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Winter Hardiness and Plant Vigor of 24 Strawberry Cultivars Grown in Denmark

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Abstract

The winter hardiness of 24 strawberry (*Fragaria x ananassa* Duch.) cultivars in a field trial planted in August 1996 was evaluated following 1996/97 winter temperatures of –12 °C with no snow cover. Significant differences among cultivars for winter hardiness were expressed by the number of dead or damaged plants. 'Senga Sengana,' 'Korona,' 'Polka,' 'Petrina' and 'Honeoye' were the most winter-hardy cultivars, whereas 'Burlington,' 'Hapil' and 'Evita' showed very low winter hardiness. A significant positive correlation was shown between winter hardiness and general plant vigor.

Introduction

Cultivated strawberries (*Fragaria x ananassa* Duch) often suffer from severe winter damage, particularly during winters with temperatures below the freezing point and no snow cover, a situation not uncommon in a number of strawberry-growing countries. Strawberry plants usually cannot endure temperatures below –12 to –15 °C (6), depending on acclimation period, weather conditions, cultivar and cultural practices (3, 10, 13, 14). Due to this relatively limited winter tolerance, artificial winter covering is commonly

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practiced and may increase yields of susceptible cultivars considerably (1, 7). The winter hardiness of strawberry cultivars differs significantly and must be considered an important trait in future strawberry breeding. Although a number of cover materials exist, they represent a rather expensive production cost. The aim of future breeding work preferably would be new, high yielding cultivars, resistant to pests and diseases, as well as to low temperatures. A prerequisite for this work, however, is a better knowledge about the winter hardiness of existing cultivars and possible reasons for their differences.

Materials and Methods

In the first half of August 1996 a strawberry cultivar trial was planted, consisting of 24 cultivars. Plants were made from new runners rooted in greenhouse during the summer. The trial was set up as a completely randomized block design with nine replications and 10 plants per plot. All plots were assigned numbers to remove cultivar name recognition bias. The plant spacing were 90 cm between rows and 33 cm between plants. As the trial was part of an organically grown research program, no pesticides were applied at any time. No covering material was used during the winter.

In May 1997, evaluations of winter damage were made using two different methods: (a) the number of dead plants in the plots were registered, and (b) an overall rating of visible winter damage (i.e. poor growth of plants following the winter) of each plot was given, using a five-point scale (1 = no damage/normal growth, 5 = severe damage/very poor growth). In addition, a rating of general plant vigor (i.e. number and size of leaves, plant height) was made, using a five-point scale (1 = weak growth, 5 = very vigorous growth).

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

Results and Discussion.

The winter 1996/97 in Denmark was very unusual as it came early and very suddenly. In a few days in mid-December, the temperature dropped from 0 to –12 °C, and with practically no snowfall (Figure 1). As this temperature drop happened early in the winter season, evaluations of winter damage to plants in the strawberry trial were made possible. Except for the 2-3 weeks around the turn of the year 1996/97, the winter was relatively mild,

Table 1. Mean number of dead strawberry plants per replication, % dead plants, winter damage and vigor of 24 strawberry cultivars.

Cultivar	No. dead plants	% dead plants	Winter damage[a]	Vigor[b]
Burlington	1.9	19	4.3	1.3
Hapil	1.9	19	3.0	2.9
Eros	0.8	8	2.9	2.8
Evita	0.8	8	3.9	1.6
Onebor/Marmolada	0.8	8	2.9	3.1
Dania	0.6	6	2.8	3.2
Melody	0.6	6	4.1	1.6
Sella	0.4	4	2.2	2.9
Symphony	0.4	4	2.4	3.1
Cortina	0.3	3	2.4	3.1
Tenira	0.3	3	3.1	2.4
Pandora	0.2	2	1.8	3.9
Pegasus	0.2	2	2.9	3.1
Thuriga	0.2	2	2.1	3.4
Zefyr	0.2	2	2.4	2.9
Cesena	0.1	1	2.7	3.0
Korona	0.1	1	1.6	3.7
Ostara	0.1	1	2.6	3.1
Petrina	0.1	1	1.3	4.2
Elsanta	0	0	2.6	3.0
Honeoye	0	0	3.0	2.6
Kent	0	0	2.8	2.8
Polka	0	0	2.0	3.4
Senga Sengana	0	0	1.6	3.9
LSD (0.05)	0.63	–	0.67	0.54

[a]1 no damage/normal growth, 5 severe damage/very poor growth.
[b]1 weak, 5 very strong vigor.

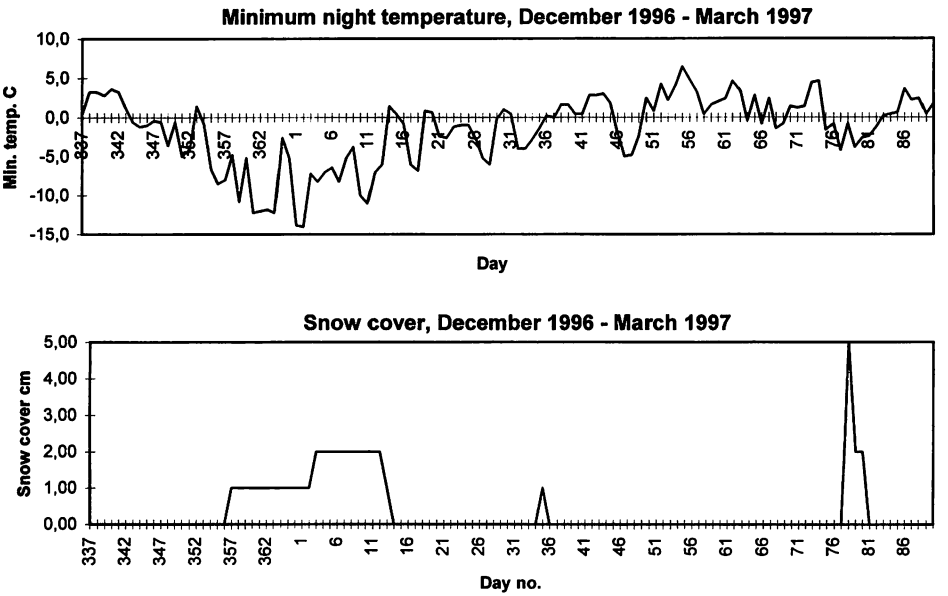

Figure 1. Minimum night temperature (°C) and snow cover (cm), December 1996-March 1997 in Aarslev.

which is normal in the maritime climate of Denmark.

The 24 cultivars included in the trial consisted of new as well as older cultivars (Table 1). The majority are shortday cultivars and a few are dayneutral ('Burlington,' 'Evita' and 'Ostara'). When the number of dead plants per 10-plant plot is considered, there are some cultivar differences. However, only two cultivars, 'Burlington' and 'Hapil,' showed poor winter survival and differed significantly from the others. It is surprising that the cultivar 'Elsanta,' which is the most commonly grown European cultivar and known to have a poor winter survival (4, 7), in this trial survived very well. As for the other cultivars showing no winter death, the results correspond to other research results: 'Honeoye' and 'Kent' (5), 'Polka' (4) and 'Senga Sengana' and 'Korona' (4, 8, 9, 11, 12, 14).

Considering the number of dead or living plants is an objective method in measuring winter survival of strawberries. However, winter hardiness is not only a matter of plant survival. It is common in strawberries that, although the plants may survive a severe winter, they often suffer from other kinds of damage including abnormal growth of leaves, decreased blossom numbers, and browning of crown tissues (6, 11). In this trial, therefore, the winter hardiness of cultivars was evaluated additionally in May, when the growth period was well under way, but before visible symptoms of winter damage had disappeared. Plants were scored for winter injury on a 1-5 rating scale. The result of this evaluation is shown in Table 1. It is evident that there is some correlation between this evaluation and the number of dead plants recorded, but there are also several differences from the general pattern. A number of cultivars showing 100% plant survival did show signs of winter damage. Examples of this are 'Polka,' 'Elsanta,' 'Kent' and 'Honeoye' with no dead plants but with symptoms of winter damage rating from 2.0 to 3.0. Contrary to this, 'Hapil' showed very low plant survival but only medium ratings for winter damage. An evaluation of winter hardiness of strawberry cultivars,

based solely on plant survival, may therefore not be sufficient.

In an attempt to correlate other characteristics of strawberry cultivars to their winter hardiness, their general plant vigor was evaluated according to a rating scale. The ratings are shown in Table 1. There was a significant positive correlation between the winter hardiness evaluations (number of dead plants and winter damage ratings) and plant vigor as the most vigorous cultivars generally seem to be the most winter-hardy ones. Correlation coefficients for plant vigor vs. number of dead plants was 0.25, and for plant vigor vs. winter damage was 0.67, both highly significant at $p = 0.001$. Previous work has indicated a similar correlation in one trial with 33 cultivars (5) and another with 18 cultivars (2), and it has also been shown that vigorous, well rooted strawberry plants which have not borne fruit are injured less by freezing temperatures than young runner plants not well rooted (13). Although the use of rating scales in general is a subjective method, the use of a large number of replications (nine in this study) greatly diminishes variation due to experimental error. The results of the subjective evaluations revealed significant differences in winter hardiness, as well as differences in vigor among strawberry cultivars, and confirmed a significant correlation between the two characteristics that contribute to winter survival.

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Predicting Kiwifruit Fruit Maturation

In New Zealand 6.2% soluble solids must be reached before harvesting kiwifruit and temperature regimes over 3 years in 6 production regions were compared. The date reaching 6.2% varied by 34 days over sites and years. The coolest site was earliest and the warmest site was the latest. Several models were developed to predict harvest date and all three performed better than a linear regression model based on mean temperature for the first growth period and the date at which regression model 5.0% SSC was reached. From Hall and McPherson. 1997. J. Hort. Sci. 72(6):949-960.