Nitrate Accumulation in a Sorghum-Sudangrass Hybrid as Influenced by Nitrogen Fertilization

A. Elgersma
Wageningen University, The Netherlands

I. Y. Tecle
Wageningen University, The Netherlands

T. Provin
Texas A&M University

ID # 09-19

NITRATE ACCUMULATION IN A SORGHUM-SUDANGRASS HYBRID AS INFLUENCED BY NITROGEN FERTILIZATION

A. Elgersma[1] I. Y. Tecle[1, 2] and T. Provin[3]
[1]Wageningen University, Crop and Weed Ecology, Haarweg 333, 6709 RZ, Wageningen, The Netherlands
[2]University of Asmara, CAAS, POBox 1220, Asmara, Eritrea.
[3]Texas A & M University, Soil and Forage Testing Lab, 77843-2474 TX, College Station, USA

Abstract

The effect of nitrogen (N) fertilization and plant stage on nitrate accumulation was studied in a sorghum-Sudan grass hybrid. Grass cv. Dynagrazer was sown at the experimental site of Texas A & M University. Six N levels were applied (0, 112 … 672 Kg. N ha$^{-1)}$. Nitrate concentrations were determined in three harvests, 5– 7 weeks after planting. Maximum levels were 2.1, 3.5 and 4.6 g nitrate-N kg^{-1} DM, respectively, which is beyond the safe limits for animal consumption. The plots were cut at heading. Regrowth took place on residual N. Nitrate-N accumulation was lowest in the leaves and increased from the top to the bottom of the stem. In forage regrown from plots initially fertilized with 336 kg N ha^{-1} or more, the nitrate levels in the bottom and central part of the stem exceeded the safety limit for feeding.

Keywords: Nitrate accumulation, sorghum-sudangrass hybrid, N effect, growth stage, animal consumption

Introduction

Under hot, dry climatic conditions, perennial forage species usually decline in both productivity and nutritive value during the summer months (Desai and Washko, 1982). Sorghum-sudangrass hybrids can make up the shortcomings of perennials during such harsh times. They are known for their better tolerance to drought than other annual summer grasses.

They are often heavily fertilized and may, especially in combination with environmental stresses, accumulate nitrate to large concentrations (McCreery and Hojjati, 1966). High concentrations of nitrate in forage plants can cause death or adverse sub-lethal effects such as weight loss, reduced milk production and abortion, when fed to animals (Nicholls, 1980). The purpose of this study was therefore to evaluate the accumulation of nitrate in a sorghum-sudangrass hybrid as affected by N fertilization and plant age.

Materials and Methods

The study was conducted at Texas A & M University Agricultural Experiment Station Farm, College Station, Texas, in the summer of 1999 under rainfed condition on a clay loam soil. The experimental design was a split plot with nitrogen fertilization rate as main plot and harvest time (day of harvest) as sub-plot. Sorghum-sudangrass hybrid (*Sorghum bicolor* (L.) Moench-*S. sudanenese* Stapf) cv. Dynagrazer was established on April 24 at a seeding rate of 90 kg ha^{-1} in 20 cm wide rows, on plots of 5x13 m. N was applied two weeks after planting at 0, 112, 224, 336, 448, and 672 kg N ha^{-1} as $(NH_4)_{2SO4}$. Harvests were carried out at 18, 25 and 32 days after N application. The plants were mowed down at the heading stage (day 49 after planting) to a stubble height of about 15 cm for the re-growth, on the residual N fertilizer from the previous growing cycle. Six weekly harvests were carried out beginning the third week after mowing. Three samples per plot were collected randomly by clipping 1 m^2 area at each sampling time. In the re-growth, nitrate distribution in the leaves, top, middle and bottom third of the stem plus sheath and whole plant was determined. Nitrate-N concentration was determined spectrophotometrically. Regression analysis and a paired samples t-tests (α=0.05) were carried in the first growth and re-growth data, respectively.

Results and Discussion

Fitted curves for the prediction of the nitrate-N accumulation at each harvest in the first growth cycle are given in Figure 1. Nitrate-N accumulation increased (r^2 = 0.95) with the increase of N fertilization at harvest one. Based on the fitted regression equation a maximum accumulation of 0.46 % nitrate-N was predicted at an N fertilization rate of 542 kg ha^{-1}. At harvest two (r^2 = 0.86) and harvest three (r^2 = 0.69) nitrate-N accumulation increased in a quadratic fashion with the increase of N fertilization rate. Based on the fitted regression equations, nitrate-N accumulation was predicted to be maximal (0.35 % of DM) at a N fertilization rate of 470 kg ha^{-1} at harvest two, and 0.21 % at 570 kg N ha^{-1} at harvest three. Wright and Davidson (1964) reported that nitrate-N accumulation starts to decline with the maturity of the plant, after reaching a maximum at about the pre-bloom stage. This could be partially due to the dilution of nitrate concentration in the plant as a result of increased dry matter accumulation or due to the reduced availability of N in the soil with the advance of the growing period. Predicted maximum nitrate-N accumulations at the three harvests in the first growth cycle were beyond the safe limit (>0.20 % DM) for feeding animals (Vough et al., 1992).

The distribution of nitrate-N accumulation on the plant parts is shown in Figure 2. Nitrate-N concentrations in leaves, top, middle, and bottom thirds of the stem plus sheath and the whole plant did not differ significantly in the residual nitrogen fertilizer plots of 0, 112 and 224 kg N ha^{-1}. Nitrate-nitrogen accumulation in the residual plots of 224 kg N ha^{-1} and lower levels was at a level safe to feed animals. Leaves accumulated the least nitrate-N (0.02 %) whereas the bottom third of the stem accumulated the highest nitrate levels in the residual N fertilizer plots of 336 kg N ha^{-1}and higher rates. Leaves are the active site of nitrate conversion into organic nitrogen. Stems are mainly transport vessels where nitrates are trapped in at times of slow reduction of nitrates in the leaves (Darwinkel, 1975). Nitrate-nitrogen accumulations at the top, middle and bottom thirds of the stem indicate that caution should be taken when allowing animals to graze the forage crop. Nitrate accumulation at the bottom third of the stem was significantly higher than in the whole plant in all treatments except those of 0 and 112 kg N ha^{-1}.

From this study it appears that predicted maximum nitrate accumulations in the sorghum-sudangrass hybrid were in levels unsafe to feed animals. Precaution is therefore recommended when formulating rations, especially when feeding at younger stages of the plant. Feeding the animals the whole plant either in hay or green chop would minimize the hazard of nitrate poisoning compared to allowing them to graze the forage plant, as they would select for the leaves and top part of the stem first. Later they would eat the bottom parts, where highest level of the nitrate-nitrogen is accumulated, at times of shortage of the tender parts of the forage plant (Fribourg, 1995).

References

Desai, S. N. and Washko J.B. (1982). Forage evaluation of four summer annuals at four harvest stages under different nitrogen levels. Production and nutritive value. J. Maharashtra Agric. Univ. **7**: 19-22.

Darwinkel, A. (1975). Aspects of assimilation and accumulation of nitrate in some cultivated plants. Centre for Agricultural publishing and Documentation, Wageningen, Netherlands.

Friburg, H. A. (1995). Summer annual grasses. In: Robert F. B. et al. (ed.) Forages. Vol. I. Iowa State University Press, Ames, USA. 463-472.

Nicholls, T. J. (1980). Nitrate/nitrite poisoning of cattle on ryegrass pasture. Aust Vet. J. **56**: 95-96.

McCreery, R. A., and Hojjati S. M. (1966). Nitrates in annual forages as influenced by frequency and height of clipping. Agron. J. **58**:381-382.

Vough, L. R., Cassel, E.K. and Barao S.M. (1992). Nitrate poisoning of livestock. In: The National Dairy Database. University of Maryland, Maryland, USA. pp.1-6.

Wright, J. M. and Davidson K. L. (1964). Nitrate accumulation in crops and nitrite poisoning in animals. Adv. Agron**. 16**:197-248.

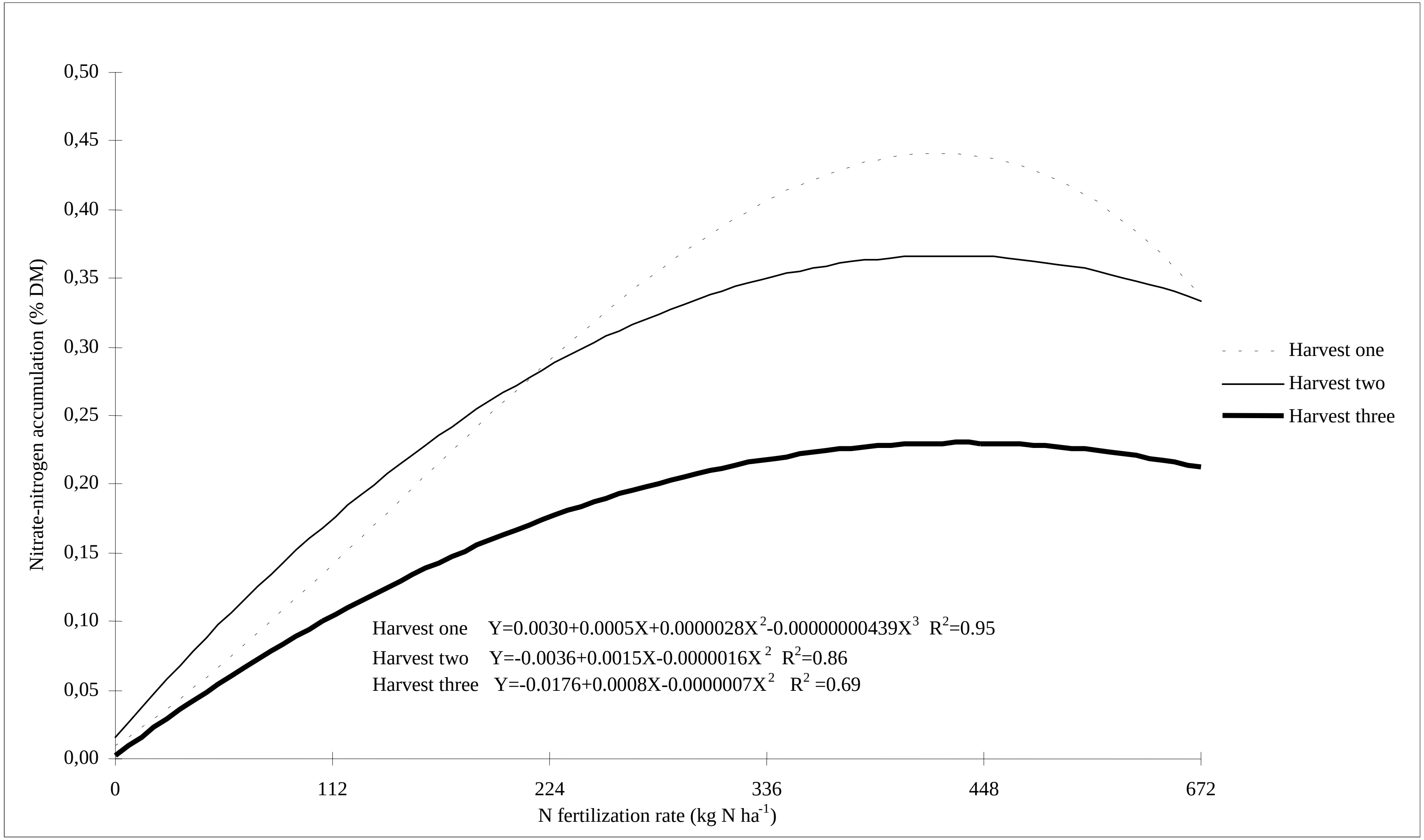

Figure 1. Model fits for nitrate-N accumulation (% DM) in a sorghum-sudangrass hybrid as influenced by N fertilization at three harvest times**.**

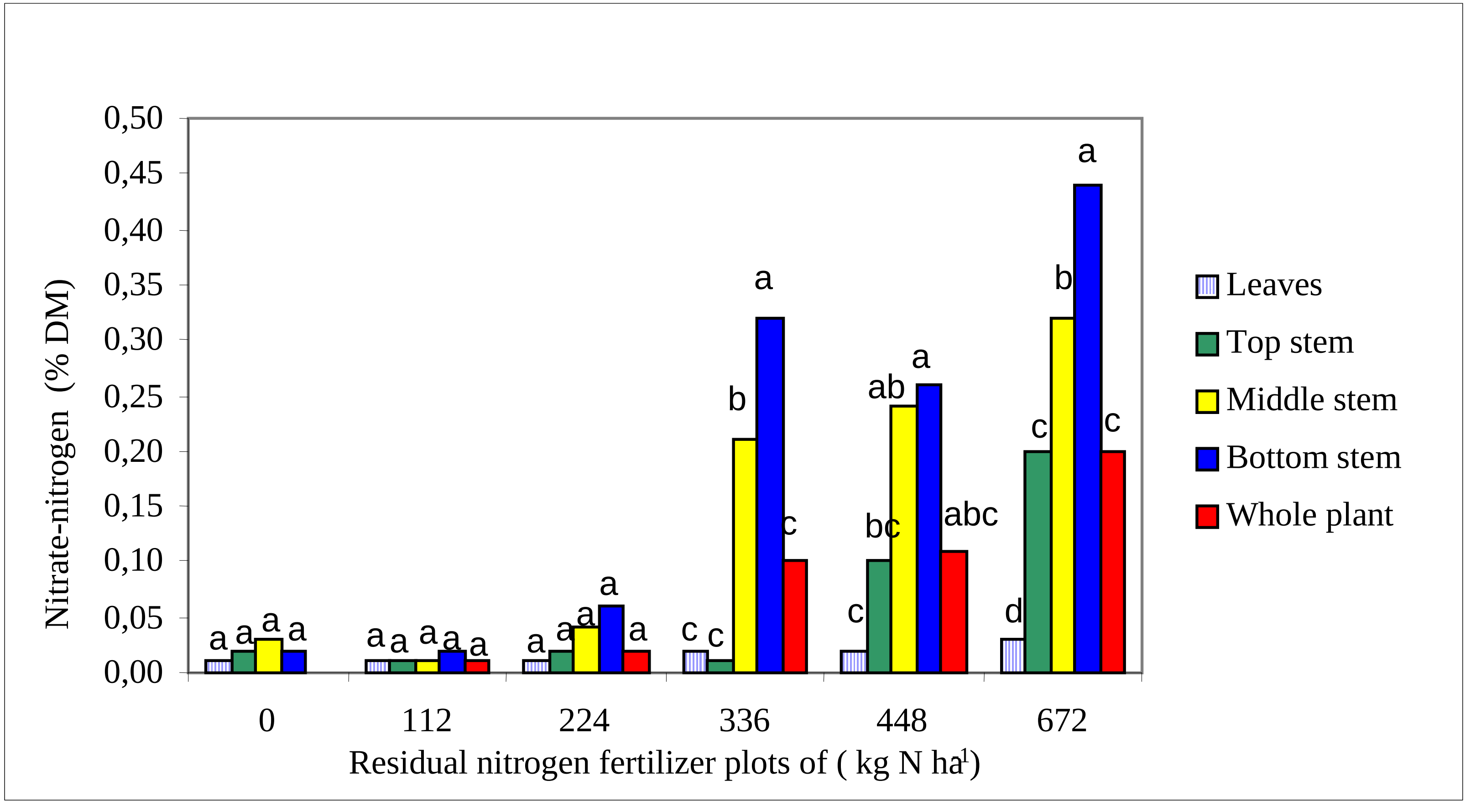

Figure 2 - Nitrate-N accumulation (% DM) in the leaves, top, middle and bottom third of the stem plus sheath and whole plant of sorghum-sudangrass hybrid, on the residual nitrogen fertilizer plots.

Note. Different letters within a residual nitrogen fertilizer plot show significant difference among plant parts