh	100
	W2	51.4 de	103.6	63.3 gh	101.6
	W3	53.1 de	107.1	62.1 gh	97.6
Tamara	G5	55.2 de	100	64.1 h	100
	W1	51.8 de	93.8	67.0 h	104.5
	W2	52.0 de	94.2	67.6 h	105.5

Legend: NA = not available; different letters in rows indicate a statistically significant difference ($\alpha=0.05$)

Discussion

Weigi® 3 showed the strongest vegetative vigour while Weigi® 2 consistently limited tree growth to a level comparable with or slightly below Gisela 5. Weigi® 1 exhibited intermediate vigour generally slightly stronger than Gisela 5. Higher vigour as induced by Weigi® 3 can be advantageous in organic and low-input systems because it supports tree vitality, root development and tolerance to drought and soil nutrient limitations. Moderate and balanced vigour level such as that provided mainly by Weigi® 2 and partly by Weigi® 1 appears most desirable for sustainable orchard management as excessive growth may increase pruning demands. Large and firm cherries are preferred by consumers due to better appearance and texture which is particularly important in organic production. Weigi® 1 and especially Weigi® 2 frequently maintained or improved fruit size and firmness compared with Gisela 5 indicating a favourable balance between growth and fruit quality. This combination fits well with the requirements of organic cherry production and with current consumer and market expectations for high fruit size, fruit firm and attractive appearance. Results confirm earlier studies demonstrating the strong influence of the rootstock genotype on scion growth and adaptation (Akçay et al., 2008; Pal et al., 2017). An important practical aspect is also the suitability of Weigi® rootstocks for replanting sweet cherry orchards on the same site that is particularly relevant in intensive systems with rain covers where long-term use of the supporting constructions are expected and repeated orchard establishment on the same plots is likely. Balanced tree vigor and high fruit quality therefore make Weigi® rootstocks a promising choice for modern and sustainable cherry growing systems including organic production. Continued evaluation under full cropping conditions will be essential to determine long-term effects Weigi® rootstocks on yield efficiency and fruit quality especially in bad growing conditions as long period of drought or high temperature as well suitability for replanting.

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