Avoiding Winter Injury to Alfalfa
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Alfalfa stands in Michigan are sometimes injured during the winter. The most common weather-related causes of winter injury are extremely low or fluctuating temperatures, persistent ice sheeting, and lack of snow cover. This bulletin describes how alfalfa plants are injured or killed during the winter and recommends practices to reduce the risk of winter injury. Also presented is a method to estimate yield losses for alfalfa stands that have sustained winter injury.

Causes of Winter Injury

Extremely Low and Fluctuating Temperatures

The capacity of plants to survive the effects of low temperatures is called cold hardiness. Cold hardiness is redeveloped each fall in response to decreasing day length and temperature. The extent to which cold hardiness develops depends upon the alfalfa variety. Cold hardiness is not developed to the same extent in all parts of the plant. Alfalfa herbage can be injured or killed when temperatures drop below 28°F in the fall. Cold hardened crowns and roots are not injured until temperatures drop below 0°F. Snow, soil, and/or stubble usually protect alfalfa from lethal effects of fluctuating or cold temperatures in Michigan.

Fluctuating temperatures are detrimental when warm temperatures cause over-wintering alfalfa to initiate growth too early for normal spring development. When temperatures rise to 50-60°F for several days during mid-winter, over-wintering alfalfa can break dormancy. When this happens, crown buds elongate and grow, depleting stored root reserves. Then, when normal cold temperatures resume, crown buds can be killed. When conditions suitable for regrowth occur in the spring, regrowth is delayed. The most cold hardy alfalfa varieties are the least apt to break dormancy in the winter.

Frost heaving is another type of injury caused by temperature fluctuations (Fig. 1). Heaving occurs when alfalfa crowns and roots are forced above the soil surface by the action of freezing and thawing. This occurs in the late winter and early spring on heavy and/or poorly drained soils.

Frost-heaved plants can be injured in four ways: (1) Roots can be mechanically damaged by the lifting itself; (2) Roots and crowns can be dried out when exposed to the air; (3) Exposed crowns and roots can be injured by cold air temperatures; and (4) Lifted plants can be cut off below the crown when harvested.

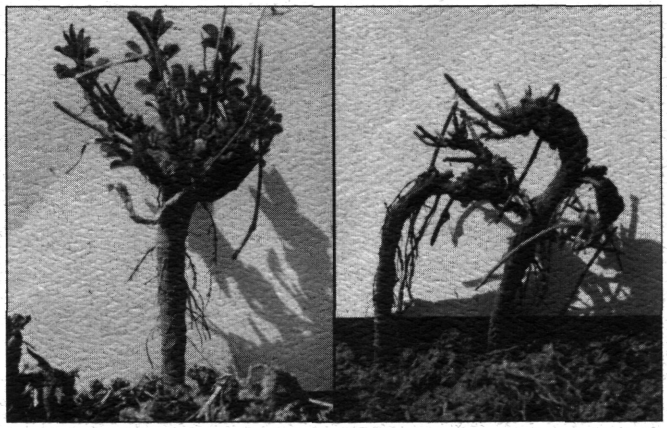

Fig. 1. Frost-heaved plants. The plant on the left will be killed at harvest if cut below the crown. Plants on the right were killed during the winter from frost-heaving.

Persistent Ice Sheeting

Persistent ice sheeting is another environmental condition that can injure or kill alfalfa during winter. Plants can be covered with ice by a sleet or ice storm or when a mid-winter thaw is followed by freezing temperatures. Injury or death can occur in two ways under these conditions. First, plants encased in ice for a week or more can be smothered by metabolic byproducts (e.g. CO_2, ethanol, and methanol) that cannot escape through the ice. Second, ice covered plants are injured when exposed to cold air temperatures due to the low insulation value of ice.

Lack of Snow Cover

Although ice can injure alfalfa, snow is usually beneficial. Snow is a good insulator, offering protection from extremely cold temperatures and fluctuating temperatures. A cover of 6 inches of uncompacted snow will protect alfalfa plants from injury down to an air temperature of -20°F. Therefore, winters without much snow cover generally cause the most damage to alfalfa stands.

Reducing the Risk of Winter Injury

You cannot control the weather. However, you can reduce the risk of winter injury through variety selection, maintaining young stands, potassium fertilization, soil drainage, snow retention, and timely cutting management.

Variety Selection

The risk of winter injury is reduced when winter-hardy varieties are grown. Winterhardiness is the capacity of a plant to survive adverse conditions during the winter. Alfalfa varieties are rated for winterhardiness based upon an observed relationship between fall dormancy and winter-hardiness. Varieties that produce the least top growth following a mid-September cutting are termed very fall dormant and tend to be more winterhardy. A fall dormancy rating system used in Minnesota, Michigan, and elsewhere, identifies nine levels of dormancy:

very dormant [index 1]
dormant [2]
moderately dormant [3]
semidormant [4,5,6]
moderately nondormant [7]
nondormant [8]
very nondormant [9]

Varieties with fall dormancy ratings of 1 and 2 are recommended for long-term stands of 5 or more years or for pasture in Michigan. Additionally, varieties with fall dormancies of 3 and 4 can be recommended for long-term stands if they have been tested in northern Michigan and show adequate productivity and survival. Varieties with fall dormancy ratings from 1 to 5 can be planted for short-term stands of 2 to 4 years. Fall dormancy ratings and recommendations for alfalfa varieties tested in Michigan are reported in an annual report of alfalfa variety trials (e.g. MSU Dept. of Crop & Soil Sciences File 22.331).

The use of fall dormancy ratings to indicate winterhardiness is based on the assumption of a strong relationship between these two characteristics. However, recent evidence indicates a weaker relationship between fall dormancy and winterhardiness in many newer semidormant varieties. These varieties are characterized by rapid regrowth after cutting and multiple disease resistance. Therefore, an accurate characterization of the winterhardiness of these varieties cannot be based solely on fall regrowth but also must include evaluating plant survival through the winter.

The risk of winter injury is also reduced when disease resistant varieties are grown. An alfalfa variety is made up of plants that are not genetically uniform. Therefore, the disease resistance rating of a variety is based upon the percentage of individual plants showing resistance to a disease. Five categories are used to rate disease resistance:

Susceptible, 0-5% resistant plants
Low Resistance, 6-14% resistant plants
Moderate Resistance, 15-30% resistant plants
Resistant, 31-50% resistant plants
High Resistance, >50% resistant plants

Disease resistance helps alfalfa plants survive the winter. The risks associated with low or fluctuating temperature, persistent ice sheeting, and lack of snow cover increase in diseased plants. Diseased plants are less vigorous, develop less cold hardiness, and can be easily injured during the winter. Wounds resulting from winter injury provide a point of entry for disease organisms. This cycle intensifies as plants grow older. Resistance to bacterial wilt is recommended for varieties grown anyplace in Michigan and resistance to anthracnose is recommended for varieties grown in the Lower Peninsula. In addition, phytophthora root rot resistance is recommended when alfalfa is grown on poorly or somewhat poorly drained soils.

Recommendation: Choose alfalfa varieties that are moderately winterhardy, winterhardy, or very winterhardy and resistant to bacterial wilt and anthracnose. Yield, winterhardiness, and disease resistance ratings of individual varieties are published in MSU Extension Bulletin E-1098 (Hesterman et al., 1991) and MSU Dept. of Crop & Soil Sciences File 22.331 (Hesterman et al., published yearly in January).

Stand Age

Another way to reduce the risk of winter injury is to maintain young stands. Young alfalfa stands are less susceptible than older stands to winter injury for two reasons. First, young plants are less likely to be affected by disease and less predisposed to winter injury. Second, young stands generally have higher plant populations than older stands, so some plants can be winterkilled with little effect on total yield. Table 1 shows that 4-year-old stands of alfalfa cut three or four times suffered greater winter injury due to cutting in mid-September and mid-October than 2-year-old stands subject to the same cutting schedules.

Table 1. Effects of alfalfa stand age and harvest schedules with variable date of fall cutting on first-cut yield and stand density following a severe Minnesota winter.

		2-yr-old stand		**4-yr-old stand**	
Cuts/yr	Final cut date	Stands	Yield	Stands	Yield
		%	Ton/acre	%	Ton/acre
3	15 Sept.	75	1.7	18	0.9
	15 Oct.	78	1.9	12	0.7
4	15 Sept.	55	1.0	12	0.5
	15 Oct.	70	1.3	16	1.2
LSD (0.05)		11	0.2	8	0.4

Source: Adapted from Sheaffer, 1989.

The risk of winter injury to seedling alfalfa increases if alfalfa is planted too late in the summer. For the hardening processes to be effective, plants need to develop several trifoliolate leaves before winter. Therefore, the last recommended dates for summer seedings are August 15 in southern Michigan and August 1 in northern Michigan.

Recommendation: Plant new stands each year, but do not plant after recommended dates. If you harvest some of your alfalfa in the fall, harvest the young stands and let the older stands remain unharvested going into the winter.

Potassium

The risk of winter injury is reduced when soil levels of potassium (K) are adequate. Adequate levels of K promote vigorous and healthy alfalfa and help protect against winter injury. Figure 2 shows how K fertilization benefits stand density. Higher K fertilizer rates resulted in higher alfalfa plant populations in the spring of the fourth year. The beneficial effect of K fertilization was especially evident with the more intense cutting schedule.

Recommendation: Test soil and apply fertilizer according to Table 2 to achieve a realistic yield goal. If the recommended amount is less than 400 lbs K_2O/acre, broadcast all the fertilizer for one year in a single application. Broadcast in the spring, summer, or fall when the soil is firm enough to support the spreading equipment and when the foliage is dry enough to prevent sticking and burning.

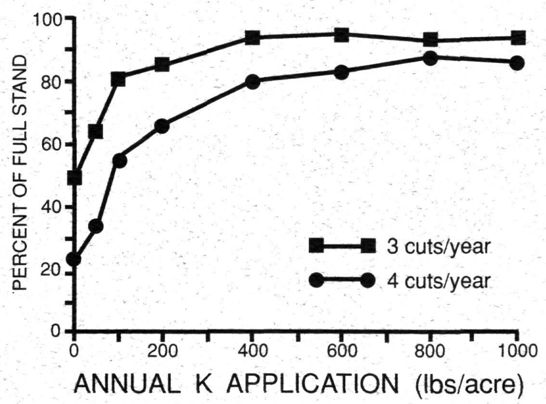

Figure 2. How K fertilizer and the number of cuts effect an alfalfa stand in the spring of the fourth year. Source: Smith et al., 1986.

Soil Drainage

The risk of winter injury is increased when alfalfa is grown on poorly or somewhat poorly drained soils. Injury from frost heaving and persistent ice sheeting is more apt to be a problem in low, wet areas or on poorly drained soils. Moreover, saturated and wet soil conditions promote diseases such as phytophthora root rot during the growing season and can limit hardening in the fall.

Recommendation: Grow alfalfa on well drained soils, and do not irrigate alfalfa in the fall. Other forage legumes (e.g. birdsfoot trefoil or clover) are better choices for wet areas. If you must grow alfalfa in wet areas, select a variety resistant to phytophthora root rot.

Snow Retention

The risk of winter injury is reduced when alfalfa is insulated from lethal cold temperatures and wide temperature fluctuations by a covering of snow. Although there is no practical way to control amount of snowfall, there are ways to retain the snow once it has fallen. Snow can be trapped by unmowed strips in the field, high stubble (6 inches), and fall regrowth. Conversely, manure spread on snow can cause the snow to melt.

Recommendation: Raise mowing height at the final harvest to 6 inches to retain snow. Avoid spreading manure on snow-covered alfalfa.

Seasonal Cutting Strategy

When and how often alfalfa is cut probably has a greater impact on winter injury than any other management practice. As you develop a seasonal cutting strategy for a field of alfalfa, consider both the impact of the strategy on the stored root reserves of the alfalfa plants and your goals for alfalfa production.

Stored root reserves are important. They provide energy for regrowth in the spring and after each cutting. Stored root reserves are also the main energy source for alfalfa during the winter. The storage and depletion of root reserves follows a cyclical pattern. Figure 3 graphically represents the relationship between alfalfa growth stage and level of stored root reserves for one regrowth cycle. Stored root reserves decline from initial regrowth (in the spring or after the alfalfa is cut) until plants have produced 8-10 inches of top growth. Plants with 8-10 inches of top growth can synthesize enough carbohydrates by photosynthesis to begin to replenish the root reserves. The maximum level of stored root reserves is usually achieved at full bloom. Between full bloom and seed maturity, the level of stored root reserves declines slightly. This decline is due to the decreased photosynthetic efficiency of the older leaves and the concentration of carbohydrates in developing seeds and new shoots.

Cutting or grazing alfalfa frequently and/or at early stages of growth throughout the season can deplete stored root reserves. Root reserves can also be depleted when frost kills fall regrowth in early growth stages. Alfalfa plants that go into the winter with depleted root reserves are more susceptible to winter injury.

Your production goals for alfalfa are the second major factor to consider as you develop a seasonal cutting strategy. Goals for alfalfa production usually relate to forage yield, forage quality, and/or stand persistence. It is impossible to simultaneously maximize forage yield, forage quality, and stand persistence. As alfalfa plants mature and increase in biomass per acre (forage yield) they decrease in concentration of nutrients per ton of biomass (forage quality). The number of years that any

Table 2. Annual potassium (K_2O) recommendations for alfalfa grown on mineral soils.

Soil Test (lbs K/a)	Yield goal (tons/acre) 3	4	5	6	7	8
Potassium recommendation, lb K_2O/acre on sandy loams and loamy sands						
25	290	310	340	360	390	410
50	260	290	310	340	360	390
75	240	260	290	310	340	360
100	210	240	260	290	310	340
125	190	210	240	260	290	310
150	160	190	210	240	260	290
175	140	160	190	210	240	260
200	110	140	160	190	210	240
225	90	110	140	160	190	210
250	60	90	110	140	160	190
275	40	60	90	110	140	160
300	0	40	60	90	110	140
325	0	0	40	60	90	110
350	0	0	0	40	60	90
375	0	0	0	0	40	60
400	0	0	0	0	0	40
Soil test (lbs K/a) — Potassium recommendation, lb K_2O/acre on loams, clay loams, and clays						
25	270	320	370	420	470	520
50	240	290	340	390	440	490
75	200	250	300	350	400	450
100	160	210	260	310	360	410
125	120	170	220	270	320	370
150	90	140	190	240	290	340
175	50	100	150	200	250	300
200	0	60	110	160	210	260
225	0	20	70	120	170	220
250	0	0	40	90	140	190
275	0	0	0	50	100	150
300	0	0	0	0	60	110
325	0	0	0	0	20	70
350	0	0	0	0	0	40
375	0	0	0	0	0	0

Source: Michigan State University Cooperative Extension Bulletin E-550

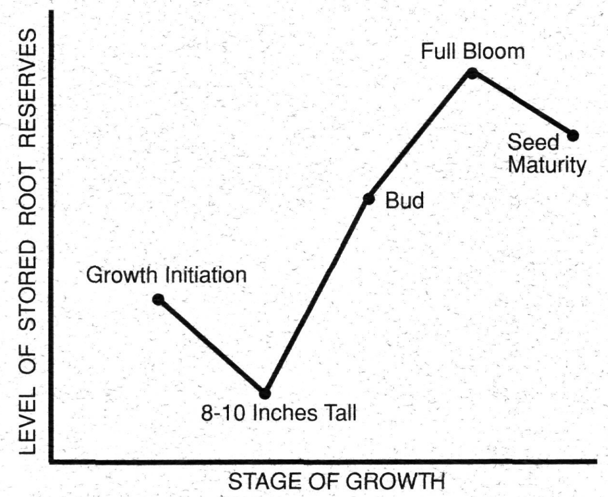

Figure 3. Alfalfa growth stages and level of stored root reserves.

alfalfa stand will be productive is affected by many factors, both controllable and uncontrollable. The seasonal cutting strategy that you develop involves a trade-off among your needs for high forage yield, high forage quality, and stand persistence.

Recommendations: (1) Schedule your cuttings based upon alfalfa stage of growth and your goals for forage production. Harvest at the early bloom stage of growth to maximize nutrient yield per acre and ensure that root reserves have been restored to a reasonably high level. Harvesting earlier maximizes forage quality but does not ensure adequate levels of stored root reserves. Harvesting later maximizes yield and stored root reserve levels but forage quality is lowered.

(2) Offset the risk of winter injury by selecting multiple disease resistant, winter hardy varieties, maintaining young stands, keeping soil fertility levels high, growing alfalfa on well drained soils, and retaining snow in the winter if possible.

(3) Delay the first cutting of winter-injured stands until full bloom. If alfalfa plants were frost heaved, cut above the normal height to avoid crown injury.

(4) Reduce the risk of winter injury by allowing time for replenishing root reserves (indicated by

early bloom growth stage or later) at least once annually if you are going to take three or four cuts in Michigan.

(5) Reduce the risk of winter injury by taking the fourth cut after the last killing frost (mid-October in southern-lower Michigan).

(6) Cut four times per year after the establishment year for high yields of quality forage with good persistence (late May through June 5 at late bud; July 5 through 10 at early bloom; August 15 through 25 at early bloom; and October 15 through 31 in southern-lower Michigan).

How to Estimate Yield Loss Due to Winter Kill

The risk of winter injury and winter kill can be reduced but not eliminated. Following a severe winter, some yield loss is inevitable. An early and reliable estimate of this yield loss may help you plan to meet forage needs. Estimates of yield losses are also important when you are trying to decide whether to maintain, reseed, or plant your alfalfa field to another crop. To estimate yield losses you need to know: (1) typical or long term average yield for that field, (2) stand age, (3) viable plant population.

Information on typical or long term average yield and stand age should be in your farm records. Viable plant population, however, can only be determined by a hands-on inspection and count. Do an initial inspection in early April when spring regrowth normally begins. If the results of this inspection are inconclusive, you need to inspect again in a couple of weeks. Although the inspection procedure may seem tedious, the only difficult part is determining whether plants are viable.

Viable plants are plants that are alive and healthy enough to produce forage throughout the season. To determine viability, split open a few crowns and roots. Viable plants have firm white roots while non-viable plants have decaying yellowish-brown to black roots. Some plants may have enough carbohydrate reserves in the crown to begin spring regrowth, but their roots are dead or will die before the end of the season. These plants are not viable. Figures 4-7 will help you to distinguish between viable and nonviable plants.

Viable plant populations are expressed as viable plants per square foot. Counting is easier if you make a 1 foot by 1 foot square frame. Throw this frame randomly in the field and count the viable plants within. Repeat this procedure at least 20 times. For areas larger than 20 acres, take a minimum of 1 count per acre (e.g. at least 30 counts for 30 acres). Calculate the average number of viable plants per square foot over the area for which the estimate is being made. If the winter injured plants are not uniformly distributed throughout the field, subdivide the field for sampling. For example, a field might have a low spot where plants were killed by ice and an upland area where there was little injury. In this case take separate counts and calculate separate averages for the low and upland areas.

Table 3 shows the effect of stand age and viable plant population on potential yield. You can use estimates directly from this table if the field that you are evaluating had a full stand last fall. A full stand is the number of plants per square foot that corresponds to the 100% potential yield level for the age of stand in question (e.g. for a stand seeded three years ago, a full stand is one with at least 5-6 viable plants per squarefoot). If the field that you evaluate had a full stand last fall, yield loss this year is estimated by the difference between 100% and the percent of potential yield as read from the table. If the field that you evaluate had less than a full stand last fall, then yield loss this year is estimated by the difference between percent of potential yield at the viable plant population last fall and the percent of potential yield at the plant population measured this spring.

Example 1. A 15 acre alfalfa field was covered by ice for two weeks last winter. According to farm records the long term average yield is 6 tons/acre. The field was seeded 3 years ago. Last fall the plant population was 7 plants per square foot (more than a full stand). This spring the farmer found a thin stand throughout the 15 acres. The farmer randomly sampled 20-one square foot areas, finding an average of 3 viable plants per square foot.

From Table 3, the farmer finds the percent of potential yield with 3 viable plants per square foot on a three-year-old seeding is 70%. The estimated yield loss is 30% (100-70) or 1.8 tons/acre (30% x 6 tons/acre).

Example 2. A 40 acre alfalfa field was seeded two years ago. The long term average yield is 5 tons/acre. There were 5 plants per square foot last fall. This field was winter killed and is now very thin. The farmer randomly sampled 40-one square foot areas and calculated the average viable plant population to be only 3 plants per square foot this spring. What is the farmer's estimated yield loss? It is calculated in three steps:

Step 1: Percent of potential yield last fall was 85% (5 plants per square foot on a two-year-old seeding).

Step 2: Percent of potential yield this spring was 60% (3 plants per square foot on a two-year-old seeding).

Step 3: Estimated yield loss this year 25% (85-60%) or 1.25 tons/acre (25% x 5 tons/acre).

Summary

In this bulletin we have discussed how alfalfa plants are injured or killed in the winter, management practices to reduce the risk of winter injury, and how to estimate yield loss due to winterkill. We have provided this information to help you reduce the risk of winter injury in your fields and anticipate and plan for yield reductions due to winterkill.

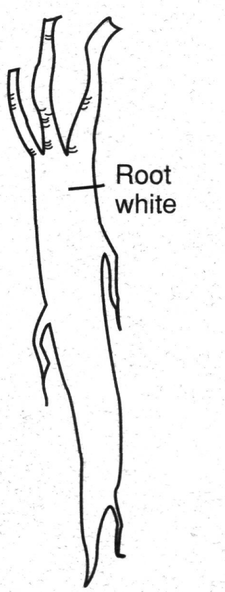

Figure 4. No injury. Roots are solid white internally. Tillers are beginning to green and are solidly attached to the root.

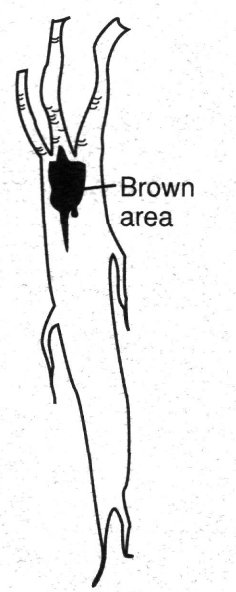

Figure 5. Moderate injury. Roots are solid and white but brown damaged areas occur in old tissue of the crown down 1 to 2 inches. Growth beginning. With favorable growing conditions and a delayed first cutting, many of these plants will survive.

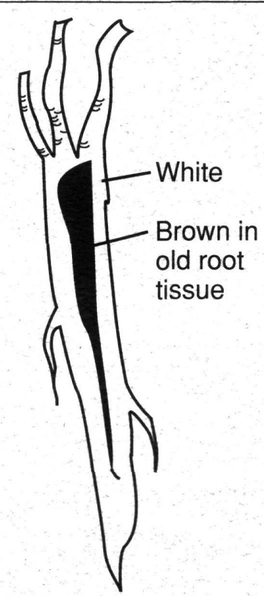

Figure 6. Severe injury. Roots white on outside. Brown discoloration carries down in center of the root. The chances are not very good that these plants will survive.

Figure 7. Dead plants. Roots are discolored, mushy, and partly rotted. Top growth can be readily pulled from the crown. (Source of Figures 4-7: Rohweder and Smith, 1978.)

Table 3. How stand age and viable plant population effect the percent of potential alfalfa yield.

Year Seeded	Viable Plants Per Square Foot							
	1	2	3	4	5-6	7-9	10-15	>15
	percent of potential yield							
Last year	15	25	30	40	50	65	80	100
2 years ago	30	50	60	70	85	100	100	100
3 years ago	30	65	70	85	100	100	100	100
4 years ago	50	70	85	100	100	100	100	100
>4 years ago	75	90	100	100	100	100	100	100

References

Hanson, A.A., D.K. Barnes, and R.R. Hill, Jr. (ed.). 1988. Alfalfa and alfalfa improvement. ASA, CSSA, SSSA, Madison, WI.

Hart, L.P. and J.L. Clayton. 1986. Alfalfa diseases. MSU Cooperative Extension Service Bulletin E-1976.

Hesterman, O.B., R.H. Leep, and J.J. Paling. 1991. Alfalfa variety recommendations for Michigan. MSU Cooperative Extension Service Bulletin E-1098.

Hesterman, O.B., R.H. Leep, and J.J. Paling. 1991 (updated yearly as a supplement to E-1098). Alfalfa varieties for Michigan in 1991. MSU Dept. of Crop & Soil Sciences File 22.331.

Rohweder, D.A. and D. Smith. 1978. Winter injury to forages. University of Wisconsin Extension Service Bulletin A2905.

Sheaffer, C.C. 1989. Fall cutting is a management option in the North. Proceedings of the 1989 American Forage and Grassland Conference. p. 23-29. AFGC. Belleville, PA.

Smith, D., R.J. Bula, and R.P. Walgenbach. 1986. Forage management 5th ed. Kendall/Hunt Publishing Company, Dubuque, IA.

Warncke, D.D., D.R. Christenson, and M.L. Vitosh. 1985. Fertilizer recommendations: vegetable and field crops in Michigan. MSU Cooperative Extension Service Bulletin E-550.

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