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# Effect of cattle manure application rate and strategy on bahiagrass yield and nutritive value

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## ABSTRACT

We evaluated the effects of N rate and two strategies of cattle manure (CM) application on dry matter yield (DMY) and nutritive value of bahiagrass (*Paspalum notatum* L. Fluege). The N rate treatments were 200 and 400 kg N $ha^{-1}$ from CM or 50/50 CM plus ammonium nitrate (AN) combination, applied either in a single or split dosage. Bahiagrass was clipped at 28-d intervals for DMY, crude protein concentration (CP) and in vitro organic matter digestibility (IVOMD). First year results showed significant effects of application strategies and N rate. The combination of CM+AN performed better than treatments with CM alone. Dry matter yields of 6.67, 6.46, 5.73 and 6.27 Mg $ha^{-1}$ were recorded for the 400 kg N $ha^{-1}$ as CM+AN in single and split, and for the 200 kg N $ha^{-1}$ as CM+AN in single and split applications, respectively. Comparatively, DMY of 6.38, 5.35, 5.98 and 4.82 Mg $ha^{-1}$ were recorded for the 400 kg N $ha^{-1}$ of CM in single and split, and for the 200 kg N $ha^{-1}$ of CM in single and split applications, respectively. The 400 kg N $ha^{-1}$ of CM+AN had the greatest IVOMD values of 547 and 543 g $kg^{-1}$ for the single and split applications. Treatments receiving split application of CM had the lowest DMY, IVOMD and CP values. Phosphorus uptake and percentage recovery were also greatest for treatments that received CM+AN combination. Between 23 to 26% of the applied P was recovered in the CM+AN treatments compared to 10 to 21% in the treatments that had CM alone. The results show that applying CM in combination with an inorganic nitrogen source can provide high forage yield of high quality and also reduce P risk to the environment.

**Key words:** Cattle Manure, IVOMD, CP, DMY and Bahiagrass

## INTRODUCTION

The rapid growth of concentrated animal feeding operations (CAFOS) in many areas of the world in recent years has caused a tremendous increase in the amount of manure produced annually. The major sources of manure in the USA are beef cattle, dairy, poultry and swine production. The beef cattle industry generates approximately 24.4 million Mg of manure per year; dairy farming 19 million Mg of manure, poultry 12.7 million Mg of litter and manure; and swine production generates the equivalent of 14.5 million Mg of manure (Walker et al., 1997; Camberato et al., 1997). The amounts of N and P generated from these livestock enterprises are equivalent to that supplied annually by inorganic sources. Edwards and Somershwar (2000), indicated that about 7.5 million Mg of N and 2.3 million Mg of P are generated in the USA annually by the

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livestock industry compared to 9 million Mg N and 1.6 million P applied to agricultural land in the form of commercial fertilizers.

The proper incorporation of cattle manure into forage production systems would be an effective way of manure recycling to reduce environmental problems, and also provide a low cost alternative to mineral fertilizer to farmers. The use of dairy effluents on forage production systems has been shown to increase forage yields (Macoon et al., 2002). Forage production removes and recycles more nutrients from the soil than other crops, especially when plants of high biomass yield and nutritive value for cattle are used (Newton et al., 2003). The cattle industry in Florida depends on grazed pastures. Seventy-five percent of the over one million hectares of improved pastures in Florida is bahiagrass (Adjei and Rechcigl, 2002). The root system of bahiagrass, once fully established, can recover up to 70% of applied N and absorb adequate amounts of P and K nutrients from the top and sub soil and recycled nutrients from manure under grazing conditions (Rechcigl et al., 1992). Bahiagrass growing on Spodozols have their roots well distributed into the Bh horizon (Ibikci et al., 1999) and has the ability to absorb P down the soil profile. Therefore, application of manures to forage crops, especially bahiagrass, will help maximize manure nutrient utilization and reduce P and N movement to surface and groundwater.

Manure application rates are usually based on crop N requirement which greatly increases soil P levels because the N: P ratios of manure are significantly smaller than N: P uptake ratios of most crops (Eghball, 2003; Sharpley et al., 1994). The excess P and $NO_3$-N from manure application can be transported in runoff or leached into the groundwater. Phosphorus and $NO_3$-N accumulation in soils and subsequent contamination of water bodies have become an environmental concern in many regions of the world. The U.S Environmental Protection Agency (EPA) has shown that agricultural nonpoint source pollution is a significant cause of stream and lake contamination that prevents the attainment of the water quality goals set by the Clean Water Act (USEPA, 2002). Recent Florida legislation requires P-based application of biosolids and manure in watersheds associated with P-sensitive water bodies (Elliot et al., 2002). The Lower Suwannee River Basin of Florida has been designated by the Florida Department of Environmental Protection as a Group 1 basin because of the increase in nitrate concentration of surface and groundwater in the Upper Floridan Aquifer (Nair and Graetz, 2004). The $NO_3$-N concentration in water from the basin exceeds the maximum contaminated level of 10 $mgL^{-1}$ set by the U.S Environmental Protection Agency (Nair and Graetz, 2004). In addition, beef ranching and dairy farming in the Lake Okeechobee Basin in South Florida have been identified as major contributors of P to the lake. The Green Swamp and the Okeechobee Basin are designated as P-limited by legislation and these areas are to have P-based nutrient budgets irrespective of the nutrient source (Nair and Graetz, 2004). The P-based nutrient management approach will reduce excess P accumulation in the soil hitherto resulting from N-based application. However, a P–based manure nutrient management means substantially lower waste and manure application rates, larger land area requirements for spreading and higher cost to transport waste outside sensitive watersheds.

The development of efficient N-based manure application strategies into forage production systems will help reduce surface and groundwater pollution and take advantage of the rich nutrients in manure. The combination of broiler litter and commercial nitrogen fertilizer has been shown to increase P and K uptake by 23 and 43%, respectively in annual ryegrass-bermudagrass pasture (Evers, 2002). The objectives of this study are to test the effect of different application strategies of cattle manure on forage yield, nutritive and P uptake. A specific objective is to evaluate the effect of combining cattle manure and inorganic N source on P recovery by bahiagrass.

## MATERIALS AND METHODS

The experiment was conducted at the University of Florida Agricultural Research and Education Center at Ona, Fla (27°26'N, 82°55'W) on a Pomona fine sand. Experimental design used was a randomized complete block with nine treatments replicated three times. The treatments were a control (no N fertilizer), 200 and 400 kg N $ha^{-1}$ from CM or 50/50 CM +AN, applied either in a single or split dosage. CM was applied in July and AN was supplemented to the CM+AN treatments in August, with the second split done in September. Bahiagrass forage was harvested at 30 d intervals to estimate dry matter yield and nutritive value. At each harvest, four random quadrants (0.25 $m^2$ each) of forage were clipped to 7.5 cm stubble in each plot and composited. The entire plot was clean-mowed to 7.5 cm stubble after each harvest. Harvest dates in 2005 were August, September, October and December. Harvested sub samples were weighed and oven dried at 60° C for 48 hr. Dried samples were weighed, ground and analyzed for crude protein (Gallaher et al., 1975) and IVOMD (Moore and Mott, 1974).

Ground sub samples were ashed in a muffle furnace, digested in HCl and analyzed for P, K, Ca and Mg. Nutrient uptake was determined by multiplying nutrient concentration of the forage by dry matter yield for each harvest and adjusted for uptake by the no-fertilizer control. Percentage nutrient recovery was calculated by diving seasonal nutrient uptake by the amount of nutrient applied.

Data was analyzed using the General Linear Model procedure of SAS (SAS Institute Inc., 1985). The Duncan multiple range test was used to indicate mean differences.

## RESULTS AND DISCUSSION

**Forage dry matter yield.** Dry matter yield increased with increased N availability and application rate. Addition of N in the form of CM or CM+AN resulted in yield increase of between 22 and 70% compared with the control. Nitrogen fertilization of warm season grasses has been shown to increase forage DM yield and N concentration (Harvey et al., 1996, Caraballo et al., 1997). Johnson et al. (2001) found a 129% yield increase in bermudagrass, stargrass and bahiagrass with 78 kg N $ha^{-1}$ per cutting. In this study the CM+AN treatments had the highest dry matter yields. DM yields of 6.67 and 6.46 Mg $ha^{-1}$ were recorded for the 400 kg N $ha^{-1}$ as CM+AN single and split respectively (Table 1).

Table 1. Bahiagrass dry matter yield as affected by N rate and method of application.

| N TREATMENT | | | Yield |
|---|---|---|---|
| Source | Application | Rate(kg $ha^{-1}$) | Mg $ha^{-1}$ |
| Control | ----- | --------- | 3.99 e[1] |
| Manure | Single | 200 | 5.98 abc |
| Manure | Single | 400 | 6.38 ab |
| Manure | Split | 200 | 4.82 d |
| Manure | Split | 400 | 5.35 cd |
| Manure + AN[2] | Single | 200 | 5.73 bc |
| Manure + AN | Single | 400 | 6.67 a |
| Manure + AN | Split | 200 | 6.27 ab |
| Manure + AN | Split | 400 | 6.46 a |

[1]Means followed by same letter(s) are not different according to the DMRT at $p>0.05$
[2]AN = ammonium nitrate

There were no differences between the 200 and 400 kg N $ha^{-1}$ CM treatments which averaged 5.98 and 6.38 Mg $ha^{-1}$. Addition of AN increased the availability of N for manure mineralization which ultimately provided more N for growth and plant yield. The AN application was done a month after CM, and this might have resulted in the observed smaller yield differences between the single CM treatments and the CM+AN treatments. In addition, because of a late start, only four harvests were taken from August to December. Split application of CM resulted in lower yields of 4.82 and 5.35 Mg $ha^{-1}$ for the 200 and 400 kg N $ha^{-1}$ treatments, respectively. However, there were no significant differences between the single and split application of CM+AN treatments. This might be due to the reduction in time for N mineralization from the split applied manure. Nitrogen availability from CM is about 40% of the total manure N in the first year after application (Eghball et al., 2002). Applying all the CM early at one time in the season provides more N and other plant available nutrients for proper growth and development.

**Nutritive value.** In vitro organic matter digestibility (IVOMD) and crude protein (CP) concentration were greater for the 400 kg N $ha^{-1}$ CM+AN treatments compared to the other treatments (Table 2). The IVOMD values were similar for 200 kg N $ha^{-1}$ CM+AN and the 200 and 400 kg N $ha^{-1}$ single CM treatments. Crude protein values were lower for the CM 200 kg N $ha^{-1}$ (72-86 g $kg^{-1}$) compared to 101-107 g $kg^{-1}$ for the same N rate but with CM+AN application. The CM+AN treatment resulted in 32% more CP. As N fertilization increased, total tissue N concentration and CP in forages increased linearly as supported by the findings of Johnson et al. (2001). The CM+AN treatment also increased forage IVOMD. In general, the digestibility of C-4 grasses increases with increase in N and CP concentration in forage tissue, hence, increased N fertilization has a dramatic impact on forage nutritive value.

Table 2. Bahiagrass nutritive value as affected by N rate and method of application.

| N TREATMENT | | Rate | IVOMD | Crude protein |
|---|---|---|---|---|
| Source | Application | (kg $ha^{-1}$) | g $kg^{-1}$ | g $kg^{-1}$ |
| Control | ------ | --------- | 487 e[1] | 72 f |
| Manure | Single | 200 | 518 bcd | 91 e |
| Manure | Single | 400 | 522 bc | 111 bc |
| Manure | Split | 200 | 508 d | 86 e |
| Manure | Split | 400 | 517 bcd | 100 d |
| Manure + AN[2] | Single | 200 | 528 b | 107 cd |
| Manure + AN | Single | 400 | 547 a | 126 a |
| Manure + AN | Split | 200 | 514 cd | 100 d |
| Manure + AN | Split | 400 | 543 a | 118 b |

[1]Means followed by same letter(s) are not different according to the DMRT at p>0.05
[2]AN = ammonium nitrate

Generally, doubling the N application rate from 200 to 400 kg N $ha^{-1}$ resulted in about 18% increase in forage CP concentration for the CM and CM+AN. However, this increase in N had very little effect on IVOMD; changing from 200 to 400 kg N $ha^{-1}$ resulted in only 2% and 5% increase in IVOMD for the CM and CM+AN treatments, respectively. This response was in agreement with what Burton et al. (1997) found, that fertilizer N rate had no effect on Pensacola bahiagrass forage IVOMD. However, CM and CM+AN improved forage nutritive value (CP and IVOMD) compared to the no fertilizer control.

**Nitrogen and Phosphorus Uptake.** Nitrogen uptake was greater for the 400 kg N $ha^{-1}$ rate for both application strategies. On the average N uptake were 100 and 138 kg $ha^{-1}$ for 200 and 400 kg N $ha^{-1}$ CM+AN treatments, respectively. Similarly, average N uptake of 75 and 100 kg $ha^{-1}$ were recorded for the 200 and 400 kg N $ha^{-1}$ CM treatments. Evers (2002) indicated that N uptake was directly related to the amount of N fertilizer applied. However, percentage N recovery was greatest for the 200 kg N $ha^{-1}$ CM+AN treatments. Nitrogen recovery was between 20 to 28% for CM+AN compared to 8 to 19% recovery for the CM treatments (Table 3). Split application of manure resulted in lower N recovery because of the reduced growth and consequent yield reduction.

Table 3. Nitrogen and Phosphorus uptake and recovery as affected by N rate and method of application

| N Treatment | | | N uptake | % N | P uptake | % P |
|---|---|---|---|---|---|---|
| Source | Application | Rate (kg ha$^{-1}$) | kg ha$^{-1}$ | Recovery | kg ha$^{-1}$ | Recovery |
| Control | ------ | --------- | 47.78 g[1] | ------- | 5.95 d | ------- |
| Manure | Single | 200 | 85.93 e | 19.1 dc | 16.82 ab | 21.8 b |
| Manure | Single | 400 | 113.95 c | 16.3 d | 17.90 a | 12.0 c |
| Manure | Split | 200 | 63.03 f | 7.6 e | 12.21 c | 12.5 c |
| Manure | Split | 400 | 84.82 e | 9.2 e | 15.61 b | 9.7 c |
| Manure +AN[2] | Single | 200 | 102.7 cd | 27.5 a | 12.40 c | 25.8 b |
| Manure +AN | Single | 400 | 144.10 a | 24.1 ab | 18.46 a | 25.0 b |
| Manure + AN | Split | 200 | 94.62 de | 23.4 abc | 16.78 ab | 46.3 a |
| Manure + AN | split | 400 | 26.54 b | 19.7 bc | 17.41 a | 22.9 b |

[1]Means followed by same letter(s) are not different according to the DMRT at $p>0.05$
[2]AN = ammonium nitrate

Phosphorus uptake was greater for the CM+AN treatment, with split application of CM producing lower P uptake values. Percentage P recovery was also higher for the CM+AN treatment. Between 23 to 43% of the applied P was recovered when CM+AN was applied. Conversely, only 10 to 22% of the P applied was recovered when CM was applied. Evers (2002), in combining broiler litter with commercial N fertilizer as a nutrient source for a ryegrass-bermudagrass production system, removed 23% more P than when no inorganic fertilizer was applied.

The application of CM supplemented with inorganic N reduced the amount of P supplied from the manure and improved the efficiency of manure nutrient utilization. Moreover, the added ammonium nitrate provided readily available N to stimulate plant growth, increasing yield and removal of more plant available P compared with when all the plant N requirements were supplied by manure.

Dry matter yield, IVOMD, CP and nutrient uptake were lower than expected for a season because forage was harvested between August and December, towards the short-day, cool season. However, bahiagrass normally produces about 86 to 90% of its total seasonal yield from April to September (Gates et al., 2001).

## CONCLUSIONS

Developing new N based manure application strategies and rates that will increase forage yield but reduce environmental impacts associated with manure will be very helpful to farmers.

Dry matter yield, IVOMD, CP and nutrient uptake were greatest among the treatments that received CM+AN combination. DM yield increased with increased N rate but N and P recovery were reduced. Doubling N application rate increased CP concentration but had no effect on IVOMD. Split application of CM resulted in lower DM yield, IVOMD, CP and nutrient uptake. Phosphorus and N uptake increased when manure was combined with ammonium nitrate with the 200 kg N $ha^{-1}$ CM+AN being most efficient. Combining CM+AN improves manure P utilization, forage yield and nutritive value. The results show that applying CM in combination with inorganic nitrogen source can provide high forage yield of high quality and also reduce P risk to the environment.

## LITERATURE CITED

Adjei, M. B., and J.E. Rechcigl. 2002. Bahiagrass production and nutritive value as affected by domestic wastewater residuals. Agronomy Journal. 94: 1400-1410.

Burton G.W., R. N. Gates and G. J. Gascho. 1997. Response of Pensacola Bahiagrass to Nitrogen, phosphorus and potassium fertilizers. Soil and Crop Science Society of Florida Proceedings 56: 31-35.

Camberato, J. J., E. D. Vance and A. V. Someshwar. 1997. Composition and land application of paper manufacturing residuals. p. 185-202. *In* J.E Rechcigl and H. C. MacKinnon (eds) Agricultural uses of by-products and wastes. ACS, Washington, DC.

Caraballo, A., D. E. Morillo, J. Faria-Marmol, and L. R. McDowell. 1997. Frequency of defoliation and nitrogen and phosphorus fertilization on *Andropogon guyanas* Kunth. 1. Yield, crude protein content and in vitro digestibility. Commun. Soil sci. Plant Anal. 28: 823-831.

Edwards J. H. and Someshwar A. V. 2000. Chemical, physical, and biological characteristics of agricultural and forest by products for land application. P. 1-62. *In* J. F. Power and W. A. Dick (eds). Land application of agricultural, industrial, and municipal by products. SSSA book series # 6. SSSA, Madison, Wisconsin.

Eghball, B. 2003. Leaching of Phosphorus fractions following manure or compost application. Communication in Soil and Plant Analysis 34: 2803-2815.

Eghball, B., B. J. Wienhold, J. E. Gilley, and R. A. Eigenberg. 2002. Mineralization of manure Nutrients. Journal of Soil and Water Conservation Society 57: 470-473.

Elliot, H. A., G. A. O`Connor and S. Brinton. 2002. Posphorus Leaching from Biosolids amended sandy soils. Journal of Environmental Quality 31:681-689.

Evers, G. W. 2002. Ryegrass-Bermudagrass production and nutrient uptake when combining nitrogen fertilizer with Broiler litter. Agronomy Journal 94:905-910.

Gallaher, R. N., C. O. Weldon, and J. C. Futral. 1975. An aluminum digester for plant and soil analysis. Soil Sci. Soc. Am. Proc. 39: 803-806.

Gates, R. N., P. Mislevy and F. G. Martin. 2001. Herbage accumulation of three Bahiagrass populations during the cool season. Agronomy Journal 93: 112-117.

Harvey, R. W., J. P. Mueller, J. A. Barker, M. H. Poore, and J. P. Zublena. 1996. Forage characteristics, Steer performance, and water quality from Bermudagrass pastures fertilized with two levels of nitrogen from swine lagoon effluent. Journal of Animal Science 74: 457-464.

Ibrikci, H., E. A. Hanlon and J. E. Rechcigl. 1999. Inorganic phosphorus and manure effects on bahiagrass production on a Spodosol. Nutrient cycling in Agroecosytems 54: 259-266.

Johnson, C. R., B. A. Reiling, P. Mislevy and M. B. Hall. 2001. Effects of nitrogen fertilization and harvest date on yield, digestibility, fiber and crude protein fractions of tropical grasses. Journal of Animal Science 79: 2439-2448.

Maccon, B., R. K. Woodard, L. E. Sollenberger, C. E. French, M. K. Portier, A. D. Graetz, M., G. Prine and H. H. Van Horn. 2002. Dairy effluent on herbage yield and nutritive value of forage cropping systems. Agronomy Journal 94:1043-1049.

Moore J. E. and G.O. Mott. 1974. Recovery of residual organic matter from in vitro digestion of forages. J. Dairy Sci. 57. 1258-1259.

Nair, V. D. and D. A. Graetz. 2004. Agroforestry as an approach to minimizing nutrient loss from heavily fertilized soils: The Florida experience. Agroforestry Systems 61: 269-279.

Newton ,G. L., J. K. Bernard, R. K. Hubbard, J. R. Allison, R. R. Lowrance, G. J. Gascho, R. N. Gates, and G. Vellidis. 2003. Managing manure nutrients through multicrop forage production. J. Dairy Sci. 86:2243-22252.

Rechigl, J. E., G. G. Payne, A. B. Botcher, and P. S. Porter. 1992. Reduced P application on bahiagrass and water quality. Agronomy Journal 84:463-468.

SAS Institute. 1985. SAS/STAT guide for personal computers. Version 6. SAS Inst., Cary, NC.

Sharpley, A. N, S. C. Chapra, R. Wedepohl, J. T. Sims, T. C. Daniel, and K. R. Reddy. 1994. Managing agricultural phosphorus for protection of surface waters: Issues and options. Journal of Environmental Quality 23: 437-451.

U. S. Environmental Protection Agency (USEPA) 2002. National Water Quality Inventory. EPA 841-R-02-001. USEPA Office of Water Quality, Washington, DC, 20460, 207 pp.

Walker, J. M., R. M. Southworth, and A. B. Rubin. 1997. U.S Environmental protection Agency regulations and other stakeholder activities affecting agricultural use of by-products and wastes. P. 28-47. In J.E. Rechcigl and H. C. MacKinnon (eds). Agricultural uses of by-products and wastes. ACS, Washington, DC.