Gartenbauwissenschaft, **65** (5). S. 213–217, 2000, ISSN 0016–478X. © Verlag Eugen Ulmer GmbH & Co., Stuttgart

Strawberry Cultivars for organic production

Erdbeer-Sorten für den Ökologischen Anbau

Holger Daugaard and Hanne Lindhard
Danish Institute of Agricultural Sciences, Dept. of Horticulture, DK-5792 Aarslev, Denmark.

Summary

In a trial 20 cultivars were evaluated under the condition of Aarslev for their suitability in organic production. Several characters were evaluated in a 3 year period including total yield, marketable yield, berry size and susceptibility to various diseases such as grey mould (*Botrytis cinerea*), mildew (*Sphaerotheca alchemillae*) and leaf spot diseases (*Ramularia grevilleana* and *Marssonia fragariae*). Some cultivars like 'Polka', 'Korona' and 'Dania' appeared to be susceptible to *Botrytis* and are not considered well adapted to organic production. 'Tenira' and 'Rafzusen', which previously have been claimed to be suitable, yielded too low or were susceptible to diseases. Among all cultivars, 'Honeoye' had the lowest susceptibility to *Botrytis* and is considered a good early ripening cultivar for organic production. During mid-season, 'Kent' and 'Cortina' yielded well, although they were moderately susceptible to *Botrytis*. In late season, 'Symphony' and 'Pandora' gave high yields, although they both appeared to be susceptible to leaf spot diseases.

Zusammenfassung

In einem Versuch wurden 20 Erdbeer-Sorten unter den Bedingungen von Aarslev auf ihre Eignung in der ökologischen Produktion geprüft. Während 3 Jahren wurden folgende Parameter untersucht: Gesamtertrag, vermarktungsfähiger Ertrag, Beerengröße und Krankheitsanfälligkeit gegenüber Grauschimmel (*Botrytis cinerea*), Mehltau (*Sphaerotheca alchemillae*) und Blattfleckenkrankheiten (*Ramularia grevilleana* und *Marssonia fragariae*). Einige der Sorten mit den höchsten Erträgen – 'Polka', 'Korona' und 'Dania', waren gegen Grauschimmel empfindlich und sind für den ökologischen Anbau nicht geeignet. Dasselbe ist für 'Tenira' und 'Rafzusen' zutreffend, die vorher empfohlen worden sind. Unter allen Sorten wies 'Honeoye' die niedrigste Anfälligkeit gegenüber *Botrytis* auf und gilt als eine gute, frühreifende Sorte für den ökologischen Anbau. Die Erträge von 'Kent' und 'Cortina' waren gut, obgleich sie gegen *Botrytis* mässig empfindlich waren. Die spätreifenden Sorten 'Symphony' und 'Pandora' gaben hohe Erträge, obgleich sie beide gegen Blattfleckenkrankheiten empfindlich waren.

Introduction

An increasing number of consumers demand agricultural products grown without the use of synthetic pesticides. As a result of that, several governments make efforts to encourage farmers' transition to so-called ecological, or organic farming. Through a number of scientific programmes attempts are being made to solve the problems of organic management. Through several decades pesticide spraying has been synonymous with conventional management, serving as a kind of insurance against losses due to various pests, diseases and weeds. Scientists working on alternative ways of controlling these factors are faced with the challenge of finding methods with less or no use of synthetic pesticides. Among cultivars, there are clear differences in susceptibility to diseases and pests. This has been a well-known fact for many years, but has been of less importance due to the availability of efficient pesticides. In organic production, however, the choice of cultivar is considered even more important than in conventional production.

Previously, cultivar trials generally were carried out using standard insect and disease control agents, but this is changing in several countries. Nowadays, cultivar trials are frequently carried out without the use of synthetic fungicides at all or at least containing unsprayed plots. A new term, 'robustness', has been introduced in some countries and is used to describe 'less susceptible' cultivars (NEUWEILER, 1997a). Furthermore, growing public interest in organic farming has caused the establishment of several organically grown cultivar trials (GRAF and HÄSELI, 1991; RÖSER, 1992; NEUWEILER, 1997a; 1997b).

The majority of European strawberry growers cultivate 'Elsanta', but this cultivar is generally not suitable for organic production. 'Elsanta' is susceptible to mildew (*Sphaerotheca alchemillae*) (THUESEN, 1984; VANG-PETERSEN, 1998), verticillium wilt (*Verticillium albo-atrum*) and red core (*Phytophtora fragariae*) (WASSENAAR et al., 1982) and prone to winter frost damage (DAUGAARD, 1998). Moreover, 'Elsanta' is often without any taste, if it is harvested before ripening because of its bright and glossy appearance. To find cultivars better adapted to organic conditions, a trial was conducted in which 20 cultivars were compared during 3 years.

Materials and methods

The cultivars were planted in the field in August 1996 on flat beds without plastic cover. Country of origin and year of introduction is listed in Table 1. The selection of cultivars was based primarily on previous results

Table 1. Country of origin and year of introduction for 20 strawberry cultivars.
Ursprungsland und Einführungsjahr von 20 Erdbeersorten.

Cultivar Sorte	Country of origin Ursprungsland	Year of introduction Einführungsjahr
Cesena	Italy	1982
Cortina	Italy	1992
Dania	Denmark	1982
Elsanta	The Netherlands	1975
Eros	England	1990
Hapil	Belgium	1978
Honeoye	USA	1979
Kent	Canada	1981
Korona	The Netherlands	1978
Onebor	Italy	1990
Pandora	England	1988
Pegasus	England	1990
Polka	The Netherlands	1987
Rafzusen	Switzerland	1991
Sella	Italy	1992
Senga Sengana	Germany	1952
Symphony	Scotland	1994
Thuriga	Switzerland	1993
Tenira	The Netherlands	1973
Zefyr	Denmark	1965

from other trials as well as practical experiences. In addition to this, a number of important cultivars used in conventional production were included ('Elsanta', 'Honeoye', 'Korona' and 'Dania'). All plants were propagated and grown at the Institute of Aarslev and were planted as rooted runner plants. Each plot consisted of 10 plants spaced 0.33 m apart and with 0.9 m between rows. There were 9 replications. Before planting, 40 tonnes of farm manure per hectare was added to the soil and the nutritional status was controlled using leaf analyses each year in July. Leaf analyses were carried out with samples consisting of 100 representative leaflets from the central part of fully developed leaves. Based on analysis results no further fertilisers were given during the trial. At the Institute of Aarslev there is a loamy soil type.

The soil between the rows was kept clean mechanically, and plants were kept unsprayed during the trial. The mechanical weed control included the use of finger harrowing during early spring, rotary cultivator 2–3 times per year and supplementary hand hoeing in the rows. All runners were removed leaving the original plants as separate plants. After flowering, 6 tonnes of cut wheat straw per hectare was placed between rows, and after harvest it was cultivated into the soil. The plants were not covered with agryl or other material during the winter period in order to assess the winter hardiness of cultivars. Following the first winter 1996/97, recordings of winter hardiness were made, and the results are previously published (DAUGAARD, 1998).

At harvest, twice a week, yield, berry size (average of 25 berries) and the amount of misshapen and rotten berries were assessed at each picking time. Berries less than 22 mm, or infested with mildew or grey mould or misshapen were considered not marketable. The amount of total berry production infested with *Botrytis* was recorded, and the plants were rated for susceptibility to mildew and leaf spot diseases after harvest, using a 9-point scale (0–9, 9 most severe attacks).

All data were subject to statistical analysis using the General Model of SAS (SAS Institute, Inc., 1989–95, Cary, NC). The least significant differences between means were determined at $P \leq 0.05$ using Fisher's LSD.

Results and discussion

Climate and harvest period

The Institute of Aarslev is situated at 10° 30' altitude and 55° 20' northern latitude in the temperate climatic zone of northern Europe with relatively mild winter temperatures and cool summer temperatures. In table 2, monthly climatic records for the research station are compared to a 30-year average. During all three years the precipitation during the growth season was above average, which may be of importance when disease attacks are considered. Furthermore, mean temperatures during July 1997 and 1999 were higher than normal, whereas they were lower than normal in 1998. The relatively favourable weather conditions combined with the loamy soil of Aarslev may at least partly explain the good yield results of the trial.

Harvest period was expressed as the total period during which each cultivar was picked (Table 3). 'Elsanta', 'Honeoye', 'Cortina' and 'Kent' were the earliest ripening cultivars whereas 'Symphony', 'Dania' and 'Pandora' were the latest ripening cultivars. The duration of harvest period per cultivar was generally between 14 and 25 days.

Marketable yield

Marketable yield records are given in table 4. The cultivars gave only a small yield in 1997 as they had been

Table 2. Monthly climatic records for Aarslev in 1997, 1998 and 1999 compared to a 30-year average.
Klimatische Aufzeichnungen für Aarslev in den Jahren 1997, 1998 und 1999 verglichen mit einem 30-Jahresdurchschnitt.

Month Monat	Mean temperature, °C Durchschnittstemperatur, °C				Precipitation, mm Niederschlag, mm			
	1997	1998	1999	Average 1961–90	1997	1998	1999	Average 1961–90
May	10.2	11.8	11.3	11.3	64	38	43	46
June	15.0	14.5	13.5	14.7	35	75	102	53
July	17.4	14.6	17.4	16.6	95	76	47	61
Average Durchschnitt	14.2	13.6	14.1	14.2	65	63	64	53

Table 3. Harvest period 1998 and 1999.
Ernteperiode 1998 und 1999.

Cultivar	1998	1999		
Sorte	Harvest period	No. Days	Harvest period	No. Days
	Ernte-periode	Anzahl Erntetage	Ernte-periode	Anzahl Erntetage
Cortina	17.6–8.7	21	21.6–9.7	18
Elsanta	17.6–8.7	21	14.6–9.7	25
Honeoye	17.6–8.7	21	21.6–9.7	18
Kent	17.6–8.7	21	21.6–9.7	18
Tenira	22.6–8.7	16	25.6–9.7	14
Zefyr	22,6–8.7	16	21.6–9.7	18
Hapil	22.6–8.7	16	21.6–12.7	21
Korona	22.6–16.7	24	21.6–9.7	18
Onebor	22.6–15.7	23	21.6–9.7	18
Polka	22.6–16.7	24	21.6–9.7	18
Sella	22.6–16.7	24	21.6–12.7	21
Cesena	29.6–15.7	16	25.6–16.7	21
Rafzusen	29.6–16.7	17	2.7–16.7	14
Thuriga	29.6–16.7	17	2.7–16/7	14
Symphony	29.6–16.7	17	29.6–20/7	21
Eros	29.6–16.7	17	25.6–12.7	17
Senga Sengana	29.6–22.7	23	29.6–16/7	17
Dania	29.6–3.8	35	5.7–23/7	18
Pegasus	8.7–16.7	8	21.6–16/7	25
Pandora	8.7–3.8	26	12.7–30/7	23

planted in August the preceding year. However, those cultivars with the highest yield in 1997 generally yielded correspondingly high the following years. Figure 1 is arranged according to the accumulated, marketable yield for 1997, 1998 and 1999 and it is evident that 'Polka', 'Pandora', 'Korona', 'Dania' and 'Honeoye' gave the highest performances, whereas 'Elsanta', 'Zefyr', 'Tenira', 'Thuriga' and 'Cesena' were at the bottom. Among the highest yielding cultivars, 'Polka', 'Pandora' and 'Dania' had consistently high yields, while 'Korona' and 'Honeoye' showed some yield fluctuations from year to year. In Denmark, 'Tenira' has previously been claimed to be suitable in organic production (ANDERSEN & THUESEN, 1989b), but this could not be confirmed in this trial. Neither 'Elsanta' seemed suitable under such conditions.

When marketable yield is calculated as percentage of total yield (Table 4), 'Honeoye', 'Symphony' and 'Tenira' showed the highest percentages and 'Sella' and 'Senga Sengana' the lowest percentages. Considering all cultivars and years, the average marketable yield constituted 76% of the total yield. In a recent review of several organic trials, average marketable yield was between 96.3 and 72.5% (DAUGAARD, 1999a).

Berry size

The average berry size of all cultivars was declining from 22,0 g/berry in 1997 to 15,2 g/berry in 1999, which is normal (data not shown). However, among cultivars average berry size varied considerably. Low yielding cultivars as 'Onebor', 'Hapil', 'Eros', 'Sella', 'Pegasus' and 'Cesena' had a more or less constant berry size during the period, while the high yielding

Table 4. Marketable yield in 1997, 1998 and 1999 recorded in tonnes per hectare and in percent of total yield, respectively.
Verkäuflicher Ertrag 1997, 1998 und 1999 in Tonnen pro Hektar und in Prozent des Gesamtertrages.

Cultivar Sorte	Marketable yield, Tonnes per ha Verkäuflicher Ertrag in Tonnen pro ha			Marketable yield, % of total yield Verkäuflicher Ertrag % des Gesamtertrages		
	1997	1998	1999	1997	1998	1999
Polka	11.6	32.8	24.3	76.8	78.5	74.8
Pandora	9.6	29.9	23.5	79.3	79.7	77.3
Korona	8.9	28.9	19.9	82.4	83.0	68.4
Dania	5.0	26.9	25.0	78.1	81.8	80.9
Honeoye	5.5	17.8	29.5	84.6	90.0	91.3
Rafzusen	9.5	17.7	24.4	73.1	72.5	79.5
Kent	3.5	21.4	23.3	77.8	73.0	71.0
Symphony	4.2	16.3	25.9	82.4	81.1	88.7
Hapil	3.0	18.9	22.6	51.7	77.1	80.1
Cortina	6.8	18.5	18.5	78.2	77.7	77.4
Onebor	4.7	20.3	18.7	75.8	71.7	71.6
Senga Sengana	8.5	18.2	16.3	80.2	64.1	61.7
Sella	4.1	16.4	20.4	53.2	60.1	71.3
Eros	4.3	16.7	16.1	65.2	74.6	78.5
Pegasus	7.1	5.6	24.3	78.9	82.3	83.8
Elsanta	3.8	18.1	14.7	69.1	78.4	83.5
Zefyr	2.1	14.6	18.0	75.0	77.2	74.7
Tenira	4.4	14.0	15.8	77.2	84.3	85.4
Thuriga	4.0	12.0	16.0	72.7	75.5	80.8
Cesena	2.3	3.1	19.7	62.2	79.5	76.1
Average	5.6	18.4	20.8	73.7	77.1	77.8
LSD_{95}	2.08	4.99	4.00	–	–	–

Table 5. *Botrytis* attacks on berries at harvest in 1997, 1998 and 1999, in percent of the total yield.
Der Befall des Grauschimmels auf Beeren in 1997, 1998 und 1999, in Prozent des Gesamtertrages.

Cultivar Sorte	*Botrytis* on berries % of total yield *Botrytis* auf Beeren % des Gesamtertrages			
	1997	1998	1999	Average
Polka	4	16	22	14
Pandora	2	8	15	9
Korona	9	8	28	15
Dania	14	14	15	14
Kent	12	16	23	17
Onebor	10	15	23	16
Hapil	24	13	14	17
Cortina	12	13	19	15
Senga Sengana	9	29	34	24
Elsanta	14	8	11	11
Honeoye	4	4	7	5
Rafzusen	6	11	29	15
Eros	14	9	18	14
Sella	20	26	23	23
Symphony	9	8	10	9
Zefyr	14	9	21	15
Tenira	4	6	10	7
Thuriga	11	12	17	13
Pegasus	6	22	13	14
Cesena	10	2	17	10
Average	10	12	19	14
LSD_{95}	11.7	12.7	5.5	–

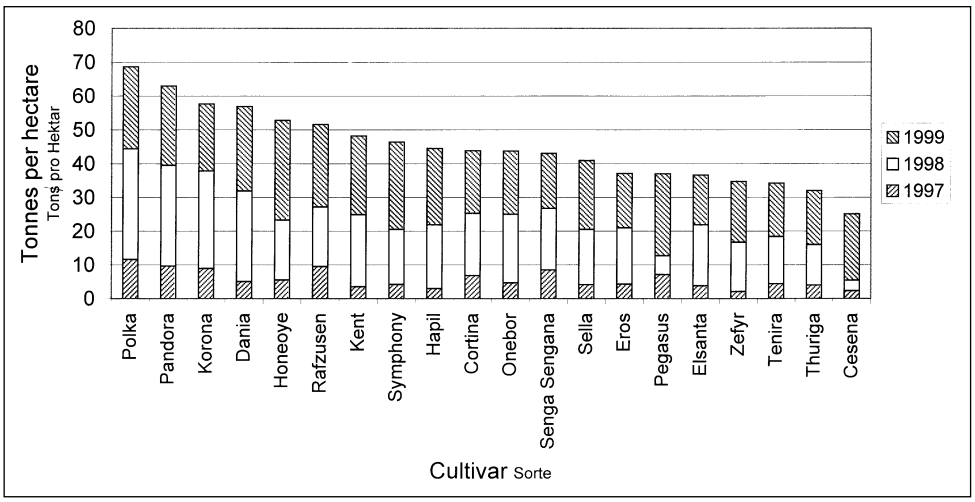


Fig. 1. Accumulated marketable yield 1997–99
Akkumulierter verkäuflicher Ertrag 1997–99

cultivars had a decline. This confirmed previous results (MELAND, 1985; VANG-PETERSEN, 1998; DAUGAARD, 1999b).

Susceptibility of cultivars to diseases and pests.

Resistance to diseases is an extremely important aspect of organic production of strawberries. In table 5 and 6, disease attacks of Botrytis, mildew and leaf spot diseases are recorded. As regards susceptibility to *Botrytis* (table 5), differences between cultivars were considerable. 'Senga Sengana', 'Sella' and 'Hapil' on average were susceptible cultivars, where up to 34% of the yield was attacked by Botrytis. 'Honeoye', 'Tenira', 'Pandora', 'Symphony', 'Cesena' and 'Elsanta' on the other hand were less susceptible. The susceptibility of 'Senga Sengana' and 'Sella' confirmed previous results (KIDMOSE et al., 1996; ANDERSEN & THUESEN, 1989a; DAUGAARD, 1999b). In general, average losses due to *Botrytis* increased with plant age, which corresponds well to previous results (MELAND, 1985). However, during all three years average yield losses were relatively moderate, which must be ascribed to the combined effects of climatic conditions and cultural practice, such as low nitrogen supply, weed control and runner removal (DAUGAARD, 1999a).

When susceptibility to mildew is considered (table 6), a few cultivars appeared to be medium susceptible ('Elsanta' and 'Zefyr'), while several cultivars were more or less resistant ('Cesena', 'Dania', 'Senga Sengana', 'Pandora', 'Cortina' and 'Sella'). In a recent cultivar trial including essentially the same cultivars, 'Zefyr' and 'Elsanta' similarly were very susceptible (DAUGAARD, 1999b). Generally, in this trial mildew attacks were moderate and situated on the leaves, only a small amount of attacked berries being recorded.

Leaf spot diseases in strawberries are generally not considered of major importance. However, in organic production any potential losses due to pests and diseases must be minimised. According to table 6, 'Pandora', 'Korona', 'Symphony' and 'Cesena' were relatively susceptible whereas the majority of cultivars only had small attacks.

The percentage of misshapen berries in 1998 and 1999, where cultivars had a full crop, is recorded in table 7. It is generally assumed that – in the absence of frost during flowering – the damage is primarily due to a variety of capsids (*Plagiognatus arbustorum* and others). The damage was more severe in 1998 when on average 14% of the berries were attacked. No clear consistency in susceptibility between cultivars seems to exist among the two years although late flowering cultivars like 'Pandora', 'Dania' and 'Symphony' apparently escaped from damage both years.

Table 6. Leaf attacks of mildew (Sphaerotheca alchemillae) and leaf spot diseases (Ramularia grevilleana and Marssonia fragariae) in 1997, 1998 and 1999.
Der Befall des Mehltaues und der Blattflecken auf Blättern in 1997, 1998 und 1999.

Cultivar Sorte	Mildew on leaves 0–9, 9 most severe Mehltau auf Blättern 0–9, 9 am Starksten			Leaf spot on leaves 0–9, 9 most severe Blattflecken auf Blättern 0–9, 9 am Starksten		
	1997	1998	1999	1997	1998	1999
Polka	0	2	1	3	2	2
Pandora	0	1	1	4	3	2
Korona	0	3	1	3	3	2
Dania	0	0	1	2	2	2
Kent	1	1	1	2	2	2
Onebor	1	1	1	1	2	3
Hapil	1	3	1	1	2	2
Cortina	0	1	1	1	2	1
Senga Sengana	0	0	1	2	1	1
Elsanta	5	6	3	1	2	2
Honeoye	1	3	2	1	3	2
Rafzusen	1	3	2	2	1	1
Eros	1	2	1	1	2	2
Sella	0	1	1	2	2	2
Symphony	1	2	1	1	3	3
Zefyr	2	5	2	2	2	2
Tenira	2	3	1	1	3	2
Thuriga	1	2	1	2	1	2
Pegasus	0	2	1	1	2	3
Cesena	0	0	1	3	3	1
Average	1	2	1	2	2	2
LSD_{95}	0.8	0.7	0.3	0.7	0.6	0.5

Table 7. Percentage of misshapen berries 1998 and 1999 probably due to a variety of capsids (Plagiognatus arbustorum and others).
Prozentsatz der unförmigen Beeren 1998 und 1999, wahrscheinlich von verschiedener Wanzen (Plagiognatus arbustorum under andere) verursacht

Cultivar Sorte	% of total % der Gesamtmenge	
	1998[1]	1999[2]
Sella	29	9
Cesena	22	5
Hapil	21	6
Tenira	20	8
Eros	20	4
Rafzusen	19	7
Onebor	16	5
Elsanta	15	9
Cortina	14	6
Korona	14	5
Kent	13	9
Senga Sengana	13	6
Pegasus	12	4
Honeoye	11	2
Zefyr	10	5
Polka	9	3
Thuriga	8	4
Symphony	8	1
Pandora	7	–
Dania	4	7
Average	14.2	5.5
LSD_{95}	3.6	3.5

[1] Sum of 3 representative pickings. Summe von 3 repräsentativer Ernten.
[2] Sum of 2 representative pickings. Summe von 2 repräsentativer Ernten.

Conclusions

In organic production, disease resistance is considered even more important than in conventional production. Especially resistance to *Botrytis*, which is the most important strawberry disease, must be given priority and taken into account when conclusions are made. Some of the highest yielding cultivars in the trial were susceptible to various diseases and are not considered well adapted to organic production. This applies for 'Polka', 'Korona' and 'Dania', which all appeared to be susceptible to *Botrytis*. 'Tenira' and 'Rafzusen', previously claimed to be suitable to organic production, had only moderate yields or disease resistance in our trial, and the same holds true for 'Elsanta'. Among early ripening cultivars 'Honeoye' had high yields and the lowest *Botrytis* susceptibility of all cultivars. Mid-season cultivars with potential in organic production may be 'Kent' and 'Cortina', although both are moderately susceptible to *Botrytis*. As late ripening cultivars 'Symphony' and 'Pandora' had high yields and relatively low disease susceptibility, although both appeared to be susceptible to leaf spot diseases.

The technical assistance of J. Eriksen, S. Vestergaard, J. Larsen and K. Nielsen is greatly appreciated.

References

ANDERSEN, H. and THUESEN, A. 1989a: Vurdering af jordbærsorter 1987–88. Tidsskrift for Planteavl **93**, 349–358.

ANDERSEN, H. and THUESEN, A. 1989b: Jordbær – sortsliste 1989–90. Frugtavleren **18**, 329–331.

DAUGAARD, H. 1998: Winter Hardiness and Plant Vigor of 24 Strawberry Cultivars Grown in Denmark. Fruit Varieties Journal **52**, 154–157.

DAUGAARD, H. 1999a. Cultural methods for Controlling *Botrytis* cinerea Pers. in Strawberry. Biological and Agriculture and Horticulture **16**, 351–361.

DAUGAARD, H. 1999b: Strawberry Cultivars for the Fresh Market in Denmark. Fruit Varieties Journal **53**, 69–72.

GRAF, B. und HÄSELI, A. 1991: Eignung einiger Erdbeersorten für den Biologischen Anbau. 4. Internat. Erfahrungsaustausch über Forschungsergebnisse zum Ökologischen Obstbau, 75–78.

KIDMOSE, U., ANDERSEN, H. and VANG-PETERSEN, O. 1996: Yield and Quality Attributes of Strawberry Cultivars Grown in Denmark 1990–1991. Fruit Varieties Journal **50**, 160–167.

MELAND, M., 1985. Verknad av plantealder på nokre avlingskomponentar hjå fire jordbærsortar. Forskning og Forsøk i Landbruket **36**, 149–152.

NEUWEILER, R. 1997a: Erdbeersorten – Fruchtqualität und Robustheit stehen im Vordergrund. Schweizerische Zeitschrift für Obst- und Weinbau **133**, 62–64,

NEUWEILER, R. 1997b: New strawberry cultivars in Swiss integrated fruit production. Acta Horticulturae **439**, 951–955.

RÖSER, I. 1992: Leistungsvergleich bei neuen Erdbeersorten mit und ohne Pflanzenschutzbehandlung im 1jährigen Anbau 1992. 5. Internat. Erfahrungsaustausch über Forschungsergebnisse zum ökologischen Obstbau, 114–117.

THUESEN, A.1984. Sortsforsøg med jordbær 1978–79. Tidsskrift for Planteavl **85**, 234–244.

VANG-PETERSEN, O.1998: Strawberry Varieties for Fresh Market in Denmark. Fruit Varieties Journal **52**, 86–89.

WASSENAAR, L. M., C. P. J. v.d. LINDELOEF and W. RADEMAKER 1982: Een nieuw aardbeiras 'Elsanta' De Fruitteelt **72**, 770–771.

Eingegangen: 21. 10. 1999 / 16. 12. 1999

Anschrift der Verfasser: Holger Daugaard, Hanne Lindhard, Danish Institute of Agricultural Sciences, Dept. of Hydroculture, 5792 Aarslev, Denmark