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## Results from a three year testing project of new strawberry cultivars in *Verticillium* infested soils and under organic farming conditions

A. Spornberger<sup>1</sup>, H. Weissinger<sup>1</sup>, R. Steffek<sup>2</sup>, J. Scheiblaue<sup>1</sup>,  
K. Jezik<sup>1</sup>, J. Altenburger<sup>2</sup>, K. Stich<sup>3</sup>

### Abstract

As part of a research project 13 cultivars were planted in 2005 at 11 sites on 9 farms in 5 different Austrian regions. The aim was to find new cultivars tolerant to soil-borne pathogens and leaf/fruit diseases, with high yield, winter hardness and good fruit quality, to serve as alternative to the highly susceptible cultivar 'Elsanta', regarding soil-borne diseases. Plant vigour and infestation with *Verticillium dahliae* and leaf diseases were evaluated in 2005 und 2006 at 7 sites and in 2007 at 3 sites.

In addition, following parameters were assessed on 2 organically managed sites in 2006 and 2007: marketable yield, percentage of different categories of unmarketable fruits and incidence of the blossom weevil. In 2006 fruit characteristics and consumer acceptance were studied.

'Elsanta' showed the highest infestation with *V. dahliae* whereas 'Salsa', 'Daroyal' and 'Alice' were most tolerant. 'Dora', 'Eva', 'Queen Elisa' and 'Daroyal' recorded significantly higher losses by the blossom weevil than 'Alice'. 'Alba' and 'Divine' were the earliest cultivars in ripening time. Highest marketable yield per plant had the late ripening cultivars, particularly 'Salsa' and 'Sonata'. Of all early ripening cultivars tested, 'Elsanta' showed the highest productivity, followed by 'Alba', 'Darselect', 'Daroyal' and 'Eva'. Regarding fruit firmness, content of ascorbic acid, shelf life and appearance, 'Alba', 'Clery', 'Eva' and 'Queen Elisa' were most convincing. The best tasting cultivars were 'Clery', 'Daroyal' and 'Divine'.

Summing up all the results, 'Alba', 'Alice' and 'Salsa' can be recommended for organic production, whereas 'Clery', 'Daroyal', 'Darselect', 'Elsanta', 'Eva', 'Queen Elisa' and 'Sonata' are classified as suitable for only a limited extent. 'Elsanta', 'Divine', 'Dora' and 'Sonata' are particularly unsuitable for growing in *Verticillium* infested soils. 'Divine', 'Dora', and 'Record' cannot be recommended for organic production at all.

**Keywords:** strawberry, cultivar, *Verticillium dahliae*, wilt, fruit quality

### Introduction

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

<sup>1</sup>Institute of Horticulture and Viticulture, Department of Applied Plant Sciences and Plant Biotechnology, University of Natural Resources and Applied Life Sciences, Austria - 1180 Vienna, andreas.spornberger@boku.ac.at

<sup>2</sup>Institute for Plant Health, Department Fruit Production and Viticulture, Agency for Health and Food Safety, Austria - 1226 Vienna

<sup>3</sup>Institute of Chemical Engineering, Faculty of Technical Chemistry, Vienna University of Technology, Austria - 1040 Vienna

## Material and Methods

Cold stored plants of 12 cultivars ('Alice', 'Alba', 'Clery', 'Daroyal', 'Darselect', 'Divine', 'Dora', 'Eva', 'Record', 'Queen Elisa', 'Salsa', 'Sonata') and 'Elsanta' as control were planted in April-June 2005 at 11 sites on 9 farms in 5 different regions of Eastern Austria (20-48 plants each cultivar and site, 1-4 replications per site). The content of microsclerotia of *V. dahliae* in the different soils was determined using the wet-sieving method described by Harris et al. (1993). Vegetative parameters were evaluated during the vegetation period at 7 sites in 2005 and 2006 and at 3 sites in 2007. Plant vigour, occurrence of leaf spot diseases (*Mycosphaerella fragariae*, *Diplocarpon earliana*), leaf mildew (*Sphaerotheca macularis*) and chlorosis were estimated with a rating schema ranging from 1 (very low) to 9 (very high). Symptoms of *V. dahliae* were examined with a rating schema concerning the infestation strength: 1=healthy leaves, 2=outer leaves wilting, young leaves without symptoms, 3= young leaves stunted, 4=plant died.

In 2006 and 2007, at 2 sites in the North East of Vienna, where plants were organically grown, incidence of the blossom weevil (*Anthonomus rubi*) was assessed and fruits were harvested. Marketable yield and average fruit weight were determined. Unmarketable fruits were divided according to the cause of damage.

In 2006 fruit characteristics and consumer acceptance were studied. Following fruit quality parameters were analysed on 10-15 fruits of each cultivar immediately after yield and after 3, 7 and 10 days while storing at 2°C: weight, fruit colour (L\* a\* b\*: chromameter, CR-200b, Minolta), fruit firmness (penetrometer, M1000E, Mecmesin), % Brix (refractometer Palette PR-101 Atago), content of ascorbic acid (reflektometer, RQflex, Merck), titratable acid (TitroLine alpha plus, Schott) and electrochemical parameters (pH, electric conductivity, redox potential, P-value: BE-T-A MT-732, Med-Tronik). Tasting experiments were done immediately after harvest with whole fruits and after storing 3 months in the freezer with pureed fruits. About 50 participants per session rated appearance, taste and fruit flesh firmness either on the basis of an open scale from 0 (very bad) to 20 (very good) or they had the choice between 5 categories (1=very bad, 2=bad, 3=medium, 4=good, 5=very good). 4 sessions were done with fresh fruits, 2 sessions were carried out with puree.

Statistical analysis of data was made with SPSS 12.0 (Variance analysis with post hoc S-N-K-test,  $\alpha = 5\%$ ).

## Results and discussion

'Salsa' had hardly any symptoms of *Verticillium* wilt at any site, followed by 'Daroyal' showing very few symptoms. 'Alice', 'Record' and 'Queen Elisa' were significantly less affected than 'Divine', 'Sonata' and 'Elsanta' and can be regarded as relatively tolerant to *V. dahliae*. 'Elsanta' was at significance the most susceptible cultivar (figure 1).

'Salsa' was the most productive cultivar, followed by 'Sonata', 'Record' and 'Alice'. Among the early ripening cultivars, 'Elsanta' had the highest yield. Yield of 'Divine', 'Dora', 'Queen Elisa' and 'Clery' was very low (figure 2).

In general, late-ripening cultivars had a higher productivity than early-ripening cultivars. 'Alba' and 'Divine' were the earliest cultivars in ripening time. 'Clery', 'Daroyal', 'Queen Elisa', 'Darselect', 'Dora' and 'Eva' started with the first picking nearly the same time as 'Elsanta', all other cultivars started later.

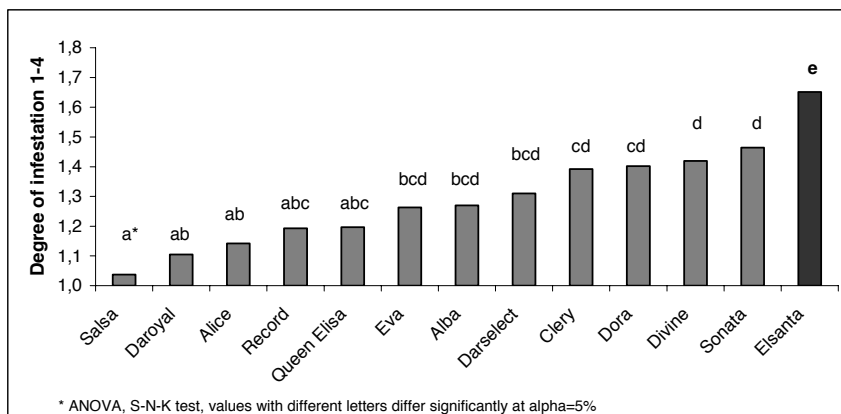
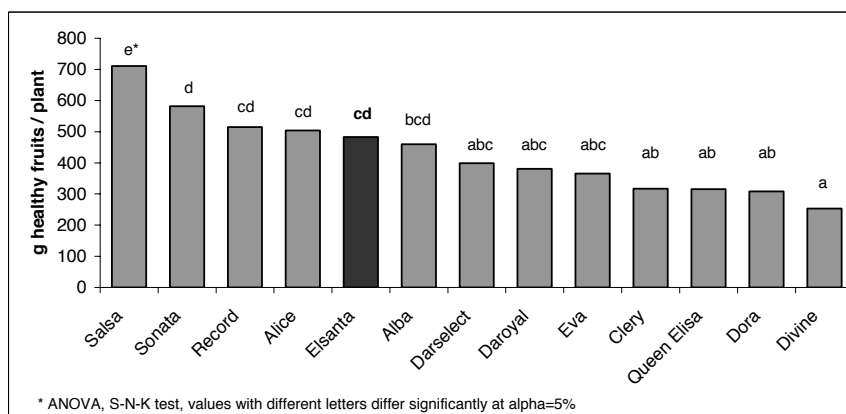
Figure 1: Infestation with *V. dahliae* (means of 2005-2007 at 7 sites)

Figure 2: Yield of healthy fruits per plant (means of 2006 and 2007 at 2 sites)

Feeding damage, infestation with *Botrytis cinerea* and gummy fruits were the primary reasons for unmarketable fruits (figure 3). There were significant differences among the cultivars in all 3 parameters (data only shown for *Botrytis* infested fruits).

The greatest losses due to unmarketable fruits showed 'Record' and 'Queen Elisa' what can be ascribed to high susceptibility to *B. cinerea*. 'Darselect' had a high percentage of marketable fruits, as well as 'Elsanta', according to low infestation with *B. cinerea*. 'Salsa' and 'Divine' proved to be fairly resistant to grey mould. Many gummy fruits (fruits that couldn't ripe properly because of water stress and therefore had a gummy texture and bad taste) were harvested from 'Salsa', 'Alice', 'Elsanta', 'Sonata', 'Eva' and 'Divine'. In comparison, 'Alba' and 'Daroyal' produced very few gummy fruits.

In the end of the harvest period, especially in the second year, an increasing number of fruits with diameter < 18 mm were harvested. 'Daroyal', 'Divine' and 'Clery' produced many fruits too small for marketing.

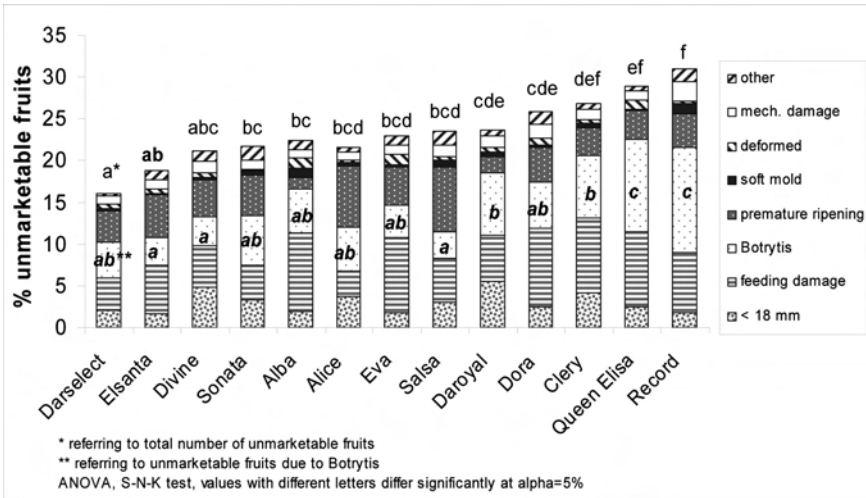


Figure 3: Percentage and components of unmarketable fruits (means of 2006 and 2007 at 2 sites)

A significantly higher average fruit weight than ‘Elsanta’ showed ‘Record’, ‘Alba’, ‘Queen Elisa’ and ‘Dora’. ‘Divine’, ‘Darselect’ and ‘Clery’ had rather small fruits (figure 4).

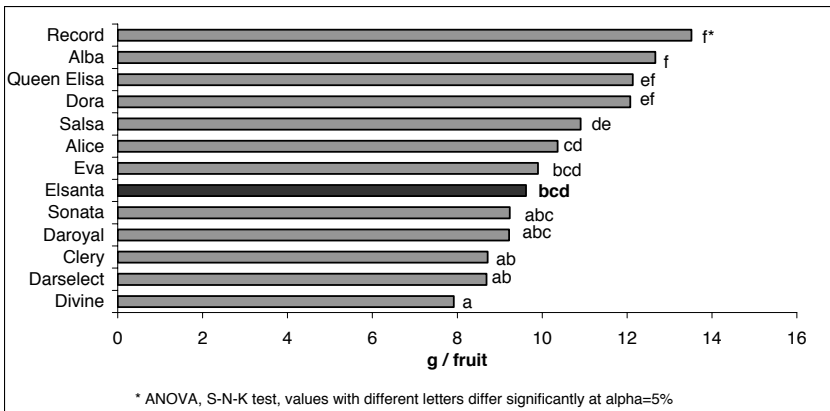


Figure 4: Average fruit weight (g) (means of 2006 and 2007 at 2 sites)

Some new cultivars (e.g. ‘Eva’, ‘Queen Elisa’ and ‘Clery’) showed a much higher fruit firmness compared to ‘Elsanta’. ‘Eva’, ‘Alba’, ‘Elsanta’ and ‘Queen Elisa’ had high contents of ascorbic acid (table 1).

At tasting sessions fruits of ‘Alba’ were appreciated most regarding their appearance. Participants liked the taste of fruits of ‘Clery’, ‘Daroyal’ and ‘Divine’ best. Medium red purees as from ‘Dora’, ‘Clery’, ‘Divine’ and ‘Alba’ and dark red ones as from ‘Daroyal’ were preferred to light red purees as from ‘Queen Elisa’ and ‘Record’. The tastiest purees came from fruits of ‘Daroyal’, ‘Darselect’ and ‘Alba’ (table 2).

Table 1: Fruit firmness, Brix, content of ascorbic acid and titratable acid during 10 days while storing at 2°C (means of 4 analyses of fruits from 'Jedlersdorf' and 'Strebersdorf', 2006)

Cultivar	Fruit firmness		Brix		Ascorbic acid		Titratable acid	
	kg/cm <sup>2</sup>	*	%	*	mg/l	*	g citric acid/l	*
Alba	1,05	bc	8,77	b	609,71	b	13,05	e
Alice	1,03	bc	8,79	b	534,11	b	12,03	de
Clery	1,21	d	9,83	cd	557,62	b	10,69	bcd
Daroyal	0,87	a	9,11	b	355,26	a	9,58	bc
Darselect	1,12	cd	9,68	c	550,00	b	11,35	cd
Divine	1,05	bc	9,82	cd	525,71	b	7,59	a
Dora	1,15	cd	9,79	cd	350,27	a	10,92	bcd
<b>Elsanta</b>	<b>0,85</b>	<b>a</b>	<b>9,90</b>	<b>cd</b>	<b>607,26</b>	<b>b</b>	<b>10,13</b>	<b>bcd</b>
Eva	1,90	f	9,11	b	741,58	c	9,53	bc
Queen Elisa	1,62	e	10,21	d	593,50	b	10,87	bcd
Record	0,83	a	8,30	a	509,00	b	10,46	bcd
Salsa	0,91	ab	8,09	a	387,78	a	8,93	b
Sonata	1,05	bc	9,19	b	334,67	a	9,57	bc

\* ANOVA, S-N-K test, values with different letters differ significantly at alpha=5%

Table 2: Appearance and taste of fresh fruits and puree (means of 4, respective 2 tasting sessions à ~50 participants with fruits from 'Jedlersdorf' and 'Strebersdorf', 2006)

Cultivar	Appearance of fresh fruits		Taste of fresh fruits		Appearance of puree		Taste of puree	
	**	*	**	*	***	*	**	*
Alba	15,38	d	11,52	abc	3,89	de	12,11	def
Alice	12,49	bc	10,70	ab	3,55	bcd	9,48	abc
Clery	14,44	cd	13,87	c	3,95	de	10,15	abcd
Daroyal	14,48	cd	13,79	c	3,98	de	13,61	f
Darselect	12,64	bc	13,14	bc	3,34	abc	12,87	ef
Divine	13,23	bc	13,69	c	3,91	de	11,00	bcde
Dora	12,11	b	11,34	bc	4,18	e	9,30	ab
<b>Elsanta</b>	<b>10,15</b>	<b>a</b>	<b>12,16</b>	<b>abc</b>	<b>3,12</b>	<b>ab</b>	<b>11,89</b>	<b>cdef</b>
Eva	13,13	bc	10,65	ab	3,80	cde	9,51	abc
Queen Elisa	14,51	cd	12,28	abc	3,29	ab	10,92	bcde
Record	11,91	b	10,97	ab	3,00	a	9,85	abcd
Salsa	11,39	ab	10,09	a	3,52	bcd	10,65	bcde
Sonata	13,57	bcd	12,49	abc	3,83	cde	8,00	a

\* ANOVA, S-N-K test, values with different letters differ significantly at alpha=5%

\*\* 0 = very bad, 20 = very good (open scale)

\*\*\* 1 = very bad, 2 = bad, 3 = medium, 4 = good, 5 = very good

## Conclusion

'Alba', 'Alice' and 'Salsa' can be recommended for organic production, whereas 'Clery', 'Daroyal', 'Darselect', 'Elsanta', 'Eva', 'Queen Elisa' and 'Sonata' are classified as suitable for only a limited extent. 'Elsanta', 'Divine', 'Dora' and 'Sonata' are particularly unsuitable for growing in *Verticillium* infested soils. 'Divine', 'Dora', and 'Record' cannot be recommended for organic production at all.

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