## Comparison of Cold Tolerance of Young Vetiver Grass Cultivars Over Multiple Winters

Eric Wiediger Leachate Management Specialists, LLC www.leachate.us

January 2022



### Cold Tolerance of Vetiver

Based on previous research, the publications *Vetiver System Applications: Technical Manual - Second Edition (Truong et al, 2008)* and *Vetiver Roots: The Vetiver System Technology Hidden Half (Truong, 2021*), the following summarizes vetiver's cold tolerance:

- ► Although vetiver is a tropical grass, it can survive and thrive under extremely cold conditions. Under frosty weather, its top growth dies back or becomes dormant and purple in color, but its underground growing points can survive.
- As its growing buds are on the corm, <u>vetiver dies when the corm or the ground is frozen</u>. As soil is a very good insulator, its underground temperature is often above surface or air temperature. When the soil surface freezes, vetiver root will continue to grow under snow or frosty conditions.
- ► Root dormancy occurs at about 5°C.
- ▶ In Australia, vetiver growth was not affected by severe frost at -14°C and it survived for a short period at -22°C in northern China.
- In Georgia, USA, vetiver survived in soil temperature of -10°C but not at -15°C. The depth of the soil temperature readings were not included.

## Cold Tolerance of Young Vetiver in China

In 2004-2005, Liyu Xu of China completed a study in Nanjing City examining simple treatment methods to protect young vetiver from cold, including plastic sheets and burying in a layer of soil. They set up plots on a North slope and South slope in October, and by December, the air temperature was dropping to 0°C or below.

- ► For the South slope where it had more sun, almost all the plants survived, no matter if covered in plastic, soil, or no protection. For the South slope's control plot, soil temperature observed at the surface was -1°C, 5 cm underground was 2°C, and 10 cm was 3°C. By spring, more than 90% of them survived.
- ► For the North slope, more than 90% of the plants survived under the plastic sheets and 60% survived buried in the soil. The control's soil temperature observed at the surface was -3°C, 5 cm underground was -1°C, and 10 cm was 0°C. By spring, 54% of those plants survived.

## Cold Tolerance of Vetiver - Comparing Cultivars

- In 2003, Robert Adams of Baylor University published a study evaluating DNA composition of 21 vetiver cultivars and found that 19 were clustered strongly with the 'Sunshine' or 'Monto' cultivar, which is one of the most common cultivars used in VS applications.
- As part of his research, winter survival of 12 cultivars was evaluated in two consecutive seasons between 1999 and 2001. The cultivars were first planted in June 1999, but the study doesn't say if they were replanted the following year or kept growing throughout the year.
- ▶ Minimum air and soil temperatures were recorded for each winter.

Parameter	1999-2000	2000-2001
Minimum Air Temperature	-13.3°C	-15.5°C
Minimum Soil Temperature, 2-inches underground (5 cm)	-4.6°C	-5.0°C
Minimum Soil Temperature, 6-inches underground (15 cm)	0°C	-0.5°C

- After the first winter, all 12 vetiver cultivars survived, although two died back significantly. As a result of the second winter, a wider variety of survival and stress were identified: 4 cultivars died completely, 5 significantly died back but survived, and 3 survived with vigorous shoots remaining. Those 3 were identified as Malawi-Lilongwe (SM), Panama B (PnB), and AVC (AV). Interestingly, Sunshine (SS) did not survive the second winter.
- ► The study made two conclusions: 1) differences in cold tolerance exist between the vetiver cultivars and 2) soil freezing at 15 cm under ground may be the critical factor for survival.

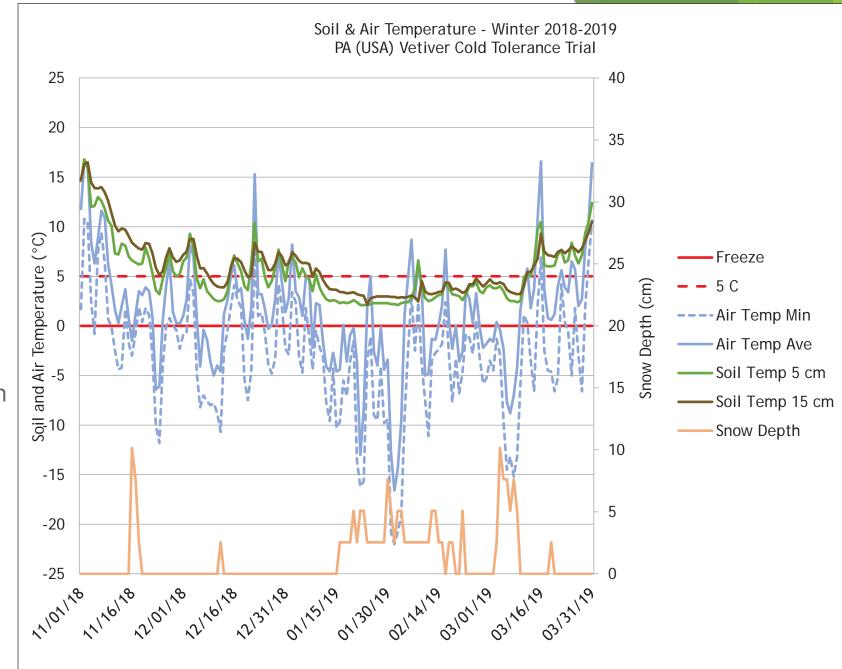
## The Trial

- ➤ To provide supplemental research to the Adams study, we wanted to compare cold tolerance of some of the same cultivars at several locations in the USA. After contacting the sources of those cultivars, it was discovered that only a few were still available. Our objective was to focus on the cultivars that performed well in the Adams study, so we tested the following:
  - ► Malawi-Lilongwe (SM)
  - ▶ Panama, Western Site B, Costa Rica (PnB)
  - ► AVC, Spain-Malaysia (AV)
  - ► Sunshine (SS)
- ▶ We planted two slips of each cultivar in Collegeville, Pennsylvania (PA) and Little Rock, Arkansas (AR) in the Fall 2018 and again in the Summer 2019. Two of the best performing cultivars were planted once again in Collegeville in Fall 2020.
- ▶ Daily soil and air temperature data were collected from the closest stations available from the National Water and Climate Center (NWCC) website. For PA, the weather station was ~160 km (100 miles) northwest of the trial site. For AR, the station was ~70 km (43 miles) southwest of the trial site.

Collegeville, Pennsylvania (PA), USA Vetiver Cold Tolerance Trial Winters 2018-2019, 2019-2020, and 2020-2021

## PA Winter 2018-2019

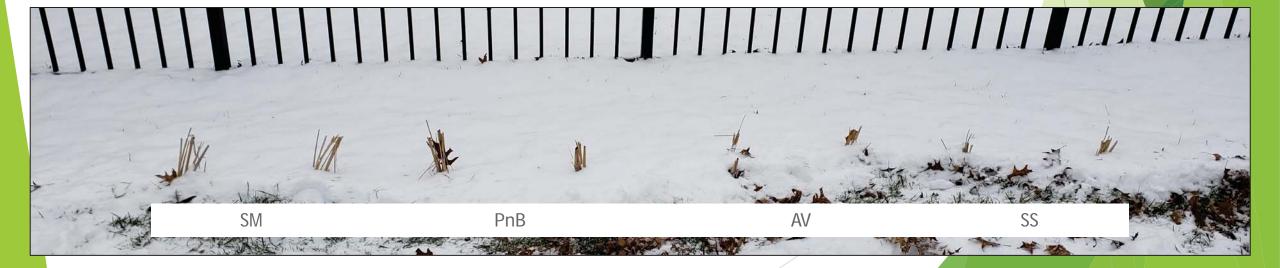
- Air temperatures fluctuated, dipping down to below -15°C several times while there was snow cover, including once down to -22°.
- ➤ The soil temperature at 5 and 15 cm underground remained below 5°C for much of the winter, but it did not drop down to freezing.
- Soil temperature leveled out at 3°C when there was snow cover, even when the air temperature dropped, which suggests snow is a good insulator.



## PA Winter 2018-2019

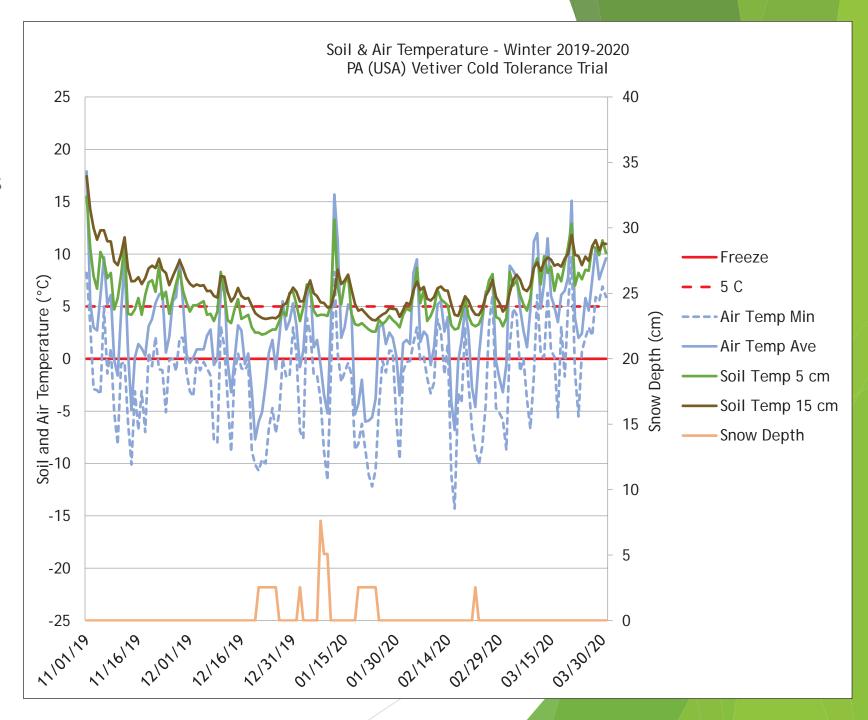
- ► Early October 2018: Planted slips in in the ground.
- November 2018: Each of the slips grew several shoots before entering dormancy for the winter.
- ▶ Spring 2019: None of the plants survived the winter.
- ► The vetiver slips only had 1 month to regrow after planting before dormancy, so they were still very young and vulnerable to environmental conditions.
- ► This indicates that 1-month-old vetiver may not be able to survive when soil temperatures are 3°C and air temperature dips down to -22°C.





## PA Winter 2019-2020

- The winter was milder than the previous year and had less snow cover.
- Air temperatures fluctuated, dipping down to below -10°C several times, but never below -15°C.
- Soil temperatures at 5 and 15 cm underground hovered around 5°C.



### PA Winter 2019-2020

- ▶ June 2019: Planted slips in the ground.
- October 2019: The plants grew well. SM had the most shoots and appeared stockier, but not as tall as the others.
- November 2019: Plants browned out as they entered dormancy for the winter.
- ▶ June 2020: Old growth was cut and removed.
- July 2020:
  - One of SM regrew very quickly, while the other survived but didn't regrow nearly as well.
  - One of PnB was the second best in regrowth, while the other one died.
  - Neither of the AV plants survived.
  - One SS regrew, while the other one died.



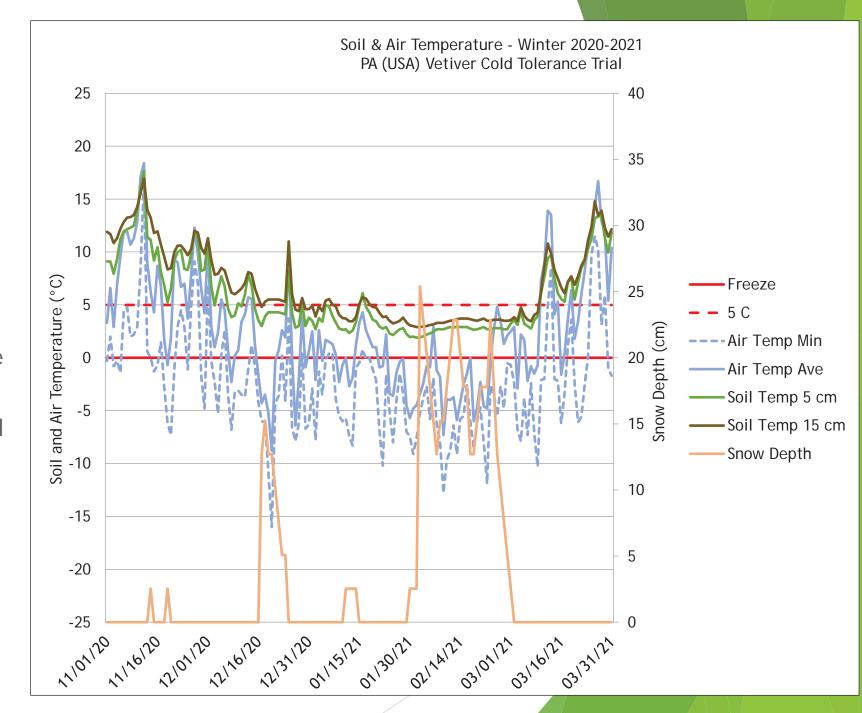


### PA Winter 2019-2020

- ► The cultivars for this year's trial had about 5 months to grow before dormancy, with average growth measured about 1 meter high.
- ▶ This winter was not as cold as the previous one and had less snowfall.
- ► The minimum air temperature was measured at -14°C.
- The soil temperature at 5 cm underground dipped to 3°C or below for 14 total days, while the temperature at 15 cm deep never hit 3°C.
- By spring, we observed a 50% survival rate.
- One of the SM cultivars and one of the PnB cultivars regrew the best.
- ► This winter's trial indicates that 5-month-old vetiver has a 50% survival rate when soil temperature at 5 cm underground dips to 3°C and air temperature drops down to -14°C.

## PA Winter 2020-2021

- Air temperatures fluctuated, dipping down to below -10°C several times while there was snow on the ground, and only once below -15°C.
- More snow fell and stayed on the ground as compared to the previous two winters.
- The soil temperatures at 5 and 15 cm underground remained below 5°C for much of the winter, but it did not drop to freezing.



## PA Winter 2020-2021

- ➤ September 2020: We decided to focus on only SM and SS cultivars this season. For each, we split last year's surviving plants and planted two slips in the ground and two in pots in a small greenhouse.
- ▶ October 2020: After trimming the old growth that died back from the replant, several new shoots started growing on each plant.
- ▶ Spring 2021: All the plants outside in the ground died, while the greenhouse ones survived.



September 2020

#### October 2020





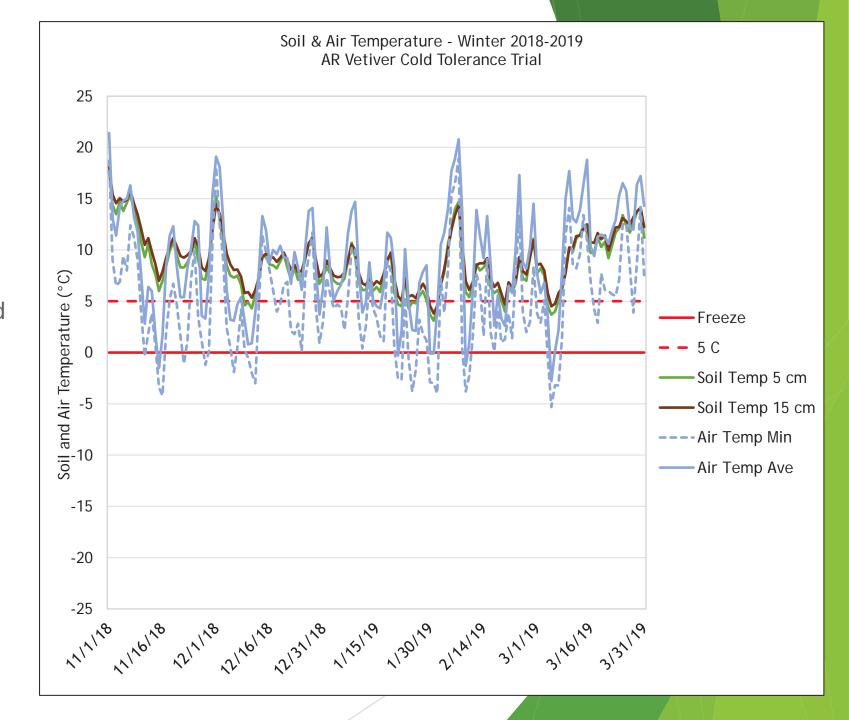
### PA Winter 2020-2021

- ► The cultivars for this year's trial had about 2 months to grow before dormancy, with each starting to grow several new shoots.
- ► The minimum air temperature was measured at -16°C.
- This winter had the most snow cover compared to the previous two years.
- ▶ Similar to the 2018-2019 winter, the soil temperature at 5 and 15 cm underground leveled out at 3°C when there was snow cover, even when the air temperature dropped, suggesting that snow was acting as an insulator.
- ► This winter's trial indicates that 2-month-old vetiver plants die when soil temperature at 5 and 15 cm underground is sustained at about 3°C and air temperature drops down to -16°C.

Little Rock, Arkansas (AR), USA Vetiver Cold Tolerance Trial Winters 2018-2019 and 2019-2020

# AR Winter 2018-2019

- Air temperatures fluctuated, dipping down to below -3°C several times. The lowest temperature was -5.3°C.
- ► The soil temperature at 5 and 15 cm underground dipped below 5°C several times.



## AR Winter 2018-2019

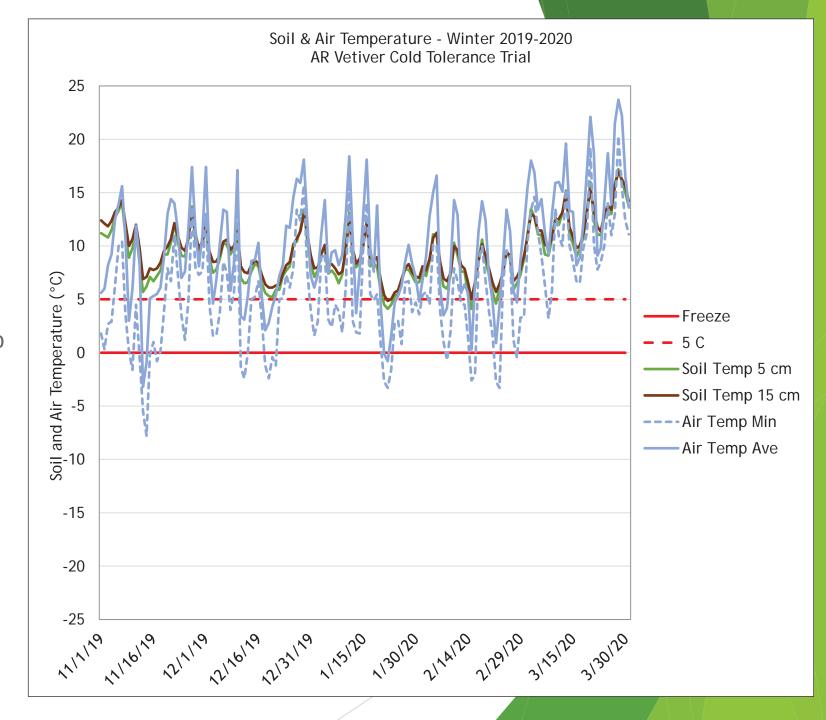
- Early October 2018: Planted slips in in the ground.
- November 2018: Most of the slips grew several shoots before entering dormancy for the winter.
- ► Spring 2019: None of the plants survived the winter.
- ► The vetiver slips only had 1 month to regrow after planting before dormancy, so they were still very young and vulnerable to environmental conditions.
- ► This indicates that 1-month-old vetiver may not be able to survive when soil temperature dips down to 5°C and air temperature drops to -5.3°C.



November 2018

# AR Winter 2019-2020

- ► Air temperatures fluctuated, dipping down to below -3°C a few times. The minimum temperature was -7.8°C.
- The soil temperature at 5 and 15 cm underground dropped to just below 5°C several times.



### AR Winter 2019-2020

- ▶ June 2019: Planted slips in the ground near a building.
- October 2019: The plants grew well, except for one of the AV slips. SM had the most shoots and appeared stockier, but not as tall as the others.
- Spring 2020: All of the plants survived the winter.
- ► The plants had 5 months to regrow after planting and most showed healthy growth.
- This winter's trial indicates that 5-month-old vetiver can survive when soil temperature dips down to 5°C and air temperature drops to -7.8°C. Although, it should be noted that these plants were placed near a building which usually creates a warmer microclimate.



Freeze in the Gulf States, USA Vetiver Phyto-Utilization Systems February 2021

# Freeze in the Gulf States, USA February 2021

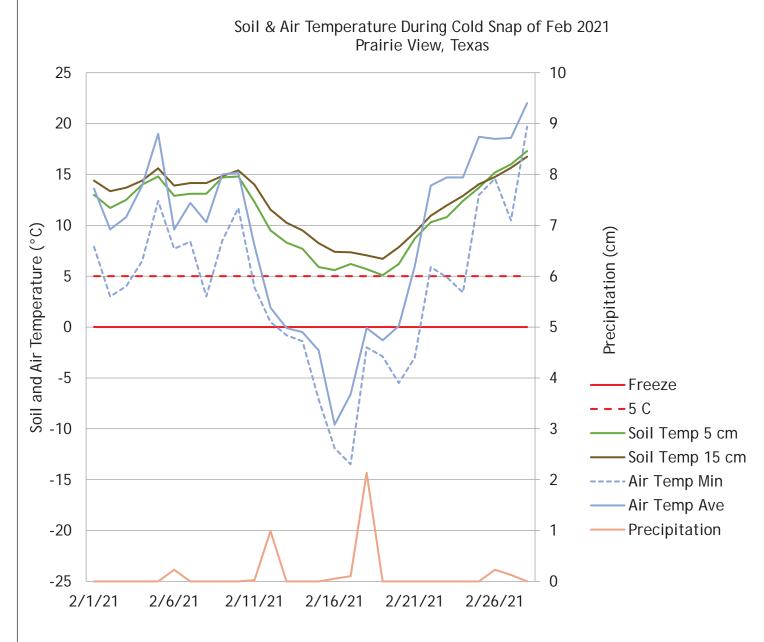
- ▶ In February 2021, the Gulf States in the USA experienced a cold snap that was very abnormal for the area, including below freezing maximum temperatures over several days.
- LMS has four Phyto-Utilization systems using vetiver to consume leachate at landfills in that region, as listed in the table.
- ► The vetiver at the College Station Texas landfill dealt with the coldest air temperatures during that period, with 0°C or below for 10 consecutive days. The area also received about 10 cm of snow during that week.

Texas 2021 Winter Freeze - Air Temperature (°C)

Day		Wed	Thur	Fri	Sat	Sun	Mon	Tues	Wed	Thur	Fri	Sat	Sun
February Date		10	11	12	13	14	15	16	17	18	19	20	21
College Station TX	Max	8.9	2.8	0.0	0.6	-0.6	-6.7	-2.8	1.1	1.1	5.0	15.6	22.2
	Ave	5.3	0.9	-0.6	-1.2	-4.3	-9.9	-7.0	-0.4	-1.6	-0.7	6.7	14.8
	Min	3.3	0.0	-1.1	-2.2	-8.3	-12.2	-14.4	-2.8	-3.3	-6.1	-1.7	6.7
	SNOW	10 cm											
Fort Bend TX	Max	17.8	6.7	2.8	2.8	1.7	-5.0	1.1	2.8	3.3	9.4	16.7	21.7
	Ave	12.8	3.9	1.7	1.7	0.0	-7.2	-3.9	1.7	1.1	2.8	8.9	15.6
	Min	6.7	2.8	1.1	0.6	-5.0	-10.0	-10.0	0.0	-1.1	2.2	-1.1	6.7
	SNOW					0.25	cm						
Sulphur LA	Max	25.6	21.1	5.6	7.8	4.4	-0.6	2.2	3.3	5.0	10.6	14.4	20.0
	Ave	20.0	11.7	4.0	3.8	2.3	-2.7	-3.8	1.6	2.2	3.5	9.1	12.9
	Min	15.6	5.0	2.2	1.1	-0.6	-6.7	-8.9	0.0	1.1	-1.1	3.3	3.3
Biloxi MS	Max	18.9	20.0	9.4	7.2	8.3	5.6	4.4	10.6	8.9	13.3	13.9	17.8
	Ave	17.4	17.8	7.6	5.5	5.2	1.1	-1.9	4.7	6.2	4.9	5.3	11.2
	Min	15.6	12.2	5.6	3.9	2.8	-4.4	-5.6	-3.3	2.8	0.6	-2.2	1.1

## College Station, Texas February 2021

- Based on weather data from a NWCC station near College Station, TX, air temperature dropped down to approximately -14°C.
- ➤ Soil temperature at 5 cm underground dipped down to 5°C briefly while the temperature at 15 cm reached 6.7°C.



## College Station, Texas February 2021

- The vetiver was planted in 2019, so they were full-grown plants.
- The aboveground biomass and snow cover helped insulate the ground and roots during the freeze, but it appears the temperature didn't drop low enough and long enough to impact them.
- By Spring 2021, new shoots started emerging on the plants, and after mowing, the site returned to a full, healthy field of vetiver.



## Conclusions

- ▶ Previous research indicates that vetiver dies when the corm or ground freeze.
- ▶ Mature vetiver has survived when the air temperature dips down to -22°C.
- Snow and biomass may help insulate and protect the corm from freezing.
- ▶ Vetiver that is 5-6 months old has a 50% survival rate when the soil temperature at 5 cm underground drops to 3°C and/or air temperature lowers to about -14°C. The Adams study indicates survival when the soil at 5 cm drops lower than -4°C and air temperature dips to -13°C.
- ▶ Vetiver that is 1-2 months old may die when air temperature drops to about -5°C and/or soil temperature at 5 cm dips to 2°C. Results from China suggest 50% survival when the soil down to 10 cm freezes.
- Vetiver cultivars may have different survival rates.
- ► These results appear to support the earlier conclusion that survival depends on if the corm or ground freezes, although cultivars may differ and younger plants are more susceptible with exposed crowns and may still die if soil under the surface doesn't freeze.

