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Strawberry Cultivars for the Finnish Fresh Market

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Abstract

Eight strawberry (*Fragaria x ananassa*) cultivars were tested in a two-year field trial in southern Finland. The trial was linked to the joint European cultivar network under project COST 836. Among the test cultivars, the two of greatest interest were 'Ciloe' and 'Vima®Zanta'. 'Ciloe' had good fruit size and firmness. Flavor was considered inadequate, however, and it is unclear whether 'Ciloe' would be accepted in Finnish strawberry markets. The advantages of 'Vima®Zanta' were earliness and fairly good flavor, but the leaves showed clear symptoms of mildew (*Sphaerotheca alchemillae*). The limiting factor for acceptance for most of the test cultivars was poor taste. Two years testing time was insufficient, however, for establishing the adaptability of the cultivars in the Finnish environment. Neither trial winter was severe and the true wintering ability of the cultivars remains unclear.

Introduction

Strawberry (*Fragaria x ananassa*) is the most important cultivated soft fruit in Finland, and almost all of the production is for the fresh market. At present, the most widely grown cultivar for main season production is the Dutch cultivar 'Polka'. In the past few years 'Polka' has surpassed 'Bounty' and 'Senga Sengana' in cultivated acreage. The Norwegian cultivar 'Jonsok' and American cultivar 'Honeoye' are grown for early production. In addition to earliness, one advantage of 'Jonsok' is good adaptation to Finnish climatic conditions, because of winter hardiness. However, the cultivar is not considered to be that flavorful and it has a tendency for small berry size. The other early cultivar, 'Honeoye', has firm, large-size berries, but it lacks winter hardiness and is not considered flavorful.

Finnish strawberry production is in need of new cultivar alternatives. A tasty early cultivar would be particularly welcome. The present concentration of main season production on largely one cultivar i.e. 'Polka' is undesirable. Furthermore, the current cultivar assortment lacks a viable late cultivar.

The cultivar trial was established in 1999 as part of the joint European cultivar network under project COST 836 (3). Strawberry trials with the same trial cultivars were established in 16 countries besides Finland. The general results for the Nordic Countries have been summarized (2).

Materials and Methods

The trial was established at MTT Horticulture in Piikkiö in southern Finland (60˚23'N and 22˚33'E). Cultivars and their country of origin as well as their year of introduction are presented in Table 1. The controls were 'Jonsok' and 'Bounty', both of them impor-

Table 1. Country of origin and year of introduction for control and test strawberry cultivars.

Cultivar	Country of origin	Year of introduction
Controls:		
Bounty	Canada	1972
Jonsok	Norway	1971
Test cultivars:		
Andana	Spain	1995
Cigoulette	France	1996
Cilady	France	1996
Ciloe	France	1996
Florence	UK, England	1997
Onda	Italy	1998
Vima®Tarda	The Netherlands	1997
Vima®Zanta	The Netherlands	1997

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tant commercial cultivars at the time. All the planting material was propagated at the institute by rooting runner plants taken from micro-propagated mother plants. The trial continued for two years according to the joint trial scheme of COST 836 project.

Trial was established on 20 July, 1999 on a slightly sloping field on medium fine sand as a randomized complete block design with three replications. Each plot consisted of ten plants, planted in double rows in low drip-irrigated beds covered with black plastic mulch. The two rows in double rows were spaced 0.35 m apart and the planting distance in each row was 0.40 m. Spacing between the beds was 1.4 m. White-fruited, non-runner-producing and vigorous wild strawberry plants were planted in between each plot and at the end of rows. The soil between the beds was covered with grass, which was kept flat with a lawn mower. During the first winter after planting, from the beginning of December until the beginning of April, the plantation was covered with non-woven acrylic cover cloth weighting 18 g/m^2.

The trial field was fertilized before planting in accordance with the soil test values. During the growing season, plants were irrigated and fertigated via drip irrigation. The irrigation was scheduled with the help of tensiometers so that the threshold for irrigation was -150 hPa. The fertigation was given in several portions trying to get good productivity and avoid over luxuriant growth. In years 2000 and 2001, the amount of fertigation was comparable to 60 and 42 kg of nitrogen per hectare, respectively.

An integrated system was used for pest control. To allow assessment of mildew resistance, no sprays against mildew (*Sphaerotheca alchemillae*) were applied. Furthermore, only two of the three recommended sprays against grey mould (*Botrytis cinerea*) were carried out during the flowering season.

Fruits were harvested twice a week and the quantities of marketable yield and discarded fruit were recorded. Fruits that were smaller than 22 mm in diameter, infested with mildew or grey mould, misshapen or with damaged skin were considered non-marketable. Average fruit weight was determined at the beginning, middle and end of the harvest. Yield data were transformed to logarithmic scale and analysed using the traditional analysis of variance for randomized complete block design where a block was considered as a normally distributed random effect. Analysis was performed by the SAS/Mixed procedure (SAS Institute, Inc., 1999-2001 Cary, NC). The proportions of fruits infected with mildew and grey mould were not analysed statistically because of the non-normal distribution of the data.

The earliness of the harvest was assessed by calculating the earliness index developed by Faedi et al.(1). The index was calculated by multiplying each picking day ordinal number by the yield of that day and dividing the sum of products by total yield. The earliness indices from two years were compared with the Tukey test.

Wintering ability was assessed by counting the dead, severely injured (more than half of the crowns lost), slightly injured (less than half of the crowns lost) and uninjured plants. These four categories were given coefficients between 0 and 1 at even intervals i.e. 0, 0.33, 0.67 and 1 respectively. A wintering index was calculated from the data.

Wintering index: $(n_1 \cdot 1.00) + (n_2 \cdot 0.67) + (n_3 \cdot 0.33) + (n_4 \cdot 0.00)$,
n_1=number of uninjured plants
n_2=number of slightly injured plants
n_3=number of severely injured plants
n_4=number of dead plants

Wintering index data after the second winter, i.e. from the year 2001, was transformed to the arc-sine scale and were then analysed using the traditional analysis of variance for randomized complete block design, where a

Table 2. Monthly climatic records for Piikkiö in 1999-2001 and 30-year averages of temperature and precipitation.

Month	Snow depth, cm			Mean temperature, °C				Precipitation, mm			
	1999	2000	2001	1999	2000	2001	Avg. 1971-2000	1999	2000	2001	Avg. 1971-2000
January	-	0-9	3-11	-	-2.4	-1.1	-4.6	-	53	30	50
February	-	9-15	6-11	-	-2.1	-7.6	-5.5	-	62	40	36
March	-	0-13	2-18[y]	-	-1.1	-3.2	-1.9	-	45	25	39
April	-	-	-	-	6.0	5.0	3.1	-	38	58	37
May	-	-	-	-	10.2	9.1	9.6	-	26	20	35
June	-	-	-	-	13.5	14.0	14.4	-	51	37	47
July	-	-	-	18.3	16.3	19.6	16.6	22	131	101	77
August	-	-	-	15.2	15.1	-	15.3	52	68	-	78
Sept.	-	-	-	13.0	9.5	-	10.4	49	21	-	64
October	-	-	-	7.0	9.2	-	5.7	141	69	-	71
Nov.	-	-	-	2.8	4.9	-	1.0	50	127	-	70
Dec.	0-6	0-5	-	1.8	1.8	-	-2.8	90	72	-	60

[y]Snow depth was 7-18 cm between 1st and 26th of March and 2-7cm between 26th and 31st of March.
Source: Finnish Meteorological Institute

block was considered a normally distributed random effect. Analysis was performed by the SAS/Mixed procedure (SAS Institute, Inc., 1999-2001 Cary, NC).

The mildew resistance of leaves was assessed twice during the growing season: once before harvest and a second time after harvest. A scale from 1 to 9, in which 1 denoted very susceptible and 9 very resistant, was used for the evaluations. Mildew data were analysed by Friedman's nonparametric test. Other plant and fruit characteristics were evaluated using the 1 to 9 scale. Fruit characteristics were evaluated by two persons twice during the harvest season: at the beginning and in the middle of the harvest. Flesh firmness was assessed by mouth and teeth by biting and skin resistance by rubbing the fruits between fingers. Flavor, sweetness and sourness were evaluated by tasting. Fruit color assessments were made with the aid of a 1 to 8 scale color chart for strawberries (CTIFL strawberry color code for experimentation ends).

Results

Yield

Yield results are given in Table 3. In general, the commercial yields were similar in the two years for the other test cultivars except 'Andana', 'Vima®Zanta', 'Vima®Tarda' and 'Cigoulette'. In cultivar comparisons, 'Ciloe' and 'Onda' were the two best yielding test cultivars. Their yields differed significantly from the yield of 'Jonsok' but not that of 'Bounty'. The yield of 'Florence' was smallest, and it differed significantly from the yield of 'Bounty' but not that of 'Jonsok'.

In a comparison of the commercial yield as percentage of total yield, 'Ciloe', 'Cilady', 'Vima®Zanta', and 'Cigoulette' obtained the highest values. The percentages of commercial yield of 'Ciloe', 'Cilady', 'Vima®Zanta' and 'Andana' significantly exceeded the percentages of 'Jonsok' and 'Bounty'. The percentage of 'Cigoulette' exceeded the percentage of 'Bounty' but not that of 'Jonsok'. Much of the poor commercial yield of 'Bounty' is explained by the number of small

Table 3. Commercial yield of strawberries and percentage of commercial and grey-mould-infected fruit in 2000 and 2001.

	Commercial Yield										Grey-mould-infected fruit	
	g/plant			Significance[z]		% of total yield			Significance[z]		% of total yield	
	2000	2001	Mean	Bounty	Jonsok	2000	2001	Mean	Bounty	Jonsok	2000	2001
Controls:												
Bounty	361	552	457	-	-	64	64	64	-	-	0.5	1.0
Jonsok	357	318	337	-	-	84	60	72	-	-	0.1	0.1
Test cultivars:												
Ciloe	522	605	564	NS[y]	**	87	85	86	***	**	1.0	0.7
Onda	479	461	470	NS	*	70	69	69	NS	NS	5.0	7.0
Andana	594	282	438	NS	NS	79	82	80	***	*	2.0	0.3
Vima®Zanta	294	514	404	NS	NS	78	84	81	***	*	1.0	0.2
Cilady	414	380	397	NS	NS	83	87	85	***	**	0.3	1.0
Vima®Tarda	249	515	382	NS	NS	56	81	68	NS	NS	3.0	0.4
Cigoulette	412	279	346	°	NS	79	77	78	**	NS	0.6	0.1
Florence	283	314	298	*	NS	62	66	64	NS	°	1.0	1.0

[z]Statistical significance for the difference between control and test cultivar.
[y]NS, °, *, **, ***Nonsignificant or significant at $P \leq 0.1, 0.05, 0.01$ or 0.001, respectively.

fruits, but in 2000 also by the great share (21 per cent) of fruits with damaged skin (data not shown). Also, the low commercial yield of 'Florence' was mainly due to fruits with damaged skin: 32 and 18 per cent in 2000 and 2001, respectively (data not shown). The percentage of marketable yield of 'Jonsok' in 2001 was lowered because of mildew infected fruits; 23 per cent of the total yield was mildew infected (data not shown). The commercial yield of 'Onda' was lowered mainly due to grey mould-infected and misshapen fruits.

Fruit weight

In general, the fruit size of the test cultivars was greater than that of control cultivars (Table 4). Only late season fruits of 'Cilady', 'Ciloe' and 'Vima®Tarda' were not significantly larger in size than the late season fruits of 'Jonsok'. Unfortunately, in 2001 the early season fruit weights of the five earliest ripening cultivars were missed during the data collection work. Because these missing values, statistical analyses for early season fruit weights only enabled comparisons of 'Ciloe', 'Florence', 'Onda' and 'Vima®Tarda' with 'Bounty'.

Earliness

The harvest periods and earliness indices are presented in Table 5. The earliness indices show that the fruits ripened earlier in 2001 than in 2000. July of 2001 was warmer and drier than July of 2000 (Table 2); in July 2001 there were 13 rainy days compared with 22 in 2000. Comparison of the means of the earliness indices for the two years showed 'Jonsok' to be the earliest cultivar and 'Onda' the latest. 'Vima®Zanta' fell partially in the early and partially in early-midseason group, together with 'Cigoulette', 'Cilady' and 'Andana'. 'Ciloe' and 'Vima®Tarda' fell in the midseason group together with the control cultivar 'Bounty'. 'Florence' did not differ significantly from the midseason cultivar 'Ciloe' and the late cultivar 'Onda'.

Mildew resistance

Data for mildew resistance is presented in Ta-

Table 4. Strawberry fruit weight (g) at beginning, middle and end of harvest in 2000 and 2001.

	Beginning of harvest				Middle of harvest					End of harvest				
	2000	2001	Mean	Significance[z]	2000	2001	Mean	Significance[z]		2000	2001	Mean	Significance[z]	
				Bounty				Bounty	Jonsok				Bounty	Jonsok
Controls:														
Bounty	11.8	9.1	10.5	-	8.2	7.9	8.0	-	-	7.0	6.2	6.6	-	-
Jonsok	16.2	-	-	-	11.2	6.9	9.1	-	-	8.2	7.5	7.9	-	-
Test cultivars:														
Andana	25.5	-	-	-	13.9	12.0	13.0	***[y]	***	14.7	11.5	13.1	***	***
Cigoulette	18.0	-	-	-	13.2	13.4	13.3	***	***	10.5	12.8	11.6	***	***
Cilady	17.0	-	-	-	11.8	11.5	11.6	***	**	7.9	9.3	8.6	**	NS
Ciloe	26.6	18.8	22.7	***	16.5	13.9	15.2	***	***	10.1	6.2	8.2	*	NS
Florence	20.7	14.5	17.6	***	13.0	12.9	13.0	***	***	13.2	7.5	10.3	***	*
Onda	23.8	19.0	21.4	***	17.7	16.8	17.2	***	***	14.7	10.1	12.4	***	***
Vima®Tarda	22.3	16.7	19.5	***	18.4	14.3	16.3	***	***	8.8	9.3	9.1	**	NS
Vima®Zanta	28.6	-	-	-	11.5	12.8	12.2	***	***	12.4	8.1	10.3	***	*

[z]Statistical significance for the difference between control and test cultivar.
[y]NS, °, *, **, ***Nonsignificant or significant at P ≤ 0.1, 0.05, 0.01 or 0.001, respectively.

Table 5. Harvest periods and earliness indices for strawberry in 2000 and 2001.

	Harvest period		Earliness index[z]		
	2000	2001	2000	2001	Mean
Jonsok	26Jun - 14July	3July - 17July	194.9	189.6	192.2ay
Vima®Zanta	3July - 21July	5July - 20July	196.1	191.9	194.0ab
Cigoulette	3July - 25July	5July - 20July	198.5	191.9	195.2b
Cilady	7July - 25July	3July - 19July	200.8	189.7	195.3b
Andana	3July - 28July	3July - 20July	199.4	192.3	195.9b
Bounty	5July - 25July	9July - 28July	201.9	196.8	199.3c
Vima®Tarda	11July - 1.Aug	5July - 24July	203.7	195.2	199.5c
Ciloe	11July - 28July	9July - 27July	203.1	196.6	199.9cd
Florence	11July -1Aug	9July - 28July	205.6	198.2	201.9de
Onda	7July - 4.Aug	5July - 31July	207.9	198.5	203.2e

[z]Earliness index by Faedi et al. (1). The index is calculated by multiplying each picking day ordinal number by the yield of that day and dividing the sum of products by total yield.

ble 6. Only a small number of infected fruits, if any, were detected in 2000, and no cultivar differences in mildew resistance were evident. The warmer harvest season 2001, with fewer days of rain than in 2000, favored mildew development on fruits, and more mildew infected fruits appeared than in the previous year. The percentage of mildew infected berries was highest for 'Jonsok', 'Cigoulette', 'Onda' and 'Florence': 23, 12, 6 and 6 per cent of total yield, respectively.

Mildew resistance expressed in the leaves in 2000 was greater for 'Ciloe' and 'Vima®Tarda' than for the control cultivar

Table 6. Mildew infected strawberry fruits as a percentage of total yield and mildew resistance expressed in leaves in 2000 and 2001.

	Mildew infected fruit % of total yield	Mildew resistance expressed in the leaves					
		Before harvest			After harvest		
		Mildew resistance[y]	Significance[z]		Mildew resistance[y]	Significance[z]	
			Bounty	Jonsok		Bounty	Jonsok
Year 2000:							
Bounty	0.1	5.0	-	*[x]	3.0	-	*
Jonsok	0.0	7.7	*	-	6.0	*	-
Andana	0.0	7.0	NS	NS	5.3	NS	NS
Cigoulette	0.1	5.7	NS	*	4.0	NS	NS
Cilady	0.2	7.0	NS	NS	4.7	NS	NS
Ciloe	0.0	8.0	**	NS	7.7	***	NS
Florence	0.5	7.7	**	NS	5.7	°	NS
Onda	0.1	7.0	NS	NS	6.3	*	NS
Vima®Tarda	0.2	8.0	**	NS	6.7	**	NS
Vima®Zanta	0.2	4.7	NS	**	2.7	NS	*
Year 2001:							
Bounty	2.0	5.3	-	NS	5.0	-	NS
Jonsok	23.0	5.0	NS	-	4.3	NS	-
Andana	2.0	6.7	NS	NS	5.0	NS	NS
Cigoulette	12.0	5.7	NS	NS	4.3	NS	NS
Cilady	0.4	7.0	NS	NS	6.7	NS	*
Ciloe	0.0	7.5	°	*	6.3	NS	*
Florence	6.0	8.0	*	*	5.0	NS	NS
Onda	6.0	7.0	NS	NS	5.7	NS	NS
Vima®Tarda	3.0	6.0	NS	NS	5.7	NS	NS
Vima®Zanta	4.0	3.3	NS	NS	3.3	NS	NS

[z]Statistical significance for the difference between control and test cultivar.
[y]Score nine-point reference (9 very resistant, no symptoms, 5 medium, 1 very susceptible, severe symptoms)
[x]NS, °, *, **, ***Nonsignificant or significant at $P \leq 0.1, 0.05, 0.01$ or 0.001, respectively.

'Bounty', both before and after harvest. Relative to 'Bounty', 'Onda' expressed more resistance after harvest and 'Florence' more resistance before harvest. Compared with 'Jonsok', 'Vima®Zanta' showed poorer mildew resistance both before and after harvest and 'Cigoulette' had poorer mildew resistance before harvest.

Less difference was observed between the control and test cultivars in 2001 than in 2000. 'Florence' and 'Ciloe' exhibited better resistance than 'Jonsok' before harvest and 'Cilady' and 'Ciloe' after harvest. 'Florence' was more resistant than 'Bounty' before harvest. In both years the scores of 'Vima®Zanta' were poorest.

Winter hardiness

In the first winter 1999-2000, when the planting was protected by acrylic cover cloth, all the cultivars wintered practically without injury. The differences in over-wintering emerged after the second winter without protection, 2000-2001. The wintering index data for the year 2001 are given in Table 7.'Vima® Tarda','Vima®Zanta','Florence', 'Andana' and 'Cigoulette' suffered more winter damage than 'Bounty'. In addition, 'Florence', 'Andana' and 'Cigoulette' were inferior in winter hardiness to 'Jonsok'. Nevertheless, the wintering differences were less drastic than they might have been. The winters 1999-2000 and 2000-2001 were not severe

and not difficult for strawberry wintering (Table 2). Even though temperatures fell below the thirty-year average in February and March 2001, the ground was covered by 6 to 18 centimetres of insulating snow until the 26th of March.

Fruit quality

Fruit characteristics are summarized in Table 8. As already noted, test cultivars exceeded the control cultivars in fruit size. The findings for flesh firmness and skin resistance followed the same pattern: the test cultivars obtained better scores than the control cultivars 'Bounty' and 'Jonsok'. In taste value, however, 'Bounty' received the best scores. 'Jonsok', 'Vima®Zanta' and 'Florence' had acceptable taste, while 'Andana', 'Onda' and 'Vima®Tarda' were assessed poorest.

Table 7. Wintering index data for 2001.

	Wintering index[z] 2001	Significance[y] Bounty	Jonsok
Controls:			
Bounty	10.0	-	-
Jonsok	9.7	-	-
Test cultivars:			
Ciloe	9.8	NS[x]	NS
Onda	9.7	NS	NS
Cilady	9.2	NS	NS
Vima®Tarda	9.2	*	NS
Vima®Zanta	9.1	*	NS
Florence	8.3	***	*
Andana	7.1	***	**
Cigoulette	6.8	***	***

[z]Score: 0-10 (0 all plants dead, 10 all plants uninjured).
[y]Statistical significance for the difference between control and test cultivar.
[x]NS, °, *, **, ***Nonsignificant or significant at $P \leq 0.1$, 0.05, 0.01 or 0.001, respectively.

Table 8. Means of scores of major strawberry fruit characteristics assessed at the beginning and middle of harvest seasons in 2000 and 2001.

Cultivar	Skin color[a]	Flesh firmness[b]	Skin resistance[c]	Flavor[d]	Sweetness[e]	Acidity[f]
Bounty	6.8	4.3	3.3	6.0	5.0	5.3
Jonsok	6.5	4.7	3.7	3.0	3.0	6.3
Andana	5.3	7.5	7.3	2.8	3.3	2.8
Cilady	5.3	4.8	6.0	4.0	3.8	6.3
Ciloe	4.3	7.8	8.0	3.0	3.0	5.0
Florence	5.5	5.5	6.5	4.0	4.5	4.5
Cigoulette	5.5	5.3	5.3	3.3	3.5	3.8
Onda	4.5	6.8	6.3	2.8	2.8	2.8
Vima®Tarda	4.8	7.0	7.8	3.0	2.5	5.5
Vima®Zanta	5.3	6.5	7.3	4.0	4.5	4.8

[a]Score eight-point reference (8 dark wine-red, 7 wine-red, 6 cardinal red, 5 blood-red, 4 bright red, 3 brick red, 2 dark orange, 1 light orange red)
[b]Score nine-point reference (9 very firm, 7 firm, 5 medium, 3 soft, 1 very soft)
[c]Score nine-point reference (9 very high, 7 high, 5 medium, 3 low, 1 very low)
[d]Score nine-point reference (9 very high, 7 high, 5 medium, 3 weak, 1 very weak)
[e]Score nine-point reference (9 very high, 7 high, 5 medium, 3 weak, 1 very weak)
[f]Score nine-point reference (9 very high, 7 high, 5 medium, 3 weak, 1 very weak)

Discussion

Among the test cultivars, 'Vima®Zanta' and 'Ciloe' obtained the highest scores overall. The advantages of 'Vima®Zanta' were earliness and fairly good taste, though the taste was regarded as more fruity than typical strawberry. Pronounced mildew symptoms appeared in the leaves, however, indicating a risk for mildew infected fruits. Poor pest and disease tolerance of 'Vima®Zanta' was found to be a substantially greater problem in Swedish trial (2).

The early mid-season cultivar 'Ciloe' was more productive than 'Bounty'. In addition to the fruit size, other fruit characteristics, especially flesh firmness and skin resistance, were good. Despite these good qualities, the taste was considered inadequate, and the acceptance of 'Ciloe' in Finnish strawberry markets is uncertain. The evaluation of taste quality was parallel with the Swedish results, while the evaluation of the external fruit quality was higher in Finland than in Sweden and Denmark (2).

In general, the limiting factor for acceptance for most of the test cultivars was poor flavor. Findings were similar in Denmark and Sweden (2). 'Jonsok' is not considered an especially tasty cultivar in Finnish strawberry markets, but in taste it usually surpassed the test cultivars. 'Bounty' is regarded more as a gourmet cultivar, but in cool and rainy weather of the year 2000 its good taste did not develop fully.

Another important factor for new cultivars is their over-wintering ability. During the trial, 'Ciloe' did not differ from the controls in this respect, but 'Vima®Zanta' suffered nine per cent more winter damage than 'Jonsok'. The two trial winters were not difficult for strawberry over-wintering, however, and the true over-wintering ability of the cultivars remains to be clarified.

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