USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

Managing Grasses to Minimize Challenges from Potassium in Dry Cow Nutrition

U.S. Dairy Forage Research Center

Introduction

High concentrations of potassium (K) in grasses can cause problems with transition dairy cows, contributing to milk fever (hypocalcemia, or low blood calcium) that commonly occurs after freshening. Potassium is absorbed from the diet at nearly 100% efficiency, and is strongly alkalinizing (NASEM, 2021). High dietary K levels raise the blood pH, which interferes with calcium absorption from feed and mobilization from bone. The recommended dietary K concentrations for dry dairy cows are 0.62% [dry matter (DM) basis] from 60 to 21 days before calving, and 0.69% during the final 21 days of pregnancy (NASEM, 2021). Grass and legume forages typically exceed this level. Cool-season grasses, and cool-season annuals can be especially problematic in this respect, as K concentrations in these grasses often exceed 3.00% of DM.

In part to address these issues, a dietary cation-anion difference (DCAD) is often calculated for diets of dry cows. Dietary cations, which include K^+, as well as Na^+, Ca^{2+}, and Mg^{2+}, all will raise blood pH when absorbed into the blood. Conversely, dietary anions (eg., Cl^-, SO_4^{2-}, or PO_4^{3-}) typically have the opposite effect. The DCAD is calculated as the sum of major cations (K^+ and Na^+) minus the sum of major anions (Cl^- and S^{2-}), where the recommended values are 66 and -100 mEq/kg DM for dry cows at 60 to 21 and < 21days before parturition, respectively (NASEM, 2021). As such, anionic salts often must be supplemented within diets for dry cows to maintain these recommended (low or negative) cation-anion difference levels.

Careful consideration of the potassium levels in grasses and other feed ingredients in dry cow and close-up rations is crucial to avoid milk fever after calving.

Forage Species/Maturity

Figures 1 and 2 summarize K concentrations within grass and legume forages that are adapted from the compendium provided by NASEM (2021). This includes thousands of results obtained from various fee-for-service laboratories throughout the United States. For Figure 1, concentrations of K are presented for legume, grass, and mixed hays, where the generalized forage type and maturity designations are provided by NASEM (2021). It is advisable to resist the assumption that legumes are inherently higher in K than grasses. The visual differences on the graph may indicate nothing more than generally better soil fertility and/or more desirable soil types for the legume forages, which are often considered a higher priority and a more valuable crop. Figure 1 summarizes only hay samples, so it is likely that some of these hays also

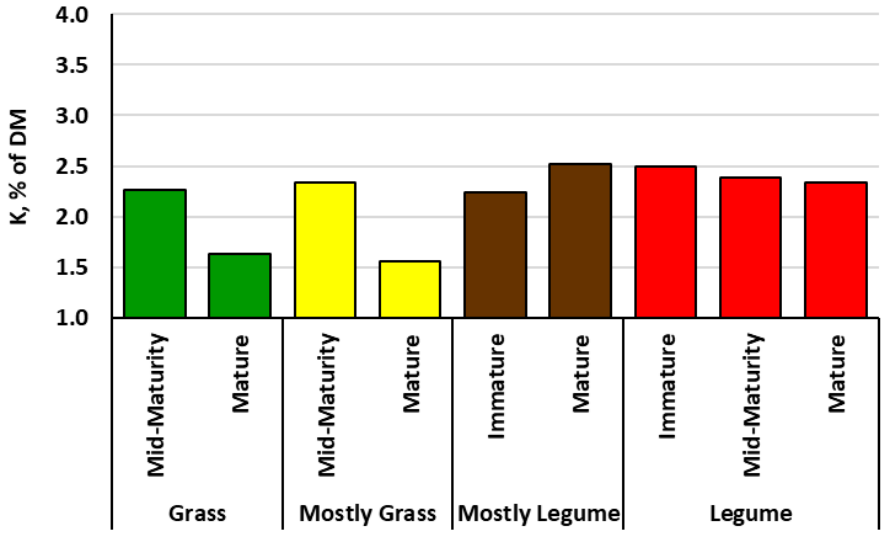

Figure 1. Concentrations of forage potassium (K) in legume, grass, and mixed hays as compiled by NASEM (2021).

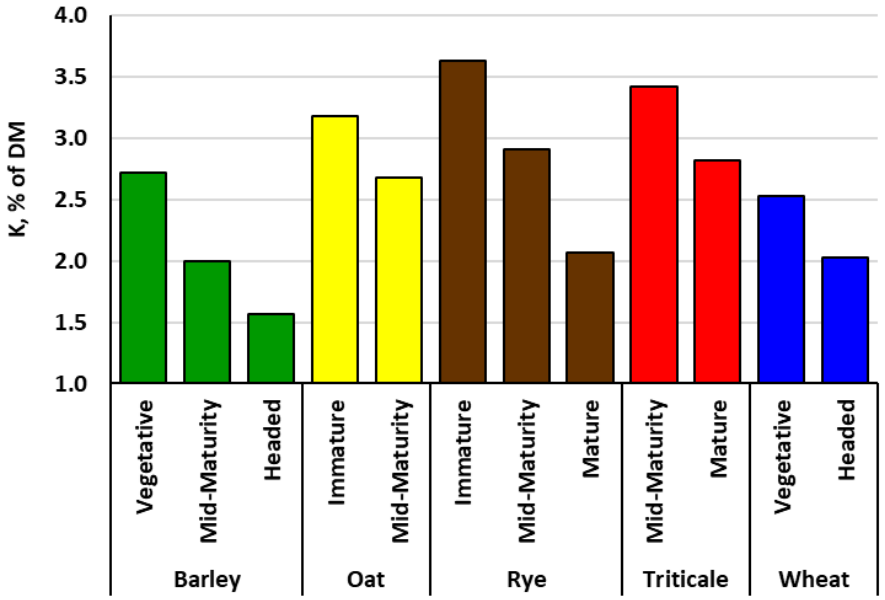

Figure 2. Concentrations of forage potassium (K) in various cereal-grain silages as compiled by NASEM (2021).

may have been damaged by rain. As a result, any leaching of minerals in response to rainfall events would be incorporated within the presented data.

Similarly, Figure 2 illustrates K concentrations in cereal-grain silages, again based on thousands of submitted producer samples compiled by NASEM (2021). As previously mentioned, concentrations of K in these silages are often excessively high, frequently exceeding 3% of DM. For that reason, they are often discouraged from use in diets requiring low K. Even wheat straw, which often is used to provide additional dietary fiber or dilute the energy density within some diets, has a relatively high concentration of K (1.72% of DM; NASEM, 2021). It also is noteworthy that plant maturity has a consistently negative effect on concentrations of K for these cereal-grain silages. In addition to the normal effects of plant maturity, cereal grains partition significant portions of total plant DM into the grain head when harvested at advanced growth stages. The grain portion of mature cereal grains typically exhibits relatively low concentrations of K, ranging narrowly from 0.47 to 0.59% of DM for wheat, triticale, oat, and barley (NASEM, 2021). This response may somewhat exacerbate the maturity effect illustrated for some of these headed or mature silages.

As suggested strongly in Figures 1 and 2, advancing plant maturity consistently reduces concentrations of K in forages. Another good example of this effect can be summarized from recent work conducted at Marshfield, Wisconsin (Coblentz et al., 2010). Although perennial warm-season forages are grown primarily in the southern US, some tall-growing species, such as eastern gamagrass are adaptable to upper Midwest environments. In the Marshfield study (Figure 3), concentrations of K in the initial growth of eastern gamagrass declined with plant maturity, ranging from 1.89 (15 June) down to 1.14% of DM (15 August). Perennial warm-season grasses often exhibit lower concentrations of K than cool-season grasses, but this generalization is dependent on many factors.

Past Fertilization History

Concentrations of K can be particularly problematic when forages are grown on high-K soils, which may reflect past histories of heavy manure distribution or potash application at the site. Numerous studies have shown a positive relationship between soil-test K and the K in the harvested forage. Recent research was conducted at Prairie du Sac, Wisconsin, where orchardgrass was fertilized with either commercial N fertilizer or manure and harvested in multiple cuttings for two years (Hedtcke et al., 2011). Across the study, manured forages averaged 0.40 percentage units greater K than forages grown with commercial N fertilization (3.40 vs. 3.00% of DM). Similarly, statistical differences based on soil-amendment source were observed consistently within individual cuttings (Figure 4). If there is a need for low-K forages, producers may wish to designate a specific field site where applications of K-laden soil amendments are based closely on soil-test recommendations, which may necessitate eliminating routine manure distributions.

Nitrogen (N) Fertilization

Effects of N fertilization on concentrations of K in grasses are notably inconsistent. Responses to N fertilization are likely related to growing conditions, as well as soil fertility (particularly soil K). Returning to the eastern gamagrass study summarized in Figure 3, N fertilization rate had a negative effect on forage K. Although concentrations of K declined very modestly from 1.56 to 1.49% of DM across N fertilization rates ranging from 0 to 180 lbs N/acre, this declining relationship was statistically significant.

In sharp contrast, concentrations of K in oat forages grown during the fall in central Wisconsin exhibited a positive linear response to N fertilization (Coblentz et al., 2016). In that study, concentrations of K were characteristically high for cereal-grain forages, ranging from 3.67 to 4.40% of DM (Figure 5). They also increased by about 0.1 percentage unit for every 10 lbs N applied. Thus, forage

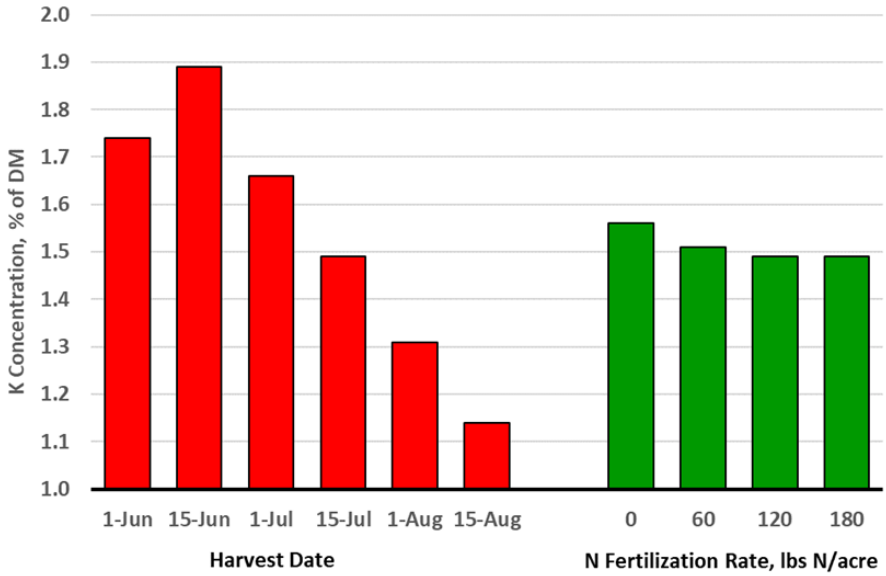

Figure 3. Concentrations of K in eastern gamagrass forages grown at Marshfield, Wisconsin, as affected by harvest date and N fertilization rate [adapted from Coblentz et al. (2010)].

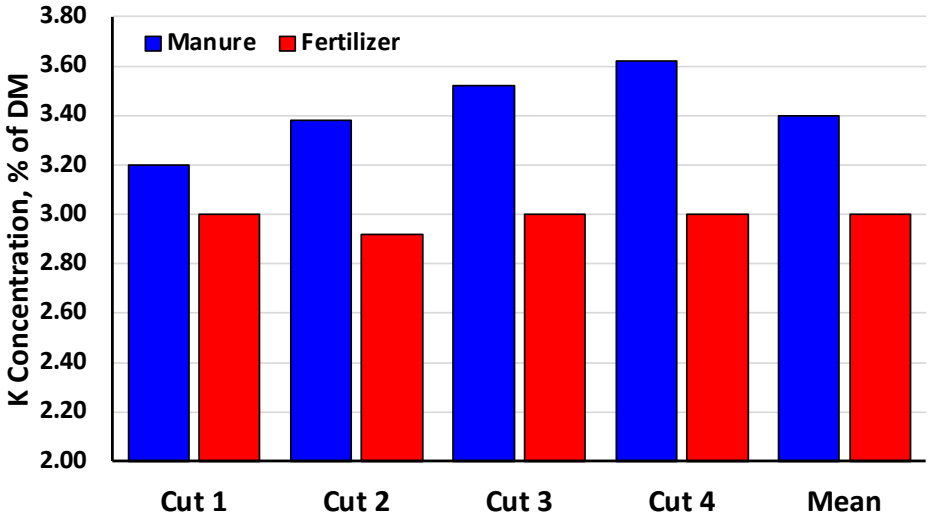

Figure 4. Concentrations of K within orchardgrass forages amended with either commercial N fertilizer or manure [adapted from Hedtcke et al. (2011)].

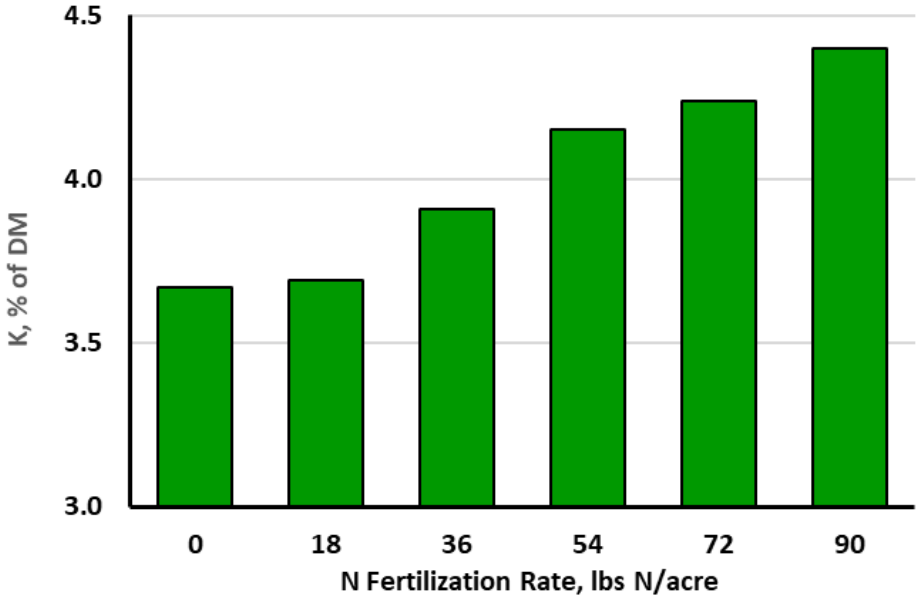

Figure 5. Concentrations of K within fall-grown oat forages fertilized with different rates of commercial N fertilizer at Marshfield, Wisconsin [adapted from Coblentz et al. (2016)].

concentrations of K may increase with N fertilization under some conditions but may not in others. These inconsistent responses to N fertilization are likely related to both growing conditions and varying availability of soil minerals.

Summary

High K concentrations can be a contributing factor to hypocalcemia (milk fever), and numerous factors can affect concentrations of plant tissue K. Normally, soil-test K is positively associated with tissue K concentrations. Therefore, sites with past histories of excessive or repeated manure applications or fertilization with commercial K sources are often problematic. Cool-season grasses, and particularly cool-season annuals, are especially prone to high K concentrations. Perennial warm-season grasses typically exhibit lower K than many other forages. Usually, concentrations of K decline as forage plants mature, but inconsistent effects may be observed in response to N fertilization. Cool-season grasses often exhibit high concentrations of K and may not be the best choice for dry dairy cows.

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U.S. Dairy Forage Research Center, USDA-Agricultural Research Service

1925 Linden Drive, Madison, WI 53706 | Phone: 608-890-0050

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