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# Nitrogen, phosphorus, and potassium removal by brown midrib sorghum sudangrass.

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## Introduction

In the past five years, Northeastern USA dairy producers have shown a growing interest in brown mid-rib sorghum sudangrass as an environmentally sound alternative to corn that, grown in a 2-cut system with planting taking place after June 1, allows for the application of manure in times that the manure nutrients are less conducive to leaching and runoff. These past years, research focused on determining best management practices including seeding rate, stand height management in a 2-cut system, nitrogen and potassium management.

For the long-term sustainability of the dairy industry, manure application rates should not exceed crop removal for more years than needed to bring low fertility soils to optimum fertility. Thus, it is important to know N, P and K removal rates by this crop. Our objectives were to determine N, P, and K removal with harvest using 6 N rate studies conducted in three major agricultural areas in New York State (Northern NY, Eastern NY and Central NY).

## Materials and Methods

Table 1 shows brief descriptions of the sites used for this study. The trial in Columbia County had received manure (about 5,600 gallons per acre plowed down within 5 hours resulting in an application of 120 lbs/acre available N assuming 65% availability of inorganic N and an organic N release of 35%) and had 5 N treatments (0, 50, 100, 150, and 200 lbs N/acre per cut using urea) as well as a control that had not received any manure or fertilizer since 2002. All other trials had 6 treatments (0, 50, 100, 150, 200, 250 lbs N/acre per cut as ammonium sulfate).

Table 1: Soil fertility of the six New York State sites used for N rate studies for BMR sorghum sudangrass in 2004.

| | Soil Fertility at Onset of the Trials (n=24) | | | | | |
|---|---|---|---|---|---|---|
| | Jefferson | St Lawrence | Columbia† | Essex | Cayuga | Tompkins |
| | Soil Series | | | | | |
| | Rhinebeck silt loam | Hailesboro silt loam | Knickerbocker fine sandy loam | Cosad loamy fine sand | Lima silt loam | Bath/Valois gravelly silt loam |
| | Cropping History | | | | | |
| | Continuous corn | Sorghum sudangrass | 3rd year after sod kill | 1st year after grass/alfalfa sod kill | Following wheat ('03) and barley ('02) | Following corn ('03) and barley ('02) |
| | Soil Fertility (Morgan extraction) | | | | | |
| pH (1:1) | 6.1 | 6.4 | 5.8 | 6.5 | 7.8 | 6.7 |
| OM (%) | 4.3 | 4.1 | 4.6 | 3.4 | 4.0 | 7.6 |
| P (lbs P/acre) | 14 (H) | 10 (H) | 15 (H) | 28 (H) | 12 (H) | 16 (H) |
| K (lbs K/acre) | 116 (H) | 106 (M) | 66 (L) | 48 (L) | 94 (M) | 206 (H) |
| Ca (lbs Ca/acre) | 2416 | 2654 | 1804 | 2500 | 5600 | 4712 |
| Mg (lbs Mg/acre) | 406 (VH) | 446 (VH) | 298 (VH) | 182 (H) | 518 (VH) | 580 (VH) |
| Nitrate (ppm) | 5.6 | 10.5 | - | 7.9 | 5.7 | 0.6 |
| Salts (mmho) | 0.14 | 0.14 | 0.12 | 0.16 | 0.16 | 0.20 |
| | Fertilizer Addition at Planting (M = added with manure) | | | | | |
| lbs $P_2O_5$/acre | 38 | 45 | 84 (M) | 20 | 30 | 20 |
| lbs $K_2O$/acre | 38 | 30 | 168 (M) | 80 | 60 | 20 |

† Soil samples were not taken at the onset of this particular trial. Basic soil fertility assessments reported in this table are based on mean values for the 0 N plots (n=4) sampled after the 1st cut.

Cutting height was 3-3.5 inches and harvest was initiated when the plots that received 150 lbs N/acre per cut had reached 35-45 inches. At each site, two harvests were done with the exception of the site in Jefferson Country where only one cut was feasible due to late planting. We determined yield and took subsamples to determine moisture content and nutrient concentrations. All samples were analyzed for total N, P, and K. Optimum N rates ranged from less than 50 lbs N/acre per cut in the manured field in Columbia County and in the field with a recent sod history in Essex County, 120-140 lbs N/acre per cut for the three sites in Jefferson, St Lawrence and Cayuga County, to 170 lbs N/acre per cut at a site with no manure or sod history in Tompkins County (see What's Cropping Up? 15(4): 4-7). In this followup article, we focus on N, P, and K concentration in the forage and total nutrient removal with harvest.

## Results and Discussion

The forage N, P, and K concentrations are listed in Table 2. Forage N content increased with N application. The lowest N concentrations in plants grown without additional N were seen in the Essex and Jefferson County trials. This may be related to the higher first cut yields for both trials (4.4 tons/acre at 35% dry matter in Jefferson Country and 6.05 ton/acre in Essex County).

Table 2: Nitrogen, P, K, Ca, and Mg concentrations as impacted by N fertilization rate in six BMR sorghum sudangrass trials in New York (2004 season). Shaded are ranges for optimum economic N rate.

| N applied | Jefferson | | St Lawrence | | Columbia | | Essex | | Cayuga | | Tompkins | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| lbs N/acre per cut | Nitrogen (% N) | | | | | | | | | | | |
| 0 | . | . | 1.63 c | 1.35 d | 1.72 d | 1.31 c | 0.98 b | 1.26 b | 1.54 b | 1.41 c | 1.54 a | 1.59 d |
| 0+M | . | . | . | . | 2.28 cd | 1.83 bc | . | . | . | . | . | . |
| 38 | 0.91 bc | . | . | . | . | . | . | . | . | . | . | . |
| 50 | 0.84 c | . | 1.97 bc | 1.53 cd | 2.89 bc | 2.21 b | 1.42 ab | 1.16 b | 1.64 b | 1.34 c | 1.42 a | 1.83 cd |
| 100 | 0.89 bc | . | 1.81 bc | 1.90 bc | 3.40 ab | 3.03 a | 2.02 ab | 1.46 ab | 1.87 ab | 1.42 c | 1.78 a | 2.13 bc |
| 150 | 1.39 b | . | 2.32 ab | 2.29 ab | 3.24 ab | 3.27 a | 2.05 ab | 1.57 a | 1.98 ab | 1.83 b | 2.15 a | 2.20 bc |
| 200 | 1.99 a | . | 2.70 a | 2.51 a | 3.62 a | 3.32 a | 2.24 a | 1.60 a | 2.19 a | 1.87 b | 2.22 a | 2.50 ab |
| 250 | 2.23 a | . | 2.72 a | 2.64 a | . | . | 1.92 ab | 1.74 a | 2.32 a | 2.26 a | 1.72 a | 2.81 a |
| | Phosphorus (% P) | | | | | | | | | | | |
| 0 | . | . | 0.32 a | 0.43 a | 0.30 ab | 0.44 a | 0.26 a | 0.41 a | 0.30 a | 0.35 a | 0.40 a | 0.38 a |
| 0+M | . | . | . | . | 0.33 a | 0.40 ab | . | . | . | . | . | . |
| 38 | 0.19 a | . | . | . | . | . | . | . | . | . | . | . |
| 50 | 0.16 ab | . | 0.32 a | 0.37 b | 0.30 ab | 0.38 b | 0.27 a | 0.30 b | 0.27 a | 0.29 b | 0.36 a | 0.36 ab |
| 100 | 0.12 b | . | 0.29 a | 0.32 c | 0.27 ab | 0.35 b | 0.22 a | 0.24 b | 0.29 a | 0.25 bc | 0.33 a | 0.35 ab |
| 150 | 0.14 b | . | 0.31 a | 0.30 c | 0.25 b | 0.35 b | 0.22 a | 0.23 b | 0.28 a | 0.24 bc | 0.34 a | 0.32 b |
| 200 | 0.14 b | . | 0.29 a | 0.29 c | 0.28 ab | 0.37 b | 0.23 a | 0.20 b | 0.27 a | 0.24 c | 0.34 a | 0.32 b |
| 250 | 0.14 b | . | 0.29 a | 0.29 c | . | . | 0.23 a | 0.24 b | 0.26 a | 0.24 c | 0.36 a | 0.31 b |
| | Potassium (% K) | | | | | | | | | | | |
| 0 | . | . | 2.73 a | 1.76 a | 2.39 a | 1.87 ab | 2.12 a | 1.69 a | 2.83 a | 1.99 a | 2.92 a | 2.27 a |
| 0+M | . | . | . | . | 2.93 a | 2.02 a | . | . | . | . | . | . |
| 38 | 2.33 a | . | . | . | . | . | . | . | . | . | . | . |
| 50 | 2.21 a | . | 2.50 a | 1.66 a | 3.01 a | 1.70 ab | 1.70 ab | 0.97 b | 2.59 a | 1.82 ab | 2.87 a | 2.29 a |
| 100 | 2.07 a | . | 2.55 a | 1.56 a | 2.83 a | 1.38 b | 1.59 ab | 0.92 b | 2.75 a | 1.62 bc | 2.82 a | 2.27 a |
| 150 | 1.98 a | . | 2.38 a | 1.54 a | 2.29 a | 1.64 ab | 1.42 ab | 0.93 b | 2.66 a | 1.54 c | 2.90 a | 1.96 a |
| 200 | 1.80 a | . | 2.30 a | 1.63 a | 3.01 a | 1.67 ab | 1.58 ab | 0.91 b | 2.50 a | 1.53 c | 2.77 a | 2.08 a |
| 250 | 2.19 a | . | 2.37 a | 1.62 a | . | . | 1.14 b | 0.81 b | 2.50 a | 1.57 c | 2.87 a | 2.39 a |

Note: Average values *within columns* with different letters (a, b, c) are statistically different (P≤0.05).

Nitrogen removal at optimum N rates ranged from 63 to 204 lbs of N/acre in the two-cut systems where no manure was added and from 188-286 lbs of $P_2O_5$/acre in the manured site (Table 3).

Phosphorus concentrations ranged from less than 0.15% at the Jefferson County site to over 0.40% in the 2nd cut in Columbia County where over 80 lbs of $P_2O_5$ were added per acre in the form of manure. Uptake at optimum N rates ranged from 41 to 65 lbs of $P_2O_5$ in the two-cut systems where no manure was added and from 71-81 lbs of $P_2O_5$ in the manured site (Table 3). Although sites differed in P uptake per unit yield, P uptake was linearly related to dry matter yield at all locations (Figure 1).

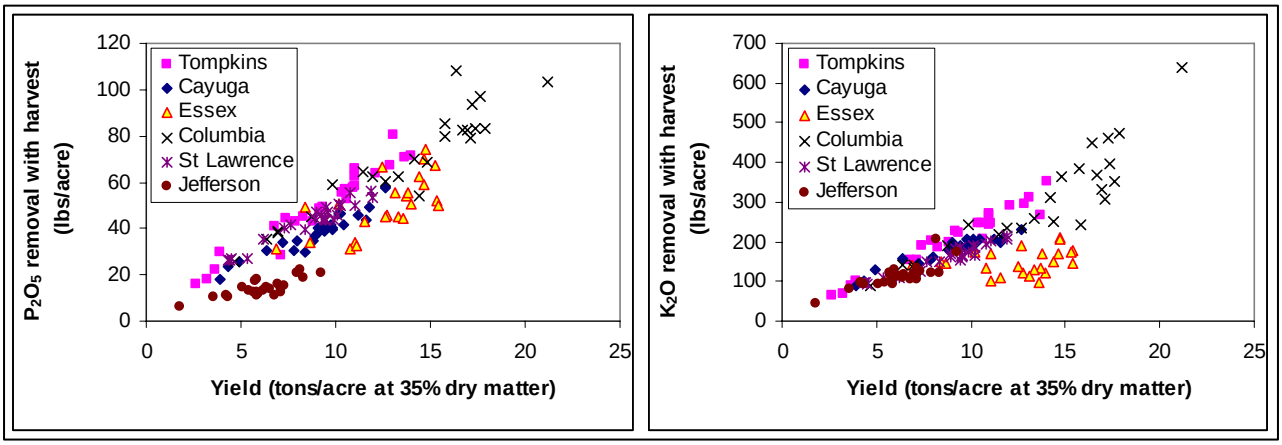
Table 3: Nitrogen, P, K, Ca, and Mg removal with harvest as impacted by N fertilization rate in six brown midrib sorghum sudangrass trials in New York (2004 season). Shaded are ranges for optimum economic N rate.

| N applied | Nutrient Removal with Harvest (1st and 2nd cut combined – one cut only for Jefferson County) | | | | | |
|---|---|---|---|---|---|---|
| | Jefferson | St Lawrence | Columbia | Essex | Cayuga | Tompkins |
| per cut lbs N/acre | Nitrogen (lbs N/acre) | | | | | |
| 0 | . | 50 c | 69 d | 63 b | 52 d | 36 b |
| 0+M | . | . | 188 c | . | . | . |
| 38 | 27 c | . | . | | | |
| 50 | 30 bc | 91 b | 286 bc | 125 ab | 88 cd | 85 b |
| 100 | 39 bc | 117 b | 320 b | 166 a | 112 bc | 148 a |
| 150 | 70 ab | 169 a | 345 b | 173 a | 137 ab | 160 a |
| 200 | 105 a | 177 a | 455 a | 183 a | 151 a | 204 a |
| 250 | 95 a | 201 a | . | 165 a | 149 a | 198 a |
| | Phosphorus (lbs $P_2O_5$/acre) | | | | | |
| 0 | . | 26.8 c | 34.5 b | 41.4 a | 24.5 b | 21.5 c |
| 0+M | . | . | 70.6 a | . | . | . |
| 38 | 13.3 a | . | . | . | . | . |
| 50 | 13.1 a | 41.0 b | 81.4 a | 64.0 a | 36.8 ab | 43.4 b |
| 100 | 12.3 a | 44.2 ab | 68.5 a | 51.0 a | 42.0 a | 59.5 a |
| 150 | 15.4 a | 51.2 a | 69.7 a | 47.9 a | 42.7 a | 57.4 ab |
| 200 | 17.0 a | 46.0 ab | 90.6 a | 47.5 a | 43.8 a | 64.5 a |
| 250 | 14.2 a | 49.4 ab | . | 49.3 a | 37.9 a | 71.9 a |
| | Potassium (lbs $K_2O$/acre) | | | | | |
| 0 | . | 99.6 c | 126.1 c | 152.9 a | 119.4 b | 81.2 d |
| 0+M | . | . | 297.9 ab | . | . | . |
| 38 | 87.9 a | . | . | . | . | . |
| 50 | 106.1 a | 138.7 bc | 358.5 ab | 169.6 a | 173.2 a | 177.3 c |
| 100 | 117.4 a | 165.9 ab | 291 2 b | 159.6 a | 195.5 a | 252.5 b |
| 150 | 127.5 a | 184.6 a | 286.9 b | 145.4 a | 195.7 a | 236.8 bc |
| 200 | 122.1 a | 173.9 ab | 443.2 a | 151.2 a | 196.4 a | 268.9 ab |
| 250 | 125.2 a | 192.2 a | . | 113.9 a | 179.0 a | 317.6 a |

Note: Average values *within columns* with different letters (a, b, c) are statistically different (P≤0.05).

The potassium content of 2nd cut forage was at all sites less than the 2.5% upper limit for feeding of forage to non-lactating cows (Table 2). First cuts were too high in K for non-lactating cows at all sites with the exception of the Essex County site. This was also the only site where K uptake was not linearly related to overall dry matter yield (Figure 1). This was due to low K concentrations in the 2nd cut and may be because this site tested low in K at the onset of the trial and K was applied at planting only.

Figure 1: Phosphorus (left) and potassium (right) removal as impacted by yield.




## Conclusions

Nutrient removal was linearly related to dry matter yields and not impacted by N application rate as long as a minimal amount of N was added (50 lbs/acre per cut or greater). However, results were very site-specific indicating that for accurate crop removal estimates, dry matter yields need to be determined and forage analyses need to be done.

## References

1. Ketterings, Q.M., G. Godwin, T.K. Kilcer, P. Barney, M. Hunter, J.H. Cherney, S. Beer (2005). Nitrogen management for brown midrib sorghum sudangrass. Results of six NY field studies in 2004. "What's Cropping Up?" 15(4): 4-7.

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