WINTERKILL POTENTIAL OF ALFALFA UNDER DIFFERENT SNOW DEPTHS

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ABSTRACT

The presence and amount of insulating winter snow cover are key factors in determining the potential of winter injury of alfalfa (*Medicago sativa* L.) In the Midwestern U.S. Four alfalfa varieties of varying fall dormancy ratings were planted in the summers of 1993 and 1994. Snow depths above the crop plots were kept constant at depths of 0, 10, and 20 cm during the subsequent winters with framed mesh covers. Winterkill percentages during the two seasons varied dramatically from 0-100% and were significantly higher for the 0 cm treatment than for 10 or 20 cm treatments. Nitro, a non-dormant variety, resulted in almost complete winter-kill while Vernal, a very dormant variety exhibited little or no injury over the two-year test period. In general, first cut alfalfa yields were lower for treatments which had higher winter injury ratings.

KEYWORDS

Alfalfa, Winter hardiness, winterkill, cold damage, snow cover

INTRODUCTION

Winterkill of alfalfa is collectively used to describe the failure of the crop to survive either extremely low temperatures throughout the winter, cold injury which occurs in early spring after dormancy is broken, or injury resulting from repeated freezing and thawing, particularly in spring, resulting in heaving and subsequent death of plants, and ultimately, lower subsequent yields (Durling et al., 1995; McKenzie and Mc Lean, 1982; Sharrat et al., 1986).

Most previous studies, however, have utilized standard climatological data to associate with subsequent crop performance (frequently taken at a different location and elevation versus the research plots) since representative winter field temperature measurements at crop canopy and soil root zone levels are rare due to the highly inconsistent nature of snow cover. Fall dormancy ratings have been associated with winter-hardiness of alfalfa varieties, however, there appears to be differences in winter-hardiness between varieties within a dormancy rating. Ratings based upon the ability of the alfalfa plants to survive winter injury may be a better means of characterizing alfalfa varieties.

The primary objectives of this study were: 1) determination of the utility of fall dormancy ratings to describe varietal susceptibility to winter injury; 2) a better understanding of the role of snow cover in moderating winter temperatures for overwintering crops; and 3) evaluation of this procedure for utility in screening varieties for winter hardiness.

METHODS

A 2-year study was conducted in the winter seasons of 1993/1994 and 1994/1995 at the Michigan Agricultural Experiment Station Upper Peninsula Farm at Chatham, MI. Lake-enhanced normal seasonal snowfall at Chatham total approx. 360 cm and daily minimum temperatures fall to -18°C or lower 26 times per season on the average (Eichenlaub et al., 1990). The soil was a Chatham Stony Loam (Typic Haplorthod). Basal P and K applications of 55 kg/ha and 165 kg/ha, respectively, were made prior to planting each season. Certified seed of public varieties, Nitro, Saranac, Vernal and a Proprietary , Magnum IV (Dairyland Seed, Clinton, WI) were seeded at 17.92 kg/ha in 15 cm rows. The varieties represented a wide difference in fall dormancy ratings from low to high. Snow cover depths were kept at constant depths of 0, 10, and 20 cm over all plots by 2.45 m X 0.9 m galvanized steel mesh-covered wooden frames. Zero cm frames were covered with a 1 mm mesh so as to allow air onto the plot but not falling snow while 10 and 20 cm frames were covered with 1.25 cm mesh to allow snow to fall and cover the plants below but still allow removal. Frames were installed in late October of both seasons just prior to crop dormancy and before permanent snow cover had developed or the ground had frozen. Fresh snow was removed daily from the 10 and 20 cm frames daily, and from the 0 cm frames using a gas-powered leaf blower (Stihl, Inc. (USA), Virginia Beach, VA). The experiment was arranged in a complete randomized block design with 3 replications per treatment combination.

Hourly mean and daily absolute maximum and minimum temperatures were taken with copper-constantan thermocouples at mid-canopy height (approx. 6 cm above the soil surface), 1 cm below the ground surface, and 10 cm below the surface for each snow cover depth within each level of cold tolerance for a total of 9 measurements at 3 plots. Measurements were also taken at a location just outside the plots at levels of 6 cm and 150 cm for a measure of the ambient conditions. Data were collected every 15 minutes with a battery-powered, Campbell Scientific CR-10 programmable data logger housed within a thermally-insulated enclosure (Campbell Scientific Inc., Logan, UT). Standard climatological data consisting of daily maximum and minimum temperatures (at 1.5 m shelter height), precipitation, and snowcover will be obtained from the weather station at the Experiment Station approximately 750 m west of the experiment site.

RESULTS

Temperatures during the winters of 1993/94 and 1994/95 were highly different, with mean 1.5 m air temperatures for the December-March period ranging from 1.2°C below normal in 1993/94 to 2.1°C above normal in 1994/95 (NOAA, 1995). Extreme minimum temperatures at canopy level with 20 cm snowcover and without snow cover ranged from -13.8°C to -29.9°C, respectively, in 1993/94 from -5.6°C to -13.8°C to in 1994/95. December-March snowfall at the site was 358 cm in 1993/94 and 368 cm in 1994/95. Winterkill and subsequent yields for the four varieties are given in Table 1. Winter injury was more severe in the 1993-1994 winter than in the 1994-1995 winter. Snow cover strongly influenced the amount of winter injury and subsequent ability to survive. First cut yields were a better indicator of actual winter injury compared to visual ratings which resulted from different snow cover depths. In almost all cases over the two-year study, increasing snow cover resulted in increased first cut yields. Nitro exhibited the most winter injury and subsequent winter-kill and Vernal exhibited the least winter injury and subsequent winter-kill. There was a greater difference in winter injury and subsequent winter-kill in the first year of the experiment which resulted from a greater fluctuation in both above and below ground temperatures throughout the winter months. Snow-cover had a greater impact in the first year of the experiment because of the colder temperatures.

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Table 1
Alfalfa winter injury and yield data by variety and snowcover treatment, Chatham, MI, for 1993-1994 and 1994-1995 growing seasons.

Variety & Snow Depth (cm)	Winter Injury% 1993-1994	Winter Injury% 1994-1995	1st Cut Yield, 1994 (t/ha)	1st Cut Yield, 1995 (t/ha)	Total Yield 1994 (t/ha)	Total Yield 1995 (t/ha)	Two Year Ave. Yld. (t/ha)
Nitro 0 cm	100.0	95.0	0.00	0.63	0.00	4.17	2.08
Nitro 10 cm	93.0	27.0	0.32	3.10	3.85	7.47	5.66
Nitro 20 cm	88.0	33.0	0.54	3.28	3.17	8.20	5.68
Variety Ave.	93.9	51.7	0.29	2.34	2.34	6.61	4.47
Saranac 0 cm	57.0	2.0	1.56	4.55	7.77	9.53	8.65
Saranac 10 cm	2.0	2.0	3.26	5.30	9.17	10.33	9.76
Saranac 20 cm	2.0	13.0	3.31	4.82	9.31	10.10	9.69
Variety Ave.	20.0	5.6	2.71	4.89	8.75	9.99	9.37
Magnum 0 cm	33.0	2.0	1.38	4.42	7.93	9.96	8.94
Magnum 10 cm	8.0	0.0	2.2	5.55	9.31	11.10	10.21
Magnum 20 cm	0.0	8.0	3.40	4.55	9.99	10.35	10.17
Variety Ave.	13.9	3.3	2.33	4.84	9.08	10.47	9.77
Vernal 0 cm	45.0	3.0	1.11	4.73	7.26	9.76	8.51
Vernal 10 cm	3.0	0.0	3.15	4.98	10.53	10.03	10.28
Vernal 20 cm	13.0	2.0	2.35	4.73	7.50	10.14	8.81
Variety Ave.	20.6	1.7	2.20	4.81	8.43	9.98	9.20
Mean	37.1	15.6	1.88	4.21	7.16	9.26	8.20
LSD (.05)	28.17	10.92	0.91	0.79	2.13	1.43	1.20
COV%	44.9	41.4	28.41	11.02	17.68	9.08	8.65