Mildew & Sunburn in Haskap (Honeyberries)

By Bob Bors, Ellen Sawchuk and Jill Thomson

Mildew and sunburn are common leaf problems for many varieties of *Lonicera caerulea.* In fact, mildew is the only disease of concern at this time for Haskap in our area. At the University of Saskatchewan we have been aware of this potential problem since 2005 and have been breeding and selecting to minimize this problem. What follows is a summary of various observations and experiments on mildew and sunburn.

Symptoms

Mildew appears at first as white circular patches with a cottony appearance. We are uncertain whether the mildew is 'powdery' or 'downy'. We were unable to full identify them since none of the plants scrutinized were found to have the fungus in the proper stage. Graduate student, James Dawson is convinced that it is 'downy mildew' based on his familiarity with how that disease occurs on grapes.

Figure 1. Mildew in an early stage.

Mildew spores are carried by the wind and can be carried long distances. When a field gets infected it is likely to have an even distribution of the disease. This is quite different from other diseases which can be seen to spread from one plant to another and gradually spread across a field.

In bad mildew years in Saskatoon, symptoms arise outside in mid-July or at any time in the greenhouse. It is quite odd that plants in the field that never have mildew symptoms can come down with the disease in the greenhouse.

The white stage often lasts only a few days, possibly being washed away by rain. Leaves then become partly or completely brown with a blotchy appearance. In some cases a mildew infected leaf will curl in on itself. Sometimes, mildew infected leaves will curl. Then it gets more complicated: the undersides of leaves could face upward toward the sun and get sunburned. Sunburn appears as an even patch of brown on the underside of the leaf often with a clear edge of where the leaf is not sunburned.

Sunburn can also occur without mildew. Early in the season when haskap is growing rapidly, the younger leaves are very flexible. A steady wind can bend the underside of the leaves upward long enough to get sunburned. This is more likely to be a problem when there are several or many cloudy days followed by a bright sunny day with steady winds. . Sunburn can appear on developing branches, but this symptom is not as noticeable as sunburn on leaves. Mildew infected and sunburn plants usually survive and indeed can actually prosper. However, they can become quite ugly and undesirable if in a public location such as in the front yard or as part of a pick-your-own orchard.

Figure 2. One of the worst cases of mildew we've ever seen. These plants looked like this on August 4th in 2011. The plant on the left is showing fall colours a month too soon. But both plants looked healthy at the start of 2012! Luckily, these particular varieties are rarely planted in North America.

Figure 3. This plant has moderate mildew but is very productive.

Figure 4. Mildew has caused these leaves to curl slightly resulting in some leaves being sunburned on the bottom side. Notice that the sunburn stops in a fairly straight line: that's where the sun never reached. The sunburn effect is easier to see on the south side of the bush.

Figure 5. Planted on Friday, burnt by Monday! These plants were already leafed out when planted. It had been cloudy for many days and the plants were in a transition shade house for several weeks after being in a greenhouse. The tops of both seedlings were burned. When this picture was taken the wind was still blowing the leaves and helping to cause more sunburn.

Figure 6. Close-up of sunburn on the underside of a leaf a day or 2 after getting damaged.

In our breeding program we often plant seedlings that already have leaves on them at planting time. Those plants are more susceptible to sunburn compared to when dormant plants are planted. When dormant plants get planted they get more sunlight since the time the buds break and are more likely to build up wax layers and pigments to protect themselves from UV light damage. Already established plants have far less sunburn damage. Farmers usually buy dormant plants but gardeners might buy plants already leafed out. Gardeners may be alarmed if their plants do this shortly after planting but they should rest assured that the following year they will see far less of this phenomenon.

Variation

Levels of mildew and sunburn vary from year to year. There can be years where no plants show any symptoms and other years where the same plants are almost completely brown by the end of July. But most years there is just a moderate amount of mildew and sunburn. There is a great deal of variability between varieties. But varieties are consistent when compared amongst themselves. Resistant varieties always look better than susceptible ones. Highly susceptible varieties always look worse than moderately susceptible varieties.

Mildew can be a bigger problem in southern areas. Likely, humidity plays an important role. Our prairie weather has far less cloudy days, lower rain and lower humidity than much of the Northern USA. Researchers trying several varieties in Ohio report that all varieties are coming down with mildew including ones that don't show symptoms in Saskatchewan.

Disease Resistance Ratings (excerpted and slightly modified from ADF project 2006-0140)

In August leaf condition was measured by Dr. Jill Thomson. We had 3 main fields that were observed: 2 fields had 6 plants of each variety grown in the same area and the 3rd field had the original stock plants. In most cases each 'n' (number of replications) was based on 6 plants grown in a block.
A type of mildew was observed on many accessions and mycelia was seen under the microscope. As the fungus was not in reproductive mode, fruiting bodies were not present, making identification of precise species impossible. A phenomenon of darkened leaves that showed no signs of pathogens was observed on many plants. It was hypothesized that this could be due to a hypersensitive reaction or possibly sunburn. Data was taken on this as it appeared to have dead leaf tissue involved and could be having a detrimental effect on plant growth and yield.
An overall rating was done which took into account the combined effects of leaf darkening and mildew. This scale may be particularly important for nurseries interested in having healthy looking plants for landscaping purposes.

Figure 7. Lonicera caerulea showing leaf disorders. Leaves on the left have a scorched look where entire leaf sections have died. The leaves on the right have a more spotted appearance. Plants like these were found in the wild and in cultivation.

The two new U of Sk varieties (Borealis and Tundra) and most of the advanced selections currently being propagated for growers showed the highest levels of resistance to mildew and the mysterious leaf darkening. Only Indigo Gem (formally 9-15) showed problems in this area. The evaluations are based on the original plants.

In fall, diseased leaves were gathered and stockpiled for use in inoculating seedlings in the greenhouse. These will be in March 2008 to attempt to create a screening technique to find resistant selections. It has been noted that mildew often occurs in the greenhouse but it is uncertain if this is the same type that occurs in the field.

Table 1. Ratings for sunburn and mildew in August of 2007. The 'overall rating' takes into account both disorders with 1 being unacceptable and 3 being highly desirable. The mysterious 'dark' disorder seems to be physiological as no pathogens have been found; one theory is that it may be sunburn. Perhaps leaves unfolding during cloudy days get sunburn if then exposed to bright sunny days. In the wild many plants were found living as understory plants, perhaps these are more prone to sunburn?

Code	Name(s)	n	% sunburn	% mildew	Overall Rating
	Highly desirable				
9-91	Indigo Treat	1	1.0	1.0	3.0
9-92	Indigo Yum	1	5.0	1.0	3.0
3-03	Blue Pacific (F-1-9-58)	2	1.0	1.5	3.0
3-05	Novinca (Blue Nova)	2	1.0	1.5	3.0
9-94	Borealis	1	1.0	5.0	3.0
9-84	Tundra	1	5.0	1.0	3.0
Ger	Gerda	2	1.0	6.5	3.0
3-02	Magadan (Blue Forest)	2	1.5	8.0	3.0
	Desirable				
3-01	Kamchatskaya (Kamchatka)	2	9.0	5.5	2.5
Ber	Berel	2	1.5	11.5	2.5
2-07	Nimfa	2	3.0	14.5	2.5
2-10	Lebedushka	2	4.0	19.5	2.5
98-11	Tomichka (Blue Belle)	2	8.5	24.5	2.5
98-12	Kiev #8 (Blue Velvet)	2	4.5	31.0	2.5
	Acceptable				
2-09	Volkhova	3	20.0	13.3	2.0
3-09	N-17 (Blue Magic)	2	12.5	14.5	2.0
2-11	Omega	4	11.3	17.0	2.0
2-05	Roksana*	2	3.5	20.0	2.0
2-12	Malvina	2	4.5	20.5	2.0
2-04	Kamchadalka*	2	10.5	20.5	2.0
2-13	Suvenir	2	4.0	21.0	2.0
2-16	Slavyanka	3	3.3	27.7	2.0
	Undesirable				
2-17	Altair	2	28.5	13.0	1.5
2-15	Pushkinskaya	2	7.5	18.5	1.5
2-08	Amfora	2	12.5	20.0	1.5
2-20	Narymskaya or Fialka	3	32.0	12.0	1.3
2-06	Morena	2	20.5	20.5	1.0
98-09	Czech #17 (Berry Blue)	1	21.0	24.0	1.0
2-14	Solovey	2	33.0	29.5	1.0
9-15	Indigo Gem	1	50.0	30.0	1.0
Ogn	Ognennyi Opal	1	56.0	68.0	1.0

Experiment 1. Evaluation of fungicides for control of mildew on haskap seedlings in the greenhouse. (Note: none of these fungicides are currently registered for Haskap. This information should be considered useful if growers want to consider getting a fungicide registered)

Introduction:

Significant levels of mildew have been observed on Haskap seedlings being grown in the greenhouse. This is of concern for two reasons:

1) The mildew infection may reduce plant vigour and have a negative impact on the seedlings when they are transplanted outside
2) Transplanting infected seedlings means that an inoculum source for the disease is present immediately the seedlings are planted out.

A fungicide treatment at the seedling stage may reduce disease levels, and possibly eliminate the pathogen before transplanting. A number of fungicide treatments were evaluated in the spring of 2008, including products available to the home grower and commercial growers.

Materials and Methods:

In early May 2008, 24 seedlings of two lines, all with obvious mildew infection on the leaves, were planted into 5" pots. The two lines chosen were RCT17 and RJJ1; both these lines have been used in the haskap breeding program, and are susceptible to mildew at the seedling stage in the greenhouse. Five fungicide treatments were applied to four plants of each line, and there was an unsprayed check treatment for each line. The fungicide treatments were:

1) No chemical check, sprayed with water only
2) Bordo copper spray (copper from Tribasic Copper Sulphate, 53%) at a rate of 4.5ml/ L water
3) Safers sulphur at 35ml/L water
4) Lance (70% boscalid, BASF Canada) at 1.2g/L water
5) Proline (prothioconazole, 480g/L, Bayer Crop Science Inc.) at 0.8ml/L water
6) Pristine (25.2% boscalid, 12.8% pyraclostrobin, BASF Canada) at 2.0g/ L water.

The copper and sulphur sprays were purchased from a local garden store and would be available to the home gardener. The three other fungicides would only be available to commercial growers Before spraying the plants were evaluated for disease. All plants had from 75-100% of their leaves infected with mildew, and cleistothecia (the perfect, overwintering stage of the fungus) were present on all except one plant. The plants were sprayed to run-off and were placed on benches in the greenhouse. The RJJ1 plants all had new growth present on the seedlings, but no new growth was present on the RCT17 plants.

The seedlings were evaluated for mildew infection three weeks after the fungicides were applied.

Results and Discussion:

There were no effects of fungicide treatments on leaves that were already infected with mildew before treatment. This is not unexpected as a fungicide treatment is unlikely to remove existing infection. The viability of the infection in terms of transmission of disease to new leaves was not examined directly. However there was very little infection of new leaves for both treated and untreated seedlings. In the RCT17 line there was only infection of new growth on one of the untreated seedlings. In this line, new growth usually occurred not as new leaves but as new side shoots. In the RJJ1 line new leaves were produced on the main shoot, and there was slight infection of the new leaves in all but the sulphur treated plants. However the differences were not great and further testing is necessary before sulphur could be recommended as a control treatment.

Experiment 2: Evaluation of fungicides for control of mildew on haskap under field conditions.

Introduction:

Mildew has often been observed on haskap bushes in the field by the beginning of August. Necrotic damage is also observed on the leaves of some lines, and it is possible that this blackening of the leaves is due to mildew infection (death of the cells due to parasitism), or a reaction of the plant to infection (death of cells to prevent infection). Fungicide application may prevent mildew infection, and also have an impact on the necrotic response of the plants. Three fungicide treatments were evaluated in August 2008 at the University of Saskatchewan orchard.

Materials and Methods:

Six plants of nine lines already established in the cultivar collection orchard at the University of Saskatchewan orchard were selected for the trial, and the plants were identified with coloured flag markers within a row. This trial contains plants that were four years old, and were already fruiting. The lines selected for the trial were: SX2-14 (2 sets), SX2-15, SX2-05, SX98-09, SX2-06, SX2-08, SX2-11, 3-09. Sprays were applied in early August, after harvest, when there was very little mildew present on the bushes. A trace of infection was observed on the lower leaves of some bushes, but the majority of bushes showed no signs of infection prior to fungicide application. There were six bushes of one line within in a row, and the three bushes on the east side were sprayed with fungicide, the other three bushes were not sprayed. The fungicides applied were:

1) Bordo copper spray at a rate of 4.5ml/ L water
2) Safers sulphur at 35ml/L water
3) Pristine at 2.0g/ L water.

These fungicides were previously evaluated in a greenhouse trial and were applied at the same rate. Two L of each fungicide were prepared and the bushes were sprayed to run off. Copper was applied to SX2-15, SX2-11, SZ98-09, Sulphur was applied to SX2-10, SX2-08, SX2-15 and Pristine was applied to SX2-14, SX2-06, SX2-14.

Results and Discussion:

Very little disease had developed by mid August and no differences were observed between treated and untreated bushes. A second spray application was made on August 15. The bushes were rated for presence of mildew and leaf necrosis on September 12. The average values for the treated and untreated bushes are given in Table 1. The data is collected from eight different genetic lines, and is not replicated therefore statistical analysis was not conducted. However, when results are compared within the treatments it can be seen that no mildew developed on the bushes sprayed with copper or Pristine, but low levels did develop on comparable bushes that were not sprayed. Levels of mildew on the sulphur treated bushes were very similar to those on untreated bushes. Thus it would seem that copper and Pristine applications are worth investigating further for control of mildew on haskap bushes. Overall mildew levels were very low, and greater differences might well be observed when infection pressure is higher.

Table 2. The effect of fungicide application on the development of mildew and leaf necrosis of haskap bushes at the University of Saskatchewan orchard, 2008.

Fungicides applied:											
Copper				**Sulphur**				**Pristine**			
Sprayed		**Unsprayed**		**Sprayed**		**Unsprayed**		**Sprayed**		**Unsprayed**	
%M*	**%N****	**%M**	**%N**	**%M**	**%N**	**%M**	**%N**	**%M**	**%N**	**%M**	**%N**
0	8.3	0.3	13.3	0.7	5	0.3	6.7	0	10	1.7	10
0	20	0.3	25	0.3	5	0.7	5	0	15	0	8.3
0	25	5.3	25	0.3	8.3	0.3	5	0	5	2.3	8.3

*Average % of bush leaf area affected by mildew
**Average % of bush leaf area affected by necrosis.

The percentage of leaf necrosis did not appear to be affected by the spray treatments suggesting this effect is not connected to disease development. It has been suggested that necrosis is a response to the presence of insects, and further investigation is recommended.

Experiment 3: Mildew Prevention in the Greenhouse

Note: The following section is a summary of Ellen Sawchuk's undergraduate thesis. She was a summer student in 2009 when this research was done. She is now a technician in our program. This research is also summarized in reports of ADF 2008-0042.

Thousands of Haskap seedlings are grown per year in greenhouse for backyard gardeners or commercial farmers. Problems begin to occur when the seedlings are being grown in these greenhouses as they can become severely infected with powdery mildew. Cultivars that are thought or seem to be resistant in the field become susceptible in the greenhouse. It is necessary to find an economical and effective way of preventing powdery mildew epidemics for this valuable crop.

Using UV-C (Ultra Violet type C) light seemed to be an attractive alternative and was evaluated against other control methods. In nature UV light often elicits plant protective responses such as more anthocyanins and thicker wax levels on leaves. Our graduate student, Tyler Kaban, was using UV-C light to induce resveratrol production in grapes. Resveritrol has anti-fungal properties. There is no literature to suggest that resveratrol in in Haskap plants, but the idea of using UV light to turn on some defence mechanism seemed like a good idea. In nature UV-C is screened out by the upper atmosphere and is much more damaging than UV-A or UV-B. As it is more intense it requires a much shorter treatment time.

In various papers and magazines it was found that using milk and garlic solutions were effective as well economical. The UV-C, garlic and milk were tested against common greenhouse preventions F-mix and Sulfur.   A wide variety of controls were tested as they specific type of mildew we unable to be identified.

The experiment was carried out as follows. Firstly, two year old Borealis plants were placed in a cooler for two months and were brought out of the cooler at three different times so that testing could be done on new leaves as well as mature leaves. All of the plants were transplanted into one litre pots. The amount of UV-C radiation that these plants could take before damage occurred was evaluated. It was found that 80 seconds was the optimum time as the leaves remained green and healthy looking after their exposure. When they were exposed to 90 seconds and higher bleach spots and leaf death ensued. It was also found that the most efficient way to inoculate was to find a naturally infected plant and rub the infected leaves on the healthy leaves in a high humidity environment.

Plants were taken out at different times some plants classified as 'old' were taken out of coolers on Oct 26 but it was decided a few days later (Nov 2) to take out more. Almost a month later (Nov 30) a second batch, labeled 'Young' were taken out.

For the mildew control experiment six plants (3 young, 3 old) were treated with 80 seconds of UV-C radiation and another six plants were treated with powdered sulphur, diluted milk (3 cups water and ¾ cups whole milk), garlic extract (one bulb of blended garlic with 500ml of water), or F-mix (5 grams baking soda, 5ml Safer Soap and 15ml of Canola oil with 500ml of water). Plants were treated once a week starting Dec. 6th and then evaluated on Dec 13th, Dec 20th and January 10th. for number of infected leaves. The experiment had 6 treatment x 2 ages x 3 observation dates x 3 reps.

ANOVA analysis using SAS statistical program is presented in table 28. Treatments, age of the plants and the interaction of Treatment*Age were highly significant while observation date was significant.

Older plants had more than 3 times the infection rate of younger plants averaging 6.5% compared to 1.9% over the 3 observation dates. Older plants had leafed out about 30 days earlier than younger plants. This results was unexpected as younger leaves are usually thought to be more susceptible particularly if wax cuticle layers have not built up on the leaves. However, in the field we often don't see infection until the plants have leafed out about 2 months.

All the treatments were significantly better than the control. Sulfur gave the lowest mean but this was statistically similar to Milk, F-mix, and garlic treatments. Sulfur was the preferred treatment for other reasons beside having slightly lower infection rates. Milk could potentially give a rancid smell to the greenhouse while garlic gave an immediately strong odor that hurt eyes during preparation. F-mix required mixing several ingredients and so was not as convenient. The sulfur and garlic treatments were deemed the best due to their superior effectiveness and economics.

Table 3. ANOVA for various treatments against mildew in the greenhouse for 'Borealis' haskap plants.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
treatment	5	852.407407	170.481481	7.34	<.0001
age	1	560.333333	560.333333	24.12	<.0001
date	2	185.12963	92.564815	3.98	0.023
rep	2	79.796296	39.898148	1.72	0.187
treatment*age	5	1346.777778	269.355556	11.59	<.0001
treatment*date	10	153.648148	15.364815	0.66	0.7559
treatment*age*date	12	259.222222	21.601852	0.93	0.5227

Table 4. Means of treatments used to control mildew infections on 'Borealis' haskap under greenhouse conditions.

Treatment	Means		
Control	9.9	A	
UV-C	4.9	B	
Milk	3.7	B	C
F-Mix	3.5	B	C
Garlic	2.1	B	C
Sulfur	1.2		C

Initially it was difficult to get mildew growing in the greenhouse, which was why leaves from outdoor plants were gathered and used. Often mildew occurs spontaneously in our greenhouse. But once it started, it almost doubled within that 1st week (table 5). But the next 20 days had only an incremental change of about 20%. In the worst treatment combination (Control + Old) The infection rate was 10% on Dec 13th, then 24% on Dec 20th and then only 25% on Jan 10th. These resulting indicate that mildew infects can progress rapidly and that growers should be prepared to immediately treat symptoms when they appear.

Table 5. Progression of mildew infection for all treatments under greenhouse conditions for 'Borealis' Haskap.

Date	Infection %		
Dec-13	2.4	a	
Dec-20	4.5	a	b
Jan-10	5.6		b

The interactions between treatments and age are presented in table 6. As was the case with the treatments by themselves, there is much overlapping of LSmeans groups. Larger sample sizes might be useful in giving more distinction between thee treatment/age combinations. It is surprizing that young control plants did not have infection yet. Perhaps the results would be different if a longer period of time was allowed for observations.

Table 6. Interaction of treatments and age of plants on % mildew infection in greenhouse grown 'Borealis' haskap plants.

Treatment & age combination			Means			
Control	+	old	19.8		A	
Milk	+	old	5.7		B	
UV-C	+	old	5.1	C	B	
UV-C	+	young	4.7	C	B	
Garlic	+	old	4.1	C	B	D
F-Mix	+	young	3.8	C	B	D
F-Mix	+	old	3.2	C	B	D
Milk	+	young	1.8	C	B	D
Sulfur	+	young	1.3	C	B	D
Sulfur	+	old	1.0	C		D
Garlic	+	young	0.0			D
Control	+	young	0.0			D

Summary

Using disease resistant varieties is the best way to combat mildew, especially since no chemical controls are currently registered. If a control were to be registered likely it should be sulfur, but it would need to be used as a preventive treatment. Sprays won't make mildew damage go away once it has happened.

Sunburn can be reduced by using dormant plants at planting time instead of leafed out plants. Fortunately, most of the University of Saskatchewan varieties are highly resistant except Indigo Gem. But even Indigo Gem looks good most years in Saskatchewan.

In most cases mildew and sunburn do not impact survival and mildew susceptible plants have been observed to be productive. However, there have not been any studies to judge if yield is being reduced by mildew or sunburn. Mildew and sunburn can make haskap plants ugly in mid-summer and are likely to be of concern for homeowners using Haskap in the landscape.

Mildew and sunburn are variable conditions dependant on environmental conditions . These conditions can vary widely from year to year and tend to be more severe in southern regions. Mildew can be severe one year and practically non-existent the next.

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