Testing of Early Ripening Strawberry Cultivars Tolerant to Soil-Borne Pathogens as Alternative to 'Elsanta'

Andreas SPORNBERGER [1(✉)]
Robert STEFFEK [2]
Josef ALTENBURGER [2]

Summary

Soil-borne pathogens, above all *Verticillium* sp., cause plant loss and yield decrease in many Austrian strawberry regions. As part of a research project 13 cultivars were planted in 2005 at 11 sites on nine farms in five different Austrian regions. The aim was to test early ripening *Verticillium* tolerant cultivars which are winter hardy, with high yield and good fruit characteristics as alternative to the highly susceptible cultivar 'Elsanta'.

Although in 2005 climatic conditions where not favorable for wilt development, 'Elsanta', 'Sonata', 'Dora', 'Eva' and 'Divine' showed typical symptoms on several sites. 'Darselect', 'Clery' and 'Queen Elisa' were less susceptible than 'Elsanta'. No indication of wilt on the several sites was observed on 'Alba' (except at one site), 'Alice', 'Daroyal', 'Record' and 'Salsa'. The results of yield and fruit quality have to be interpreted carefully, because they were obtained only at one site in the year of planting. 'Alba', 'Clery' and 'Daroyal' started ripening two days before 'Elsanta'; 'Queen Elisa' and 'Dora' at the same day as 'Elsanta' and all other cultivars started later. High yield per m^2 had 'Elsanta', 'Salsa', 'Record' and 'Sonata'. High average fruit weight showed 'Salsa', 'Record' and 'Darselect', while 'Divine', 'Clery' and 'Queen Elisa' had rather small fruits. Some new cultivars (e.g. 'Eva', 'Queen Elisa', 'Alba' and 'Record') had a much higher fruit firmness in comparison to 'Elsanta'; nevertheless this was not favourable in the tasting experiment. Further examinations are planned in future.

Key words

strawberry, cultivar, *Verticillium dahliae*, wilt

[1] University of Natural Resources and Applied Life Sciences, Vienna, Department of Applied Plant Sciences and Plant Biotechnology, Institute of Horticulture and Viticulture, A-1180 Vienna, Gregor Mendel Straße 33, Austria
✉ e-mail: andreas.spornberger@boku.ac.at
[2] Agency for Health and Food Safety, Institute for Plant Health, Department Fruit Production and Viticulture, A-1226 Vienna, Spargelfeldstraße 191, Austria

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Introduction

Soil-borne pathogens, above all *Verticillium* sp. cause plant loss and yield decrease in many Austrian strawberry regions. 'Elsanta', the main cultivar in Austria, is highly susceptible to soil-borne pathogens, as well as to plant and fruit diseases (Barth *et al*. 2002, Spornberger *et al*. 2005). As part of a research project new strawberry cultivars were planted in 2005 with the aim to test early ripening cultivars, with tolerance to *Verticillium* and other diseases, winter hardy, with good yield and good fruit quality characteristics as alternative to 'Elsanta'.

Materials and methods

Cold stored frigo plants of 12 cultivars ('Alice', 'Alba', 'Clery', 'Daroyal', 'Darselect', 'Divine', 'Dora', 'Eva', 'Record', 'Queen Elisa', 'Salsa', 'Sonata') and 'Elsanta' as control were planted between 24th April and 21st June at 11 sites (Table 1.) on nine farms in five different regions of Eastern Austria (20-48 plants per each cultivar and site, 1-4 replications per site). The content of microsclerotia of *Verticillium dahliae* in the different soils was determined using the wet-sieving method described by Harris *et.al*., 1993. At each site growth vigorousness, and symptoms of plant diseases (or other symptoms like chlorosis) were estimated during the vegetation period with a rating schema ranging from 1 (very low) to 9 (very high). Symptoms of *Verticillium dahliae* were examined at different stages with a rating schema concerning the infestation strength: 1=healthy leaves, 2=outer leaves wilting, young leaves without symptoms; 3= young leaves stunted and 4=plant died.

At one site flower stalks were not removed and the total and marketable yield (g m^{-2}) and the average fruit weight were evaluated. The following fruit quality characteristics were analysed on 12 fruits of each cultivar immediately after harvest: fruit shape (fruit form index = fruit length /thickness x brightness); fruit colour (L* a* b* with Tristimulus colorimeter); fruit firmness (penetrometer M1000E Mecmesin); % Brix (refractometer Palette PR-101 Atago) and pH-value (WTW-pH-electrode). Tasting experiments were done immediately after harvest and after one week of storage (2°C) with a scale from 1 (very low) to 9 (very high). When possible, statistical analysis of data was made with SPSS 11.0 (Anova with post hoc S-N-K-test, $\alpha = 5\%$).

Table 1. Trial sites, previous culture and *Verticillium* content of soils (microsclerotia/g soil). On all sites the variety Elsanta was planted

Planting date	Site	Previous culture	Vertic. MS/g
25.April	NÖ 1-2	Cereals; never strawberries	0
25.April	W	Dahliae; never strawberries	6,8
27.April	NÖ 2	Strawberries	3,4
28.April	Bgld-1	Strawberries	0
28.April	Bgld-2-1	Strawberries	10,4
28.April	Bgld-2-2	Fallow, strawberries 4 years ago	6,6
28.Apr	Stmk	Summer wheat; strawberries 4 years ago	5,1
02.May	OÖ-1	Barley/mustard; strawberries 5 years ago	7,8
24.May	NÖ 1-1	Strawberries	1,4
09.June	NÖ 3	Potatoes; strawberries 5 years ago	1,7
21.June	NÖ 4	Onions; never strawberries	1,5

Results and discussion

Due to the content of microsclerotia of *Verticillium dahliae* in the soil, the predicted risk for wilt-symptoms in susceptible cultivars like 'Elsanta' was high at nine of 11 sites (Table 1).

A strong growth showed 'Clery', 'Darselect' and 'Salsa', while 'Eva', 'Alba', 'Elsanta' and 'Sonata' grew weak (Figure 1).

Although in 2005 climatic conditions where not favourable for wilt development, 'Elsanta', 'Sonata', 'Dora', 'Eva' and 'Divine' showed typical wilt symptoms on several sites. 'Darselect', 'Clery' and 'Queen Elisa' were less susceptible than 'Elsanta'. The cultivars 'Alba' (except at

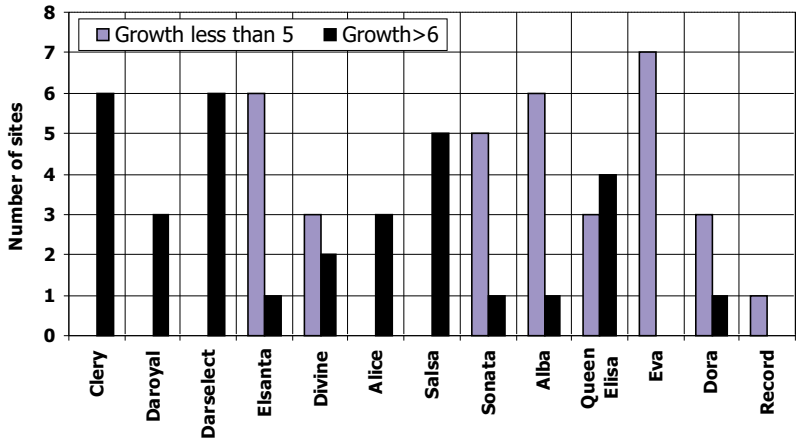

Figure 1.
Vigour of the different cultivars, evaluated at nine sites (red bars indicating the number of sites on which the cultivar grew vigorously (evaluated >6); blue bars indicating poor growth).

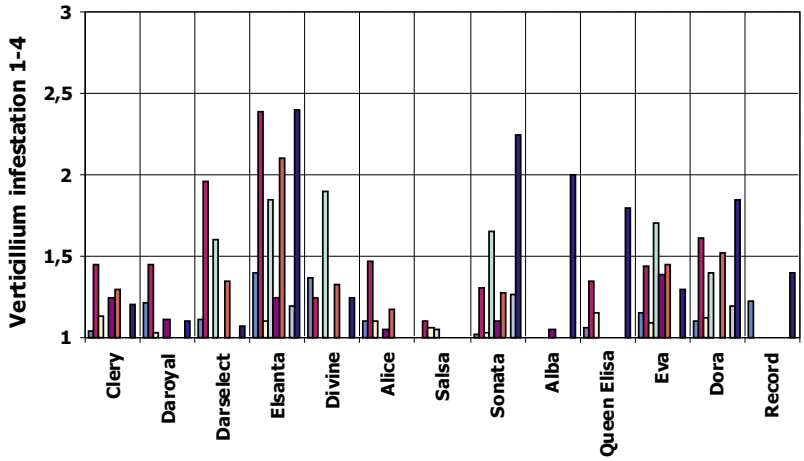

Figure 2.
Occurrence of soil-borne diseases at nine sites in 2005

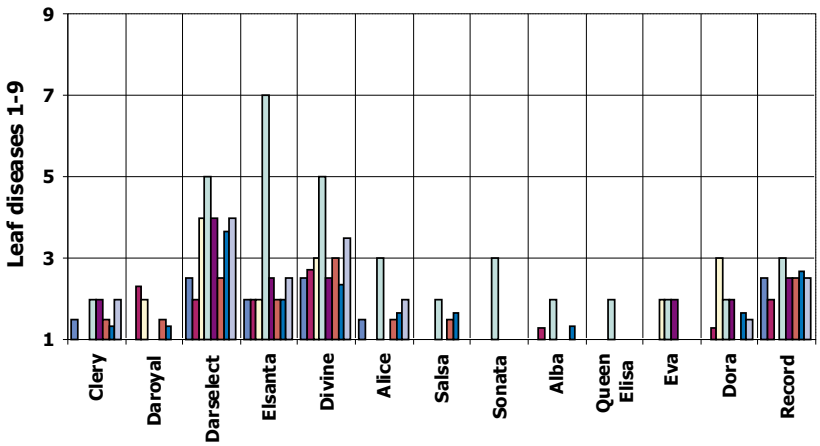

Figure 3.
Occurrence of leaf diseases (*Sphaerotheca macularis, Mycosphaerella fragariae, Diplocarpon earliana*) at nine sites in 2005

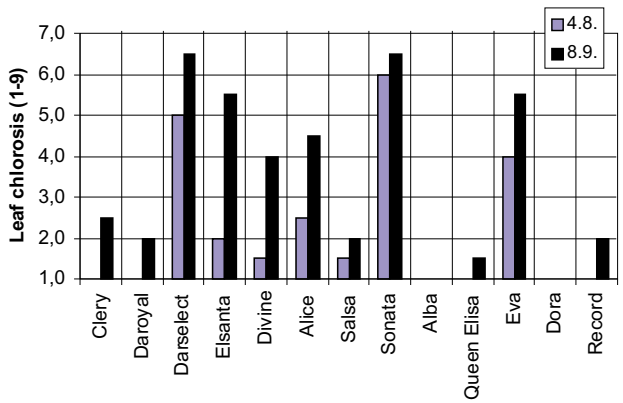

Figure 4.
Occurrence of leaf chlorosis at 1 site (evaluated two times: in August and September) in 2005

one site), 'Alice', 'Daroyal', 'Record' and 'Salsa' had no indication of wilt on the several sites (Figure 2).

A medium to high occurrence of leaf diseases (*Sphaerotheca macularis, Mycosphaerella fragariae, Diplocarpon earliana*) could be found in 'Elsanta', 'Darselect', 'Divine', 'Record' and 'Dora' (Figure 3).

At one site, during summer, chlorotic plants could be found in 'Darselect', 'Sonata', 'Eva' and 'Elsanta', while a few cultivars were with few or even no symptoms ('Alba', 'Dora', 'Queen Elisa', 'Daroyal', 'Salsa') (Figure 4).

The results concerning yield and fruit quality have to be interpreted carefully, because they were obtained only at one site in the year of planting. 'Alba', 'Clery' and 'Daroyal' started ripening two days before 'Elsanta'; 'Queen Elisa' and 'Dora' at the same time as 'Elsanta' while all other cultivars started ripening later. Highest yield per m^2 had 'Elsanta', 'Salsa', 'Record' and 'Sonata' (Table 2).

'Darselect' (97.9 %) and 'Elsanta' (96.4 %) had the highest percentage of marketable fruit, however only 'Dora' (80.7 %) was significantly worse because of a high amount of too small fruits (diameter < 18mm). High average fruit weight showed 'Salsa', 'Record' and 'Darselect'.

Table 2. Yield at site W in 2005 by dates (g m^{-2})

Cultivar	13.6.	15.6.	17.6.	20.6.	22.6.	24.6.	27.6.	30.6.	4.7.	8.7.	12.7.	15.7.	22.7.	Total
Alba	20 b*	55 c	44 ab	69 bcd	21 a	15 a	20 abcd	15 ab	8 ab	0 a	0 a	0 a	0 a	361 ab
Clery	38 c	36 b	70 ab	82 cd	36 a	27 a	43 bcde	20 ab	6 ab	2 a	1 a	0 a	0 a	192 abc
Daroyal	16 b	32 b	52 ab	33 b	9 a	7 a	8 a	23 ab	8 ab	4 a	0 a	0 a	0 a	503 a
Elsanta	0 a	19 ab	106 b	96 d	54 a	31 a	53 cde	65 cd	37 ab	23 ab	14 a	4 a	1 a	217 c
Queen Elisa	0 a	20 ab	35 a	36 b	17 a	18 a	30 abcd	31 abc	29 ab	6 a	3 a	0 a	2 a	319 a
Dora	0 a	5 a	75 ab	85 cd	27 a	31 a	46 bcde	33 abc	15 ab	2 a	0 a	0 a	0 a	197 abc
Darselect	0 a	0 a	57 ab	65 bcd	27 a	21 a	16 ab	8 a	2 a	1 a	0 a	0 a	0 a	249 a
Divine	0 a	0 a	47 ab	50 bc	22 a	29 a	18 abc	29 abc	27 ab	19 ab	7 a	0 a	1 a	272 ab
Eva	0 a	0 a	30 a	46 bc	29 a	19 a	51 cde	38 abc	31 ab	21 ab	3 a	2 a	2 a	440 ab
Sonata	0 a	0 a	36 a	65 bcd	46 a	37 a	73 e	71 d	50 b	30 ab	9 a	20 a	3 a	276 bc
Alice	0 a	0 a	4 a	53 bc	12 a	29 a	54 de	53 bcd	39 ab	31 ab	1 a	0 a	0 a	467 ab
Record	0 a	0 a	0 a	32 b	63 a	31 a	57 e	87 d	81 c	76 c	33 b	5 a	2 a	458 bc
Salsa	0 a	0 a	0 a	0 a	47 a	52 a	121 f	84 d	86 c	51 a	6 a	5 a	6 a	0 bc

**=Anova, significancy at 5 % level (S-N-K test)

Table 3. Characteristics of fruit quality 2005

Cultivar	Average fruit weight* (g/piece)	Marketable fruits (%)	Soluble dry substance (% Brix)	pH-value	Fruit firmnes (kg/cm^2)	Tasting quality (1=weak, 9=high)
Alba	9.1 ab**	85.2 ab	9.5 ab*	3.5 a	6.3 bc	3.9
Alice	10.5 ab	87.2 ab	10.8 bc	3.5 a	5.8 bc	4.8
Clery	8.0 a	92.6 ab	10.6 bc	3.9 cd	5.8 bc	6.2
Daroyal	9.6 ab	89.6 ab	9.4 ab	3.9 cd	4.9 ab	7.0
Darselect	7.8 b	97.9 b	10.6 bc	3.9 cd	5.4 ab	7.0
Divine	11.9 a	88.8 ab	10.1 abc	4.2 c	5.3 ab	5.5
Dora	10.3 ab	80.7 a	9.9 abc	3.7 abc	5.3 ab	5.5
Elsanta	10.8 ab	96.4 b	10.5 cd	3.9 cd	3.8 a	6.4
Eva	8.9 ab	89.4 ab	10.0 bcd	3.8 bcd	11.0 d	2.3
Queen Elisa	8.1 a	84.6 ab	11.1 abcd	3.7 abcd	7.3 c	3.3
Record	12.0 b	92.9 ab	9.1 ab	3.6 ab	6.2 bc	2.4
Salsa	15.1 c	90.0 ab	9.7 ab	3.6 ab	4.8 ab	8.7
Sonata	9.9 ab	93.1 ab	10.2 ab	3.6 ab	5.6 abc	5.0

*=mean of all harvested fruits at site W: **=Anova, significancy at 5 % level (S-N-K test)

Table 4. Fruit shape (fruit form index) and fruit colour (with Tristimulus L* a* b*)

Cultivar	Fruit shape (fruit form index) lenght:(brightness x thickness)	Tristimulus colorimeter		
		Glossiness - L*	Red partition - a*	Yellow partition - b*
Alba	1.65 f**	38.8 bcd	32.9 bc	19.5 b
Alice	0.89 a	39.3 bcd	34.5 cd	21.8 bcde
Clery	1.14 cd	38.5 abcd	36.9 e	22.0 cde
Daroyal	1.14 cd	34.3 ab	31.3 a	14.5 a
Darselect	1.10 c	36.7 abcd	34.5 cd	21.8 bcde
Divine	1.04 bc	37.0 abcd	34.1 bcd	21.5 bcd
Dora	1.22 d	39.1 bcd	33.3 bcd	21.0 bc
Elsanta	0.97 ab	42.0 d	35.0 d	23.8 de
Eva	1.36 e	40.6 cd	34.3 bcd	21.7 bcde
Queen Elisa	1.14 cd	40.8 cd	35.0 d	23.9 e
Record	1.04 bc	37.4 abcd	33.9 bcd	21.4 bc
Salsa	0.96 ab	33.4 a	32.4 ab	20.5 bc
Sonata	0.91 a	36.2 abc	34.3 bcd	21.7 bcde

**=Anova, significancy at 5 % level (S-N-K test)

Small average fruit weight values had 'Divine', 'Clery' and 'Queen Elisa' (Table 3).

Some new cultivars (e.g. 'Eva', 'Queen Elisa', 'Alba' and 'Record') showed a much higher fruit firmness in comparison to 'Elsanta'; nevertheless this was not favourable in the tasting experiment. A higher tasting quality in comparison to 'Elsanta' showed only 'Salsa', 'Daroyal', and 'Darselect'. High soluble dry substance over 10.5 % Brix, which was the value of 'Elsanta', were measured in fruits of 'Queen Elisa', 'Alice', 'Clery' and 'Darselect' (Table 3).

The fruit form index is a good indicator for fruit shape. Values higher than 1 indicate an oblong form; what was the case with the cultivars 'Alba' (1.65!), 'Eva' (1.36), 'Dora' (1.22), 'Clery', 'Daroyal', 'Queen Elisa' (all 1.14) and 'Darselect' (1.10). 'Alice' (0.89) and 'Sonata' (0.91) had an oblate form with a fruit form index clearly below 1; the other cultivars had values around 1, which are typical for a nearly round fruit shape. Concerning fruit colour values significant differences could be measured. The highest L* - value which is an indicator for high glossiness showed the reference cultivar 'Elsanta' (42.0); The L*-values were very low for 'Salsa' (33.4.) and 'Daroyal' (34.3). 'Elsanta' showed high values also in the red (a*) and yellow (b*) partitions; 'Queen Elisa', 'Clery', 'Alice' and 'Eva' had high values as well (Table 4).

Conclusions

After one year of observations first conclusions of the suitability of the tested cultivars under Eastern Austrian growing conditions can be made. Some of the tested cultivars ('Darselect', 'Clery', 'Queen Elisa') were less susceptible to *Verticillium* than 'Elsanta' and some of them ('Daroyal', 'Alba', 'Record') were so far even without symptoms. Concerning yield and fruit quality the cultivars 'Alice', 'Clery', 'Darselect', 'Record' and 'Salsa' showed promising characteristics, but the results have to be confirmed in the next years. Thus, further examinations of the cultivars are planned.

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