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(15 minutes per tree) is more time expensive compared to the Electroflor (4 minutes per tree) and hence not affordable for farmers.

Both treatments with fungicides, sulphur (3.0%) and lime sulphur (2.5%) reduced the flower infestation by *M. laxa* compared to the control (16.9%) and the untreated hand thinning variant of young fruits (13.3). We found no differences in the percentage of marketable fruits between the variants (table 5).

Regarding fruit quality characteristics in the treated variants no important differences could be found compared to the control (data not shown).

Conclusions

- Late pruning of fruit branches during blossom on trees of early ripening cherry cultivars reduced growth and yield without increasing fruit size and fruit quality.
- Mechanical thinning of flowers of early ripening cherry cultivars with Electroflor increased the single fruit weight and had also an effect on some fruit quality characteristics.
- Some treatments (Electroflor, manual thinning of young fruits, lime sulphur, ATS) showed a strong thinning effect and an increase of fruit size on the cultivars 'Blaze Star' and 'Merchant'. Nevertheless, yield losses due to lower number of fruits caused by thinning could only partly be replaced through the larger fruit size. Looking at the tested mechanical variants, the Electroflor is more suitable for farmers than hand thinning of flowers or fruits because of lower time need. The treatments with lime sulphur and wettable sulphur showed a reducing effect on flower infestations with *Monilinia laxa*. No influence on fruit diseases and internal fruit quality could be found due to the treatments.

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Black and red currant cultivars for organic production

H. Lindhard Pedersen[1] and L. Andersen[2]

Abstract

*Organic or unsprayed production of black currants (*Ribes nigrum*) and red currants (*Ribes rubrum*) needs cultivars which are resistant or less susceptible to the most common pests and diseases like powdery mildew (*Sphaerotheca mors-uvae*) and leaf spot (*Gloeosporidiella ribis*). The aim of this study was to find promising less disease susceptible, high-yielding cultivars with an acceptable juice quality for organic production. 13 black currants and 10 red currants were evaluated in 2009 to 2011 in Denmark. The black currant cultivar 'Narve Viking' was the best cultivar for organic production. 'Narve Viking' had high yields, good juice quality and resistance to pests and diseases. However; also the more disease susceptible cultivars 'Ben Lomond', 'Ben Hope' and 'Ben Tirran' had high yields and good juice quality when grown unsprayed.*

The red currant cultivar 'Red Poll' had the highest yield, the best juice quality and was most resistant to diseases when grown unsprayed. 'Roodneus' also had a high yield, acceptable juice quality and disease resistance.

Keywords: Unsprayed, yield, susceptibility to pests and diseases, juice quality, industrial use.

Introduction

Organic or low pesticide production of black currants (*Ribes nigrum* L.) and red currants (*Ribes rubrum* L.) for industrial use needs cultivars which are resistant or less susceptible to the most common pests and diseases like American gooseberry mildew (*Sphaerotheca mors-uvae* Schweinitz), leaf spot (*Gloeosporidiella ribis* Libert), white pine blister rust (*Cronartium ribicola* J.C. Fischer) and black currant gall mite (*Cecidophyopsis ribis* Westwood) or reversion virus (*Atavismus*). Disease infections may cause an early leaf drop followed by reduced yield (Lindhard Pedersen, 1998).

The cultivars must also be suited for mechanical harvest and obtain a satisfying juice quality for industrial use. To achieve a satisfying colour in black currant jam or juice a minimum level of 300 mg malvidine chloride per 100 gram berries must be reached and a level of 130 mg per 100 gram berries of ascorbic acid is important to ensure the healthiness of the product (Kaack and Groven, 1981).

In an earlier study the results from the first two fruiting years, 2005 and 2006 from an unsprayed trial including 13 black currants and 10 red currants were reported (Lindhard Pedersen, 2007). The conclusion was that the black currant cultivars 'Narve Viking', 'Tiben', 'Ben Hope' and maybe 'Ben Gairn' and the red currant cultivars 'Rolan' and maybe also 'Augustus' were promising new cultivars for organic or low pesticide production of currants.

The aim of this study was to follow up on these cultivars and to investigate if the promising less disease susceptible, high-yielding cultivars of black and red currants suited for organic industry production were the same when the planting grew older.

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Material and Methods

In April 2003 at Department of Food Science, Aarslev, 13 black- and 10 red currant cultivars, respectively, were planted as one-year-old plants at a planting distance of 3.5 x 0.5 m. Plots consisted of 6 bushes per cultivar planted in three blocks and totally randomised inside each block for black and red currants. Planting was done in Mypex™ in the bush row and grass was established in the alleyways. Plants were irrigated the first two years after planting and manuring was done using poultry manure pellets due to leaf analyses. Plants were kept unsprayed from planting and until 2011.

Black currant gall mite and reversion spread by the mite are severe pests of black currants. Big buds infested with gall mites were removed from the planting two to three times during each winter by hand to try to control the pest.

Harvest time and machine harvested yield and berry size were recorded in 2009, 2010 and 2011. Scores for foreign elements in the harvested product, vegetative annual growth, leaf healthiness and infections of occurring pests and diseases were carried out in June and August in 2009-2011 on a scale from 1-9, where 1= nothing. Samples of the harvested berries were collected for analysing of the fruit juice. Samples were stored frozen and analysed in winter. 200 grams of berries were homogenised with 100 g distilled water and the content of soluble solids was analysed with refractometer (Bellinngham + Stanley LTD. RFM 330). Content of total titrable acid was measured according to Kaack (1988). Total acids were converted to citric acid, which is dominating in black currants. Content of total anthocyanins was analysed with spectrophotometer (Shimadzu MPS 2000,) according to Wrolstad (1976). Statistical analyses of data were performed using SAS (Version 9 www.sas.com). Differences among cultivars were analysed with GLM-procedure. Means were separated with Duncan's test and statistical significance was defined at $p< 0.05$.

Results

The black currant cultivars 'Narve Viking', 'Ben Lomond', 'Ben Hope' and 'Ben Tirran' had the highest yields (Table 1). 'Ben Lomond' and 'Ben Avon' had the biggest berries and 'Ben Gairn' had the cleanest product. The highest content of soluble solids (sugar) was obtained by the cultivars 'Baldwind and 'Titania'. 'Ben Tirran' and 'Tiben' had the highest level of acid and 'Ben Gain' had the highest content of colour in the juice (Table 1). The harvest was carried out in second half of July and the beginning of August. 'Ben Gain' was the earliest cultivar and 'Baldwind' the latest (Table 1).

The black currant cultivars 'Titania', 'Tiben' and 'Narve Viking' had the strongest growth and together with 'Ben lomond' the healthiest looking green leaves in June (Table 2). 'Ben Avon' was most susceptible to aphids and 'Baldwin' and 'Ben Lomond' to mildew (Table 2). In August white pine blister rust developed 'Narve Viking' and 'Ben Dorain' were the most susceptible cultivars. Whereas 'Baldwin', '8944-4' and 'Ben Lomond' were most susceptible to leaf spot. Due to disease infection the leaf healthiness was reduced in August. The cultivars 'Narve Viking' and 'Ben Gairn' maintained the best looking healthy leaves in August (Table 2). No other important pests or diseases occurred during the three years.

The highest-yielding red currant cultivars were 'Red Poll', 'Roodneus', 'Rovada', 'Augustus', 'Rolan' and 'Tatran' (Table 1). 'Rovada', and 'Rosetta' had the biggest berries and juice of 'Rondom' had the highest sugar content followed by 'Red Poll'. 'Red Poll' juice had the highest content of acid and colour.

The red currant cultivars 'Roodneus' and 'Red Poll' had the strongest growth and together with 'Rovada' the healthiest looking green leaves in June (Table 2). No severe infestation of aphids occurred. In June the cultivars 'Red Lake' and 'Red Start' already had an

infection of leaf spot and in late August all the leaves of these two cultivars had dropped due to a severe leaf spot infection (Table 2). All the cultivars had severe infections of leaf spot in August. The cultivars 'Red Poll', and 'Roodneus' had the most healthy looking leaves in August (Table 2). No other important pests or diseases occurred during the three years.

Table 1: Origin, harvest date, yield, berry size, foreign elements in the harvested product and soluble solids, citric acid and colour content of the juice in 13 cultivars of black currants and 10 cultivars of red currants in average of 2009-2011.

Black currants	Origin	Harvest	Yield	Berry size	Foreign elements in the harvested product	Soluble solids	Citric Acid	Colour, Malvidin Chloride
Cultivar	Country	Date	Tonne/ha	G/100 berries	Score 1-9 1=nothing	%	Mg/g	Mg/100g
Baldwind	Scotland	7 Aug	3.4 ef	60 e	5.4 a	18.0 a	34.6 h	441 g
Ben Alder	Scotland	3 Aug	5.7 bcd	62 e	4.7 b	16.4 g	36.1 f	691 b
Ben Avon	Scotland	26 Jul	6.1 bc	81 ab	5.0 ab	15.4 i	35.3 g	485 f
Ben Dorain	Scotland	27 Jul	4.3 cdef	63 e	4.3 bc	17.4 b	38.4 c	651 c
Ben Gairn	Scotland	21 Jul	4.1 def	74 cd	3.7 c	17.2 c	29.2 k	772 a
Ben Hope	Scotland	1 Aug	7.8 a	74 cd	4.8 ab	16.8 e	36.3 e	637 c
Ben Lomond	Scotland	2 Aug	8.8 a	84 a	5.0 ab	16.6 f	37.6 d	542 e
Ben Tirran	Scotland	3 Aug	7.4 ab	76 bc	4.3 bc	15.8 h	40.6 a	502 f
Narve Viking	Norway	3 Aug	8.9 a	70 d	4.7 b	15.5 i	29.6 j	638 c
Tiben	Poland	29 Jul	5.2 cde	77 bc	5.0 ab	17.0 d	40.4 a	640 c
Titania	Sweden	23 Jul	2.8 fg	76 bc	4.7 b	18.0 a	39.9 b	526 e
8944-4	Scotland	23 Jul	1.6 g	50 f	4.3 bc	15.0 j	25.1 l	498 f
8944-13	Scotland	23 Jul	4.8 cde	63 e	5.0 ab	14.1 k	31.5 i	598 d
Red Currants	Origin	Harvest	Yield	Berry size	Foreign elements in the harvested product	Soluble solids	Citric Acid	Colour, Malvidin Chloride
Cultivar	Country	Date	Tonne/ha	G/100 berries	Score 1-9 1=nothing	%	Mg/g	Mg/100g
Augustus	Holland	14 Aug	14.4 ab	40 e	5.0 ab	9.0 j	27.9 b	68 e
Red Lake	North America	4 Aug	0.8 d	33 f	4.0 d	10.4 h	25.2 e	67 e
Red Poll	England	7 Aug	17.3 a	53 cd	5.0 ab	13.2 b	30.2 a	123 a
Red Start	England	31 Jul	0.6 d	37 ef	3.8 d	10.3 i	27.7 d	63 f
Rolan	Holland	31 Jul	13.0 abc	57 bc	5.0 ab	12.6 d	21.4 g	71 c
Rondom	Holland	4 Aug	10.5 bc	50 d	5.1 a	13.6 a	23.8 f	71 c
Roodneus	Holland	7 Aug	15.4 ab	55 bcd	5.1 a	12.5 e	27.6 c	122 b
Rosetta	Holland	7 Aug	8.3 c	60 ab	4.6 c	12.1 f	21.0 h	59 g
Rovada	Holland	7 Aug	14.5 ab	63 a	4.7 bc	11.4 g	28.2 b	69 d
Tatran	Slovakia	9 Aug	12.5 abc	51 cd	5.1 a	12.7 c	27.5 c	67 e

Numbers followed by the same letter for the same species in columns do not differ significantly for $P \leq 0.05$.

Table 2: Scores for growth, leaf healthiness, infestations of aphids, infections of mildew, rust and leaf spot in 13 cultivars of black currants and scores for growth, leaf healthiness, infestations of aphids and leaf spot in 10 cultivars of red currants in average of 2009-2011.

Black currants	Growth, June	Leaf Healthiness June	Aphids, June	Mildew, June	Rust, August	Leaf Spot, August	Leaf Healthiness August
Cultivar	Score 1-9 1= no growth	Score 1-9 1= no leaves	Score 1-9 1= no infestation	Score 1-9 1= no infection	Score 1-9 1= no infection	Score 1-9 1= no infection	Score 1-9 1= no leaves
Baldwind	4.8 d	5.5 e	1.7 f	2.8 b	2.8 f	8.2 a	1.8 d
Ben Alder	4.7 d	6.2 d	2.7 bc	1.2 cd	3.9 de	6.4 cd	3.2 c
Ben Avon	6.2 c	6.6 c	3.3 a	1.1 cd	4.4 c	6.0 def	3.5 c
Ben Dorain	4.9 d	5.9 de	2.3 de	1.2 cd	5.1 ab	5.6 f	3.5 c
Ben Gairn	5.1 d	5.7 de	3.0 ab	1.0 d	3.0 f	4.2 g	5.1 a
Ben Hope	6.1 c	6.9 bc	1.7 f	1.0 d	4.7 bc	6.3 cde	3.3 c
Ben Lomond	6.0 c	7.1 abc	2.1 ef	3.1 a	3.5 e	7.3 b	2.1 d
Ben Tirran	5.8 c	6.7 c	2.2 de	1.2 cd	4.4 cd	6.4 cd	3.1 c
Narve Viking	6.4 abc	7.3 ab	2.0 ef	1.0 d	5.5 a	1.7 h	5.2 a
Tiben	6.8 ab	7.5 a	2.9 ab	1.2 cd	2.6 f	6.9 bc	3.4 c
Titania	6.8 a	7.1 abc	2.8 bc	1.0 d	1.0 h	5.7 ef	4.2 b
8944-4	4.8 d	4.8 f	2.5 cd	1.0 d	2.0 g	7.3 b	3.0 c
8944-13	5.9 c	6.9 bc	2.5 cd	1.3 c	2.7 f	6.6 cd	4.1 b
Red Currants	Growth, June	Leaf Healthiness, June	Aphids, June	Leaf Spot, June		Leaf Spot, August	Leaf Healthines, August
Cultivar	Score 1-9 1= no growth	Score 1-9 1= no leaves	Score 1-9 1= no infestation	Score 1-9 1= no infection		Score 1-9 1= no infection	Score 1-9 1= no leaves
Augustus	5.4 bc	7.1 cd	1.2 abc	2.3 b		8.6 ab	1.4 de
Red Lake	3.9 e	4.4 g	1.3 abc	3.1 a		.	1.0 e
Red Poll	6.4 a	7.6 ab	1.6 a	1.5 de		6.7 d	3.2 a
Red Start	4.1 e	3.9 h	1.3 abc	2.9 a		.	1.0 e
Rolan	4.7 d	6.7 ef	1.2 bc	1.6 de		8.8 ab	1.7 d
Rondom	5.6 bc	7.3 bc	1.5 ab	1.8 cd		7.7 c	2.6 bc
Roodneus	6.6 a	8.0 a	1.4 abc	1.6 de		7.1 d	3.0 ab
Rosetta	4.8 d	6.3 f	1.1 c	1.3 e		8.3 bc	2.3 c
Rovada	5.9 b	7.8 a	1.1 c	2.0 c		9.0 a	1.1 e
Tatran	5.2 cd	6.7 de	1.4 abc	1.6 de		8.3 bc	1.8 d

Numbers followed by the same letter in columns do not differ significantly for P≤0.05

Discussion

The highest yielding Norwegian cultivar 'Narve Viking' was also the highest yielding cultivar when the planting was young (Lindhard Pedersen, 2007). The Scottish cultivar 'Ben Hope' was also among the highest yielding cultivars both as young and older plants, whereas 'Ben Lomond' and 'Ben Tirran' were more on the average (Lindhard Pedersen, 2007). The four highest yielding cultivars also had satisfactory juice quality and strong growth in the period. Especially 'Narve Viking' was rather resistant to the common diseases and kept the healthy green leaves until late August. 'Ben Hope' is a promising cultivar for organic production as it is resistant to gall mites. However, it is more susceptible to leaf spot than 'Narve Viking'. The two cultivars 'Tiben' and 'Ben Gairn', which were promising as young plants (Lindhard Pedersen, 2007), had rather low yields in 2009 to 2011 (Table 1). 'Ben Gairn' is an interesting cultivar for organic production as it is resistant to the reversion virus. In 2009 it had a good juice quality with high sugar and very high colour content and 'Ben Gairn' is also rather resistant to the common diseases. However, it had a low yield. 'Ben Lomond', 'Ben Hope' and 'Ben Tirran' had high yields even they were rather susceptible to diseases (Tables 1 and 2).

'Titania' and 'Ben Alder' were earlier recommended for organic production (Lindhard Pedersen 1998), but in this investigation and in Lindhard Pedersen (2007) the yielding of 'Titania' was very low. Ben Alder is no longer among the highest yielding cultivars. 'Ben Alder, had a satisfactory juice quality, but the leaf healthiness was rather low and it was susceptible to rust and leaf spot.

'Ben Lomond' and 'Ben Tirran' are two rather old Scottish cultivars, which are used in conventional production in Denmark. Unsprayed they are among the highest yielding cultivars and have a satisfactory juice quality. Their leaf healthiness was not very good and 'Ben Lomond' was one of the most susceptible cultivars to mildew and leaf spot. Only the variety 'Baldwind' was more susceptible. Despite that 'Ben Lomond' and 'Ben Tirran' were rather high-yielding, this was also found by Lindhard Pedersen (1998).

The red currant cultivars 'Roland', 'Rovada' and 'Augustus' were promising cultivars for organic production when the plants were young (Lindhard Pedersen 2007). Also in this evaluation these three cultivars are among the highest yielding. However, these cultivars were very susceptible to leaf spot and had poor leaf healthiness in August (Table 1 and 2). The highest yielding cultivars over time were 'Red Poll' and 'Roodneus'. These cultivar also had a fine juice quality with high sugar and acid content and the highest content of colour and the best looking leaves and the lowest susceptibility to leaf spot.

Conclusion

The black currant cultivar 'Narve Viking' was the best cultivars for organic production. This cultivar had high yield, good juice quality and resistance to pests and diseases. But also the more disease susceptible cultivars 'Ben Lomond', 'Ben Hope' and 'Ben Tirran' had high yields and good juice quality when grown unsprayed.

The red currant cultivar 'Red poll' had the highest yield, the best juice quality and was most resistant to diseases when grown unsprayed. 'Roodneus' also had a high yield and acceptable juice quality and disease resistance.

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Breeding of resistant strawberry cultivars for organic fruit production – Diallel crossing strategies and resistance tests for *Botrytis cinerea* and *Xanthomonas fragariae.*

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Abstract

Organic strawberry production suffers from high yield losses caused by numerous fungal and bacterial diseases. Two of the most important diseases are the grey mould disease caused by Botrytis cinerea *Pers. (teleomorph* Botryotinia fuckeliana*), and the bacterial angular leaf spot disease caused by* Xanthomonas fragariae *(Kennedy & King). Beside cultivation methods and organic plant protection measures, the development of resistant cultivars seems to be the most promising strategy in order to improve the productivity in organic strawberry cultivation. Therefore, we established resistance tests to determine resistant and susceptible strawberry cultivars and breeding selections. In a first run, 40 different cultivars and selections were tested for their susceptibility towards* B. cinerea *by artificial inoculation of fruits and leaves and evaluation of the disease symptoms. Plants of 40 cultivars were tested for susceptibility to* X. fragariae *by artificial inoculation in the greenhouse. In a diallel crossing approach, 12 commonly cultivated strawberry cultivars have been crossed reciprocally and propagated in a field trial. Important characteristics of the progeny such as ripening time, yield, morphological traits and occurrence of diseases have been evaluated for a period of two consecutive years and lead to the determination of general (GCA) and specific (SCA) combining abilities. Together with the results of the resistance tests we identified a set of genotypes that show resistant characteristics towards* B. cinerea *and might be suitable for use in organic cultivation systems. Furthermore, they can be used for targeted breeding experiments in the future.*

Keywords: *Fragaria* × *ananassa*, grey mould, angular leaf spot, combining ability

Introduction

The necrotrophic fungus *B. cinerea* causes severe damage in a broad spectrum of host plants (Elad *et al.*, 2007; Williamson *et al.*, 2007) and the control requires high efforts especially in organic farming (Boff *et al.*, 2001) due to the fact that botryticides are not permitted. Warm temperatures and high humidity lead to a high rate of sporulation (Sosaalvarez *et al.*, 1995). Hence, the released conidia are spread widely by wind and cause infections of flowers, leaves and fruits. Once the conidia germinated in strawberry flowers, the mycelial growth is temporarily suppressed by high levels of the Flavan-3-ols Catechin, Epicatechin and Proanthocyanidin (Puhl & Treutter, 2008). The content of those substances decreases during ripening of the fruits and the fungus continues its life cycle. Due to the fact that there are numerous factors influencing the disease progress and the pathogen reacts in a rather unspecific way, there are no incidences for a monogenic

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