Current UF-IFAS Recommendations Regarding Pasture Fertilization

Ed Hanlon
Soil & Water Science Department
University of Florida, Gainesville

The Extension Soil Testing Laboratory has been offering soil testing services to the Florida public for more than 20 years. To insure that both soil testing interpretations and fertilization recommendations remain current, the University of Florida, Institute of Agricultural Sciences (UF-IFAS) has initiated a review process that involves researchers, state extension specialists, county extension faculty, producers, and other interested parties. This paper discusses the review process in light of current and proposed UF-IFAS pasture fertilization recommendations.

Fertilization Philosophy: An Overview

The approach one uses to address a subject is an abstract idea commonly called a philosophy. Fertilization recommendations, whether they originate from a public or private laboratory, are based upon the underlying philosophy of that laboratory. Because this philosophy is not stated nor readily available, but always implied, recommendations can vary among laboratories, even when the soil samples are from the same field. Differences in recommendations among laboratories are usually viewed as errors by clients when, in fact, the different recommendations were intended to accomplish the goals of the underlying philosophy. Thus, without an understanding of these goals, clients can become confused and misunderstanding can be perpetuated.

All recommendations from UF-IFAS are based upon the Crop Nutrient Requirement concept. The crop nutrient requirement for a specific crop is that amount of a nutrient (N, P, K, etc.) needed to produce optimum plant growth and quality. Even with Florida's sandy soils and high rainfall, nutrients can be present in sufficient quantities to satisfy the crop nutrient requirements of crops. The management problem is how to decide if those conditions exist. A traditional approach is through soil testing.

Soil testing can be helpful as a decision tool regarding fertilization. However, soil-test methods must be calibrated for the crop and conditions. Tests that have not been calibrated are not useful for fertilization decisions because they do not have an established link among the soil test value, added fertilizer, and crop response.

Once calibrated, if the soil-test value is found to be in the HIGH or VERY HIGH range, then the crop nutrient requirements can be satisfied from the soil alone. If the value lies within the VERY LOW, LOW, or MEDIUM ranges, then some portion of the crop nutrient requirement must come from added nutrients, usually from fertilizer.

Fertilizers are added to produce a positive crop response. If fertilizers are added and the crop does not respond, then it is possible that overfertilization has occurred. In other words, high fertilizer efficiency is an important objective of the crop nutrient requirement concept. Fertilizers should be used efficiently because fertilizer resources are limited. High efficiency also means that the reason for adding the fertilizer in the first place has been achieved: high yield and quality. An added benefit is that little residual fertilizer will remain to affect water quality or other segments of the ecosystem.

The UF-IFAS Recommendation Process

Initiation of a Review Review of recommendations can be initiated by either state extension specialists or county extension faculty. This first step takes advantage of the excellent Cooperative Extension Service information pathways to our clients. The ability to start the review process from a number of sources also means that a greater group has access and input into the UF-IFAS Standardized Fertilization System. The goal of this system is to insure that consistent recommendations are available to our extension clients throughout the state, and that the recommendations are based as much as possible on the applicable research and experience of our professionals at every level within the university.

The Working Group If a particular concern or problem arises and the area of concern has not been addressed recently (within about 2 years), then the most closely related departmental chair or unit director forms a Working Group. The Working Group usually contains state extension commodity specialists, selected county extension faculty, and researchers from both the main university campus and from the Research & Education Centers, and one or more administrators.

Tasks for the Working Group The overall objective of the Working Group is to produce a recommendation that is based upon as much fact as possible. Facts in this case are usually data and their interpretations reported from laboratory, greenhouse, and field experimentation reported in peer-reviewed journals, demonstration projects, and scientific observations. Emphasis is placed on this information in an attempt to separate opinions from observed facts. While we are all allowed and encouraged to have opinions, which often lead to disagreements, most of us can agree on facts.

This approach also leads the Working Group to consensus much faster than a discussion of opinion-based understanding. Consensus herein means that the members of the group accept the recommendation as practical and useful for achieving the goals of the crop nutrient requirement concept. This approach also identifies possible researchable topics, if funds and personnel resources are available.

State-wide Review After the Working Group has prepared a working document satisfying the above conditions, the manuscript is sent to additional research and extension faculty, growers, and other interested parties. These reviewers are encouraged to identify concerns or problems within the document for further action by the Working Group.

After addressing the state-wide reviewers' comments, the Working Group forwards the document to the Fertilization Oversight Committee. This committee is composed of the Dean for Extension, the Dean for Research, and selected departmental chairs and unit directors. The purpose of this committee is to insure that the document is as complete as possible, that consensus within UF-IFAS is achieved, that researchable topics are identified, and that possible impacts of the proposed recommendation are understood. If the latter are of sufficient import, possible redirection of resources is considered.

Incorporation of New and/or Improved Recommendations Publication of the document produced by the Working Group allows the circulation of new recommendations throughout the Cooperative Extension Service information network, to both our faculty and customers. Traditionally, publication has meant printed, stand-alone documents, but inclusion on UF-IFAS CD-ROM is now a viable option. Additionally, access through other computer-controlled means is also possible.

Once published, the new/improved recommendations are incorporated into extension programs and available via the Extension Soil Testing Laboratory reports.

Extension Soil Testing Lab Reports

This soil-test report is the one the laboratory provides for each submitted soil sample. This report has been evolving for considerable time to include as much pertinent information as possible. A fertilizer rate is provided, but to consider this value without using the additional information is shortsighted. The footnote section has been developed to provide quick reference information concerning fertilizer timing, placement, sources, and warnings. Additionally, the local county faculty member is identified to assist customers needing more information. All of this information can contribute toward making correct fertilization choices.

New Recommendations Activity

Two documents have recently undergone this recommendation process: lettuce fertilization on the Histosols of the Everglades Agricultural Area (UF-IFAS Special Publication – 153); citrus fertilization (UF-IFAS Special Publication – 169, in press); peanut fertilization (regional work being incorporated at the Working Group level); and bahiagrass fertilization in pastures (Working Group level).

Current Pasture Grass Recommendations

Tables 1 and 2 contain the current pasture grass recommendations and related footnotes. Table 3 presents the current footnote text. This information is useful as a reference source, and should be a part of all fertilization decisions. The interpretation scales (VL through VH) linking the actual soil test ranges to fertilizer rates are described in Notes in Soil Science No. 35 (revised) by Kidder et al. (1990).

Table 1. Target pH, and recommended N, P_2O_5, and K_2O fertilizer rates for agronomic crops. Phosphorus and K rates are based on interpretation of a Mehlich-I soil test.

Crop Code	Crop Description	pH	N	P_2O_5, lb/A/year					K_2O, lb/A/year				
		target	lb/A	VL	LO	MED	HI	VH	VL	LO	MED	HI	VH
14	Summer Annual Grasses	6.0	**	80	80	40	0	0	80	80	40	0	0
21	Warm Season Legumes	6.0	0	30	30	30	0	0	60	60	30	0	0
22	Cool Season Legumes or Legume-Grass Mixtures	6.5	0	100	100	60	0	0	160	160	120	0	0
24	Bahiagrass Pasture												
	High-N option	5.5	160	40	40	0	0	0	80	80	40	0	0
	Medium-N option	5.5	100	25	25	0	0	0	50	80	0	0	0
	Low-N option	5.5	50	0	0	0	0	0	0	0	0	0	0
25	Improved Perennial Grasses (excluding Bahia)	5.5	160	40	40	0	0	0	80	80	40	0	0
26	Cool Season Annual Grasses	6.0	**	80	80	40	0	0	80	80	40	0	0
28	Perennial Peanut	5.0	0	30	30	30	0	0	60	60	60	0	0

** Nitrogen recommendation is contained in footnotes 111 and 112.

Table 2. Applicable footnote numbers and additional reading for agronomic crops.

Crop Code	Crop Description	Footnotes	References
14	Summer Annual Grasses	111 124	Agronomy Facts 147
21	Warm Season Legumes	121 124	Agronomy Facts 147
22	Cool Season Legumes / Legume-Grass Mixtures	115 122 124 129	Agronomy Facts 147
24	Bahiagrass Pasture	124 131	Agronomy Facts 70 and 147
25	Improved Perennial Grasses (excluding Bahia)	124 125 126	Agronomy Facts 70 and 147
26	Cool Season Annual Grasses	112 124	Agronomy Facts 70 and 147
28	Perennial Peanut	119 124 130	Agronomy Facts 147

Table 3. Text of footnotes used with agronomic crops.

111 Apply 30 lb N/A, 50% of the K_2O, and all of the P_2O_5 fertilizer in a preplant or at-planting application. Apply 50 lb N/A and the remaining K_2O after the first grazing period. Apply an additional 50 lb N/A after each subsequent grazing period.

112 When planting on a prepared seed bed, apply 30 lb N/A, 50% of the K_2O, and all of the P_2O_5 fertilizer in a preplant or at-planting application. Apply 50 lb N/A and the remaining K_2O after the first grazing period. Apply an additional 50 lb N/A after each subsequent grazing period. For overseeding established perennial grasses with cool season annual grasses, apply 50 lb N/A plus all P_2O_5 and K_2O after emergence. Apply an additional 50 lb N/A after each subsequent grazing period.

115 Apply all of the P_2O_5 and 50% of the K_2O fertilizer in late fall. Apply the remaining K_2O in early spring. If legumes are planted in combination with oats, rye, wheat, and/or ryegrass, apply 30 lb N/A in a preplant or at-planting application plus one additional 50 lb N/A application after the grass is well established.

119 For perennial peanuts, make an annual application of 20 to 30 lb S/A for intensive hay production.

121 Apply all of the P_2O_5 and K_2O in spring or early summer when seedlings or regrowth are 3 to 4 inches tall. Species included are aeschynomene, alyce clover, desmodiums, hairy indigo, perennial peanut, and other tropical legumes.

122 Species included are all true clovers (white, red, arrowleaf, crimson, subterranean), vetches, lupines, and sweet clover.

124 IFAS recommendations emphasize efficient fertilizer use without losses of yield or of crop quality. Efficient fertilizer use results in high production with minimum impact to our environment. Since fertilizer use and management are only two aspects of crop production, growers are encouraged to consider IFAS recommendations in light of their entire management strategy, including financial considerations.

125 Grass species included are bermuda, star, limpo, and digit.

126 For new plantings, apply only 100 lb N/A and split as follows: apply 30 lb N/A, all of the P_2O_5, and 50% of the K_2O as soon as plants have emerged; apply the remaining K_2O and 70 lb N/A 30 to 50 days later.

For grazed, established stands, apply 80 lb N/A, all of the P_2O_5, and 50% of the K_2O in early spring. Apply the remaining N and K_2O at mid-season. Under intensive management in central and south Florida, up to 200 lb N/A may be economically viable for stargrass and bermudagrass. In that situation, apply 80 lb N, all of the P_2O_5 and K_2O in early spring, follow with 50 lb N/A in mid-season, and 70 lb N/A and the other 50% K_2O in mid to late September.

If cutting for hay or silage, apply 80 lb N/A, all of the P_2O_5 and K_2O in early spring. Apply an additional 80 lb N/A and 40 lb K_2O/A after each cutting.

129 These recommendations are made assuming adequate soil moisture will be available either from rainfall or irrigation. In south Florida, lack of adequate rainfall during the cool season frequently causes stand failure or limits growth. Under non-irrigated conditions in south Florida, the probability of inadequate moisture is high and the likelihood that the crop will benefit from applied fertilizer is low.

130 Apply all of the P_2O_5 and 50% of K_20 in early spring. Apply the remaining K_2O at midseason.

131 Fertilization Management Notes for Bahiagrass Pastures

For new plantings, apply only 100 lb N/A split as follows: apply 30 lb N/A, all of the P_2O_5, and 50% of the K_2O as soon as plants have emerged; apply the remaining K2O and 70 lb N/A 30 to 50 days later.

For established stands of bahiagrass, apply all of the fertilizer in the early spring to maximize much-needed spring forage. Bahiagrass is a very efficient forager and recovers nutrients from deeper in the soil profile than other popular forage grasses, so danger of leaching losses is low. Three fertilization options are presented below. Choose the option which most closely fits your fertilizer budget, management objectives, and land capability.

<u>High-N Option</u> Apply 160 lb N/A and the soil-test-based recommended rates of P_2O_5 and K_2O for each of your pastures. The fertilization rates suggested in this option are high enough to allow bahiagrass pasture to achieve well above average production. Management and environmental factors will determine how much of the potential production is achieved and how much of the forage is utilized.

<u>Medium-Nitrogen Option</u> Apply around 100 lb N/A this year. At that level of N fertilization, P and K may be limiting if your soil tested low in these nutrients. Apply 25 lb P_2O_5/A if your soil tested low in P, and none if it tested medium. Apply 50 lb K_2O/A if your soil tested low in K, and none if it tested medium. Re-test your soil every second or third year to verify P and K levels. If you plan to make a late-season cutting of hay, apply 80 lb N/A between August 1 and 15 (about 6 weeks before the growing season ends).

Low-Nitrogen Option (for Grazed Pastures Only) Apply around 50 lb N/A this year, recognizing that N will be the limiting nutrient. Thus, do not apply P or K. If you follow this practice of applying only N to your pasture for more than one year, apply the P and K recommended by soil test every third or fourth year to avoid excessive depletion of those nutrients. Do not use this option if you cut hay, since nutrient removal by hay is much greater than by grazing animals.

Proposed Bahiagrass Fertilization Changes

During the past 2 years, consideration of bahiagrass fertilization has been addressed by a Working Group using recently published data. Findings in peninsular Florida suggest that yield responses of bahiagrass in pastures to additions of P and K fertilizer is much less than responses in clipping (hay production) studies. Furthermore, the ability of soil testing to assist with the decision to add either P or K should be questioned. Yield responses to added P or K on soils testing low have not been consistently observed with pasture management, indicating that either the grass was obtaining sufficient nutrition from the soil (presumably from soil not tested by a 6-inch depth sample), or that factors other than fertility were controlling yield. In either case, these findings do not support the traditional reliance on soil testing as a fertilizer management tool. In fact, regular P and K fertilization should be strongly reviewed for bahiagrass pastures.

The use of soil testing was originally developed for annual crops and was extended to perennial crops, such as grasses, usually based upon hay production. For these uses, soil testing continues to work well. It is only for bahiagrass pastures in central Florida that soil testing has not proven effective as a fertilization decision tool.

Soil horizons, such as the spodic horizon ("hardpan"), tend to accumulate P and to a lesser extent K. These horizons occur in many of the soils used for bahiagrass production. However, these horizons are well below normal soil sampling depths, so their potential nutrient contribution can not be predicted from the soil test. Additionally, bahiagrass requires only small amounts of P and K for pasture production, since a portion of these nutrients is recycled through dead plant tissue and from animal waste products.

A decided production advantage for 50 to 60 lb N/acre was observed in a nine-county study completed on cooperator fields. The next paper, given by Ed Jennings, deals with the economics of bahiagrass fertilization in pastures. Since bahiagrass is produced as a feed source for cattle, the efficiencies of fertilization must be judged on criteria describing cattle production, not forage production.

Based upon these findings, the Working Group proposes the following changes for fertilization of bahiagrass in pasture management in central Florida:

- Fertilization with N should be 50 lb N/acre/year.
- Fertilization with P or K is not needed for bahiagrass pasture production. Use of these nutrients should be based upon economic considerations.
- Decisions for P or K additions of bahiagrass pastures are not aided by traditional soil testing. Decisions concerning P and K fertilizer additions should be based upon economic considerations.
- The target pH for bahiagrass pastures should remain at 5.5.
- Growers are encouraged to make changes in fertilizer use slowly. Changing practices slowly insures that the new practice or input level is suitable for site-specific conditions and overall management objectives.
- These proposed changes do not apply to any other pasture grasses.

Ongoing research in northern Florida will be looking at the use of soil testing and P and K fertilization on bahiagrass production. However, this study is only in its first year. It will be several years before any pasture experiments will be completed. A document will be prepared in 1995 to summarize the Working Group efforts for fertilization of bahiagrass pastures in central Florida. You are encouraged to pass along comments concerning these proposed changes through your local county extension faculty.

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Bibliography

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Allen, R.J., Jr., and F.T. Boyd. 1959. Pasture development in the Everglades. Soil Crop Sci. Soc. Fla. Proc. 19:154-161.

Blue, W.G. 1966. The effect of nitrogen sources, rates and application frequencies on Pensacola bahiagrass forage yields and nitrogen utilization. Soil Crop Sci. Soc. Fla. Proc. 26:105-109.

Blue, W.G. 1970. The recovery of autumn and winter applied potassium by a warm-season grass from Leon fine sand. Soil Crop Sci. Soc. Fla. Proc. 31:75-77.

Blue, W.G. 1971. Nitrogen fertilization in relation to seasonal Pensacola bahiagrass (Paspalum notatum Flugge) forage nitrogen and production distribution on Leon fine sand. Soil Crop Sci. Soc. Fla. Proc. 30:9-15.

Blue, W.G. 1973. Role of Pensacola bahiagrass stolon-root systems in fertilizer nitrogen utilization on Leon fine sand. Agron. J 65:88-90.

Blue, W.G. 1974. Efficiency of five nitrogen sources for Pensacola bahiagrass on Leon fine sand as affected by lime treatments. Soil Crop Soc. Fla. Proc. 33:176-180.

Blue, W.G. 1977. Comparison of sulfur-coated urea and ammonium nitrate as fertilizers for Pensacola bahiagrass on a Spodosol. Soil Sci. Soc. Amer. J. 41:1191-1193.

Blue, W.G. 1979. Forage production and N contents, and soil changes during 25 years of continuous white clover: Pensacola growth on a Florida Spodosol. Agron. J. 71:795-798.

Blue, W.G. 1980. Soil fertility management for improved pastures. Soil Crop Sci. Soc. Fla. Proc. 39:5-8.

Blue, W.G. 1988. Response of Pensacola bahiagrass (Paspalum notatum Flugge) to fertilizer nitrogen on an Entisols and a Spodosol in north Florida. Soil Crop Sci. Soc. Fla. Proc. 24:20-26.

Blue, W.G. 1988. Response of Pensacola bahiagrass on a Florida Spodosol to nitrogen sources and times of application. Soil Crop Sci. Soc. Fla. Proc. 47:135-139.

Blue, W.G., C.L. Dantzman, and V. Impithuksa. 1980. The response of the three perennial warm-season grasses to fertilizer nitrogen on Eaugallie fine sand (Alfic Haplaquod) in Central Florida. Soil Crop Sci. Soc. Fla. Proc. 39:44-47.

Blue, W.G., D.W. Jones, and J.B. Sartain. 1976. Interpretation of soil and forage tissue analytical data. Memorandum.

Blue, W.G., N. Gammon, Jr., and H.W. Winsor. 1961. Accumulation of organic matter and nitrogen on flatwoods soils planted to white clover-grass pastures. Soil Crop Sci. Soc. Fla. Proc. 21:74-81.

Blue, W.G., and N. Gammon, Jr. 1963. Differences in nutrient requirements of experimental pasture plots managed by grazing and clipping techniques. Soil Crop Sci. Soc. Fla. Proc. 23:152-161.

Boyd, F.T. 1961. Fertility responses of St. Augustine, Pangola, and Pensacola bahia grasses on south Florida sandy soils. Soil Crop Sci. Soc. Fla. Proc. 19:172-178.

Dunavin, L.S., Jr., and O.C. Ruelke. 1959. The Evaluation of Cold Hardiness in Florida Pasture Grasses. Soil Crop Sci. Soc. Fla. Proc. 47:139-142.

Gammon, N., JR., and W.G. Blue. 1961. Nitrogen in pasture and field crop production. Soil Crop Sci. Soc. Fla. Proc. 21:283-287.

Gonzalez, J.S., W.G. Blue, and C.L. Dantzman. 1973. Availability of native subsoil phosphorus in flatwoods soil from Central Florida. Soil Crop Sci. Soc. Fla. Proc. 32:138-141.

Hodges, E.M., and J.E. McCaleb. 1959. Pasture development at the range cattle station. Soil Crop Sci. Soc. Fla. Proc. 19:150-154.

Hodges, E.M., W.G. Kirk, F.M. Peacock, and J.E. McCaleb. 1970. Supplemental feeding of steers on Pangolagrass and Pensacola bahiagrass warm season pastures (Series II). Soil Crop Sci. Soc. Fla. Proc. 30:337-341.

Hodges, E.M., and F.G. Martin. 1975. Forge production of Perennial grasses as affected by fertilizer rate and season. Soil Crop Sci. Soc. Fla. Proc. 34:158-161.

Impithuksa, V., C.L. Dantzman, and W.G. Blue. 1979. Fertilizer nitrogen utilization by three warm-season grasses on an Alfic Haplaquod as indicated by nitrogen-15. Soil Crop Sci. Soc. Fla. Proc. 38:93-97.

Impithuksa, V., W.G. Blue, and D.A. Graetz. 1984. Distribution of applied nitrogen in soil-Pensacola bahiagrass components as indicated by nitrogen-15. Soil Sci. Soc. Am. J. 48:1280-1284.

Impithuksa, V., and W.G. Blue. 1977. The fate of fertilizer nitrogen applied to Pensacola bahiagrass on sandy soils as indicated by Nitrogen-15. Soil Crop Sci. Soc. Fla. Proc. 37:213-217.

Impithuksa, V., and W.G. Blue. 1985. Fertilizer nitrogen and nitrogen-15 in three warm-season grasses grown on a Florida Spodosol. Soil Sci. Soc. Am. J. 49:1201-1204.

Jones, V. 1991. Set stocking recommended for spring pasture. The Stockman Grass Farmer. p. 8-9.

Kidder, G., S.L. Sumner, E.W. Jennings, and M. Ramsey. 1992. Save energy, resources, and money with IFAS bahiagrass pasture fertilization recommendations. Fla. Coop. Ext. Serv. Videotape.

Killinger, G.B. 1959. Pasture herbage changes in Florida during the past two decades (1939-1959). Soil Crop Sci. Soc. Fla. Proc. 19:162-165.

McCaleb, J.E., C.L. Dantzman, and E.M. Hodges. 1966. Response of Pangolagrass and Pensacola bahiagrass to different amounts of phosphorus and potassium. Soil Crop Sci. Soc. Fla. Proc. 26:248-256.

Monteiro, F.A., and W.G. Blue. 1990. Effects of sulfur and molybdenum applied to Spodosol on White Clover-Pensacola bahiagrass growth and composition. Soil Crop Sci. Soc. Fla. Proc. 49:72-77.

Neller, J.R. 1963. Comparisons of phosphorus fertilizers for pastures on flatwoods soils in Florida. Soil Sci. Soc. Fla. Proc. 4:55-60.

O'Donnell, J.J., J.E. Rechcigl, W.D. Pittman, and D.M. Sylvia. 1991. Establishment and growth of Vigna parkeri on an acid Florida Spodosol in response to lime and phosphorus. p. 491-500. In R.J. Wright et al. (ed.). Plant-soil interactions at low pH. Kluwer Academic Pub., Netherlands.

Pate, F.M. 1993. Mineral supplement is more important with new fertilizer recommendations. Florida Cattleman 57,11:32,50.

Phillips, J.M., and C.S. Snyder. 1988. Effect of limestone and magnesium on bahiagrass yield, quality, nutrient concentration and uptake and soil test levels. Arkansas Agr. Exp. Sta. Bull. 914, 23 p.

Rechcigl, J.E., G.G. Payne, A.B. Bottcher, and P.S. Porter. 1992. Reduced phosphorus application on bahiagrass and water quality. Agron. J. 84:463-468.

Rechcigl, J.E., P. Mislevy, and F.M. Pate. 1991. Influence of limestone and phosphogypsum on bahiagrass. Ona A.R.E.C. Res. Rep. RC-1991-3:1-9.

Rechcigl, J.E., P. Mislevy, and A.K. Alva. 1991. Influence of limestone and phosphogypsum on bahiagrass growth and development. A.R.E.C. J. Series R-01774.

Rechcigl, R.E., G.G. Payne, A.B. Bottcher, and P.S. Porter. 1992. Reduced phosphorus application on bahiagrass and water quality. Agron. J. 84:463-468.

Rhoads, F.M., and R.L. Stanley, Jr. 1989. Coastal Bermudagrass yield, soil-pH, and ammonium sulfate-nitrate rates. FAES, IFAS. NFREC, Quincy Res. Report 89-9. 11 p.

Rodriguez-Kabana, R., D.B. Weaver, R. Garcia, D.F. Robertson, and E.L. Carden 1989. Bahiagrass for the management of root-knot and cyst nematodes in soybean. Nematropica. 19:185-193.

Ruelke, O.C. 1960. Fertility, as a limiting factor for pastures in Florida. Soil Crop Sci. Soc. Fla. Proc. 20:23-27.

Ruelke, O.C., and G.M. Prine. 1971. Performance of six hybrid Bermudagrasses, Pangola digitgrass, and Pensacola bahiagrass at three fertility levels in north central Florida. Soil Crop Sci. Soc. Fla. Proc. 31:67-71.

Saturnino, R., and W.G. Blue. 1970. The availability to forage plants of accumulated phosphorus in Leon fine sand. Soil and Crop Sci. Soc. Fla. Proc. 30:167-173.

Schroder, V.N., and O.C. Ruelke. 1968. Nutritional studies of root and shoot development of yellowed Bahiagrass. Soil Crop Sci. Soc. Fla. Proc. 28:35-43.

Staff. 1990. Phosphorus is key to grass tetany. BEEF p. 14.

Stanley, R.L., Jr., and R.W. Wallace. 1970. Crimson clover and Argentine bahiagrass yields as related to fertilizer rate and time of application. Soil Crop Sci. Soc. Fla. Proc. 30:90-99.

Sumner, S., W. Wade, J. Selph, J. Southwell, V. Hoge, P. Hogue, E. Jennings, P. Miller, and T. Seawright. 1991. Fertilization of established Bahiagrass pasture in Florida. Univ. Fla., Fla. Coop. Extn. Serv. Circ. 916, Gainesville, FL.

Teare, I.D., D.L. Wright, R.L. Stanley, and B.T. Kidd. 1986. The economics of fertilizing Bahiagrass under pines. Field Day handout.

Van Buren, N. 1991. FORAGE FERTILITY MANAGEMENT/Improving Quality Can Open New Customer Markets. Solutions p. 48-49, 58-59.

Varco, J.J. and J.B. Sartain. 1986. Effects of phosphorus, sulfur, calcium hydroxide, and pH on growth of annual Bluegrass. SSSAJ 50:128-132.

Weiser, G.C., and R.L. Smith. 1988. Nitrogen related characteristics of Switchgrass and Bahiagrass in Florida. Soil Crop Sci. Soc. Fla. Proc. 47:161-164.