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Susceptibility of highbush blueberry (*Vaccinium corymbosum L.)* cultivars to Godronia canker (*Godronia cassandrae* f. sp. *vaccinii*) in Norway

Anfälligkeit von Sorten der Amerikanischen Blaubeeren für Godronia Krebs

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Summary

Godronia canker, caused by the fungus *Godronia cassandrae* f. sp. *vaccinii*, was detected for the first time on highbush blueberry (*Vaccinium corymbosum*) in Norway in 1995, and has caused severe stem wilting and dieback of young bushes. The disease was investigated over five years (1995-1999) in two experimental plantings, and in a survey carried out in 51 highbush blueberry plantings in Norway during the summer of 1998. Altogether, 31 cultivars were included in the investigations. None of the cultivars were completely resistant, but there were great differences in susceptibility. 'Goldtraube' and 'Hardyblue' were the most resistant cultivars, but 'Bluetta' and 'Patriot' also seemed to have low susceptibility to Godronia canker. 'Ama', 'Heerma' and 'Spartan' had low to moderate susceptibility, 'Berkeley', 'Bluecrop', 'Duke' and 'Ivanhoe' had moderate to high susceptibility, and 'Blueray', 'Collins', 'Earliblue', and 'Jersey' were most susceptible. The latter four should not be recommended for highbush blueberry production in the cool, wet climate of Norway.

Zusammenfassung

Die ersten Plantagen mit Sorten der Amerikanischen Blaubeere wurden in Norwegen 1988 angepflanzt. Begleitet von einem Fünfjahres-Forschungsprojekt an der Landwirtschaftlichen Universität in Ås, entstanden in den südlichen Anbaugebieten bis heute Anbauflächen von etwa 30 ha.

Nach wenigen Jahren zeigte sich der Befall von Jungpflanzen und etablierten Kulturen mit *Godronia cassandrae* f. sp. *vaccinii* als begrenzender Faktor des Anbaus von *V. corymbosum*-Sorten in Norwegen.

Da keine wirksamen Fungizide verfügbar sind, ist eine Befallsbegrenzung nur durch die Auswahl von Sorten mit geringerer Anfälligkeit, Propfung und Pflanzenhygiene gegeben.

Im folgenden Beitrag wird über unterschiedliche Anfälligkeit von Sorten der Amerikanischen Blaubeere gegen *Godronia* in Norwegen berichtet.

Introduction

The first commercial planting of highbush blueberry (*Vaccinium corymbosum* L.) was established in Norway in 1988. A five-year research project was started in the same year at the Agricultural University of Norway (AUN), and many cultivars of highbush blueberry were planted to study their performance in the cool climate of the country (VESTRHEIM et al. 1997). Since then, many growers in the southern regions of the country have established plantings of highbush blueberry. Today there are approximately 30 hectares of highbush blueberry in Norway (VESTRHEIM et al. 1997). The normal temperature for the months May to September in regions where highbush blueberries are planted, is 12–14 °C, and the annual precipitation varies between 500 and 2000 mm. The highbush blueberry reaches full bloom during the first part of June, and harvesting is carried out from the end of July through September to early October, depending on the cultivar and the climate of the area.

It was assumed that low winter temperatures, often poor snow cover, and a short growing season would be the most limiting factors for highbush blueberry production in Norway (VESTRHEIM et al., 1997). After a few years it became evident that it was often difficult to establish highbush blueberry fields because of wilt of stems and death of young bushes caused by the fungus *Godronia cassandrae* (Peck) f. sp. *vaccinii* Groves (conidial stage: *Topospora myrtilli* Feltg., syn. *Fusicoccum putrefaciens* Shear) (STENSVAND and LANGNES 1995). *G. cassandrae* has been described on many different hosts (GROVES 1965, SMERLIS 1968). It has been found in wild growing *Vaccinium* species (*V. myrtillus, V. vitis-ideae*) and *Calluna vulgaris* in Norway (ERIKSSON 1970). It is a specialised form of the species that infects *Vaccinium* (GROVES 1965). Earlier reports show that Godronia canker has caused severe damage to highbush blueberry in cool, humid regions of Europe and North America (CREELMAN 1958, ZUCKERMAN 1960, LIEBSTER 1979), which suggests that the pathogen should be well adapted to the Norwegian climate.

The fungus overwinters as mycelium in living stems and crowns of the bushes (CREELMAN 1958). It is the imperfect stage of the fungus that is important for spreading of the disease (MELZER and HOFFMANN 1980a), and the perfect stage has never been reported from European countries. Pycnidia are visible in the lesions from early spring and throughout the growing

season. Conidia produced in the pycnidia are dispersed in rainwater and serve as inoculum. Inoculation studies indicate that the infections mainly occur in the autumn and spring (McKEEN 1958, LOCKHART and CRAIG 1967, WEINGARTNER and KLOS 1969). Infections are often localised at leaf scars, but the fungus is also capable of penetrating intact tissue in one- and two year old wood (WEINGARTNER and KLOS 1975b). Most lesions occur near ground level (CREELMAN 1958), but lesions may also be located higher up on the stems. On young stems the lesions first appear as reddish spots, and as they enlarge, the margins remain reddish while the bark in the middle turns grey (CREELMAN 1958). Sometimes the lesions show different bands of red to dark brown colours encircling the locus of infection (ZUCKERMAN 1960). Complete girdling of stems by the lesions will cause wilting above the infection site. The disease is of particular importance in young plantings as it inhibits growth and development. Although older plants are rarely killed, the disease may cause major yield losses in well established plantings (McKEEN 1958).

There are no fungicides available proved to be effective in controlling Godronia canker. Control has for the most part been based on pruning and removal of diseased stems. However, it is difficult to find all the diseased stems in a field, thus this control measure is not sufficient alone (PARKER and RAMSDELL 1977).

Several reports have shown that cultivars differ in susceptibility. Thus, growing cultivars with low susceptibility would apparently be important as a preventive control measure. Observations have indicated that susceptibility can vary between sites, as it has been experienced that a certain cultivar can be heavily infected in one region, while it appears to be much more resistant in another (McKEEN 1958, WEINGARTNER and KLOS 1975a, MENZINGER and KRUPP 1977, LIEBSTER 1979). The objective of the present work was to investigate the susceptibility of highbush blueberry cultivars planted in Norway to Godronia canker. This work was part of a thesis at AUN (STRØMENG 1999).

Materials and Methods

Two fields of highbush blueberries were planted adjacent to each other at AUN, Ås. One field was established in 1990, the other one in 1993. The 1990 planting consisted of seven cultivars; 'Bluecrop', 'Blueray', 'Bluetta', 'Collins', 'Earliblue', 'Hardyblue' (previously called 13-16-A), and 'Patriot'; and the 1993-planting of eight cultivars; 'Ama', 'Berkeley', 'Bluechip', 'Bluejay', 'Duke', 'Goldtraube', 'Heerma', and 'Spartan'. Each field was planted in a randomised block design, with four replicates, each containing four plants. The 1990 field was established on ground level, while the 1993 field was established on raised beds. Bark was used as mulching material, and watering was carried out by drip irrigation. The cultivars in both fields were propagated by seedlings and imported from Germany as 3–4 year old plants.

During 1995–1999, Godronia canker was recorded once each year before full bloom, either at the end of May or in early June. No pruning was carried out prior to assessments. In each of the four replicates of each cultivar, ten one year old stems were examined for infections. Stems coming from the base of the bushes were preferred, but in some cultivars growth of new stems from the base was limited, and then new shoots coming from higher positions were included. The number of infected stems and the total number of lesions with Godronia canker were recorded. Lesions less than 0,5 cm in length were neglected, as it was impossible to decide whether they were caused by *G. c. vaccinii* or not by examining them in the field. Individual plants, and even whole replicates of some cultivars did not survive all years of assessments, or the stems were wilted to the ground in spring due to frost or damage by Godronia canker (but with regrowth occurring from the ground). To confirm significant differences in susceptibility to Godronia canker between the cultivars, analysis of variance was carried out, using the SAS procedure GLM (ANONYMOUS 1985). Least significant differences (LSD 5%) were calculated between means of each cultivar.

The other part of the study was carried out during the time from April to August in 1998, when 51 fields (altogether 31 cultivars) of highbush blueberry were visited in southern Norway. The fields (number of fields in brackets) were in the following counties (Fig. 1): Østfold (4), Akershus (8), Buskerud (3), Vestfold (1), Telemark (1), Aust- Agder (4), Vest-Agder (6), Rogaland (1), Hordaland (6), Sogn og Fjordane (16), and Møre og Romsdal (1). The field size was 0,1–0,3 hectares. They were established on ground level or raised beds. Mulching material, either bark, polyethylene, woven polyethylene, or sawdust, was applied in some fields, but many fields had no mulches. Grass covers between the plant rows were common, but a few fields were clean cultivated. In some cases overhead irrigation was practised, however, watering was generally carried out by drip irrigation. There were differences from field to field concerning practice of pruning, fertilisation and weed control. Origin of the plant material differed, and cultivars planted up to 1995 were mainly propagated by seedlings and imported from Germany or The Netherlands as 2–3 year old plants. Later, the main planting material used was micropropagated plants imported from Finland or USA.

Godronia canker was recorded on ten one-year old stems in three replicates, each replicate containing three bushes planted next to each other in the row. The position of the replicates were chosen randomly in the field. Due to poor growth and/or few plants of certain cultivars in some fields, it was sometimes necessary to include more than three bushes in one replicate, and/or have less than three replicates of a certain cultivar. Lesions on the stems were recorded in the same manner as in the field at AUN. It should be noted that in the survey assessments in 1998, the field at AUN was also included. The means of each cultivar in each field were calculated. Based on these means, overall means and standard error of the means were calculated for each cultivar.

Results and Discussion

There were great differences among the cultivars in their susceptibility to Godronia canker, although none of the cultivars had full resistance.

In the field at AUN planted in 1990, the cultivars 'Hardyblue, 'Patriot, and 'Bluetta had significantly

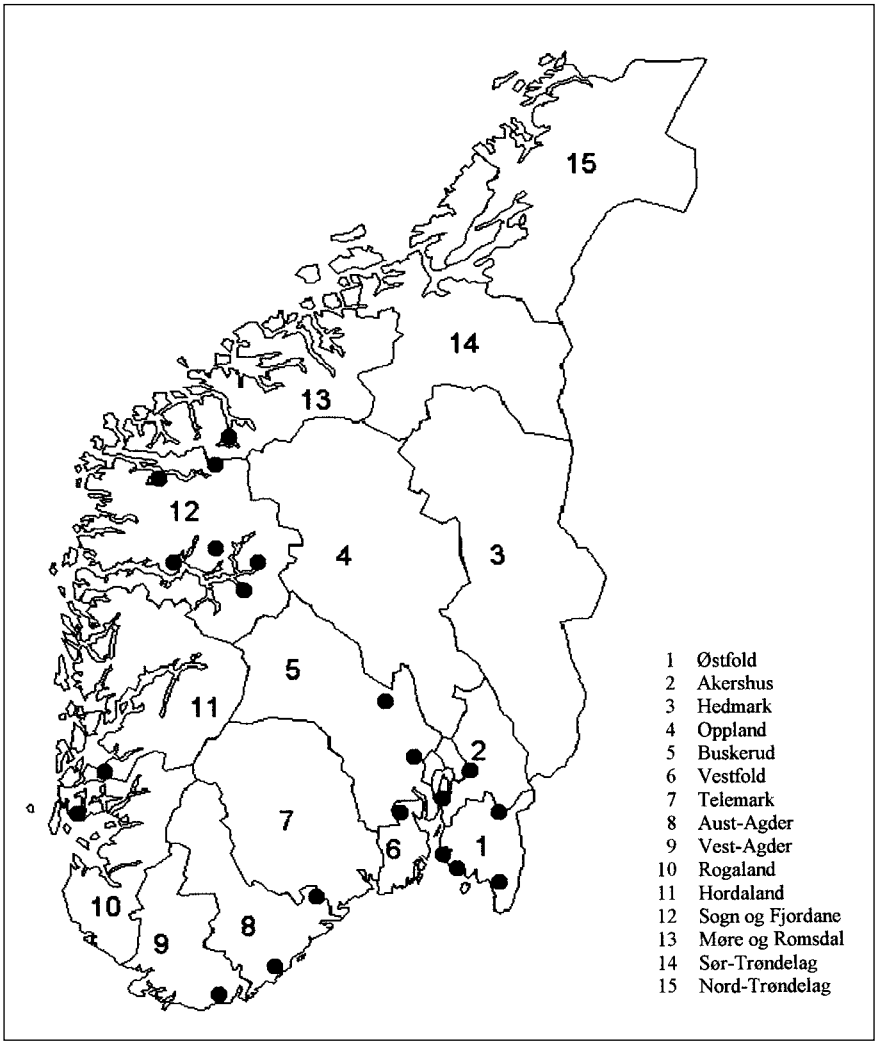


Fig. 1. Areas in southern Norway (black dots) where fields of highbush blueberry were assessed for attack by *Godronia cassandrae* f. sp. *vaccinii* in 1998. The different counties are numbered 1–15 (Map source: Statens kartverk, Hønefoss, Norway).
Anbau von Sorten der Amerikanischen Blaubeere in Südnorwegen (schwarze Punkte) zur Erhebung des Befalls mit G. cassandrae f. sp. Vaccinii.

fewer infected stems and fewer infections in total than the cultivars 'Bluecrop', 'Blueray', 'Collins', and 'Earliblue' (Tab. 1). In the field at AUN planted in 1993, the highest mean number of lesions was found in 'Duke' (Tab. 2). The cultivars could not be placed in specific groups like cultivars in the 1990 field. There were no differences between the cultivars in the first year of assessments (1995). However, in the overall results (1995–1999), 'Goldtraube' was significantly less infected than any of the other cultivars. 'Heerma' had fewer infected stems and fewer lesions in total than 'Duke', 'Bluechip' and 'Berkeley'. Both 'Ama' and 'Spartan' had fewer infected stems than 'Duke' and fewer lesions in total than 'Duke', 'Bluechip' and 'Berkeley', and 'Bluejay' had fewer lesions than 'Berkeley'.

The survey of plantings in 1998 showed that the disease was present in 35 out of 51 fields. None of the diseased fields were established later than 1995. Godronia canker was found in all counties where fields were examined (Fig. 1), but the damage was most severe in Akershus and Østfold counties, and in a few fields in Aust-Agder and Vest-Agder counties. The disease was absent in 16 fields, of which 13 were established in Sogn og Fjordane county in 1997 and 1998 (these 13 fields were not included in the analysis of the results below). The remaining three fields were located in Aust-Agder (two fields, planted in 1995 and 1996) and Sogn og Fjordane counties (planted in 1995).

For the 1998 survey, the overall means of infections for the fifteen most commonly planted cultivars are shown in Tab. 3. The total number of stems examined of each cultivar varied from 90 to 680. 'Goldtraube', 'Hardyblue', and 'Spartan' were the least infected cultivars. For 'Goldtraube' and 'Hardyblue', the results of the 1998 survey fit well with the observations at AUN. 'Spartan' and 'Hardyblue' were heavily attacked in one field each, but wilting of bushes in these cultivars was never observed. 'Hardyblue' showed vigorous growth in all fields, and also proved to be winter hardy. 'Spartan' blooms late and fruit early (PRITTS and HANCOCK 1992), and this should make it suitable for growing in Norway. Bushes of 'Goldtraube' had wilted in one field early in the summer. Cankers were found on wilted stems, so it is possible that Godronia canker caused the wilting. On the other hand, 'Goldtraube' proved highly resistant in a European cultivar trial (LIEBSTER 1979), where the two selections 53 and 71 suffered no losses due to Godronia canker while many other cultivars were severely attacked. It is not known which selections of 'Goldtraube' that are planted in Norway.

Table 1. Infections of *Godronia cassandrae* f. sp. *vaccinii* in 7 cultivars of highbush blueberry at the Agricultural University of Norway, Ås, planted in 1990. The infections were recorded either in late May or early June during 1995–1999 as number of infected stems and number of lesions per stem. Each number is mean of 10 one year old stems and 4 replicates.
Infektion mit G. cassandrae an fünf bis neun Jahre alten Pflanzen von sieben Sorten der Amerikanischen Blaubeere. Die Boniturwerte beziehen sich auf die Anzahl infizierter, einjähriger Sprosse und die Anzahl Lesionen an diesen Sprossen. Die Angaben sind Mittelwerte aus zehn Bonituren und vier Wiederholungen

	1995		1996		1997		1998		1999[2)]		1995–1998	
Cultivar	Stems	Lesions	Stems	Lesions	Stems	Lesions	Stems	Lesions	Stems	Lesions	Stems	Lesions
Patriot	3,50	6,00	3,25	3,75	3,00	4,50	4,25	8,25	2,00	2,50	3,50	5,63
Bluetta	4,75	7,50	1,25	1,25	4,75	6,00	3,75	5,50	3,25	4,25	3,63	5,06
Hardyblue	4,00	5,25	0,75	0,75	5,75	12,25	4,00	5,75	3,00	4,75	3,63	6,00
Bluecrop	7,50	12,75	6,25	11,50	6,25	18,25	7,50	16,00	6,00	14,25	6,88	14,63
Earliblue	7,50	16,50	5,75	9,25	7,75	17,00	8,50	31,75	9,50	21,00	7,38	18,63
Collins	8,00	15,50	8,00	14,75	9,00	18,00	7,75	15,75	10,00	14,00	8,19	16,00
Blueray [1)]	9,33	15,67	8,00	10,00	6,00	16,33	9,50	26,50	9,50	30,00	8,21	17,13
F-test	**	**	**	**	*	*	*	**			***	***
LSD 5%	2,65	5,90	3,20	6,36	3,06	9,53	3,22	12,45			1,40	4,21

n.s.=not significant, *=p≤0,05, **=p≤0,01, ***=p≤0,001
[1)] 'Blueray' was recorded in only 2 replicates in 1996 and 1998, and is left out of the statistical analysis in those years. In 1995 and 1997 it was recorded in 3 replicates.
[2)] The assessments of 1999 are left out of the statistical analysis because of only 2 replicates in the cultivars 'Blueray', 'Collins', and 'Earliblue'.

'Blueray', 'Earliblue' and 'Jersey' were the most infected cultivars in the survey. Dead bushes and bushes about to wilt from attack by Godronia canker were observed in all these cultivars. 'Earliblue' and 'Jersey' are considered highly susceptible in Europe (LIEBSTER and SPRAU 1970) and North America (LOCKHART and CRAIG 1967). 'Blueray' was heavily infected in a European cultivar trial (LIEBSTER 1979), but in Nova Scotia, Canada it was described as only moderately susceptible (LOCKHART and CRAIG 1967). As 'Blueray' proved to be highly susceptible at AUN and in the 1998 survey, the cultivar cannot be recommended in Norway.

In the 1998 survey, 'Collins' and 'Bluecrop' came closest in susceptibility to the three most severly attacked cultivars. 'Bluecrop' was the most commonly planted cultivar in all regions of the country where highbush blueberry is grown. Wilted bushes of both 'Bluecrop' and 'Collins' were observed in some fields, and cankers were visible on the dead stems, indicating that Godronia canker was the cause of the wilting. However, there were fields where 'Bluecrop' managed well despite the presence of *G. c. vaccinii*. Due to high susceptibility to Godronia canker, 'Collins' was not recommended for growing in Scotland (CORMACK 1979). LIEBSTER and SPRAU (1970) described 'Bluecrop' as a susceptible cultivar, and placed it in the same group as 'Collins', 'Berkeley', 'Blueray' and 'Earliblue'. This is also in accordance with the observations over five years at AUN (Tab. 1).

'Heerma', 'Patriot', 'Duke', 'Berkeley', 'Ivanhoe', 'Ama', and 'Bluetta' were clearly less attacked than 'Bluecrop' and 'Collins' in the 1998 survey, with 'Heerma' having the highest number of infected stems and 'Bluetta' the lowest. In four fields 'Patriot' was heavily infected, but still the bushes seemed to grow vigorously. In one field where Godronia canker was severe, 'Patriot' was the only surviving cultivar (other cultivars were 'Bluecrop', 'Blueray', and 'Collins'). In Germany, 'Patriot' was considered to have low susceptibility to Godronia canker (LIEBSTER 1980). Like 'Patriot', 'Bluetta' had high numbers of lesions in a few fields, but in most fields there was no or very little attack. However, the cultivar seemed to suffer from winter damage, and should probably not be recommended in Norway. 'Heerma', 'Duke', 'Berkeley', and 'Ama' were severely infected only at AUN. However, 'Berkeley' often showed a general decline in vigour. It is not known whether this was caused by the pathogen or not. In Germany this cultivar was found to have more than 30% diseased plants in a field, and was one of the most diseased cultivars (MENZINGER and KRUPP 1977). 'Berkeley' was reported to be moderately susceptible in Canada (LOCKHART and CRAIG 1967). Susceptibility to Godronia canker has been found in all ancestors of 'Duke', including 'Earliblue' and 'Berkeley'. This suggests that 'Duke' may have high susceptibility as well. In one field, plants of 'Ama' and 'Heerma' had wilted early in the summer 1998. Cankers on the dead stems indicated that Godronia canker had caused the wilting. Dieback of whole plants of these two cultivars was not observed in any other fields. In the European trial 'Heerma' was little affected by the fungus (LIEBSTER 1979). On the other hand, MENZINGER and KRUPP (1977) reported that in a field in Germany the cultivar had a high incidence (>30%) of diseased plants. No reports have been found on susceptibility to Godronia canker in 'Ama'. The 1998 survey indicated that 'Ama' was slightly more resistant than 'Heerma', but at AUN there were no significant differences between the two cultivars. The large European trial showed that 'Ivanhoe' was among the most susceptible cultivars (LIEBSTER 1979), but in Norway it was only lightly affected. It should be mentioned though, that this cultivar was not planted at AUN, where the inoculum level in the field probably was higher than in most other fields examined.

The other cultivars examined in the 1998 survey, but not presented in Tab. 3, were planted in only one or two fields, which made it difficult to assess their sus-

Table 2. Infections of *Godronia cassandrae* f. sp. *vaccinii* in 8 cultivars of highbush blueberry at the Agricultural University of Norway, Ås, planted in 1993. The infections were recorded either in late May or early June during 1995–1999 as number of infected stems and number of lesions per stem. Each number is mean of 10 one year old stems and 4 replicates.
Infektionen mit G. cassandrae an zwei bis sechs Jahre alten Pflanzen von acht Sorten der Amerikanischen Blaubeere. Weitere Angaben s. Tab. 1.

	1995		1996		1997		1998		1999		1995–1999	
Cultivar	Stems	Lesions	Stems	Lesions	Stems	Lesions	Stems	Lesions	Stems	Lesions	Stems	Lesions
Goldtraube	4,50	5,50	1,25	1,25	3,75	5,00	2,75	3,25	2,33	3,33	2,90	3,65
Heerma	7,25	9,75	4,75	6,75	3,50	4,50	5,50	10,00	3,67	5,33	4,95	7,25
Spartan	5,25	8,75	4,75	4,75	6,50	9,25	5,50	7,50	4,75	7,75	5,35	7,60
Ama	7,50	9,50	7,00	7,25	4,00	5,75	4,25	6,50	5,50	8,50	5,65	7,50
Bluejay[1)]	5,50	6,25	4,25	5,50	6,75	14,75	6,50	14,25	5,00	10,00	5,68	9,58
Berkeley[1)]	7,25	10,75	6,25	11,25	5,50	10,50	5,25	12,25	6,50	17,00	6,32	13,58
Bluechip	6,25	7,75	5,50	8,50	7,50	13,25	6,75	14,25	6,75	18,50	6,55	12,45
Duke[2)]	8,00	10,33	6,00	9,00	7,75	11,00	7,50	13,75	4,67	12,00	6,88	11,35
F-test	n.s.	n.s.	*	*	**	*	n.s.	*	*	*	*	***
LSD 5%	3,18	5,37	3,15	4,94	2,35	5,46	3,42	7,52	2,73	12,26	1,22	3,04

n.s.=not significant, *=p≤0,05, **=p≤0,01, ***=p≤0,001
1) 'Bluejay' and 'Berkeley' had 3 replicates in 1999
2) 'Duke' was recorded in 3 replicates in 1995, 1996, and 1999

Table 3. Infections of *Godronia cassandrae* f. sp. *vaccinii* in 15 cultivars of highbush blueberry from a survey accomplished during May to August 1998. The infections were recorded on 10 stems per replicate, and there were 1–4 replicates of each cultivar in each field. Standard error of the mean (in brackets) was calculated based on the mean from each field (n=the number of fields examined). The cultivars are ranked according to increasing number of infected stems.
Infektionen mit G. cassandrae an Pflanzen von fünfzehn Sorten der Amerikanischen Blaubeere. Die Infektionen wurden an zehn Sprossen pro Sorte mit eins bis vier Wiederholungen pro Sorte und Anbauregion erfaßt. Sie Standardabweichung vom Mittelwert (in Klammern) basiert auf dem Mittel erfaßter Anbauregionen.

Cultivar	Number of fields examined	Number of fields with Godronia canker	Stems		Lesions	
Spartan	8	2	0,73	*(0,68)*	0,98	*(0,93)*
Hardyblue	19	8	0,89	*(0,41)*	1,25	*(0,64)*
Goldtraube	5	3	0,95	*(0,51)*	1,18	*(0,59)*
Bluetta	18	8	1,23	*(0,47)*	1,69	*(0,67)*
Ama	4	2	1,23	*(1,02)*	1,79	*(1,58)*
Ivanhoe	5	4	1,27	*(0,52)*	1,53	*(0,63)*
Berkeley	11	10	1,57	*(0,47)*	2,69	*(1,08)*
Duke	5	2	1,57	*(1,48)*	2,88	*(2,72)*
Patriot	17	10	1,60	*(0,50)*	2,23	*(0,75)*
Heerma	7	4	1,62	*(0,82)*	2,36	*(1,39)*
Bluecrop	24	19	2,15	*(0,47)*	4,03	*(1,05)*
Collins	11	10	2,89	*(0,88)*	5,98	*(1,84)*
Jersey	6	6	3,69	*(1,02)*	7,28	*(3,51)*
Earliblue	9	6	3,78	*(1,23)*	8,69	*(3,61)*
Blueray	11	11	4,70	*(0,91)*	8,61	*(2,31)*

ceptibility sufficiently. 'Herbert', 'Pemberton', and 'Dixi' were planted in one field each and showed no symptoms. However, 'Herbert' was heavily attacked in the European survey (LIEBSTER 1979). FITZPATRICK and MacSWAN (1952) reported from British Columbia that 'Pemberton' was particularly susceptible. On the other hand, 'Dixi' was considered to have low susceptibility by LIEBSTER and SPRAU (1970), but it ripens late in the season and is therefore not suited for Norwegian growing conditions. 'Rancocas' was planted in one field, and symptoms of *G. c. vaccinii* were observed. WEINGARTNER and KLOS (1975a) reported that although this cultivar was often heavily cankered, it was the most resistant to wilting in Michigan, USA. 'Rancocas' was also recognised as highly resistant in Finland (HÅRDH 1959), Russia (MUKHINA et al. 1993), and Canada (McKEEN 1958, LOCKHART and CRAIG 1967). 'Toro' and 'Sunrise' each showed symptoms of Godronia canker in one out of two fields. 'Northsky' and 'Northland' was planted in one field each, and had no cankers. 'Nortblue' was infected in the only field where it was planted. 'Bluechip' and 'Bluejay' have not performed well in Norway (Prof. S. Vestrheim, pers. comm.) and they were very susceptible to Godronia canker at AUN. Thus, they cannot be recommended for growing in this country. 'Aron' is a Finnish hybrid of *V. corymbosum* and *V. uliginosum*. Godronia canker was observed in this cultivar in the present survey. It has poor fruit quality, which makes it less interesting. The cultivars 'Nui', 'Puru', 'Sierra', and 'St.Cloud' were planted in 1997 and 1998, and thus it was impossible to draw any conclusions concerning susceptibility in these cultivars at the time of assessment.

Although the pathogen was widespread in most areas, it did not damage all the plantings to the same extent.

In some fields the disease did not seem to affect the plants seriously, while other fields were almost totally destroyed. The different cultivars showed a wide variation in growth vigour, attack by Godronia canker, and survival, but there were also differences within a cultivar from field to field, even where fields were located in the same area. These findings suggest that factors like plant material, climate and cultural practices play a role. Such factors may be of particular importance in the intermediately susceptible cultivars, as these seem to manage well despite the presence of *G. c. vaccinii* when given the best possible growing conditions. Weed control is important, as weeds will reduce air circulation and delay drying after rain, providing favourable conditions for *G. c. vaccinii*. As the fungus is spread in water droplets, drip irrigation would be an advantage compared to overhead irrigation. The importance of proper pruning was demonstrated in a field that had drip irrigation equipment and negligible amounts of weeds. Pruning had never been carried out, and many old, wilted twigs with cankers were left on the bushes. All cultivars were heavily cankered, even the supposedly more resistant ones. This was probably due to a gradual build-up of inoculum in the field over several years. The investigations suggested that plants propagated by seedlings probably have introduced the disease to highbush blueberry plantings.

Severe attack in a few plantings, but no dieback of 'Hardyblue' and 'Patriot' could be explained by the findings of MELZER and HOFFMANN (1980b), who claimed that the resistance towards Godronia canker consisted in restraining growth of the pathogen after infection by developing callus barriers. The fungus did not seem to be able to grow through callus. A cultivar could therefore have high numbers of cankers on the stems, but still be resistant to wilting. They inoculated pieces of stems of different cultivars, and observed that the lesions developed twice as fast on stems of 'Jersey', than on stems of 'Hardyblue'.

The cultivars planted in Norway mainly originated from USA, but 'Goldtraube' is a Dutch cultivar, 'Ama' and 'Heerma' are German, and 'Nui' and 'Puru' are from New Zealand. The three northern European cultivars were all among the more resistant ones in this study. One reason could be the cooler climate of Germany and The Netherlands compared to New Jersey where most American cultivars have been selected. The disease has not been reported from New Jersey. However, in Germany and The Netherlands the disease may have caused dieback and poor growth in certain selections in the breeding programmes, and hence, these selections have been turned down. Godronia canker has not been reported from New Zealand. Further investigations therefore need to be carried out before susceptibility of 'Nui' and 'Puru' can be determined.

One objective of modern breeding programmes is to develop cultivars that are adapted to climates that differ from the climate where highbush blueberries traditionally have been grown. To develop cultivars that are suited for cooler climates, interspecific hybridism between highbush and lowbush (*V. angustifolium*) blueberry have been carried out (GOUGH 1994). Two of the cultivars most commonly planted in Norway, 'Bluetta' and 'Patriot' both have a hybrid parent as results of crossings between highbush and lowbush blueberry. 'Bluetta' and 'Patriot' showed low susceptibility to Godronia canker in the present study. LOCKHART (1975) found that lesions caused by *G. c. vaccinii* in lowbush blueberry developed more slowly compared to lesions on highbush blueberry. Further, the fungus could kill stems of highbush blueberry in only one season, but this was never observed in lowbush blueberry. 'Patriot' and 'Bluetta' may have inherited low susceptibility from their lowbush grandparents. If so, the cultivars 'Northsky', 'Northland', 'Northblue', 'Sierra', 'St. Cloud', and 'Sunrise', which are results of breeding where lowbush blueberries were included, may have inherited some resistance as well. Further studies are needed to assess their susceptibility correctly.

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