# NITRATE CONCENTRATIONS IN OKLAHOMA HYBRID SUDANGRASS AND PEARL MILLET HAYS

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## Story in Brief

Samples (n=1772) of hybrid Sudangrass and Pearl Millet hays were collected from three Agronomy Research Stations in two years. Forty varieties in 1990 and 34 varieties in 1991 were evaluated for yield potential and nitrate accumulation. Forage types included in the data were: 1) Sorghum x Sudan; 2) Sorgo x Sudan; 3) Sudan x Sudan; and 4) Pearl Millet. Field locations were Eastern Oklahoma Station, South-Central Oklahoma Station, and the Southwestern Oklahoma Station. Nitrogen was applied as split applications of 50 lb of actual nitrogen per acre at planting and after each harvest. Planting occurred in late May and harvesting was done as plants reached pre-boot to boot stage of seed head development. Plants were mechanically harvested at approximately 4 inches above the ground. Two or three cuttings were made at each location each year. Sun-cured samples (approximately 1 lb) consisting of leaves and stems were obtained from each plot. Nitrate content was determined and adjusted to 100% dry matter forage. Varieties within forage type were not different from each other. A significant location x type interaction was observed. Pearl Millets had greater concentrations of nitrate at all locations. The magnitude of the difference was greater when all plants were stressed resulting in large amounts of nitrate in all forage types. The relationship between forage yield and nitrate content was positive, but very small. A much greater proportion of the Pearl Millet samples had greater than 10000 ppm nitrate and would be considered potentially toxic to ruminants.

(Key Words: Nitrate, Hybrid Sudangrass, Millet.)

## Introduction

Death loss from nitrate is an occasional problem in ruminants consuming certain standing or harvested forages. Nitrate accumulation usually results from plant stress such as drought and is accentuated by excessive soil nitrogen. Most nitrate accumulates in plant stems rather than leaves, and concentration tends to be highest in immature forage. Seeds seldom contain significant amounts. Poisoning can be avoided with good management. Fertility programs consistent with plant needs and growing conditions minimize the problem. Potentially dangerous forage should be tested before feeding. Often

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hay containing excessive nitrate can be fed safely when diluted with other feed, particularly concentrates.

Annual forage crops such as sorghums, Sudangrass hybrids, Pearl Millets and small grains make valuable contributions to profitable beef production in Oklahoma. They are well adapted, very productive and provide high quality forage. Occasionally, some of these plants accumulate toxins that can result in costly livestock losses.

Nitrate is the primary nutrient form of nitrogen in most soils and is a normal constituent of plants. Normally nitrate is assimilated so rapidly following uptake from soil that its concentration in plant tissues is low. Occasionally, excessive levels occur in plants. The most notorious accumulators of nitrate in Oklahoma are the sorghums and Pearl Millet. Other annuals that less frequently accumulate nitrate are small grains (wheat, oats, rye and barley). Some perennial grasses (bermudagrass, fescue and johnsongrass) and certain weeds (pigweed, mustard, nightshade and lamb's quarters) also can contain dangerous levels.

Accumulation is usually triggered by some environmental stress, where plant growth is restricted but absorption of nitrate from soil continues. The most common stress of summer annuals is drought. Lack of moisture, together with excessive soil nitrogen for existing growing conditions, is a frequent cause of toxic levels of nitrate in sorghums. Other stress factors which favor buildup are reduced sunlight from cloudiness or shading, frost, certain herbicides including 2,4-D, acid soils, low growing temperatures, and deficiencies of essential nutrients like phosphorus and sulfur.

When more soil nitrogen is present than needed for maximum growth, some plants tend to accumulate nitrate even without environmental stress. This response is particularly true with hardy soil feeders like sorghums, noted for "luxury consumption" of certain nutrients. Rate of uptake diminishes with increasing maturity; thus mature plants usually contain less nitrate than immature ones. Differences in potential for accumulation exist among species and varieties.

The level of nitrate that causes toxicity in ruminants varies depending on rate of intake, diet, acclimation to nitrate and nutritional and reproductive status. As a rule, forage containing less than 6,000 ppm nitrate on a dry matter basis is safe for non-breeding cattle. Forage containing 6,000 to 10,000 ppm nitrate is considered potentially toxic when provided as the only feed. Forage containing over 10,000 ppm nitrate is considered "dangerous" but often can be fed safely after proper dilution with other feeds. Some diagnostic laboratories are even more conservative and suggest that 9000 ppm nitrate can be lethal. A characteristic symptom of nitrate toxicity is a chocolate-brown color to the blood.

Questions among cattle producers and hay growers about the potential nitrate accumulation in various forages caused the following experiment to be conducted and reported.

## Materials and Methods

During the summer of 1990, 17 varieties of Sorghum x Sudan, 12 varieties of Sorgo x Sudan, five varieties of Sudan x Sudan hybrids, and six varieties of Pearl Millets were grown at three Oklahoma State University Agronomy Experiment Stations for yield evaluations. The second year of the study was conducted in 1991 with 18 varieties of sorghum x Sudan, nine varieties of Sorgo x Sudan, two varieties of Sudan x Sudan hybrids and five Pearl Millets. Six varieties were present both years. Field locations were: Eastern Oklahoma Agronomy Experiment Station at Haskell, OK in Muskogee County; South-Central Oklahoma Agronomy Experiment Station in Grady County near Chickasha; and the Southwestern Oklahoma Station near Tipton in Tillman County. Four replicated plots were randomly assigned to each variety at each experiment station. Each plot was approximately 27 to 36 square feet in size. Fertilization of the plots consisted of phosphorus and potassium according to the soil test. Nitrogen was applied in split applications of 50 lb of actual nitrogen per acre at planting and 50 lb of actual nitrogen top-dressed after each cutting of forage. Planting was in late May and harvesting was initiated as plants reached the pre-boot to boot stage of seed head development. Harvesting was mechanical and plants were cut approximately 4 inches above the ground. Sun-cured hay samples (approximately 1 lb) consisting of leaves and stems were obtained from each plot. Samples were labeled and brought to Stillwater for nitrate concentration analysis and percentage dry matter determination. Duplicate nitrate analyses were made on each sample and were within 1000 ppm nitrate or the nitrate procedure was repeated. The average of the two readings was then considered the nitrate content after being adjusted to 100% dry matter.

Two or three cuttings were made at each location each year. In the second year, very heavy rains at the Eastern Station forced the re-planting of the plots in late June rather than the late May plantings at the other locations. The very hot dry months of July and August then produced heat and drought stress on the plants at that location. The very high concentrations of nitrate in the first cutting of 1991 at the Eastern Station apparently were the result of those weather conditions. Data from the hay samples of the first cutting at the South-Central station in 1991 were not available. The statistical analysis of this large data set was performed by the analysis of variance procedure with differences due to forage type, variety within forage type, field station location and year as the sources of variation studied.

## Results and Discussion

This study contains one of the largest data sets known to exist comparing nitrate concentrations in Oklahoma summer annual hays. The four forage types included in the data were 1) Sorghum x Sudan; 2) Sorgo x Sudan; 3) Sudan x Sudan; and 4) Pearl Millet. Varieties within forage type were not different from each other, therefore we could quickly conclude that different varieties within any of the four types accumulated nitrates similarly. However, there were differences between the four forage types.

A statistically significant two-way forage type by location interaction meant that we should look at each location each year to study the differences in nitrate accumulation among the four forage types. Table 1 illustrates the mean concentration of nitrates in parts per million (100% dry matter) for each forage type. Pearl Millets had greater ($P<.05$) mean concentrations of nitrate at all locations. The magnitude of difference was greater when all plants were stressed and each forage type had increased nitrate content. The relationship between yield per acre and nitrate content was very small. The partial correlation was $r = .08$. Chi-square analysis was used to determine if differences in the frequency of "dangerous" (>10000 ppm) samples were significant. A greater ($P<.01$) proportion of the Pearl Millet samples was found to be in the "dangerous" category than other forage types. Also a slightly greater ($P=.05$) proportion of Sorghum x Sudan hybrid samples were categorized as "dangerous" than Sorgo x Sudan and Sudan x Sudan hays (Table 2). The OSU Current Reports 2112 for 1990 and 1991 list the varieties, yield data, and rainfall totals by month at each of the experiment stations. No difference in mean nitrate concentration was found among the other three forage types. These results agree closely with an earlier, and much smaller study from two different research stations in central Oklahoma (Lemon and McMurphy, 1984). Nitrate accumulated in Pearl Millets in greater concentrations than Sorghum x Sudan hybrids, Sorgo x Sudan hybrids, or Sudan x Sudan hybrids.

**Table 1. Least squares means and standard error of means for nitrate concentration in ppm for four types at three locations.**

| | Location | | |
|---|---|---|---|
| Forage type | Eastern | South-Central | Southwest |
| Sorghum x Sudan | 7795 ± 292 | 3302 ± 390 | 7049 ± 325 |
| Sorgo x Sudan | 7291 ± 366 | 3255 ± 465 | 6673 ± 405 |
| Sudan x Sudan | 8079 ± 662 | 3461 ± 794 | 7190 ± 721 |
| Pearl Millet | 14122 ± 506 | 6572 ± 683 | 10534 ± 574 |

**Table 2. Proportion of samples that exceeded 10000 ppm nitrate among the four forage types.**

| Forage type | Proportion of samples |
|---|---|
| Sorghum x Sudan | 0.178[a] |
| Sorgo x Sudan | 0.121[b] |
| Sudan x Sudan | 0.129[ab] |
| Pearl Millet | 0.419[c] |

[a,b,c] proportions with different superscripts are different (P<.05).

## Literature Cited

Lemon, M.D. and W.E. McMurphy. 1984. Proc. 1984 Forage and Grassland Conf. Houston, TX.