Resilience of Alfalfa Cultivars to Winter Stress in Wisconsin

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Alfalfa is the most important perennial forage legume, produced primarily for high-quality hay and silage for cattle (Undersander et al., 2011). Farmers across the U.S. are facing the challenge of losing alfalfa production caused by extreme climatic conditions including winter injury. Frequency of harvest and cutting timing in the fall affect alfalfa winter injury. Generally, the shorter the interval between cuttings, the greater the risk of winter injury. It is recommended the last cutting of alfalfa should not be taken in September since plants are unable to replenish root carbohydrate reserves before winter (Cosgrove and Undersander, 2003). Winter injury can occur in extremely cold winters and is affected by snow cover and the succession of cold and warm temperatures. It is difficult to predict winterkill based only on temperature, since cold temperatures and lower snow cover with occasional brief periods of warmer temperatures melt snow and refreeze it, ultimately causing lack of oxygen below ground (Picasso et al., 2019). Therefore, it is necessary to develop a greater understanding of the resilience of alfalfa cultivars to winter injury or kill. Resilience is defined as the ability of a system to withstand and keep producing under a crisis. Developing resilient crop production systems is critically important in the context of changing climate and extreme weather conditions. The results of a study to quantify and better understand the resilience of alfalfa cultivars to cold stress in experimental field conditions were recently compiled and released in an effort to increase our understanding of alfalfa winterkill.

Alfalfa cultivars for winter stress field experiments were sown on May 14, 2019, in Arlington, WI. Treatment design: a) cold stress with two levels – cold stress (harvest including September) and no cold stress (harvest excluding September), and b) alfalfa cultivars with 24 levels (modern cultivars selected based on diverse morphological traits from three seed companies – Corteva, FGI, and S&W, and two historical cultivars as controls). Experimental design was a split-plot with a completely randomized block design including four replications for the main plot (winter stress) and cultivar as the split-plot.

Forage biomass harvest followed a similar schedule for both treatments (twice in 2019, and four times in 2020 and 2021) with the exception of the date for the last harvest. In 2019, the cold stress treatment had a third harvest on Sept 24 and the no stress was not harvested. Harvesting dates for cold stress and no stress plots were: Sept 1 and Sept 23 in 2020, and Sept 14 and Sept 27 in 2021, for stress and no stress plots, respectively. The total dry matter (DM) yield of each cultivar was determined and compared between cold stress and no stress in 2020 and 2021. Resilience for each alfalfa cultivar by block was determined by dividing the yield under stress plots by yield under no stress plots.

Mean forage yield across 24 alfalfa cultivars at individual harvest and total harvest under winter stress plots and no winter stress plots is given in Table 1. Alfalfa yields under winter stress plots were on average lower than under no stress plots at each harvest and across the harvests in each year but were not statistically different. Although the resilience across 24 cultivars at each harvest and total harvest in each year was relatively high (resilience value ranging 0.87-0.95 in 2020, and 0.90-0.98 in 2021), they were marginally significant at fourth harvest in 2020 (P=0.05).

Table 1. Mean DM forage yield (kg ha^{-1}) and resilience to winter stress (RW) per harvest for the experimental period, and annual across 24 cultivars in Wisconsin.

	2020			2021		
Variable	Cold stress	No stress	RW	Cold stress	No stress	RW
First harvest	3263	3476	0.94	3744	4172	0.90
Second harvest	3473	3489	0.92	2189	2318	0.94
Third harvest	977	1120	0.87	1259	1284	0.98
Fourth harvest	525	557	0.94	507	563	0.90
Annual total harvest	8237	8642	0.95	7699	8337	0.92

Table 2. Total forage harvests DM yield (kg ha^{-1}) and resilience to winter stress (RW) of alfalfa cultivars (for space limitations 19 other cultivars were omitted). No statistical differences were found.

	2020			2021		
Cultivar	Cold stress	No stress	RW	Cold stress	No stress	RW
FG11	8498	7938	1.07	9104	7382	1.23
AX5	8734	8074	1.08	9265	7673	1.21
SW4	8540	8413	1.02	7307	8049	0.91
VERNAL	7634	8296	0.92	5899	6883	0.86
SW5	7429	7974	0.93	5975	7149	0.81
AX1	7916	8919	0.89	6232	9540	0.65
FG12	7838	9795	0.80	6571	10545	0.62

Yield of seven selected alfalfa cultivars under cold stress and no cold stress in each year is given in Table 2. Variation was found in the resilience among cultivars (data for all 24 cultivars not shown) in both years and some cultivars were consistently higher in resilience values than others. For example, FG11 had higher resilience values (1.07 in 2020; 1.23 in 2021) whereas FG12 had lower resilience values (0.80 in 2020; 0.62 in 2021). Resilience values were positively associated with the yield under stress, so the cultivars with higher yields under stress were more resilient. However, resilience was negatively associated with yield under no stress, so the high-yielding cultivars were the least resilient.

While this study only provided experimental results of winter resilience of 24 alfalfa cultivars from one (Wisconsin) location, more information from ongoing analysis of winter stress from a second location (Minnesota) and a combined analysis of both locations hold potential to increase our ability to discover relevant differences in resilience among cultivars. The trade-off between resilience to cold and productivity must be explored further to give farmers the best opportunity to maximize their alfalfa production.

References

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