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Effects of natural and simulated rainfall on indicators of ensilability and nutritive value for wilting alfalfa forages sampled before preservation as silage[1]

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ABSTRACT

The frustrations of forage producers attempting to conserve high-quality alfalfa (*Medicago sativa* L.) silage during periods of unstable or inclement weather are widely known. Our objectives for this series of studies were to (1) assess indicators of ensilability, such as pH, buffering capacity, water-soluble carbohydrates (WSC), and starch for wilting alfalfa forages receiving no rainfall or damaged by simulated or natural rainfall events; (2) use these data as inputs to calculate the threshold moisture concentration that would prohibit a clostridially dominated fermentation; and (3) further evaluate the effects of rain damage or no rain damage on measures of forage nutritive value. Rainfall events were applied to wilting forages by both simulated and natural methods over multiple studies distributed across 4 independent forage harvests. Generally, simulated rainfall was applied to alfalfa under controlled conditions in which forages were relatively wet at the time of application, and subsequently were dried to final moisture endpoints under near ideal conditions within a constant temperature/humidity environmental chamber, thereby limiting postwetting wilting time to ≤21 h. As a result, indicators of ensilability, as well as measures of nutritive value, changed only marginally as a result of treatment. Consistently, reductions in concentrations of WSC and starch occurred, but changes in WSC were relatively modest, and postwetting concentrations of WSC may have been buoyed by hydrolysis of starch. When forages were subjected to natural rainfall events followed by prolonged exposure under field conditions, indicators of ensilability were much less desirable. In one study in which alfalfa received 49.3 mm of natural rainfall over a prolonged (8-d) field-exposure period, fresh pH increased from 6.48 to 7.43 within all forages exposed to these extended, moist wilting conditions. Furthermore, sharp reductions were observed in buffering capacity (410 vs. 337 mEq/kg of DM), WSC (6.13 vs. 2.90%), starch (2.28 vs. 0.45%), and clostridially dominated fermentation (62.7 vs. 59.4%). Based on these experiments, the potential for good fermentation is affected only minimally by single rainfall events applied to relatively wet forages, provided these events are followed by rapid dehydration; however, attaining acceptable silage fermentations with forages subjected to prolonged exposure under poor drying conditions is likely to be far more problematic.

Key words: alfalfa, nutritive value, rain damage, silage

INTRODUCTION

Currently, alfalfa is the most common perennial forage legume grown in the United States, occupying approximately 10 million ha (Sheaffer and Evers, 2007), and it is harvested as both hay and silage for subsequent use in dairy and other livestock diets. Alfalfa often is viewed as a difficult crop to ensile, primarily because of its high buffering capacity, low concentrations of water-soluble carbohydrates (**WSC**), and vulnerability to undesirable secondary clostridial fermentations, especially when ensiled at moisture concentrations >70% (Muck and Kung, 2007). Producers attempting to conserved high-quality alfalfa forage during periods of unstable or inclement weather often are frustrated because preliminary (field) wilting is required for proper preservation of both hay and silage. Frequently, hay or silage producers must weigh the consequences of delaying conservation against the risks of damage by rainfall events that occur before the wilting forage can be harvested. The decision to delay conservation of alfalfa in an attempt to avoid unstable weather also is not without cost, and generally results in a more mature forage crop coupled with associated reductions in nutritive value that are

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widely recognized and understood (Brink et al., 2010). Furthermore, damage to wilting forage crops by unexpected rainfall events often is unavoidable, occurs frequently, and has been described as more damaging to nutritive value than delaying harvest to avoid unstable weather (Fonnesbeck et al., 1986). The specific effects of rain damage to wilting forage crops have been outlined in several research reports. A partial list of these effects includes (1) forage species respond differently to rain damage (Collins, 1982; Scarbrough et al., 2005); (2) generally, forages that are relatively dry at the time rainfall occurs are more susceptible to losses of DM and deleterious changes in nutritive value than forages subjected to rain immediately after mowing (Scarbrough et al., 2005); (3) soluble cell components are leached from forage tissues during rainfall events (Sundberg and Thylén, 1994); (4) the primary leachates are nonstructural carbohydrates (Collins, 1982); (5) losses of leachates result indirectly in greater concentrations of stable forage constituents, such as NDF (Collins, 1982, 1983; Rotz et al., 1991; Scarbrough et al., 2005) and often CP (Collins, 1982, 1983; Scarbrough et al., 2005); and (6) the combined factors described previously act to reduce estimates of in vitro (Collins, 1982, 1983; Rotz et al., 1991) and ruminal in situ DM disappearance (Scarbrough et al., 2005).

Although the scope of these research efforts has established a relatively clear picture of the practical consequences of rain damage to wilting forages, these collective works have been focused primarily on quantifying losses of DM, as well as concurrent deterioration of forage nutritive value, mostly within the context of hay production. Much less information is available concerning the effects of rain damage on wilting forages as they relate to conservation as silage. Most of the effects of rainfall are viewed as obstacles to good silage fermentation, and have been evaluated in review (Muck et al., 2003) with specific emphasis on losses of NSC through direct leaching or via prolonged respiration by plant enzymes, both of which would limit available substrate for silage fermentation. In addition, it is logical to suspect that rewetting may alter the normal epiphytic microflora adhered to wilting forages; however, little actual research has been reported (Muck et al., 2003), and these effects are largely speculative. Taken in total, most of the known effects of rainfall events on wilting alfalfa would not be expected to improve silage fermentation characteristics; however, recommendations to producers for avoiding problematic fermentations are largely based on educated conjecture, rather than observations obtained directly from replicated research studies.

Recently, rainfall simulation techniques have been developed (Miller, 1987), primarily to assess nutrient runoff from pastures and crop-production fields. This general approach has been adapted within a few studies evaluating rain damage to wilting forage crops, including grasses (Scarbrough et al., 2005), as well as alfalfa (Rotz et al., 1991; Smith and Brown, 1994). The main advantage of using these techniques is they permit application of graded levels of simulated rainfall under controlled conditions, which eliminates the random nature of conducting studies that follow naturally occurring rainfall events. Our objectives for this series of studies were to (1) assess indicators of ensilability, such as pH, buffering capacity (**BC**), WSC, and starch for wilting alfalfa forages receiving no rainfall or damaged by simulated or natural rainfall events; (2) use these data as inputs to calculate the threshold moisture concentration that would prohibit a clostridially dominated fermentation (**MAX**; O'Kiely and Muck, 1998); and (3) further evaluate the effects of rain damage or no rain damage on measures of forage nutritive value.

MATERIALS AND METHODS

Source of Forages

Experiments 1 through 4 were conducted during 2010, using monocultures of alfalfa grown at the University of Wisconsin Marshfield Agricultural Research Station (Marshfield, WI; 44°39′ N; 90°08′ W). The forage source for experiments 1 through 3 was Starbuck alfalfa (Spangler SeedTech Inc., Jefferson, WI) that was established in a clean-tilled seedbed with seeding at 22.4 kg/ha on May 4, 2007. This forage source comprised approximately 0.5 ha, and served as a plot border area surrounding other existing small-plot alfalfa field trials. For experiment 4, alfalfa forage was obtained from a small, 0.1-ha area within a 16.5-ha production field of Pioneer 53V52 alfalfa (Pioneer Hi-Bred, Johnston, IA) that had been no-till seeded at 17.9 kg/ha into winter-rye stubble on June 4, 2008. Previously, the winter rye had been harvested as silage from the site on May 29, 2008.

Experiment 1

Experiment 1.1. At 1115 h on June 1, 2010, standing alfalfa forage was harvested from a small (8.5 × 18.3-m) portion of the field site at the first-flower stage of growth with a Case-International Harvester mower-conditioner (model 8830; J. I. Case Co., Racine, WI); this was the first cutting from this field site during 2010. Immediately after mowing was completed, alfalfa forage from random locations within the field site was gently loaded into the bed of a pickup truck, and transported to the laboratory for preliminary processing.