USDA-ARS

Rain Damage on Wilting Forages

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A common problem encountered by hay or silage farmers is how to manage production schedules around unfavorable weather, and what damage is done to wilting forage crops as a result of unpredictable rainfall events. Estimating damage to wilting forage crops subjected to rainfall is more complex than simply quantifying nutrient leaching, or the consequences of extended or reactivated plant respiration. Other (secondary) consequences of uncooperative weather also may include:

- increased leaf and/or dry matter (DM) losses from any additional swath manipulation required to dry rain-damaged forages,
- spontaneous heating and/or combustion occurring when farmers try to complete baling operations of incompletely wilted hay prior to an oncoming rainfall event,
- poor silage fermentation,
- excessively mature forage that results from delaying haying or silage-harvesting operations until weather is more favorable.

While all of these factors are worthy of a detailed discussion, this article will be confined to a discussion of leaching coupled with other direct effects of rain damage.

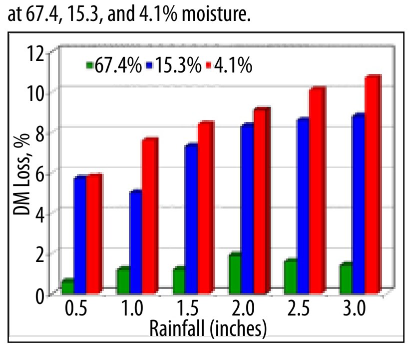
Whenever rainfall damages mowed forages, soluble nutrients (primarily sugars) can be leached from the forage. Even without rain damage, respiration by active plant cells during the field-wilting of mowed/conditioned forages oxidizes plant sugars. This persists at moistures suitable for ensiling, but slows considerably by the time forages reach 50% moisture. However, respiration of plant sugars may continue at a low level until the forage is nearly dry enough to bale as hay. Collectively, these factors explain why rapid drying to the target moisture concentration for silage or hay is important:

- sugars are assumed to be 100% digestible, and unnecessary losses negatively affect the DM digestibility and energy density of the forage,
- sugars are the primary substrate needed for silage fermentation.

Rainfall events during field-wilting can reactivate respiration within dry forages and promote additional growth of microorganisms on the forage. Secondary respiration of this type causes additional plant sugars to be respired, resulting in even greater losses of DM and further reductions in nutritive value.

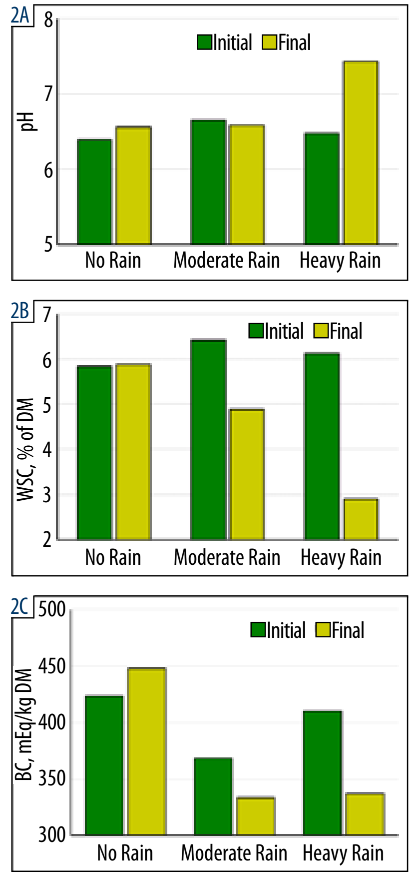
Effects of Rainfall on DM Losses. Leaching losses vary with forage species, forage moisture concentration, concentrations of soluble sugars within the forage, and the number, amount, intensity, and/or duration of the rainfall event(s). An excellent example illustrating some of these effects is based on recent University of Arkansas work [*Agron. J. (2005) 97:604-614*]. Second-cutting orchardgrass forages were field-wilted to one of three moisture concentrations: wet (67.4%), ideal for baling (15.3%), or excessively dry (4.1%). Simulated rainfall was applied in 0.5" increments ranging from 0.5-3.0" (Figure 1). Losses of DM were minimal (<2% of DM) when rain was applied to wet forages, but they were far greater when the orchardgrass was dry enough to bale (15.3%), exceeding 8% of DM when rainfall amounts were >2". Losses were even greater for excessively dry forages, and losses increased with rainfall amount regardless of whether the forage was ideal for baling or excessively dry. Unfortunately, these leaching losses are not distributed equally across all plant parts and/or nutrients; rather, they are disproportionately associated with the most digestible portions of the forage, particularly sugars. As a result, concentrations of fiber components, such as neutral detergent fiber or acid detergent fiber, increase, while the energy density of the forage decreases. Within the previously mentioned University of Arkansas work, parallel studies were

Figure 1. Losses of DM from (2nd-cutting) orchardgrass forages subjected to simulated rainfall in 0.5" increments (0.5-3.0"). Rainfall was applied to forages at 67.4, 15.3, and 4.1% moisture.



conducted with bermudagrass (a perennial warm-season grass) having a very low concentration of sugar. In that parallel study, DM losses from forages dry enough to bale (13% moisture) did not exceed 2.1% over rainfall amounts ranging from 0.5-3.0". In part, this starkly contrasting response can be explained on the basis of the inherently lower concentrations of sugars and other water-soluble compounds within the bermudagrass forage.

Figure 2A-C. Measurements of pH, WSC, BC in alfalfa forages immediately after mowing (Initial) and at ensiling (Final) as affected by natural rainfall events including no rain, moderate rain (1.1"), or heavy rain (1.9"). Heavy rain occurred over an 8-day exposure period. Each rainfall scenario was associated with an independent alfalfa harvest.



Effects of Rainfall on the Ensilability of Alfalfa. A recent study conducted at the University of Wisconsin Marshfield Agricultural Research Station [*J. Dairy Sci. (2012) 95:6635-6653*] examined mowed/conditioned alfalfa forages field-wilted under three scenarios: ideal conditions without rain, moderate rain damage (1.1"), and severe rain damage (1.9") continuing over an 8-day period. Forages were sampled and analyzed for water-soluble carbohydrates (WSC; sugars), pH, and buffering capacity (BC). Normally, BC is an indicator of the natural resistance to pH change during the silage fermentation process, and a lower BC typically makes the forage easier to ensile. Responses to these three wilting scenarios are summarized in Figure 2A-C.

A reliable indicator of aerobic deterioration within forages is an elevated pH. With heavy rain damage, final pH after field-wilting was elevated a full pH unit compared to freshly mown alfalfa; however, there was only minimal change with moderate rain or no rain (Figure 2A). Sugars (WSC) provide the primary substrate for production of lactic and other silage fermentation acids, and they were reduced by 23.5% (6.4 vs 4.9% of DM) with moderate rain damage, but by 52.5% (6.1 vs. 2.9% of DM) with heavy rain damage coupled with a prolonged 8-day exposure period (Figure 2B). In addition, concentrations of starch were reduced in response to rainfall events (not shown), and the hydrolysis of starch under these weathering conditions may actually offset some losses of WSC. These losses of substrate for silage fermentation occurring either by direct leaching or by prolonged respiration can compromise the potential for a good silage fermentation and increase the probability of observing problematic clostridial fermentation products, such as ammonia or butyric acid. Effects of rain damage on BC actually reduce resistance to pH change (Figure 2C), which is beneficial for silage fermentation, but it should not be inferred this compensates for losses of WSC, as well as other consequences of rain damage. The high BC reported for alfalfa is largely associated with leaf tissue, and anything reducing the leaf-to-stem ratio, such as additional tedding/raking or advancing plant maturity, also is likely to reduce BC. Unfortunately, these factors work in opposition to maintaining or optimizing forage quality.

Generally, results of these studies suggest damage to wilting forages becomes more severe as the forage dries. Prolonged exposure in the field, coupled with poor drying conditions and/or multiple rainfall events, is highly problematic, causing substantial increases in pre-ensiled forage pH and significant losses of sugars. When ensiling rain-damaged alfalfa, farmers should consider wilting forages to <60% moisture, and using a silage inoculant formulated to support production of lactic acid. These efforts will decrease the risk of secondary (clostridial) fermentations dominated by production of ammonia and butyric acid as fermentation products.