AN EVALUATION OF THREE COOL-SEASON PERENNIAL FORAGES FOR WHITE-TAILED DEER AND EFFICACY OF MILORGANITE® TO PROTECT AGRONOMIC AND ORNAMENTAL PLANTS FROM DEER DAMAGE

by

ODIN LEE STEPHENS

(Under the Direction of Karl V. Miller and Michael T. Mengak)

ABSTRACT

I conducted a series of experiments assessing the palatability of deer supplemental forages and repellency of Milorganite® on agronomic and ornamental plantings. Durana white clover (*Trifolium repens*), Regal ladino white clover (*T. repens*) and MaxQ tall fescue (*Festuca arundinacea*) supplemental food plots were planted in three physiographic regions of Georgia during November 2002. Forage production, seasonal utilization and crude protein levels of these forages were compared during the 2003 and 2004 growing seasons. Throughout the study, Durana and Regal clover had similar forage production and utilization in all regions except during the 2004 growing season when Durana produced more forage than Regal on the Coastal Plain site. The utilization of MaxQ tall fescue was lower than both clovers throughout most of the study. As expected, crude protein levels of the clovers were consistently higher than MaxQ tall fescue throughout the study. In addition to the forage study, I tested the efficacy of Milorganite® as a short-term repellant on soybeans (*Glycine max*) in supplemental food plots in the Piedmont physiographic region and chrysanthemums (*Chrysanthemum morifolium*) in the Ridge and Valley physiographic region of Georgia during the summer of 2003. I then assessed deer browsing intensity for a 5-week period. My data suggest that Milorganite® can be used to reduce deer damage on ornamental and agronomic plants, depending on deer densities and amounts of available forage.

INDEX WORDS: Chrysanthemum, Crude protein, Milorganite, Durana white clover, Forage production, MaxQ tall fescue, Regal ladino white clover, Repellent, Soybeans, Utilization, White-tailed deer

AN EVALUATION OF THREE COOL-SEASON PERENNIAL FORAGES FOR WHITE-TAILED DEER AND EFFICACY OF MILORGANITE® TO PROTECT AGRONOMIC AND ORNAMENTAL PLANTS FROM DEER DAMAGE

by

ODIN LEE STEPHENS

B.S., The University of Georgia, 2001

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2005

AN EVALUATION OF THREE COOL-SEASON PERENNIAL FORAGES FOR WHITE-TAILED DEER AND EFFICACY OF MILORGANITE® TO PROTECT ARGONOMIC AND ORNAMENTAL PLANTS FROM DEER DAMAGE

by

ODIN LEE STEPHENS

Co-Major Professors: Karl V. Miller
Michael T. Mengak

Committee: Karl V. Miller
Michael T. Mengak
Robert J. Warren
Carl S. Hoveland

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
May 200

ACKNOWLEDGEMENTS

The Daniel B. Warnell School of Forest Resources provided funding for this research and Pennington Seed Co. provided seed and fertilizer. The Georgia Department of Natural Resources (DNR) provided assistance throughout the study.

I would like to thank Mr. Kent Kammermeyer, Dr. George Gallagher, Mr. John Gallagher, and Mr. Mike Hunter for their contributions and involvement during the project. Additionally, I would like to thank DNR and B. F. Grant employees who assisted in establishment and maintenance of the test areas. I appreciate Mr. David Osborn, Dr. Fred Simonton, Dr. David Allen, Mr. Mike Aiken, and Mr. Walter Stephens for allowing me to use their property to conduct research. I would especially like to thank Mr. Mike Harrison, Mr. David Osborn, Mr. Leif Stephens, Mrs. Pat Stephens, and Ms. Kym Armstrong for their time in helping collect data.

I thank my committee members Drs. Robert Warren and Carl Hoveland for their guidance and support. Special thanks goes to my co-major professors, Drs. Karl Miller and Mike Mengak, for directing and assisting me throughout this project. I am forever indebted to Dr. Karl Miller for the knowledge gained during my graduate career.

I owe a great deal to my family for their support, advice, and patience during my long college journey. Thanks to my father for providing me with the joys and pleasures of life.

TABLE OF CONTENTS

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

INTRODUCTION

Meeting the nutritional demands of a deer herd throughout the year is a critical component in creating a quality deer herd. Quantity and quality of the available forage is the primary determinate of a herd's nutritional status. Understanding nutritional status, forage yield potential, and palatability of forages throughout the year is pertinent to establishing a well-managed deer herd (Scwalbach 1990).

Establishment of supplemental food plots for white-tailed deer (*Odocoileus virginianus*) is widely used as a management tool throughout the southeastern United States. Supplemental food plots provide deer with nutrition when native vegetation nutritional levels are insufficient to support nutritional demands, and they help facilitate harvest (French et al. 1956, Blair et al. 1977, Johnson et al. 1987). Late summer and late winter are the two most nutritionally stressful periods for deer in the Southeast (Deitz 1965, Segelquist et al. 1971, Short et al. 1975, Blair et al. 1980). Grasses and legumes are the primary forages used in these supplemental plantings (Crawford 1984). MaxQ tall fescue and Durana white clover are cool-season forages, which may provide an alternative to other commonly planted forages; however, research has not been conducted to evaluate their use in a supplement food plot situation.

Intense browsing pressure can limit the selection of forage crops available for wildlife forage plantings. In particular, large-seeded legumes, such as soybeans (*Glycine max*) and iron clay peas (*Vigna unguiculata*), are susceptible to total stand failure in the face of early deer browsing. Additionally, ornamental plants often are damaged or lost from deer overbrowsing. Repellents often are used to deter deer from overbrowsing favored plants. While there is an abundance of repellents available, their efficacy varies and is often untested in controlled experiments.

My study objectives were to evaluate the forage production, utilization by white-tailed deer, and seasonal crude protein levels provided by the following three cool-season forages: MaxQ tall fescue, Regal ladino white clover, and Durana white clover; and to determine the effectiveness of Milorganite® as a temporary deer repellent when applied immediately after planting an annual, warm-season wildlife food plot and ornamental plants. Chapter 2 describes the cool-season forage study and Chapter 3 evaluates the effectiveness of Milorganite®. Chapter 2 represents a manuscript that will be submitted to the *Proceedings of the Southeastern Association of Fish and Wildlife Agencie*s. Chapter 3 represents a manuscript that will be submitted to the *Eleventh Annual Wildlife Damage Management Conference*.

LITERATURE REVIEW

Cool-Season Forage Study

Supplemental food plots are planted as a method to compensate for perceived nutritional deficiencies that occur in native vegetation (Waer et al. 1992) and/or to facilitate deer harvest. Warm and cool-season forages are commonly planted to compensate for these deficiencies. Thigpen et al. (1990) reported that 47% of 7,399 lease operators surveyed in Texas provided additional feed for white-tailed deer.

High-quality, cool-season perennial grasses offer longer grazing seasons, lower maintenance, and increased stand longevity compared to legumes (Ball et al. 2002). Cool-season perennial legumes have been widely planted to supply supplemental nutrition, but stands can be difficult to establish and maintain. Cool-season forages often are planted to concentrate deer during hunting season and provide additional food during winter months. Hehman and Fulbright (1997) reported that food plot utilization is directly related to the nutritional quality of the established forages. Waer et al. (1992) reported that deer preferred forages when the plants were high in protein. There are several species of warm and cool-season annuals/perennials that may be planted for forage. The choice depends on factors such as time of year, soil pH, site location, soil drainage, temperature, available soil nutrients, possible pest problems, and the amount of rainfall (Ball et al. 2002).

White clover (*Trifolium repens*) is a cool-season legume that provides excellent nutrition, but can be difficult to establish. There are several varieties of white clover, two of which are Regal ladino and Durana. Regal ladino has proven very successful in the cooler climates of northern Georgia, where it is considered to be an excellent food plot forage (Kammermeyer et al. 1993, Yarrow and Yarrow 1999). Kammermeyer et al. (1993) reported that ladino clovers provided an average of 24% crude protein in northeastern Georgia. Durana white clover was recently developed from a collection of white clover ecotypes and has been shown to tolerate heavy livestock grazing and persist better than ladino varieties (Brink et al. 1999, Bouton et al. 2004). Evaluation of Durana white clover as an alternative food plot forage for deer has not been done.

Tall fescue (*Festuca arundinacea*), a cool-season perennial, is the most widely grown pasture grass in the U. S. (Ball et al. 2002). It has not been utilized for deer food plots due to the fungal endophyte, *Neotyphodium coenophialum,* which reduces palatability and is toxic to deer and other livestock (Spyreas et al. 2001). Some endophyte strains do not produce toxic alkaloids; yet still furnish the same growth benefits to the plant as a toxic endophyte (Bouton et al. 1993a, Bouton et al. 1993b). An example of this technology is the development of MaxQ tall fescue. The non-toxic endophyte embedded in MaxQ tall fescue provides the grass with the toughness and persistence of original grass varieties without the palatability and toxicity problems (Bouton et al. 2001). However, research conducted to date has been limited to livestock production.

Repellent Study

When populations become overabundant, deer can cause a variety of negative economic impacts (Craven and Hygnstrom 1994). Along with increases in the population of humans and deer the number of deer-human conflicts has increased (Conover 1997). Deer can damage gardens, landscape and crops, and serve as hosts for diseases common to livestock and humans (Conover 2002). Suburban areas provide high-quality foods in ornamental plantings, gardens, and fertilized lawns (Swihart et al. 1995). Likewise, deer diets in rural areas often consist mainly of agricultural crops (Austin and Urness 1993). Conover's (1997) nationwide survey reported that deer cause losses of $251 million to households and $100 million to agricultural property annually. West and Parkhurst's (2002) survey reported that 58% of stakeholders in Virginia experienced deer damage to their ornamental plants or crops.

Warm-season forages are planted to provide nutrition for deer during early fawn development and antler growth. Intensive browsing during the early developmental stages of annual, warm-season legumes can reduce stand success and ultimately decrease potential forage production, often leading to replacement of preferred plants by less-desirable invasive plants (Conover and Decker 1991). Higginbotham and Kroll (1993) reported utilization rates of soybeans were > 95% at 30 days post-establishment. Garrison and Lewis (1987) found that defoliation of soybeans before week 4 post establishment dramatically reduced soybean yield.

The use of chemical repellents is a nonlethal alternative to reduce damage in situations where plants are vulnerable for a limited period of time. A wide variety of repellents are commercially available, but some are either not effective or too expensive for widespread use (Nolte et al. 1994a, Wagner and Nolte 2001). The active ingredients in these products incorporate fear, conditioned avoidance, pain, or odor/taste.

Deer may perceive fear-inducing repellents (predator urine, meat proteins, garlic) as indicators of predator activity and thereby avoid treated areas (Nolte et al. 1994b). Repellents that use conditioned avoidance cause animals to associate treated items with illness. Products that induce pain contain ingredients like capsaicin or ammonia, which causes pain in the nasal cavity, mouth or gut of the animal (Wagner and Nolte 2001). Repellents that contain bittering agents use taste as a negative response, but herbivores do not generally avoid these compounds (Andelt et al. 1992, 1994).

Odor and/or taste-based repellents may be applied to individual plants (systemic and contact deliveries) or spread throughout an area which contains multiple plants (area delivery). Harris et al. (1983) tested the response of 14 repellents applied to shelled corn and reported that Big Game Repellent (BGR), Feathermeal, Hinder, hot sauce, and thiram protected plants from deer damage. Müller-Schwarze (1972) reported that the presence of predator scat and fecal odors in deer feeding areas suppressed deer damage. Melchiors and Leslie (1985) found that predator fecal odors were as effective as commercial egg-based repellents (BGR) in reducing browsing by penned deer. Though an abundance of research has been conducted on deer repellents, few have been conducted on free-ranging deer.

Milorganite®, a slow release organic fertilizer, was developed in 1913 in Milwaukee, Wisconsin from treated human sewage (Anon. 2003). Anecdotal evidence has suggested that

Milorganite® could be a potential area repellant for deer. Hani and Conover (1995) reported Milorganite® was not effective as a repellent, but their research was conducted in penned settings with excessive deer densities. Further research in needed with free-ranging deer to assess the repellent's effectiveness under more natural conditions.

LITERATURE CITED

Anonymous. 2003. Our History. http://www.milorganite.com/. accessed 2003.

Andelt, W. F., D. L. Baker, and K. P. Burham. 1992. Relative preference of captive cow elk for repellent-treated diets. Journal of Wildlife Management 56:164-173.

Andelt, W. F., D. L. Baker, and K. P. Burham. 1994. Effectiveness of capsaicin and bitrex repellents for deterring browsing by captive mule deer. Journal of Wildlife Management 58:330-334.

Austin, D. D., and P. J. Urness. 1993. Evaluating production losses from mule deer depredation in alfalfa fields. Wildlife Society Bulletin 21:397-401.

Ball, D. M., G. D. Lacefield, and C. S. Hoveland. 2002. Southern Forages. Potash and Phosphate Institute and Foundation of Agricultural Research, Atlanta, Georgia, USA.

Blair, R. M., H. L. Short, and E. A. Epps, Jr. 1977. Seasonal nutrient yield and digestibility of deer forage from a young pine plantation. Journal of Wildlife Management 41:667-676.

Blair, R. M., H. L. Short, L. F. Burkart, A. Harrell, and J. B. Whelan. 1980. Seasonality of nutrient quality and digestibility of three southern deer browse species. United States Department Agriculture, Forest Service, Research Paper SO-161. 17pp.

Bouton, J.H., R. N. Gates, D. P. Belesky, and M. Owsley. 1993a. Yield and persistence of tall fescue in the southeastern coastal plain after removal of its endophyte. Agronomy Journal 85:52-55.

Bouton, J.H., R. N. Gates, D. P. Belesky, M. Owsley, and D.T. Wood. 1993b. Registration of Georgia 5 tall fescue. Crop Science 33:1405.

Bouton, J. H., R. N. Gates, and C. S. Hoveland. 2001. Selection for persistence in endophyte-free Kentucky 31 tall fescue. Crop Science 41:1026-1028.

Bouton, J. H., D. R. Woodfield, C. S. Hoveland, M. A. McCann, J. R. Caradus. 2004. New white clover cultivars for the southeastern USA. American Forage and Grassland Council Proceedings 13:338-342.

Brink, G. E., G. A. Pederson, M. W. Alison, D. M. Ball, J. H. Bouton, R. C. Rawls, J. A. Stuedemann, and B. C. Venuto. 1999. Growth of white clover ecotypes, cultivars, and germplasms in the southeastern USA. Crop Science 39:1809-1814.

Conover, M. 1997. Monetary and intangible valuation of the deer in the United States. Wildlife Society Bulletin 25:298-305.

Conover, M. 2002. Resolving human-wildlife conflicts: the science of wildlife damage management. Lewis Publishers. CRC Press, Boca Raton, Florida, USA.

Conover, M., and D. J. Decker. 1991. Wildlife damage to crops: perceptions of agricultural and wildlife professionals in 1957 and 1987. Wildlife Society Bulletin 19:46-52.

Craven, S. R., and S. E. Hygnstrom. 1994. Deer. Pages D-28 – 40. In S. E. Hygnstrom, R. M. Timm and G. E. Larson, editors. Prevention and control of wildlife damage. Cooperative Extension Division, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, USA.

Crawford, H. S. 1984. Habitat Management. Pages 629-649. In L. K. Halls, editor. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Deitz, D. R. 1965. Deer nutrition research in range management. Transactions of the North American Wildlife Conference 30:274-284.

French, C. E., L. C. McEwen, N. E. Magruder, R. H. Ingram, and R. W. Swift. 1956. Nutritional requirements for growth and antler development in white-tailed deer. Journal of Wildlife Management 20:221-232.

Garrison, R. L., and J. L. Lewis. 1987. Effects of browsing by white-tailed deer on yields of soybeans. Wildlife Society Bulletin 15:555-559.

Hani, A. E. and M. R. Conover. 1995. Comparative analysis of deer repellents. Pages 147-155. In Repellents in wildlife management conference proceedings. Mason, J. R. (editor) National Wildlife Research Center, Fort Collins, Colorado, USA.

Harris, M. T., W. L. Palmer, and J. L. George. 1983. Preliminary screening of white-tailed deer repellents. Journal of Wildlife Management 47:516-519.

Hehman, M. W., and T. E. Fulbright. 1997. Use of warm-season food plots by white-tailed deer. Journal of Wildlife Management 61:1108-1115.

Higginbotham, B. J., and J. C. Kroll. 1993. Warm season supplemental forages for white-tailed deer in the pineywoods of east Texas. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 47:185-197.

Johnson, M. K., B. W. Delany, S. P. Lynch, J. A. Zeno, S. R. Schultz, T. W. Keegan, and B. D. Nelson. 1987. Effects of cool-season agronomic forages on white-tailed deer. Wildlife Society Bulletin 15:330-339.

Kammermeyer, K., W. M. Lentz, E. A. Padgett, and R. L. Marchinton. 1993. Comparison of three ladino clovers used for food plots in northeastern Georgia. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 47:44-52.

Melchiors, M. A., and C. A. Leslie 1985. Effectiveness of predator fecal odors as black-tailed deer repellents. Journal of Wildlife Management 49:358-362.

Müller-Schwarze, D. 1972. Response of young black-tailed deer to predator odors. Journal of Mammalogy 53:393-362.

Nolte, D. L., D. L. Campbell, and J. R. Mason. 1994a. Potential repellents to reduce damage by herbivores. Proceedings of the Vertebrate Pest Conference 16:228-232.

Nolte, D. L., J. R. Masin, G. Epple, E. Aronov, and D. L. Campbell. 1994b. Why are predator urines aversive to prey? Journal of Chemical Ecology 20:1505-1516.

Scwalbach, R. P. 1990. Opportunity in the south. Deer and Deer Hunting 4:40-51.

Segelquist, C. A., M. Rogers, and F. D. Ward. 1971. Quantity and quality of Japanese honeysuckle on Arkansas Ozark food plots. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 25:47-53.

Short, H. L., R. M. Blair, and E. A. Epps Jr. 1975. Composition and digestibility of deer browse in southern forests. United States Department of Agriculture, Forest Service. Research Paper SO-11. 12pp.

Spyreas, G., D. J. Gibson, and B. A. Middleton. 2001. Effects of endophyte infection in tall fescue (*Festuca arundinacea*: Poaceae) on community diversity. Journal of Plant Science 162:1237-1245.

Swihart, R. K., P. M. Picone, A. J. DeNicola, and L. Cornicelli. 1995. Ecology of urban and suburban white-tailed deer. Pages 35 -44. In Urban deer: a manageable resource (J. B. McAninch, ed.). Proceedings of the 1993 Symposium of the North Central Section, The Wildlife Society, St. Louis, Missouri, USA.

Thigpen, J., C. E. Adams, and J. K. Thomas. 1990. Texas hunting leases. Leaflet-2441. Texas Agriculture Extension Service, College Station, Texas, USA.

Wagner, K. K., and D. L. Nolte. 2001. Comparison of active ingredients and dietary systems in deer repellents. Wildlife Society Bulletin 29:322-330.

Waer, N. A., H. L. Stribling, and M. K. Causey. 1992. Production and nutritional quality of selected plantings for white-tailed deer. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 46:274-286.

West, B. C., and J. A. Parkhurst. 2002. Interactions between deer damage, deer density, and stakeholder attitudes in Virginia. Wildlife Society Bulletin 30:139-147.

Yarrow, D. T., and G. K. Yarrow. 1999. Managing Wildlife. Alabama Wildlife Federation. Birmingham, Alabama, USA.

CHAPTER 2

FORAGE PRODUCTION, UTILIZATION BY WHITE-TAILED DEER (*Odocoileus virginianus*), AND SEASONAL CRUDE PROTEIN LEVELS OF THREE COOL-SEASON FORAGES IN GEORGIA[1]

[1] Stephens, O. L., M. T. Mengak, K. E. Kammermeyer, and K. V. Miller.
Submitted to *Proceedings of the Southeastern Association of Fish and Wildlife Agencies*

ABSTRACT

We evaluated forage production, seasonal utilization by white-tailed deer (Odocoileus virginianus), and seasonal crude protein levels of MaxQ tall fescue (Festuca arundinacea), Regal ladino white clover (Trifolium repens), and Durana white clover (Trifolium repens) planted alone or in combination. Two 1-ha food plots were planted in the Upper Coastal Plain, Piedmont, and Blue Ridge physiographic regions of Georgia in November 2002. Forage production and utilization were measured every 30 (±3) days over two growing seasons. MaxQ tall fescue had the greatest amount of standing crop across regions throughout most of the study period. Forage production and standing crops of Durana and Regal were similar throughout the study except during year 2 in the Upper Coastal Plain, when Durana had greater standing crops than Regal. MaxQ tall fescue and combination plots produced similar amounts of forage over the three regions. Generally, Durana and Regal had the greatest utilization compared to other forage plots over the three study areas. Durana and Regal white clover consistently maintained higher crude protein levels than MaxQ tall fescue across the three research sites.

Key words**:** cool-season forages, crude protein, Durana white clover, forage production, forage utilization, MaxQ tall fescue, Regal ladino white clover, supplemental food plots, white-tailed deer

INTRODUCTION

In the southeastern United States, supplemental food plots may compensate for annual and seasonal fluctuations in forage quality or quantity (Halls and Stransky 1968, Short 1975). Besides facilitating deer (Odocoileus virginianus) harvest, supplemental foods plots produce abundant, high-quality forages, and often are incorporated into many management programs (Blair et al. 1977, Johnson et al. 1987).

Cool-season forages may concentrate deer during hunting season and also provide additional food during winter and spring months. There are many varieties of cool-season annuals/perennials that may be used as forage, and choice depends on factors such as time of year, soil pH, site location, soil drainage, temperature, available soil nutrients, possible pest problems, and the amount of rainfall (Ball et al. 2002).

White clover (Trifolium repens) is among the most widely planted pasture legume due to perennial nature, aggressive running stolons, and broad adaptability under a wide range of climate conditions (Medeiros and Steiner 2000). Waer et al. (1992) tested 17 forages and reported that deer preferred forages when the plants grew rapidly and were high in crude protein. Kammermeyer et al. (1993) reported that ladino clovers provided an average of 24% crude protein for three years in northeastern Georgia.

Regal is a variety of ladino white clover that provides high-quality, year-round forage for deer, especially between April and November. McDonald and Miller (1995) found that of eight cool-season forages tested, Regal was utilized the most throughout their study. In an evaluation of three varieties of ladino clover, Kammermeyer et al. (1993) reported that Regal was the most economical forage to purchase for the nutrition it provided.

Durana white clover, an intermediate-leaved, common type of white clover, offers landowners a legume that provides increased stand persistence (Bouton et al. 2004). It was developed through the collection and repeated selection of white clover ecotypes. Durana has smaller leaves than ladino white clovers, but produces more stolons, which enable the legume to grow vigorously in heavy soils (Brink et al. 1999). Bouton et al. (2004) reported that Durana is more tolerant than Regal to grazing pressure and drought. Evaluations of Durana as an alternative to ladino clover for wildlife food plots have not been done.

Tall fescue (Festuca arundinacea), a cool-season perennial grass, is the most widely grown grass in the U. S., covering over 14 million hectares. It is adaptable to a wide range of soils, and offers grazing throughout most of the year (Bouton et al. 1993a, Bouton et al. 1993b, Joost 1995). Although tall fescue has many desirable agronomic characteristics, it has not been used for supplemental food plots because of low palatability and the presence of a toxic fungal endophyte that produces ergot alkaloids (Hill et al. 1991). Consumption of the endophyte alkaloids can result in reduced reproduction and low weight gain in livestock (Latch et al. 1994, Bacon 1995, Forcherio et al. 1995). Thus, tall fescue often is eradicated from wildlife food plots in favor of more suitable wildlife forages (Barnes and Washburn 1998).

Endophyte-free tall fescue varieties, including AU Triumph, Martin, and Star grazer, have demonstrated excellent animal performance in livestock trials, but were damaged or lost when grazed too closely (Ball et al. 2002). Jesup, a new endophyte-free variety appears to be superior to other endophyte-free varieties with respect to tolerance to grazing and drought (Ball et al. 2002).

A new variety of tall fescue, MaxQ, has been developed by inserting a nontoxic “friendly endophyte”. This non-toxic endophyte furnishes the excellent livestock performance of endophyte-free tall fescue but with the toughness and persistence of toxic tall fescue (Bouton et al. 2001, Hoveland 2000). In livestock trials, this new tall fescue variety does not seem to have palatability problems associated with older varieties (Parish et al. 2003). However, no research has been conducted on deer utilization of MaxQ tall fescue.

We report on a 2-year evaluation of forage production, utilization by white-tailed deer, and seasonal crude protein levels of MaxQ tall fescue, Regal ladino white clover, and Durana white clover. The specific objectives were to determine forage production and seasonal utilization by white-tailed deer of Regal ladino white clover, Durana white clover, and MaxQ tall fescue when planted alone and in combination, to assess adaptability of these forages to the Blue Ridge, Piedmont, and Coastal Plain physiographic regions of Georgia, and to evaluate the nutritional quality of each of these forages as measured by crude protein analysis.

STUDY AREAS

Research was conducted in the Coastal Plain, Piedmont, and Blue Ridge physiographic provinces of Georgia and included study areas in Tift County (private property), Putnam County (B. F. Grant Wildlife Management Area [WMA]), Fannin County (Blue Ridge WMA) and Lumpkin County (Chestatee WMA).

The Coastal Plain study area was on well-drained to excessively drained Norfolk loamy sand soils with very gentle slope (Jensen et al. 1959). Deer densities were estimated at 8 to 12 deer per km^2 in Tift County (Georgia DNR, unpubl. data 2000).

Soils of the Piedmont site were on well drained Cecil sandy loam soils with slopes ranging from 2 to 6% (Payne 1976). Deer densities range from 17 to 21 deer per km^2 in Putnam County (Kammermeyer et al. 2001).

The Blue Ridge study area located in Fannin County was on deep, well drained, moderately permeable Cowee fine loamy soils with slopes ranging from 10% to 25%. The Lumpkin County study area was on very deep, well-drained, moderately permeable Evard fine loamy soils with slopes ranging from 10 to 25% (Cabe 1976). Deer densities in Fannin and Lumpkin County range from 6 to 10 deer per km^2 (Kammermeyer 2003).

METHODS

Forage production and utilization by white-tailed deer of three cool-season perennial forage species was measured over two growing seasons beginning in February 2003 and concluding in May 2004. Soil tests were obtained prior to planting, and fertilizer and lime were applied to each site according to recommendation. Each site was fertilized again in September 2003 with a complete fertilizer and March 2004 with Potassium (K) only subsequent to data collection to encourage forage growth. In August 2003, each site was mowed following data collection to remove competing vegetation and enhance new growth.

Within each physiographic region, we established two food plots located at least 1.6 km apart, with three forages (Durana white clover, Regal ladino white clover, and MaxQ tall fescue) planted in various combinations. Each site, approximately 1-ha, was divided into five, 0.2-ha sections. Sections were randomly assigned and planted in pure Regal ladino (8.4 kg/ha), pure Durana clover (8.4 kg/ha), pure MaxQ tall fescue (19.6 kg/ha), a combination of MaxQ tall fescue and Regal ladino white clover (8.4 kg/ha; 5.0 kg/ha), and a combination of MaxQ tall fescue and Durana white clover (8.4 kg/ha; 5.0 kg/ha). Prior to planting, each site was mowed and harrowed to remove existing vegetation and minimize weed competition. All clover seeds were inoculated with appropriate Rhizobium sp. prior to planting.

We randomly placed three 0.5-m² exclosures on each 0.2-hectare section after planting to prevent deer browsing. Two 1-m rebar stakes were used to anchor each exclosure to the ground. Exclosures were 1.22-m high and made of 14-gauge galvanized mesh wire with 5.06 cm X 10.1 cm openings. Plantings were made in October in the Blue Ridge and November in the Piedmont and Coastal Plain. These dates were a month later than those usually recommended for clover plantings due to tactical problems with start up of the project. Consequently, start up of top growth on clovers was slow before onset of cold weather and dormancy.

As a result, forage sampling began approximately 90 days after planting at each site. Precipitation data were obtained from the National Oceanic and Atmospheric Administration (NOAA) recording sites located closest to the research sites. All plants within each exclosure were clipped to a uniform height of 2.5 cm from the ground and all clippings were collected for analysis. An equal area (0.5 m²) was clipped outside of each exclosure during sampling periods. Clipping samples were placed into a paper bag and labeled. After this initial sampling, all sections were clipped every 30 days (± 3 days). After each sampling, the exclosures were randomly moved within each section for the next sampling period.

Within 1 to 2 days post-clipping, samples were placed into an oven drier calibrated at 95º C, dried for at least 48 hours, and then weighed. Standing crop, forage production, utilization and utilization rate were calculated each month from dry weight data. Standing crop for the sample period was obtained from the dry weights of the forage samples inside each exclosure. The following formulas were used to obtain the forage production, utilization, and utilization rate:

$$\text{FORAGE PRODUCTION} = \left(\begin{array}{l}\text{Dry forage weight}\\ \text{from inside each}\\ \text{exclosure}\end{array}\right) - \left(\begin{array}{l}\text{Dry forage weight}\\ \text{from outside each}\\ \text{exclosure from the}\\ \text{previous month}\end{array}\right)$$

$$\text{UTILIZATION} = \left(\begin{array}{l} \text{Dry forage weight} \\ \text{from inside each} \\ \text{exclosure} \end{array} \right) - \left(\begin{array}{l} \text{Dry forage weight} \\ \text{from outside each} \\ \text{exclosure} \end{array} \right)$$

$$\text{UTILIZATION RATE (\%)} = \left(\frac{(\text{Utilization})}{(\text{Standing Crop})} \right) \times 100$$

After dry weights were recorded, we composited samples obtained from outside the exclosures and extracted a 4-g subsample from the pure Durana, Regal, and MaxQ plots. The 4-g subsamples were ground in a Wiley mill over a 5-mm screen and placed into a whirl-pac. Each subsample was analyzed for crude protein at the UGA Warnell School of Forest Resources (WSFR) Forage Lab using the analysis methods described by Schultz (1975). Protein levels were evaluated from April 2003 – March 2004 to attain a complete year of data.

Equal availability was assumed because all sections at each site were planted. Variance tests were utilized, accessed through the Statistical Analysis System (SAS), to analyze standing crop, yield production, utilization, utilization rates, and crude protein. Arc-sine transformation was applied to the percentage data prior to analysis. The SAS mixed procedure model with repeated measures was used to analyze the data. All results were considered statistically significant at the alpha = 0.05 level.

RESULTS

Standing crop, production, utilization and utilization rates varied among the three physiographic regions; therefore region data were not combined. In the Blue Ridge, data were not collected due to lack of forage growth during February 2003 and March 2003. In the Coastal

Plain, rainfall was above average February to October 2003 and below average during the remainder of the study. Rainfall was above average from February to August 2003 and below average during the remainder of the study in the Piedmont and Blue Ridge (Figure 2.1).

Standing Crop

Generally, MaxQ tall fescue and combination plots had greater standing crops than either clover among the regions throughout the study (Figure 2.2). The MaxQ and combination plots had similar standing crops throughout most of the study; similarly, Durana and Regal standing crop values usually did not differ.

In the Coastal Plain, the five stands of forages did not differ ($P < 0.05$) during the months of April, May and September 2003. MaxQ had greater standing crop than other forages throughout most of 2004. Durana had a greater standing crop than Regal during January (t_{20} =5.43, $P = 0.0002$), February ($t_{20} = 3.40$, $P = 0.0211$), and April 2004 ($t_{20} = 3.40$, $P = 0.213$). Also, MaxQ/Durana combination plots had a greater standing crop than MaxQ/Regal during April (t_{20} =3.27, $P = 0.218$) and May 2004 ($t_{20} = 3.36$, $P = 0.0229$). In the Piedmont, MaxQ/Durana combination plot had a greater standing crop than MaxQ/Regal combination plot during May ($t_{20} = 3.68$, $P = 0.0115$), June ($t_{20} = 3.37$, $P = 0.0343$) and November 2003 ($t_{20} = -7.03$, $P = 0.0404$). In February 2004, MaxQ and MaxQ/Regal combination plot had the greatest standing crop. In the Blue Ridge, MaxQ had less standing crop than Regal (t_{20}=3.62, P = 0.0131) and Durana ($t_{20} = 6.02$, $P < 0.0001$) in September 2003. MaxQ had a greater standing crop than MaxQ/Regal during January ($t_{20} = 4.30$, $P = 0.0029$), March ($t_{20} = 3.70$, $P = 0.0110$) and April 2004 ($t_{20} = 5.26$, $P = 0.0003$).

Forage Production

MaxQ tall fescue and combination plots generally produced similar amounts of forage among the plots during 2003 and 2004 ($P > 0.05$); likewise, the forage production of both clovers was similar throughout most of 2003 and 2004 (Figure 2.3).

In the Coastal Plain, forage production on all plots was not significantly different during April, May, August, October, and December 2003 ($P > 0.05$). Durana produced more forage than Regal during January 2004 ($t_{20} = 4.42$, $P = 0.0022$). MaxQ/Durana combination plot had a greater forage production than MaxQ/Regal combination plot during January ($t_{20} = 3.36$, $P = 0.0229$), March ($t_{20} = 15.217$, $P = 0.0183$) and April 2004 ($t_{20} = 3.30$, $P = 0.0261$). MaxQ produced the least amount of forage during May 2004. In the Piedmont, no differences were detected in production among forages during February and June 2003 and during January, March, and April 2004. In the Blue Ridge, all plots produced similar amounts of forage during October and November 2003, and during January, February, March and April 2004. Durana production in May 2004 ($t_{20} = -3.21$, $P = 0.0319$) was greater than MaxQ production.

Utilization

Utilization on the combination plots was similar among the regions throughout most of 2003 and 2004 ($P > 0.05$). Further, the pattern of utilization was similar between Durana and Regal clovers (Figure 2.4).

In the Coastal Plain, utilization was similar among plots during all months except during February, June and July 2003, and April 2004. During April 2004, Durana and MaxQ/Durana were utilized more than MaxQ and MaxQ/Regal ($P < 0.05$). In the Piedmont, no difference in utilization was detected between plots throughout most of 2003. However, MaxQ was utilized more than Regal ($t_4 = 1.36$, $P = 0.0162$) and Durana ($t_4 = -5.97$, $P = 0.0182$) during November

2003. No difference in utilization was detected among plots in 2004. In the Blue Ridge, MaxQ/Regal combination plot was utilized more than MaxQ during June (t_4 = -10.12, P = 0.0026) and July 2003 (t_4 = -10.24, P = 0.026). MaxQ/Durana was utilized more than other plots in February 2004. Utilization did not differ during the remainder of 2004.

Utilization Rate

Durana and Regal had the highest utilization rate among the three regions throughout most of the study (Figure 2.5). The utilization rates of MaxQ were consistently the lowest among the regions during 2003 and 2004. Utilization rate of both clovers were similar; also, combination plots exhibited a similar utilization rate during most of the study ($P > 0.05$).

In the Coastal Plain, utilization rate did not differ among plots during February, March, April, May, October and November 2003 and during March and May 2004 ($P > 0.05$). In the Piedmont, there was no difference among plots during March and May 2004. In the Blue Ridge, the utilization rates between forages were similar except during April, July and December 2003. No difference was found in any month, between the utilization rates of combination plots and MaxQ during 2003 and 2004.

Crude Protein

The crude protein (CP) content of Durana and Regal was consistently higher than MaxQ throughout the study (Figure 2.6). Both clovers averaged over 20.0 % CP and MaxQ fescue ranged from 9.56 – 13.59% CP over the three study areas.

In the Coastal Plain, CP levels for all forages were significantly different during April and December 2003. In the Piedmont, all forages were similar during June and December 2003. MaxQ CP levels were similar to Regal during May (t_2 = -3.64, P = 0.1210) and August 2003 (t_2

= -5.18, P = 0.0637). In the Blue Ridge, CP levels of both clovers were greater than MaxQ during the entire study.

DISCUSSION

Several factors influenced forage growth at each site. Mean monthly precipitation was above normal during the first half of 2003 for the three study sites. The differences in standing crop and forage yield among the three sites may have been due to rainfall variations among sites. During 2004, mean monthly precipitation was below normal at all sites, which possibly contributed to the low standing crop values and production of the tested forages. All sites were mowed in August 2003 and fertilized during September 2003 and March 2004 soon after data were collected each month. This may have affected standing crop, production and utilization values during the next month. Weed competition at the Piedmont site may have reduced production of planted forages.

Overall production was somewhat consistent among forages. Bouton et al. (2001), based on work in the Georgia Piedmont and Coastal Plain, suggested that MaxQ tall fescue can tolerate stressful environmental conditions better than other endophyte-free fescue varieties. In the Coastal Plain, our production estimates for Durana were slightly higher than Regal in 2004, suggesting that Durana has the capability to produce more forage than Regal during the second growing season. This difference also was noticed between the combination plots where MaxQ/Regal plots produced slightly less forage than MaxQ/Durana plots during 2004. Andrae et al. (2003) reported Durana had higher area coverage than Regal three years after establishment.

Overall utilization varied among plant varieties and regions. Generally, both clovers were utilized similarly and MaxQ was utilized the least. The preference for the combination plots over pure MaxQ plots likely was a result of the clover component producing higher quality forage itself and providing extra N for the fescue. Intensity of forage utilization during the early growth stages in the Piedmont site may have influenced later stand success. From these results, we suggest that Durana can withstand intense grazing pressure when compared to Regal and thus may be able to produce more forage year after year under high deer densities. The high utilization rates of tall fescue and combination plots in the Piedmont compared to the other regions were reflective of higher deer densities.

Crude protein was considered to be an indicator of forage quality in this study. This trait is very important when considering what forages to plant for deer in order to provide supplemental protein during the nutritionally stressful periods of the year. The forage quality of Durana and Regal was similar during the study period. Both forages provided more than 17% CP during late summer and late winter. MaxQ had the lowest mean CP of all tested forages during the study, and ranged from 8% to 13% CP during late summer and late winter. MaxQ had greater CP levels increased in October in response to the fertilizer applied during the previous month.

CONCLUSION

An ideal forage would be one that produces year-round, high-quality forage preferred by deer. Selecting the appropriate forage depends on local conditions (soil type, weather, native forage availability, deer density, etc.) and management objectives.

Durana white clover seemed to grow better than Regal in the Coastal Plain and Piedmont after the first growing season. In agricultural forage trials, Durana produced more than ladino at 3 to 4 years post-establishment. Based on our results, and those in other reported trials, we suggest that Durana may be superior to ladino in terms of long-term productivity.

MaxQ tall fescue grew well in all three regions. However, based on low utilization rates, we do not recommend it as a food plot forage except in areas of high deer densities and low amounts of available native forage. MaxQ should be planted in combination with a legume to boost available CP levels. Deer utilized the combination plots more than the pure tall fescue plots in all three regions.

ACKNOWLEDGEMENTS

The study was funded by McIntire-Stennis Project GEO-0126-MS. Pennington Seed graciously provided seed and fertilizer and the Georgia Department of Natural Resources provided assistance throughout the study.

We thank J. Gallagher, M. Hunter, F. Manning, and D. Clayton for their contributions during the project. Additionally, we thank D. Osborn, L. Stephens, P. Stephens, and K. Armstrong for their time in collecting data. We thank R. Warren and C. Hoveland for their technical guidance and comments on previous drafts of this manuscript.

LITERATURE CITED

Andrae, J., C. Hoveland, and G. Durham. 2003. White clover of the future is here! Crop and Soil Sciences Department. University of Georgia, Athens, USA.

Bacon, C. W. 1995. Toxic endophyte-infected tall fescue and range grasses: historic perspectives. Journal of Animal Science 73:861-870.

Ball, D. M., G. D. Lacefield, and C. S. Hoveland. 2002. Southern Forages. Potash and Phosphate Institute and Foundation of Agriculture Research, Atlanta, Georgia, USA.

Barnes, T G., and B. E. Washburn. 1998. Postemergence tall fescue control at different growth stages with glyphosate and AC 263, 222. Weed Technology 14:223-230.

Blair, R. M., H. L. Short, and E. A. Epps, Jr. 1977. Seasonal nutrient yield and digestibility of deer forage from a young pine plantation. Journal of Wildlife Management 41:667-676.

Bouton, J.H., R. N. Gates, D. P. Belesky, and M. Owsley. 1993a. Yield and persistence of tall fescue in the southeastern coastal plain after removal of its endophyte. Agronomy Journal 85:52-55.

Bouton, J.H., R. N. Gates, D. P. Belesky, M. Owsley, and D.T. Wood. 1993b. Registration of Georgia 5 tall fescue. Crop Science 33:1405.

Bouton J. H., R. N. Gates, and C. S. Hoveland. 2001. Selection for persistence in endophyte-free Kentucky 31 tall fescue. Crop Science 41:1026-1028.

Bouton, J. H., D. R. Woodfield, C. S. Hoveland, M. A. McCann, and J. R. Caradus. 2004. New white clover cultivars for the southeastern USA. American Forage and Grassland Council Proceedings 13:338-342.

Brink, G. E., G. A. Pederson, M. W. Alison, D. M. Ball, J. H. Bouton, R. C. Rawls, J. A. Stuedemann, and B. C. Venuto. 1999. Growth of white clover ecotypes, cultivars, and germplasms in the southeastern USA. Crop Science 39:1809-1814.

Cabe, D. E. 1996. Soil survey of Fannin and Lumpkin County. United States Department of Agriculture. Natural Resource Conservation Service and Forest Service 63-64 pp.

Forcherio C., M. Kerley, B. Larson, J. Paterson, and M. Samford. 1995. The effects of fescue toxicosis on beef cattle productivity. Journal of Animal Science 73:889-898.

Halls, L. K., and J. J. Stransky. 1968. Game food plantings in southern forests. Transactions of the North American Wildlife Conference 33:315-325.

Hill, N. S., D. P. Belesky, and W. C. Stringer. 1991. Competitiveness of tall fescue as influenced by Acermonium coenophialum. Crop Science 31:185-190.

Hoveland, C. S. 2000. Achievements in management and utilization of southern grasslands. Journal of Range Management 53:17-22.

Jensen, E. R., L. E. Aull, J. L. Shepard, C. B. Thomas, R. C. Carter, E. S. Haygood, and R. G. Middleton. 1959. Soil survey of Tift County, Georgia. United States Department of Agriculture. Natural Resource Conservation Service and Forest Service 7-8 pp.

Johnson, M. K., B. W. Delany, S. P. Lynch, J. A. Zeno, S. R. Schultz, T. W. Keegan, and B. D. Nelson. 1987. Effects of cool-season agronomic forages on white-tailed deer. Wildlife Society Bulletin 15:330-339.

Joost, R. E. 1995. Acremonium in fescue and ryegrass: boon or bane? A review. Journal of Animal Science 73:881-888.

Kammermeyer, K. E., W. M. Lentz, E. A. Padgett, and R. L. Marchinton. 1993. Comparison of three ladino clovers used for food plots in northeastern Georgia. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 47:44-52.

Kammermeyer, K., D. Forster, K. Grahl, J. Ezel, H. Barnhill, S. McDonald, B. Cooper, G. Waters, and J. Bowers. 2001. Georgia white-tailed deer management plan 2000-2005. Georgia Department of Natural Resources. Wildlife Resources Division. Social Circle GA 25pp. plus Appendix.

Kammermeyer, K. 2003. Deer population characteristics on wildlife management areas in Georgia from 1977-2002. Federal Aid PR project W-55-R Georgia Department of Natural Resource Wildlife Resources Division Social Circle GA 26pp. plus tables, graphs and Appendix.

Latch, G. M., M. P. Rolston, G. C. Waghorn. 1994. Prolactin assay for fescue toxicity in sheep. New Zealand Veterinary Journal 42:195-197.

McDonald, J. S., and K. V. Miller. 1995. An evaluation of supplemental plantings for deer in the Georgia Piedmont. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 49:399-413.

Mederinos, R. B., and J. J. Steiner. 2000. White clover seed production: III. Cultivator differences under contrasting management practices. Crop Science 40:1317-1324.

Parish, J. A., M. A. McCann, R. H. Watson, C. S. Hoveland, L. L Hawkins, N. S. Hill, and J. H. Bouton. 2003. Use of nonergot alkaloid producing endophytes for alleviating tall fescue toxicosis in sheep. Journal of Animal Science 81:1316-1322.

Payne, H. H. 1976. Soil survey of Baldwin, Jones and Putnam County, Georgia. United States Department of Agriculture. Natural Resource Conservation Service and Forest Service. 10-11pp.

Short, H. L. 1975. Nutrition of southern deer in different seasons Journal of Wildlife Management 31:679-685.

Waer, N. A., H. L. Stribling, and M. K. Causey. 1992. Production and nutritional quality of selected plantings for white-tailed deer. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 46:274-286.

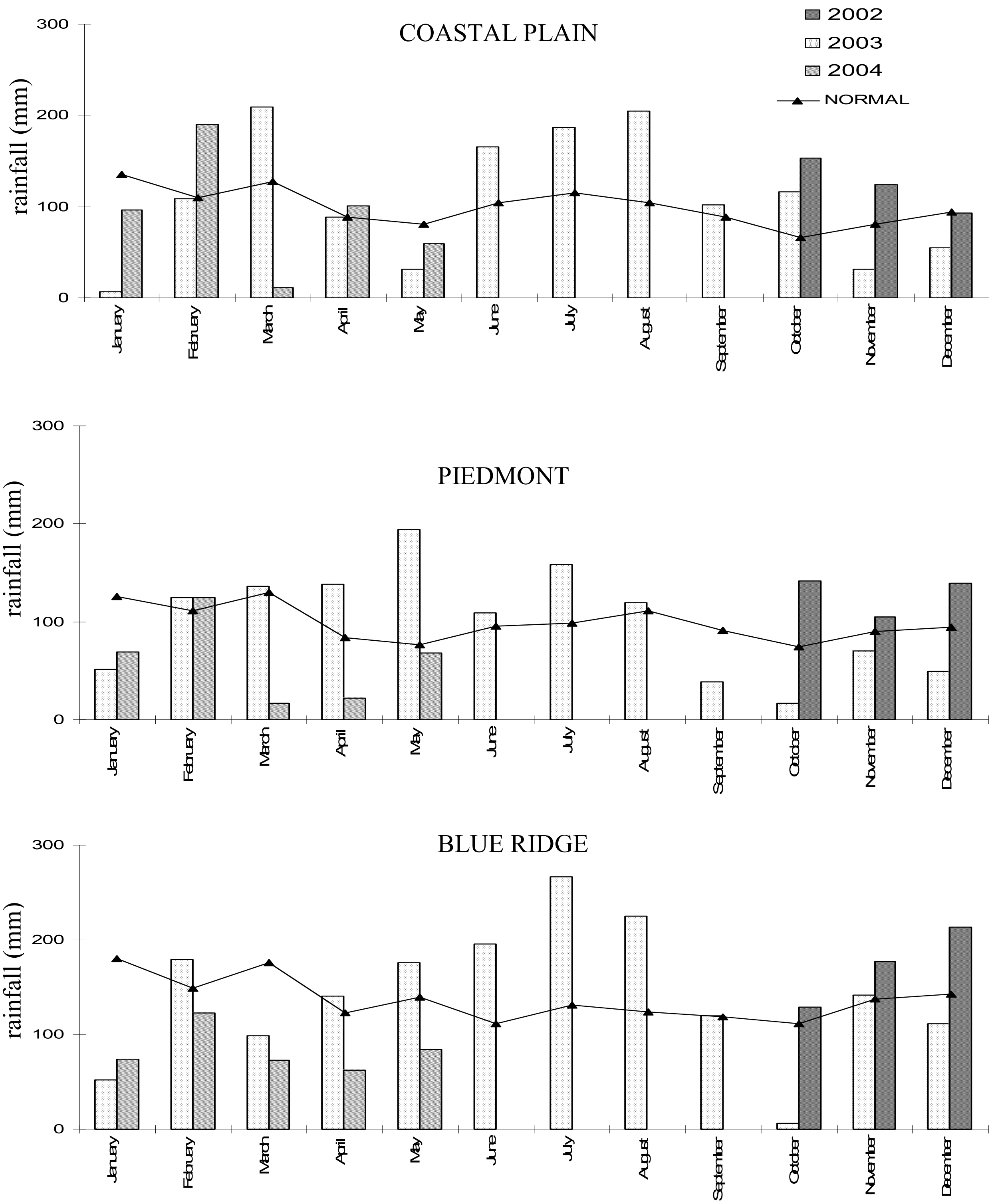


Figure 2.1. Precipitation data of study sites from October 2002 – May 2004. Rainfall data were obtained from the National Oceanic and Atmospheric Administration (NOAA) recording sites located closest to the research sites. Forages were established in October and November 2002 and sampled from February 2003 – May 2004.

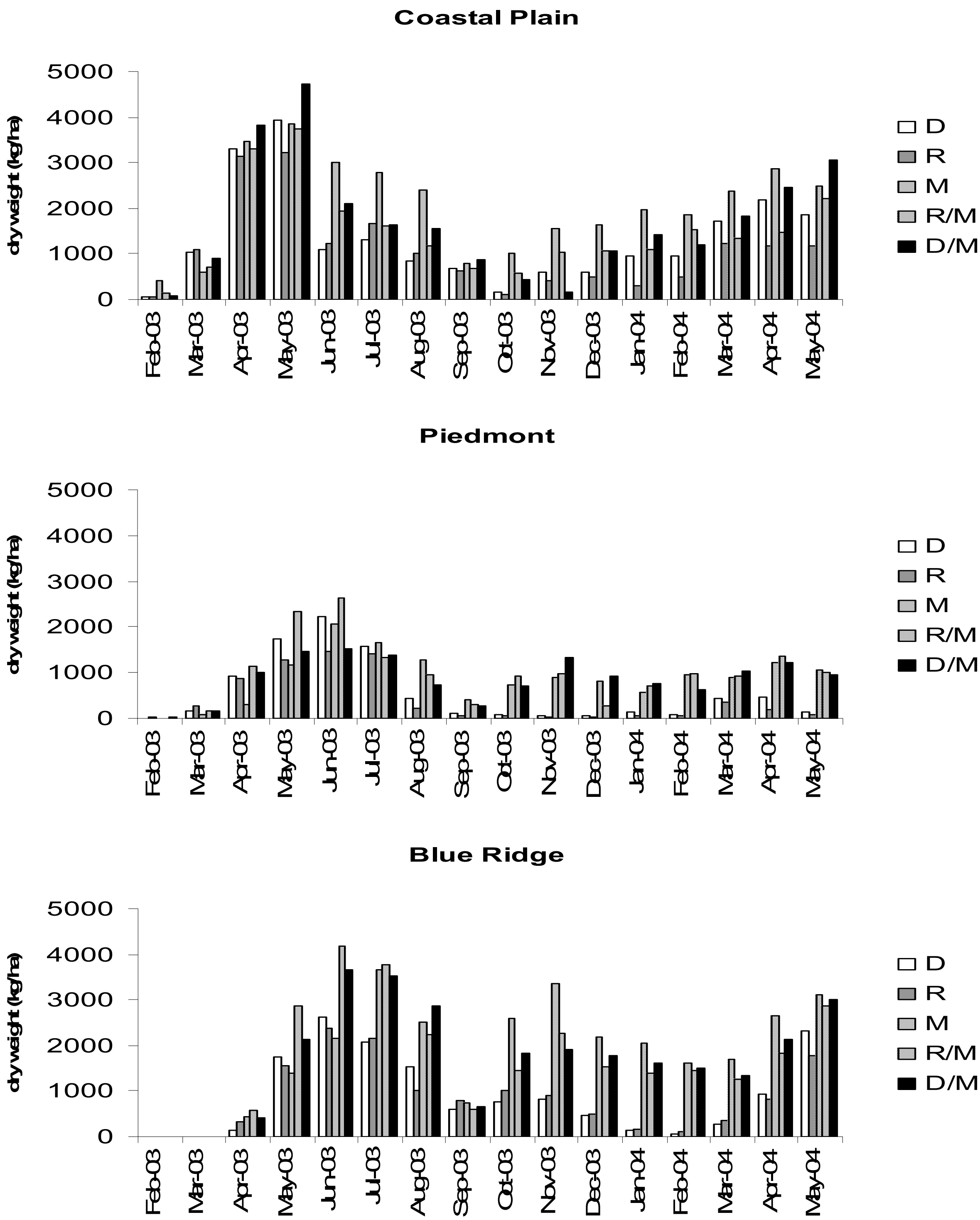


Figure 2.2. Mean monthly standing crop (kg/ha) of three cool-season forages established in Tift, Putnam, Fannin and Lumpkin County, Ga., in October and November 2002. Fannin and Lumpkin County data collection started in April 2003 due to lack of forage growth. Legend: D = Durana; R = Regal; M = MaxQ; R/M = Regal plus MaxQ combination; D/M = Durana plus MaxQ combination.

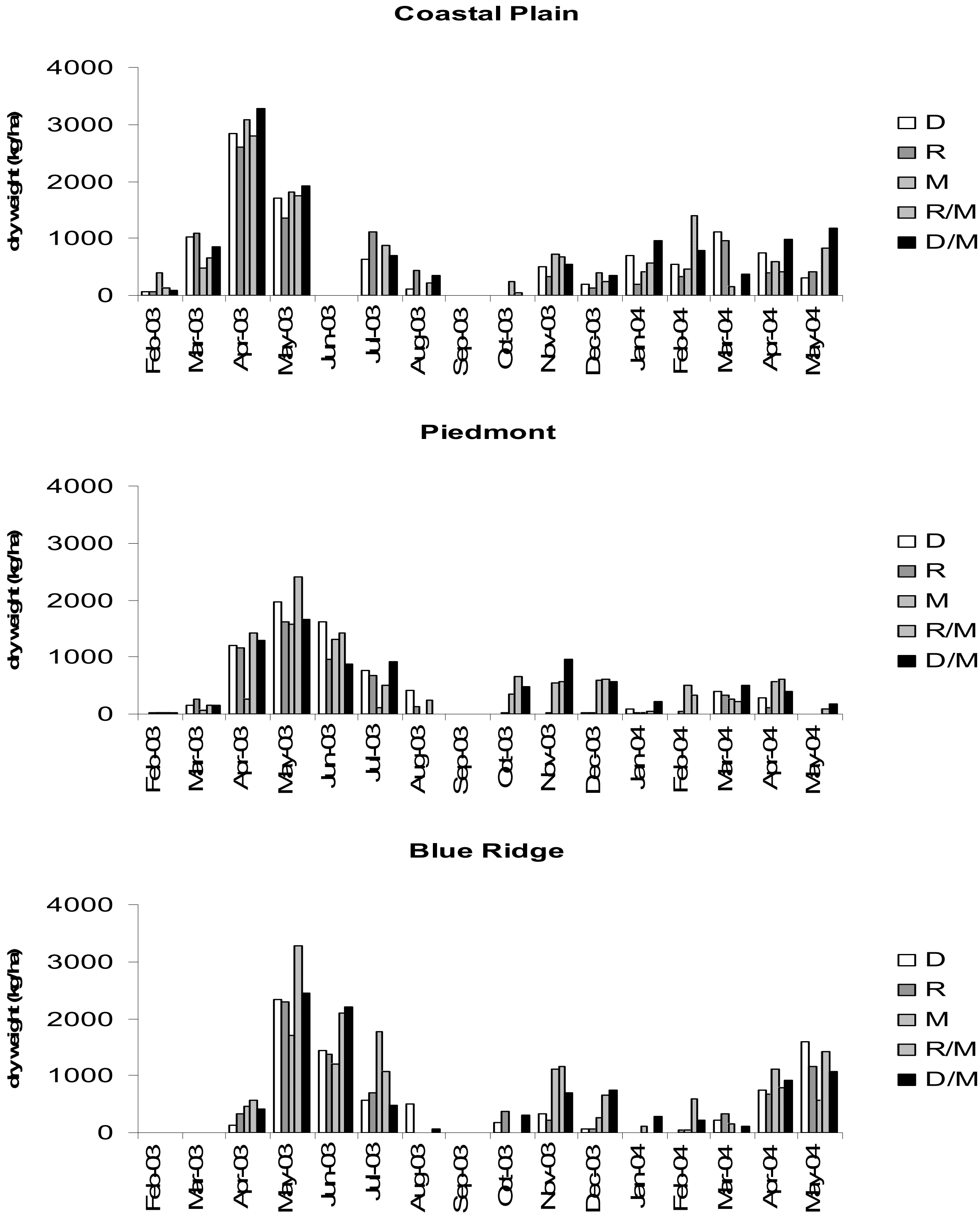


Figure 2.3. Mean monthly forage production (kg/ha) of three cool-season forages established in Tift, Putnam, Fannin and Lumpkin County, Ga., in October and November 2002. Fannin and Lumpkin County data collection started in April 2003 due to lack of forage growth. Legend is defined in Figure 2.2.

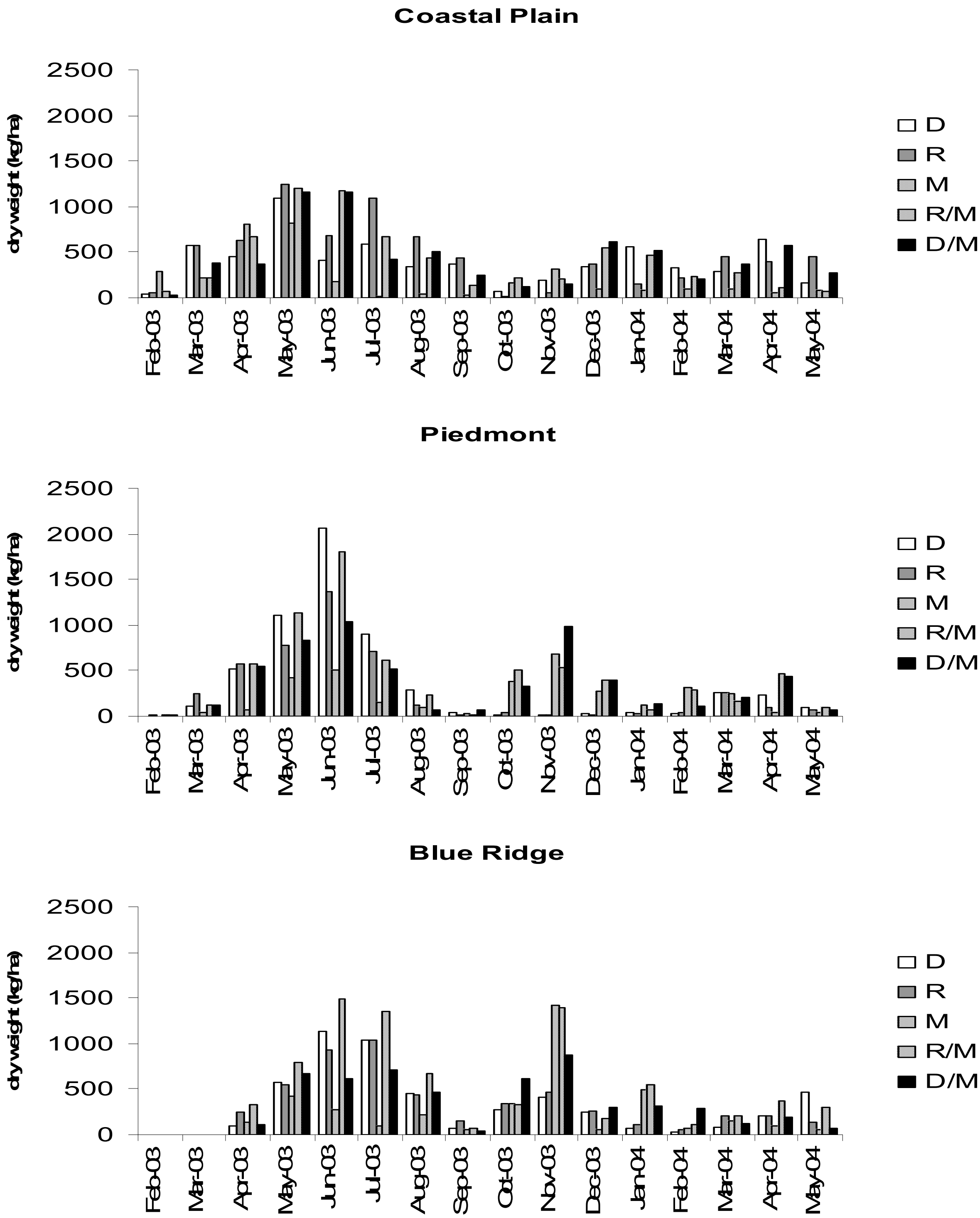


Figure 2.4. Mean monthly utilization (kg/ha) of three cool-season forages established in Tift, Putnam, Fannin and Lumpkin County, Ga., in October and November 2002. Fannin and Lumpkin County data collection started in April 2003 due to lack of forage growth in February and March 2003. Legend is defined in Figure 2.2.

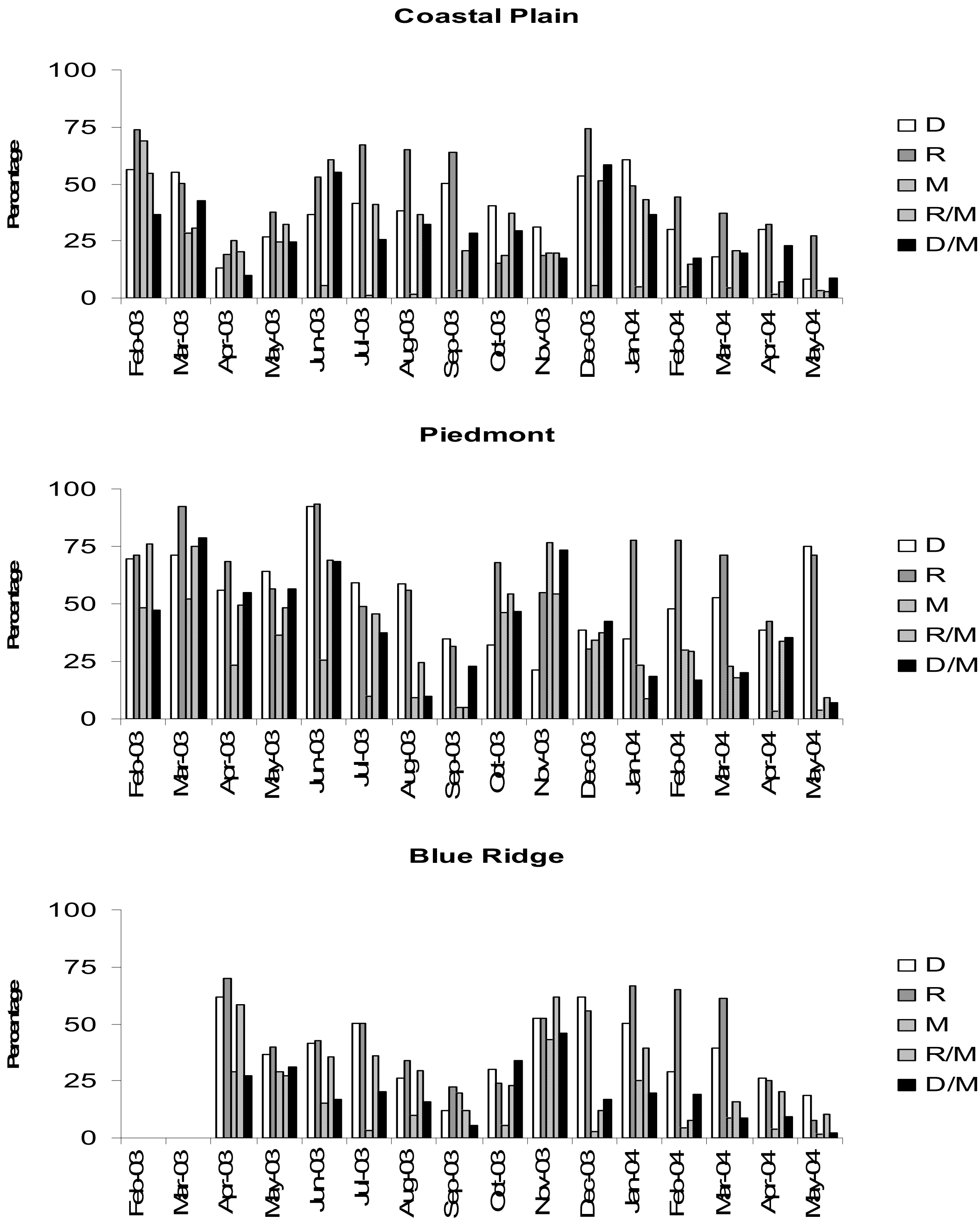


Figure 2.5. Mean monthly utilization rate (%) of three cool-season forages established in Tift, Putnam, Fannin and Lumpkin County, Ga., in November 2002. Fannin and Lumpkin County data collection started in April 2003 due to lack of forage growth in February and March 2003. Legend is defined in Figure 2.2.

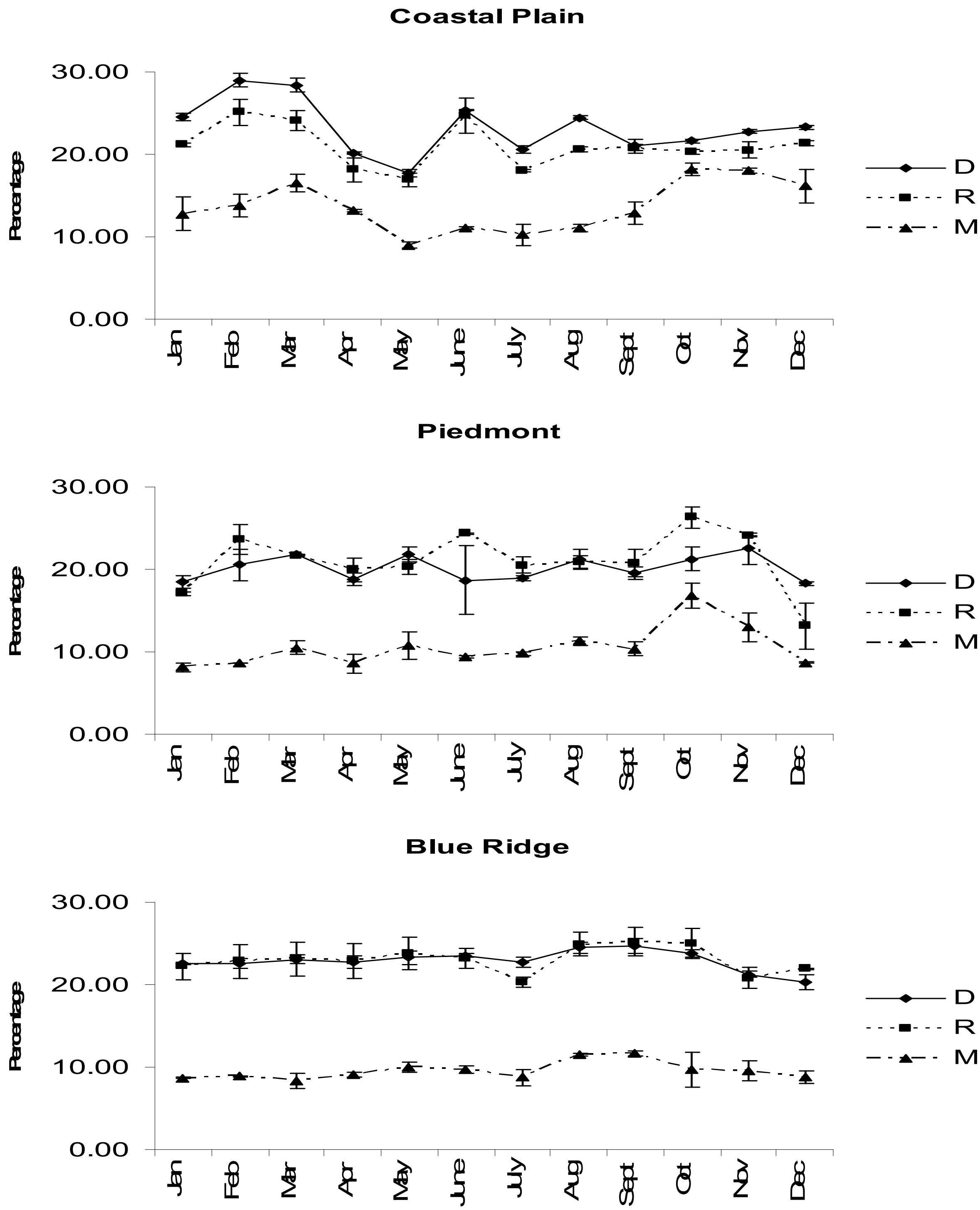


Figure 2.6. Mean monthly crude protein (%) of three cool-season forages established in Tift, Putnam, Fannin, Lumpkin County, Ga., in November 2002 and sampled from April 2003 – March 2004. Bars represent standard error. Legend: D = Durana; R = Regal; M = MaxQ.

CHAPTER 3

EFFECTIVENESS OF MILORGANITE® AS A REPELLENT TO PROTECT ORNAMENTAL AND AGRONOMIC PLANTS FROM DEER OVER-BROWSING[1]

[1]Stephens, O. L., M. T. Mengak, G. R. Gallagher, D. A. Osborn, K. V. Miller. Submitted to the *11th Annual Wildlife Damage Management Conference*

ABSTRACT

When deer populations become locally overabundant, browsing of ornamental and agronomic plants negatively affects plant establishment, survival, and productivity. Milorganite® is a slow-release, organic fertilizer produced from human sewage. We tested Milorganite® as a deer repellent on chrysanthemums (Chrysanthemums morifolium) in an urban/suburban environment, and soybeans (Gycine max) in a rural agriculture environment. Six beds of chrysanthemums at two sites were monitored for 28 to 35 days. Treatment plants received a top dressing of 104 grams of Milorganite® (1120.9 kg/ha). Milorganite® treated plants had more ($P < 0.001$) terminal buds and achieved greater height ($P < 0.002$) compared to controls at one site, however damage observed was similar at the second site. In a second experiment, 0.2-ha plots of soybeans (Glycine max) were planted on five rural properties in northeastern Georgia and monitored for ≥ 30 days. Treated areas received 269 kg/ha of Milorganite®. In 4 of 5 sites, Milorganite® delayed browsing on treated plants from 1 week to >5 weeks post-planting. Duration of the protection appeared to be related to the difference in deer density throughout most of the study areas. Results of this study indicate Milorganite® has potential use as a deer repellent.

Key words: white-tailed deer damage, Milorganite®, chrysanthemums, soybeans

INTRODUCTION

The white-tailed deer (Odocoileus virginiaus) population in North America has increased from an estimated 350,000 in the 1900's to 26 million in the 1990's (Miller et al. 2003). As this population has increased, damage to field crops (Conover 1984, Wywialowski 1994, Nolte et al. 2001), nurseries (Conover 1984) and reforestation efforts (Blackwell et. al. 2002) have escalated. Increasing human populations and land development have necessitated intensive deer management strategies in some areas (Butifiloski et al. 1997). Unlike other nuisance animals, deer cannot be casually eliminated when human conflicts arise, nor can landowners be expected to carry the entire burden of support for this public resource (Craven and Hygnstrom 1994). Deer damage control can be socially and politically difficult and pose biological and logistical problems. Scare devices, repellents, and shooting can be effective strategies to control deer damage in some situations (Butifiloski et al. 1997).

Repellents are frequently used in orchards, gardens, ornamental plantings, and on agronomic crops. New repellants continue to enter the market, but efficacy varies greatly (Trent et al. 2001). Success is determined by the reduction of damage, not total elimination. Repellents generally rely on fear, pain, taste, or conditioned avoidance (Conover 2002). Repellents may be incorporated into the plant (systemic delivery), spread throughout an area (area delivery), or applied to the plant (contact delivery). Efficacy may vary depending on several factors, including deer density, learned behavior, resource availability, and seasonal changes in plant palatability (Conover 2002).

Vegetation damage caused by deer browsing represents a serious economic loss to some homeowners, foresters and farmers in the United States (Conover and Decker 1991). Conover's (1997) nationwide survey indicated that deer cause losses of $750 million in timber productivity,

$251 million to households and $100 million to agricultural property annually. In recent decades, a number of deer repellents have been promoted in an attempt to reduce these losses, but most suffer from being expensive, untested, unreliable or a combination (Harris et al. 1983, Palmer et. al. 1983 and Trent et al. 2001).

Wildlife food plots often are established by hunters or resource agencies to enhance the quantity and quality of food resources available and increase opportunities for viewing and deer harvest. Heavy browsing pressure can limit the hunter's selection of forage crops. Heavy-seeded annual, warm-season legumes such as soybeans (Glycine max), lablab (Lablab purpureus) and iron clay peas (Vigna unguiculata) are especially susceptible to browsing during their early stages of development. Hehman and Fulbright (1997) found that the intensity of use of food plots was related to standing crop and nutritional quality of food plot forages. Higginbotham and Kroll (1993) reported that soybeans and iron clay peas were heavily utilized to the point of elimination 30 days after establishment. The development of methods to delay browsing pressure on these crops would enhance the potential planting success, provide additional forage for longer periods, and provide the planter with additional forage options.

Milorganite® is a low-potency, organic fertilizer (6-2-0) produced from human sewage (sludge) (Anon. 2003). The processing method allows for an extended duration of decomposition and subsequently persistent odor. This slow-release, organic fertilizer is approved by the U. S. Environmental Protection Agency for use on food crops and golf courses. Milorganite® has been recognized as a potential deer repellant by home owners and land managers, although definitive research on efficacy has not been conducted. Milorganite® is listed in the Georgia Department of Natural Resources guide to managing deer damage (Kammermeyer et al. 2001). Milorganite® is commercially available at a cost per 18.14 kg bag ranging from $7.00 to $10.00.

In the only published study conducted to date, Hani and Conover (1995) indicated that Milorganite® was not effective as a repellent. However this research was conducted in penned settings with excessive deer densities. Research is needed with free-ranging deer to assess the efficacy of Milorganite® as an area repellent. Therefore, we tested the efficacy of Milorganite® to repel free-ranging deer from ornamental and agronomic plants. Our specific objectives were to determine the effectiveness of Milorganite® as a temporary deer repellent when applied to newly planted ornamental plants during the summer and the effectiveness of Milorganite® as a temporary deer repellent when applied immediately after planting an annual, warm-season wildlife food plot.

METHODS

Ornamental Plant Study

This experiment was conducted on the Berry College campus and the Oak Hill Gardens in Northwest, Georgia, September 12 through October 22, 2003. Deer population on the wildlife refuge area (1417 ha) of the main campus is estimated at 23 per km^2 (T. Touchstone, Georgia Department of Natural Resources, personal communication). Observations of deer at the Oak Hill Gardens indicate a population exceeding 46 per km^2 on the 71.7 ha facility. Deer at both locations are generally habituated to the typical human activities.

Three new bedding plots (3 m x 3 m), greater than 0.5 km apart, were established on the Berry College campus. Each plot was within 50 m of an academic building and paved road. Number of terminal buds and plant height to the tallest terminal bud on non-flowering chrysanthemums (C. morifolium) were recorded. Plants were sorted to balance number of terminal buds and assigned to each plot prior to planting. Each plot consisted of two rows of ten plants each, planted at 30 cm spacing with each row 3 m apart. One row of each plot received a topdressing application of 107 g of Milorganite® (1120.9 kg/ha). The remaining row of plants at each plot served as controls. Water was provided on an as needed basis. Every 7 days, number of remaining terminal buds and height of each plant were recorded for a 35-day period.

Two established formal gardens of the Oak Hill Gardens were divided into three plots. Two connecting "U" shaped plots, 2.15 m x 55.38 m were sectioned into two respective control and treatment sites. Two additional strip gardens, approximately 1.85 m x 18.46 m were assigned as a third treatment and control plot. All plots were planted with several varieties of chrysanthemums (C. morifolium), at a density of 9 per m^2. Milorganite® was applied at an equivalent of 1120.9 kg/ha in the U shaped plots (3.1 kg) and in the strip treatment plot (2.7 kg) on the same day as planting to eliminate any pre-test plant damage by deer. Twenty plants uniformly distributed throughout each treatment and control plot were labeled and utilized as a sample subset population. Number of terminal bites and plant heights were recorded at 7-day intervals for 28 days.

Multivariate analysis procedures of SPSS 12.0 (SPSS 2003) were utilized to compare differences in number of terminal buds and plant height on campus plots and number of terminal bud bites and plant height at Oak Hill Garden plots.

Agronomic Plant Study

A second series of trials was conducted using soybeans on five sites in the Georgia Piedmont during July 2003 – September 2003. Two sites each were located in Oconee and Madison Counties and one site was located in Clarke County. Clarke County's deer density is estimated at 10 to 14 deer per km^2. Oconee County has a deer density of 12 to 15 deer per km^2 and Madison County deer density is estimated at 14 to 17 deer per km^2. Study sites within the same county varied in deer density because of past herd management practices.

At each site we established two 0.2-ha plots (control vs treated) located 15-300 m apart. Prior to planting, fertilizer and lime were applied to each site according to soil test recommendations. Soybeans (Gycine max) were planted in each food plot at a rate of 67.3 kg/ha. The treatment plots received one application of Milorganite® at a rate of 269 kg/ha after first plant emergence. Milorganite® was broadcast using a tractor-mounted fertilizer spreader. On each plot, we marked the beginning and end of five rows of 100 plants each. Browse levels were subjectively rated according to percentage of the plant removed: 0 – 0%, 1 – 25%, 2 – 50%, 3 – 75%, 4 – 100%. We collected data for >30 days after first plant emergence. After data collection was completed, browse rating categories 1, 2, and 3 were condensed into a single category for analysis (category 0 = no browse, 1 = partly browsed, 2 = completely browsed). Precipitation data were obtained from the National Oceanic and Atmospheric Administration (NOAA) recording sites located 15 – 30 km from the research sites. Precipitation data were used to determine if rainfall had an influence on the effectiveness of the repellent.

Equal availability of plants between treatment and control plots at the same site was assumed because plots were planted nearly side by side. The ANOVA (analysis of variance) model in SAS (Statistical Analysis System) with repeated measures procedure was used to analyze the data. Significance was assumed at an alpha level of 0.05. The null hypothesis was Milorganite® will deter deer over-browsing on soybeans up to four weeks with one application of 269 kg/ha.

RESULTS AND DISCUSSION

Ornamental Plant Study

Results of damage observed to the planted chrysanthemums on 7-day intervals are presented in Figure 3.1. While browsing of terminal buds was clearly evident among the controls, high variation in damage to treated plants across plots was noted. Differences in degree of damage between treated and control chrysanthemums were not evident during the 7-day periods until the 21-day data collection period. While variability in damage was observed among plots of chrysanthemums planted in new beds, across all plots Milorganite®-treated plants exhibited more ($\underline{P} < 0.001$) terminal buds per plant (70.5 ± 4.3) and greater ($\underline{P} < 0.002$) plant height (19.4 cm ± 0.7) compared to respective controls (37.3 ± 5.0; 15.1 cm ± 1.0).

Milorganite®-treated plants in the established beds at the Oak Hill Gardens received similar damage across all plots and time periods compared to controls (Figure 3.1). Terminal bud bites for treated plants were 19.3 ± 7.9 and 34.7 ± 8.6 for the controls ($\underline{P} = 0.199$). Plant height for treated plants (25.5 cm ± 0.3) and control plants (24.6 cm ± 0.4) were also similar ($\underline{P} = 0.969$).

While Milorganite® application reduced deer damage overall, a high degree of variation in effectiveness was observed between plots and locations. While types of forages differed significantly between the Campus sites and Oak Hill Gardens, alternative forages appeared available at both locations. Additionally, both locations have higher deer populations compared to the regional average (14 to 15 per km^2), with the Oak Hill Garden population at least twice as high compared to the Berry College main campus. This higher density of animals may have contributed to the greater observed damage to the plant material. Habituation to a repellent as a result of previous exposure to organic fertilizers and numerous repellents that had been frequently utilized at the Oak Hill Gardens, may also have contributed to the limited effectiveness of Milorganite® at this location. The rapid conditioning of deer to common repellents has been documented (Gallagher and Prince 2001).

Agronomic Plant Study

In the Clarke County plots, treatment areas had fewer plants ($P < 0.05$) completely browsed from the beginning of the study to day 20 (Figure 3.2).

At Madison County site 1, the treatment plot had fewer plants completely browsed than the control plot at day 3 ($t_{20} = -11.06$, $P < 0.01$), while number partially browsed remained similar at days 3 ($t_{20} = -1.79$, $P = 0.4938$) and 6 ($t_{20} = 2.99$, $P = 0.0677$). On days 9, 12 and16, number of plants partly browsed in the control plot was greater ($P < 0.01$) than in treatment plots. Throughout the sampling period, the treatment plot had fewer ($P < 0.01$) plants completely browsed compared to the control plot. At Madison County site 2, the treatment plot had more ($P < 0.01$) plants not browsed from day 3 to day 20 than the control plot. From day 9 to day 45, the treatment site had significantly fewer plants ($P < 0.01$) completely browsed compared to the control site.

At Oconee County site 1, the treatment plot had more ($P < 0.01$) plants without browse than the control plot during day 6 to day 31. The plots had similar number of plants partly browsed during day 3, 6, 9, and 38. On days 3, 6, 9 and 38, the treatment plot had similar plants completely browsed ($P > 0.01$) compared to the control plot. At Oconee County site 2, the treatment plot had more ($P < 0.01$) plants not browsed from day 3 to day 20 than the control plot. The number of plants partly browsed differed between sites except during days 3 ($t_{20} = -0.83$, $P = 0.9585$) and 16 ($t_{20} = -2.29$, $P = 0.2448$).

The degree of protection to soybean plants appeared to be directly related to deer densities on study areas. At the Clarke County and Madison County site 1, deer densities were greater than other sites and Milorganite® provided limited protection (0 – 1 week). On the other sites (Madison County site 2, Oconee County sites 1 and 2) very little browsing was observed on all treatment sites during the first 2 weeks post treatment. In addition, because of the apparent effects of Milorganite®, once increased browsing evidence was observed, 2 weeks to 4 weeks post-treatment, plants were of sufficient maturity that subsequent deer browsing had little detrimental effect on the plants. On all 3 of these sites, soybean plants persisted throughout the 45-day sampling period.

Precipitation was similar between the Oconee and Madison sites. Both sites had greater amounts of rainfall than the Clarke County site during the study period. Research at the Clarke County site was conducted a month later than at the other study areas. Additional rainfall at the Oconee and Madison sites may have had a leaching effect on the applied Milorganite®, thus decreasing the repellent's effectiveness. Further research is needed to determine the effects of rainfall on Milorganite®.

CONCLUSION

Results of this study suggest that Milorganite® has potential for reducing browsing damage, but effectiveness may be associated with other factors. The degree of effectiveness of a repellent may be influenced by size of area to be protected, density of animal population, availability of alternative forages, and conditioning (Mason 1998). Weather, particularly rainfall likely influences the duration of effectiveness. The encouraging results of this study suggest that further research related to application rates and frequency of reapplication of Milorganite® is warranted.

ACKNOWLEDGEMENTS

The study was funded by McIntire-Stennis Project GEO-0126-MS. Pennington Seed graciously provided seed and fertilizer. I thank D. Simonton, D. Allen, M. Aiken, and W. Stephens for allowing us to use their property to conduct research. We also thank M. Harrison, L. Stephens, P. Stephens, H. Keen, R. Wilkerson and K. Armstrong for their assistance in collecting data.

LITERATURE CITED

Anonymous. 2003. Our History. http://www.milorganite.com. accessed 2003.

Blackwell, B.F., J.D. Cepek, and T.W. Seamens. 2002. Coyote hair as an area repellent for white-tailed deer. International Journal of Pest Management 48:301-306.

Butifiloski, J. W, D. I. Hall, D. M. Hoffman, and D. L. Forster. 1997. White-tailed deer management in a coastal Georgia residential community. Wildlife Society Bulletin 25:491-495.

Conover, M. 1984. Effectiveness of repellents in reducing deer damage in nurseries. Wildlife Society Bulletin 12:399-404.

Conover, M. 1997. Monetary and intangible valuation of the deer in the United States. Wildlife Society Bulletin 25:298-305.

Conover, M. 2002. Resolving human-wildlife conflicts: the science of wildlife damage management. Lewis Publishers. CRC Press, Boca Raton, Florida, USA.

Conover, M., and D. J. Decker. 1991. Wildlife damage to crops: perceptions of agricultural and wildlife professionals in 1957 and 1987. Wildlife Society Bulletin 19:46-52.

Craven, S. R., and S. E. Hygnstrom. 1994. Deer. Page 28. In S. E. Hygnstrom, R. M. Timm and G. E. Larson, editors. Prevention and control of wildlife damage. Cooperative Extension Division, Institute of Agriculture and Natural Resources, University of Nebraska – Lincoln, USA.

Gallagher, G.R., and R.H. Prince. 2001. Conditioning of deer to two common deterrents. Proceedings of the 9th Wildlife Damage Management Conference 9:238-246.

Hani, A. E. and M. R. Conover. 1995. Comparative analysis of deer repellents. Pages 147-155. In Repellents in wildlife management conference proceedings. Mason, J. R. (editor) National Wildlife Research Center, Fort Collins, Colorado, USA.

Harris, M. T., W. L. Plamer, and J. L. George. 1983. Preliminary screening of white-tailed deer repellents. Journal of Wildlife Management 47: 516-19.

Hehman, M. W., and T. E. Fulbright. 1997. Use of warm-season food plots by white-tailed deer. Journal of Wildlife Management 61:1108-1115.

Higginbotham, B. J., and J. C. Kroll. 1993. Warm season supplemental forages for white-tailed deer in the pinewoods of east Texas. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 47:185-197.

Kammermeyer, K E., D. Foreater, K Grahl, J. Ezell, H. Barnhill, S. McDonald, B. Cooper, G. Waters, and J. Bowers. 2001. Georgia white-tailed deer management plan 2000-2005. Georgia Department of Natural Resources. Wildlife Division, Social Circle, Georgia, USA.

Mason, J.R. 1998. Mammal repellents options and considerations for development. Vertebrate Pest Conference 18:325-329.

Miller, K. V., L. I. Muller, and S. Demarias. 2003. White-tailed Deer. Pages 920-921. In Feldhamer, G. A., B. C. Thompson, and J. A. Chapman, editors. Wild Mammals of North America: ecology, management, and conservation. The Johns Hopkins University Press, Baltimore, Maryland, USA.

Nolte, D. L., L. A. Shipley, and K. K. Wagner. 2001. Comparison of active ingredients and delivery systems in deer repellents. Wildlife Society Bulletin. 29:322-330.

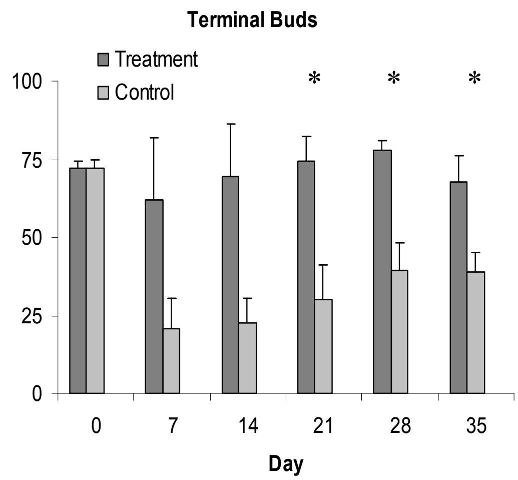
Palmer, W. L., R. G. Wingard, and J. L. George. 1983. Evaluation of white-tailed deer repellents. Wildlife Society Bulletin 11:164-166.

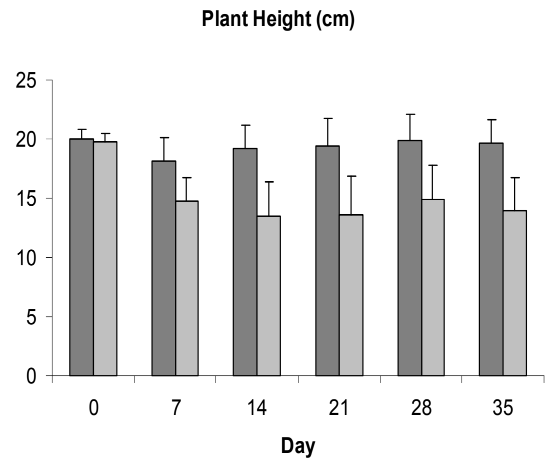
SPSS. 2003. SPSS, Professional Statistics, Version 12.0.1. Chicago, Illinois, USA.

Trent, A., D. Nolte, and K. Wagner. 2001. Comparison of commercial deer repellents. Tech Tips. 0124-2331-MTDC.

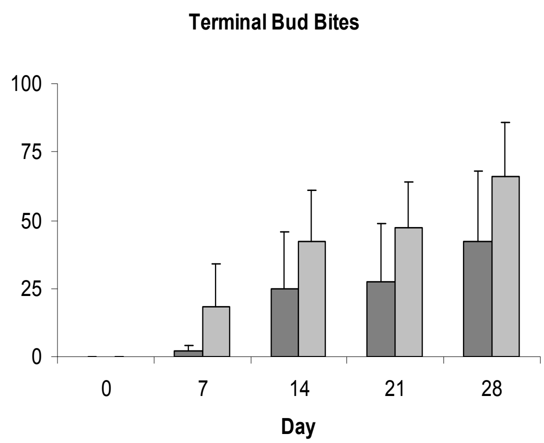
Wywialowski, A. 1994. Agricultural producers' perceptions of wildlife caused losses. Wildlife Society Bulletin 22:370-382.

CAMPUS SITE





OAK HILL GARDEN SITE



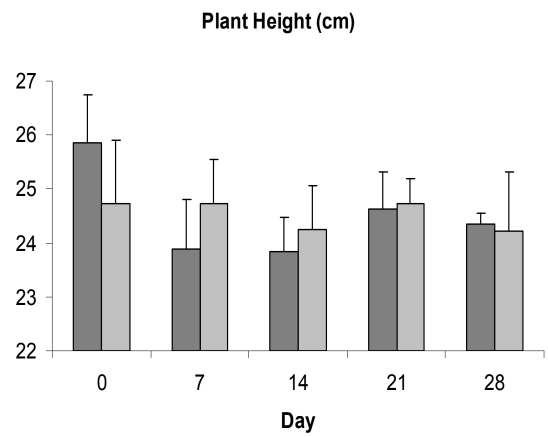


Figure 3.1. Mean number of terminal buds, terminal bud bites and plant height (cm) on chrysanthemums at Berry College in Floyd County, Georgia during August – September 2003. Bar indicates standard error.
* indicates a significant difference, $\underline{P} < 0.05$.

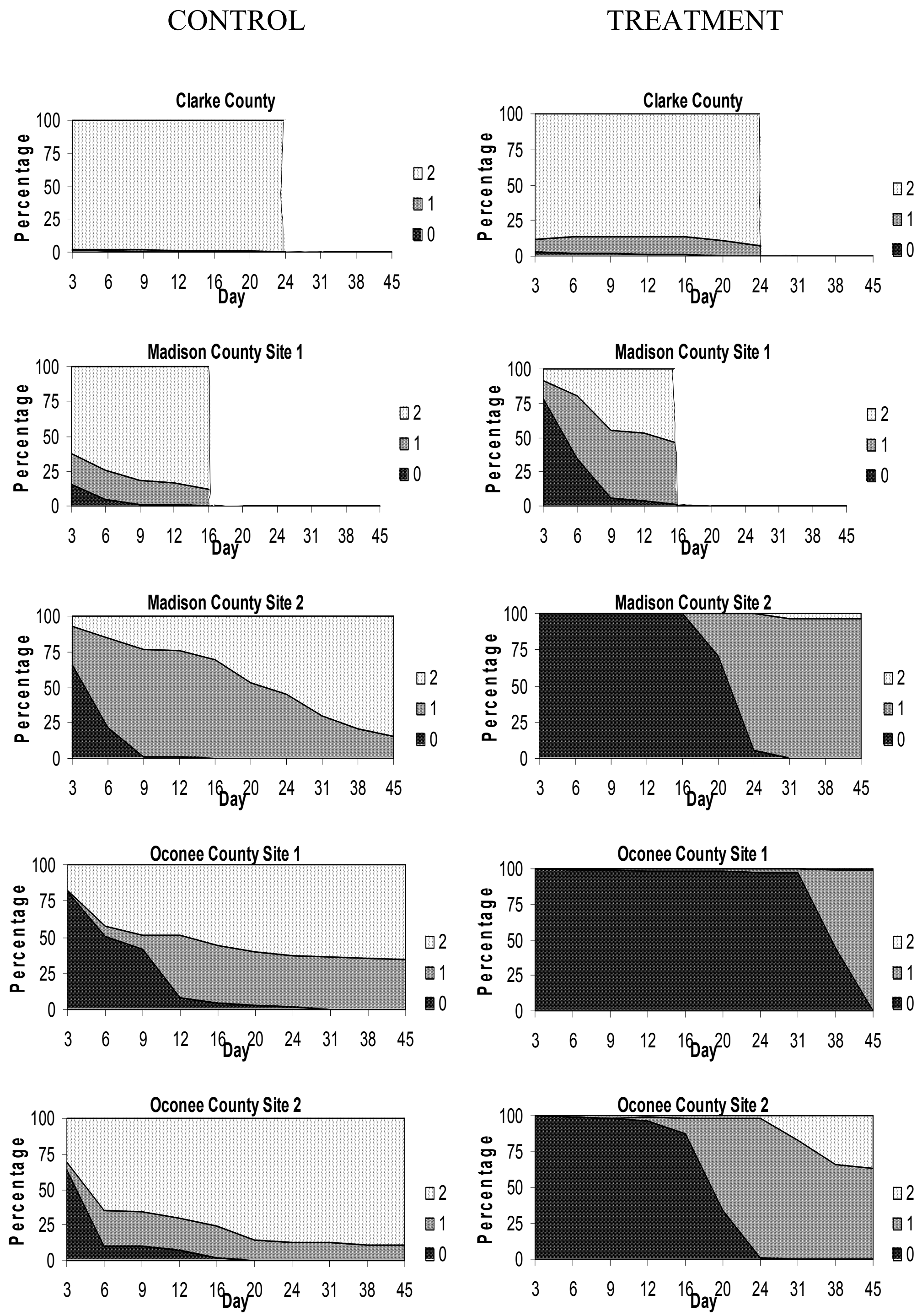


Figure 3.2. Mean number of soybeans, within each browse rating category, on research sites where 0 = no browse, 1 = partly browsed, 2 = completely browsed. Data were collected during July-August 2003 on Madison and Oconee County sites and during August-September 2003 on the Clarke County site. Data collection concluded on Day 24 for Clarke County site and day 16 for site 1 in Madison County due to intense browse pressure.

CHAPTER 4

SUMMARY AND CONCLUSIONS

Cool-Season Forage Study

In summary, MaxQ tall fescue grew well in all regions and had the greatest amount of standing crop of tested forages. Conversely, the utilization rate and crude protein levels of MaxQ were the lowest among forages. The results suggest that MaxQ should not be considered as an alternative to other food plot forages, except in situations with high deer densities and low amounts of available forage. MaxQ would be an ideal forage to establish in this situation given its stand persistence and yearly production rates. However, MaxQ should be planted in combination with a legume to boost crude protein levels. MaxQ fescue and combination plots produced similar amounts of forage over the three regions, but deer utilized the combination plots more than the pure fescue plots.

From my results, Durana white clover seems to grow better than Regal ladino white clover in the Coastal Plain and Piedmont during the second growing season. Forage production and standing crops of Durana and Regal were similar throughout the study except during year 2 in the Coastal Plain and Piedmont, when Durana surpassed Regal in production. Based on my results, and those in other reported agricultural trials, I suggest that Durana may be superior to ladino in terms of long-term productivity. I concluded that Durana will provide a high-quality, perennial alternative forage to establish with production persisting for two years post-establishment. Further research needs to be conducted to determine the duration of Durana's productivity.

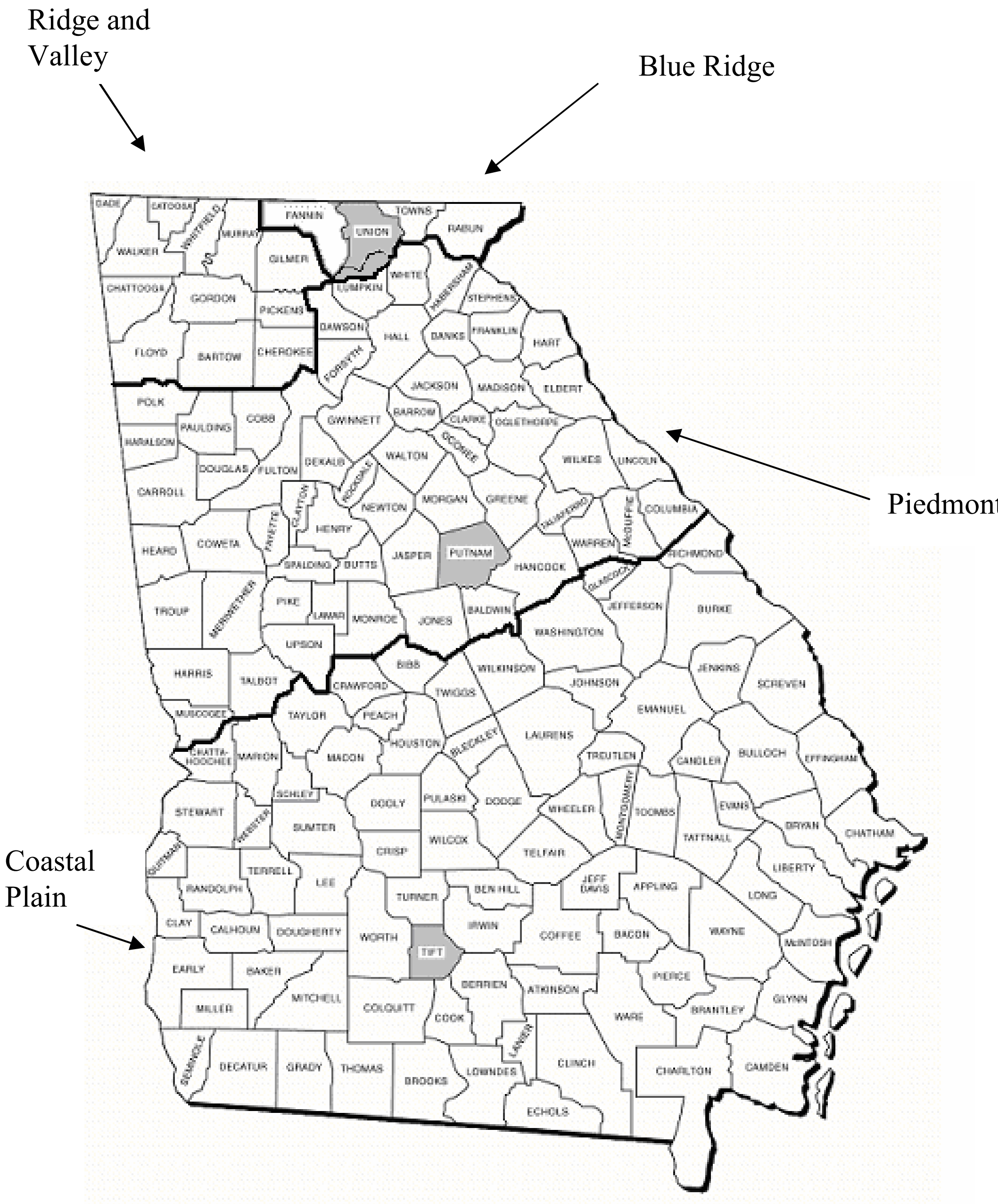
Repellent Study

Milorganite® can be used to reduce deer damage on ornamental and agronomic plants. During the ornamental trial, Milorganite® treated plants had significantly more ($P < 0.05$) terminal buds at 21, 28 and 35 days post treatment on one site. However protection did not differ statistically at the second site. During the agronomic trial, Milorganite® delayed significant browsing on treatment plants from 1 week to >5 weeks post planting in 4 of 5 sites.

From these results, Milorganite® can be a useful tool to aid in the establishment of warm-season food plots for deer and may repel deer from ornamental plantings. Though the repellent does not eliminate deer damage, it reduces the overall impact. Duration of the protection appeared to be related to the difference in deer density among my study areas. Also, the effectiveness of the repellent is somewhat dependent on weather and alternative resource availability. Rainfall coupled with high deer densities and low resource availability may reduce the efficacy of Milorganite® as a repellent. The amount of deer damage may be further reduced if Milorganite® is reapplied every two weeks. Further research involving different application rates (both dose and timing) will prove useful in determining the deer tolerance level to Milorganite®.

APPENDIX A

Location of study sites in the Coastal Plain, Piedmont, and Blue Ridge physiographic regions of Georgia for the forage production study reported in Chapter 2


Ridge and Valley
Blue Ridge
Piedmont
Coastal Plain
DADE
CATOOSA
WHITFIELD
MURRAY
FANNIN
UNION
TOWNS
RABUN
WALKER
GILMER
WHITE
HABERSHAM
CHATTOOGA
GORDON
LUMPKIN
STEPHENS
PICKENS
DAWSON
HALL
BANKS
FRANKLIN
HART
FLOYD
BARTOW
CHEROKEE
FORSYTH
JACKSON
MADISON
ELBERT
POLK
PAULDING
COBB
GWINNETT
BARROW
CLARKE
OGLETHORPE
HARALSON
OCONEE
WILKES
LINCOLN
DOUGLAS
FULTON
DEKALB
WALTON
CARROLL
ROCKDALE
CLAYTON
NEWTON
MORGAN
GREENE
TALIAFERRO
MCDUFFIE
COLUMBIA
FAYETTE
HENRY
WARREN
RICHMOND
HEARD
COWETA
PUTNAM
JASPER
HANCOCK
SPALDING
BUTTS
GLASCOCK
TROUP
MERIWETHER
PIKE
LAMAR
MONROE
JONES
BALDWIN
JEFFERSON
BURKE
WASHINGTON
UPSON
HARRIS
TALBOT
BIBB
WILKINSON
JENKINS
SCREVEN
CRAWFORD
TWIGGS
JOHNSON
MUSCOGEE
TAYLOR
PEACH
EMANUEL
LAURENS
CHATTAHOOCHEE
MARION
HOUSTON
BLECKLEY
MACON
TREUTLEN
CANDLER
BULLOCH
EFFINGHAM
SCHLEY
PULASKI
DOOLY
DODGE
MONTGOMERY
STEWART
WEBSTER
SUMTER
WHEELER
TOOMBS
EVANS
BRYAN
CHATHAM
TATTNALL
WILCOX
CRISP
TELFAIR
QUITMAN
TERRELL
LIBERTY
RANDOLPH
LEE
TURNER
BEN HILL
JEFF DAVIS
APPLING
LONG
CLAY
CALHOUN
DOUGHERTY
WORTH
IRWIN
COFFEE
BACON
WAYNE
MCINTOSH
TIFT
EARLY
BAKER
PIERCE
BERRIEN
ATKINSON
MITCHELL
GLYNN
MILLER
COLQUITT
WARE
BRANTLEY
COOK
LANIER
SEMINOLE
DECATUR
GRADY
THOMAS
BROOKS
LOWNDES
CLINCH
CHARLTON
CAMDEN
ECHOLS

Appendix B. Soil amendment and planting data for forage establishment among the three physiographic regions in Georgia for the study described in Chapter 2.

SITE	**FETILIZER**	**FERTILIZER** (kg/ha)	**LIME** (kg/ha)	DATE
TIFT COUNTY	--	--	2240	10/10/02
(Coastal Plain)	25-80-50	112	--	10/14/02
	0-70-40	112	--	9/14/03
	0-0-60	112	--	4/10/04
PUTNAM COUNTY	10-25-10	336	4480	11/23/02
(Piedmont)	0-80-90	112	--	9/26/03
	0-0-60	112	--	4/24/04
FANNIN COUNTY	--	--	4480	10/3/02
(Blue Ridge)	5-20-30	224	--	10/4/02
	0-110-20	224	--	9/22/03
	0-0-60	112	--	3/24/04
LUMPKIN COUNTY	--	--	4480	8/5/02
(Blue Ridge)	5-20-30	224	--	10/9/02
	0-110-20	112	--	9/22/03
	0-0-60	112	--	3/24/03

Appendix C. Mean monthly standing crop (kg/ha) of three cool-season forages established in the Coastal Plain in November 2002 and sampled from February – December 2003.
Standard errors are presented parenthetically.*

SAMPLE PERIOD	Forage Species: DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
February	65.03	b	63.87	b	402.77	a	133.07	b	77.17	b
	(24.57)		(24.15)		(88.00)		(35.16)		(9.28)	
March	1046.30	a,b	1101.60	a	611.17	b	717.20	a,b	912.13	a,b
	(165.06)		(104.37)		(139.53)		(140.92)		(165.04)	
April	3319.63	a	3131.50	a	3483.47	a	3296.07	a	3814.47	a
	(186.36)		(138.42)		(331.10)		(399.69)		(209.75)	
May	3935.93	a	3231.90	a	3853.47	a	3740.10	a	4735.70	a
	(452.42)		(263.19)		(642.05)		(444.98)		(239.11)	
June	1097.37	d	1232.50	c,d	3013.27	a	1934.30	b,c	2095.53	b,c
	(164.17)		(118.62)		(528.96)		(150.79)		(244.28)	
July	1322.97	b	1668.13	b	2796.97	a	1621.93	b	1642.50	b
	(216.03)		(135.60)		(456.25)		(286.80)		(213.16)	
August	848.83	d	1014.87	b,c	2400.13	a	1182.13	b,c	1566.40	b
	(49.01)		(112.00)		(210.55)		(226.82)		(229.34)	
September	683.60	a	633.00	a	789.83	a	672.70	a	884.77	a
	(159.96)		(144.64)		(180.89)		(77.19)		(215.82)	
October	160.83	b	105.40	b	1009.77	a	577.13	a,b	432.17	b
	(36.61)		(23.54)		(176.30)		(222.58)		(63.70)	
November	606.03	b,c	410.33	d	1567.40	a	1043.60	a,b	168.48	b,c
	(166.51)		(94.26)		(232.37)		(255.80)		(854.77)	
December	599.93	c,d	480.33	d	1638.73	a	1070.87	b,c	1062.57	c
	(150.92)		(112.59)		(242.96)		(170.49)		(185.32)	

* Means followed by the same letter within rows are not significantly different from each other at the P ≤ 0.05 level, Tukey's Mixed Model Test.

Appendix D. Mean monthly standing crop (kg/ha) of three cool-season forages established in the Coastal Plain in November 2002 and sampled from January - May 2004.
Standard errors are presented parenthetically.*

SAMPLE PERIOD	Forage Species: DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
January	964.93	c	304.43	d	1965.53	a	1093.07	b,c	1408.63	b
	(118.11)		(48.87)		(202.38)		(142.37)		(68.74)	
February	944.83	c	486.00	d	1863.77	a	1542.43	a,b	1214.27	b,c
	(187.01)		(51.00)		(173.63)		(178.95)		(178.88)	
March	1730.20	b	1225.93	b	2387.07	a	1335.03	b	1840.83	a,b
	(204.74)		(134.28)		(260.25)		(215.27)		(333.54)	
April	2185.90	a,b,c	1163.20	d	2877.53	a	1470.23	c,d	2459.90	a,b
	(300.96)		(229.84)		(256.24)		(247.81)		(307.65)	
May	1845.23	b,c	1187.57	c	2498.93	a,b	2201.50	b	3066.03	a
	(356.74)		(288.29)		(189.88)		(398.32)		(267.30)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix E. Mean monthly standing crop (kg/ha) of three cool-season forages established the Piedmont in November 2002 and sampled from February - December 2003.
Standard errors are presented parenthetically.*

	Forage Species								
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
February	7.80	a	16.03	a	11.03	a	12.23	a	14.77	a
	(3.78)		(9.48)		(5.23)		(6.02)		(6.68)	
March	154.40	a,b	266.07	a	70.10	b	157.47	a,b	156.70	a,b
	(36.81)		(92.69)		(7.13)		(46.98)		(56.38)	
April	929.77	a,b	878.27	a,b	303.70	b	1151.30	a	1004.83	a
	(201.76)		(272.96)		(40.02)		(432.05)		(477.48)	
May	1733.43	a,b	1276.67	b	1169.50	b	2346.83	a	1469.83	b
	(241.71)		(296.52)		(95.17)		(394.70)		(452.40)	
June	2236.60	a,b,c	1465.30	b,c	2055.53	a,b,c	2623.63	a	1517.73	c
	(114.66)		(217.87)		(346.07)		(209.59)		(368.56)	
July	1569.07	a	1421.10	a	1666.57	a	1331.07	a	1398.63	a
	(178.84)		(91.85)		(312.16)		(72.87)		(414.68)	
August	443.23	c,d	209.17	d	1290.43	a	961.37	a,b	745.67	b,c
	(134.99)		(44.26)		(312.06)		(86.90)		(171.28)	
September	107.13	b	54.13	b	412.00	a	293.30	a	283.93	a
	(23.08)		(12.01)		(71.61)		(27.29)		(33.03)	
October	79.03	b	56.40	b	738.67	a	925.57	a	709.10	a
	(22.48)		(20.24)		(151.44)		(106.53)		(79.29)	
November	63.00	c	33.63	c	892.77	b	983.73	b	1336.23	a
	(9.22)		(7.14)		(110.29)		(209.30)		(82.54)	
December	63.73	b	35.53	b	804.37	a	270.62	a	930.13	a
	(7.59)		(6.34)		(99.48)		(1060.83)		(267.80)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix F. Mean monthly standing crop (kg/ha) of three cool-season forages established in the Piedmont in November 2002 and sampled from January - May 2004.
Standard errors are presented parenthetically.*

SAMPLE PERIOD	Forage Species: DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
January	126.37	b	41.27	b	560.37	a	719.40	a	761.40	a
	(19.68)		(10.23)		(119.75)		(95.97)		(168.92)	
February	76.47	c	52.23	c	949.27	a	975.67	a	620.93	b
	(18.36)		(12.32)		(121.41)		(173.89)		(116.98)	
March	445.00	b	343.63	b	908.67	a	916.77	a	1022.97	a
	(80.88)		(82.83)		(123.88)		(159.22)		(118.70)	
April	471.53	b	197.27	b	1216.00	a	1370.70	a	1215.93	a
	(101.55)		(54.50)		(260.58)		(287.40)		(190.07)	
May	128.00	b	88.67	b	1070.37	a	1005.73	a	959.63	a
	(20.33)		(7.77)		(250.20)		(238.93)		(162.43)	

* Means followed by the same letter within rows are not significantly different from each other at the P ≤ 0.05 level, Tukey's Mixed Model Test.

Appendix G. Mean monthly standing crop (kg/ha) of three cool-season forages established in the Blue Ridge in November 2002 and sampled from April - December 2003.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
April	137.60	c	331.33	b,c	450.43	a,b	564.37	a	417.17	a,b
	(32.52)		(61.76)		(92.52)		(104.57)		(129.63)	
May	1759.97	b	1554.53	b	1382.70	b	2880.67	a	2118.97	a,b
	(333.39)		(468.08)		(285.19)		(831.43)		(486.40)	
June	2634.73	b,c	2376.50	c	2162.03	c	4184.07	a	3657.83	a,b
	(380.35)		(344.73)		(517.43)		(728.94)		(561.03)	
July	2067.53	b	2151.03	b	3651.90	a	3776.37	a	3527.93	a
	(104.67)		(244.25)		(450.21)		(162.44)		(298.16)	
August	1528.23	b	1002.10	b	2519.47	a	2243.27	a	2877.50	a
	(168.65)		(163.22)		(350.77)		(248.17)		(221.28)	
September	595.80	b	797.73	a,b	729.92	c	610.05	a,c	655.12	c
	(125.81)		(83.01)		(377.76)		(118.52)		(251.68)	
October	770.76	d	1019.47	c,d	2591.73	a	1444.80	c	1825.35	b
	(43.82)		(35.59)		(128.31)		(120.05)		(124.59)	
November	816.23	c	900.93	c	3353.30	a	2262.40	b	1913.57	b
	(43.52)		(70.73)		(253.90)		(300.92)		(145.26)	
December	464.27	c	499.83	c	2186.83	a	1525.90	b	1782.10	a,b
	(173.76)		(115.33)		(169.40)		(115.96)		(333.06)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix H. Mean monthly standing crop (kg/ha) of three cool-season forages established in Blue Ridge in November 2002 and sampled from January - May 2004.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
January	134.73	c	156.13	c	2046.50	a	1384.87	b	1600.77	a,b
	(28.97)		(29.60)		(166.71)		(68.98)		(225.59)	
February	67.67	b	97.07	b	1604.47	a	1437.00	a	1503.50	a
	(15.27)		(32.22)		(111.40)		(382.22)		(220.58)	
March	266.33	c	367.93	c	1682.67	a	1255.40	b	1328.27	a,b
	(34.92)		(79.06)		(77.97)		(120.93)		(208.51)	
April	926.30	c	830.07	c	2647.83	a	1836.83	b	2139.07	a,b
	(180.95)		(135.34)		(239.16)		(186.15)		(360.37)	
May	2317.00	a,b	1781.17	b	3125.43	a	2882.10	a	3004.13	a
	(238.31)		(89.47)		(294.56)		(197.30)		(369.51)	

* Means followed by the same letter within rows are not significantly different from each other at the P≤ 0.05 level, Tukey's Mixed Model Test.

Appendix I. Mean monthly production (kg/ha) of three cool-season forages established in the Coastal Plain in November 2002 and sampled from February – December 2003.
Standard errors are presented parenthetically.*

	Forage Species				
SAMPLE PERIOD	DURANA CLOVER	REGAL LADINO CLOVER	MAXQ FESCUE	MAXQ FESCUE/ REGAL LADINO CLOVER	MAXQ FESCUE/ DURANA LADINO CLOVER
February	65.03 b	63.87 b	402.77 a	133.07 b	77.17 b
	(24.57)	(24.15)	(88.00)	(35.16)	(9.28)
March	1024.73 a,b	1087.40 a	491.43 b	656.87 a,b	863.27 a,b
	(164.04)	(103.16)	(115.47)	(142.22)	(162.97)
April	2841.27 a	2597.33 a	3088.83 a	2799.20 a	3289.13 a
	(182.65)	(81.04)	(295.35)	(274.76)	(172.44)
May	1698.27 a	1356.67 a	1806.77 a	1746.90 a	1921.17 a
	(320.04)	(197.19)	(291.47)	(201.19)	(189.38)
June	-1742.80 c	-757.07 a,b	-20.27 a	-609.73 a	-1482.87 a,b
	(234.97)	(129.82)	(170.07)	(345.86)	(93.79)
July	636.67 a,b	1115.00 a	-38.47 b	866.07 b	703.10 b
	(160.05)	(118.77)	(407.31)	(218.90)	(103.73)
August	111.17 a	444.83 a	-377.67 a	227.10 a	347.47 a
	(75.35)	(99.64)	(438.28)	(110.05)	(164.14)
September	-300.03 a	-180.67 a	-2037.20 b	-546.00 a	-649.30 a
	(122.98)	(127.60)	(159.37)	(203.94)	(152.17)
October	-160.70 a	-88.70 a	248.30 a	44.47 a	-202.00 a
	(47.73)	(12.29)	(164.23)	(224.05)	(123.54)
November	509.00 a,b	318.80 b	720.07 a	680.17 a	549.23 a,b
	(168.25)	(99.55)	(177.75)	(132.20)	(138.68)
December	186.93 a	121.40 a	391.60 a	232.87 a	359.13 a
	(152.35)	(162.73)	(201.29)	(174.46)	(95.95)

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix J. Mean monthly production (kg/ha) of three cool-season forages established in the Coastal Plain in November 2002 and sampled from January – May 2004.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
January	710.13	a,b	197.00	c	422.10	b,c	574.93	b	965.80	a
	(74.61)		(37.03)		(104.12)		(111.42)		(60.09)	
February	538.27	b	330.23	b	452.10	b	1389.90	a	792.90	b
	(131.65)		(37.32)		(59.77)		(144.05)		(176.27)	
March	1113.87	a	961.07	a,b	146.13	b,c	-452.67	c	365.23	a,b
	(148.87)		(125.43)		(148.95)		(274.03)		(228.87)	
April	742.80	a,b	389.27	b	591.40	a,b	411.03	b	981.17	a
	(89.31)		(160.63)		(104.52)		(101.90)		(163.61)	
May	301.37	b	418.73	a,b	-328.40	c	837.23	a,b	1173.63	a
	(143.43)		(182.12)		(205.35)		(187.17)		(225.37)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix K. Mean monthly production (kg/ha) of three cool-season forages established in the Piedmont in November 2002 and sampled from February – December 2003.
Standard errors are presented parenthetically.*

	Forage Species				
SAMPLE PERIOD	DURANA CLOVER	REGAL LADINO CLOVER	MAXQ FESCUE	MAXQ FESCUE/ REGAL LADINO CLOVER	MAXQ FESCUE/ DURANA LADINO CLOVER
February	8.00 a	16.23 a	11.23 a	12.43 a	14.97 a
	(3.78)	(9.48)	(5.23)	(6.02)	(6.68)
March	151.77 a,b	262.77 a	64.87 b	154.53 a,b	148.90 a,b
	(35.67)	(91.43)	(5.76)	(45.71)	(53.37)
April	1207.30 a	1168.87 a	269.87 b	1428.47 a	1288.80 a
	(195.55)	(263.14)	(38.07)	(423.83)	(467.92)
May	1961.77 a,b	1609.83 b	1572.53 b	2400.10 a	1651.47 b
	(117.19)	(233.59)	(66.07)	(239.96)	(336.79)
June	1609.87 a	962.23 a	1312.23 a	1415.13 a	880.03 a
	(81.38)	(136.73)	(394.06)	(93.03)	(225.29)
July	755.53 a,b	681.83 a,b	110.63 b	512.87 a,b	920.93 a
	(142.73)	(67.79)	(199.67)	(72.96)	(369.68)
August	411.33 a	127.13 a,b	-223.03 b	238.93 a,b	-129.33 a,b
	(141.09)	(44.86)	(227.33)	(80.34)	(105.67)
September	-516.37 a	-503.43 a	-1249.23 b	-903.33 a,b	-861.87 a,b
	(24.48)	(11.73)	(256.59)	(109.70)	(135.71)
October	8.53 c	19.00 c	347.80 b,c	646.13 a,b	489.83 a,b
	(13.07)	(12.00)	(182.81)	(97.57)	(73.92)
November	4.10 c	20.83 c	542.63 b	562.70 a,b	957.37 a,b
	(15.14)	(4.63)	(91.02)	(212.76)	(82.50)
December	14.30 b	22.10 b	590.27 a	610.90 a	574.23 a
	(8.73)	(4.93)	(72.07)	(153.47)	(189.91)

* Means followed by the same letter within rows are not significantly different from each other at the P ≤ 0.05 level, Tukey's Mixed Model Test.

Appendix L. Mean monthly production (kg/ha) of three cool-season forages established in the Piedmont in November 2002 and sampled from January – May 2004.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
January	86.40	a	16.17	a	32.10	a	54.53	a	224.20	a
	(21.86)		(5.72)		(67.32)		(82.24)		(52.02)	
February	-6.63	b,c	41.63	b,c	506.07	a	318.37	a,b	0.40	b,c
	(14.64)		(9.51)		(154.80)		(95.86)		(40.86)	
March	402.60	a	331.30	a	272.40	a	227.23	a	506.77	a
	(69.32)		(80.87)		(102.98)		(75.75)		(76.14)	
April	286.80	a	110.37	a	557.83	a	620.47	a	397.37	a
	(82.30)		(44.60)		(246.65)		(226.65)		(74.98)	
May	-112.30	b	-14.73	a,b	-102.50	a,b	95.80	a,b	174.30	a
	(31.85)		(25.25)		(82.34)		(109.02)		(76.75)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix M. Mean monthly production (kg/ha) of three cool-season forages established in the Blue Ridge in November 2002 and sampled from April – December 2004.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
April	137.80	c	331.53	b,c	450.63	a,b	564.57	a	417.37	a,b
	(32.52)		(61.76)		(92.52)		(104.57)		(129.63)	
May	2345.10	a,b	2291.93	a,b	1709.20	b	3279.43	a	2449.87	a,b
	(323.21)		(384.65)		(232.80)		(814.35)		(415.02)	
June	1448.60	b,c	1374.10	a,b,c	1206.23	c	2093.20	b,c	2202.63	a
	(143.77)		(183.34)		(352.07)		(175.33)		(265.04)	
July	563.83	b	704.50	b	1768.07	a	1079.63	a,b	486.70	b
	(175.40)		(199.02)		(323.60)		(528.23)		(385.78)	
August	503.40	a	-113.80	a	-1037.10	b	-174.67	a,b	65.70	a
	(196.13)		(370.10)		(442.93)		(108.65)		(315.62)	
September	-957.8	b	-237.20	a	-1081.70	a,b	-590.63	a,b	-1339.93	b
	(146.37)		(45.12)		(372.19)		(161.63)		(248.61)	
October	173.72	a	380.40	a	-321.56	a	-51.15	a	296.40	a
	(103.34)		(107.28)		(610.03)		(67.27)		(334.06)	
November	319.63	b	219.97	b	1105.87	a	1149.93	a	705.53	a
	(55.60)		(28.56)		(134.23)		(237.67)		(133.82)	
December	61.67	b	64.97	b	261.07	a,b	654.60	a,b	745.57	a
	(101.71)		(54.64)		(186.57)		(77.85)		(249.25)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix N. Mean monthly production (kg/ha) of three cool-season forages established in the Blue Ridge in November 2002 and sampled from January – May 2004.
Standard errors are presented parenthetically.*

	Forage Species				
SAMPLE PERIOD	DURANA CLOVER	REGAL LADINO CLOVER	MAXQ FESCUE	MAXQ FESCUE/ REGAL LADINO CLOVER	MAXQ FESCUE/ DURANA LADINO CLOVER
January	-228.07 a	-207.27 a	108.20 a	-31.13 a	287.67 a
	(46.27)	(75.20)	(15.73)	(223.51)	(206.32)
February	-2.93 a	48.23 a	50.70 a	595.27 a	217.30 a
	(13.78)	(32.61)	(163.37)	(304.62)	(62.48)
March	219.40 a	331.03 a	144.97 a	-75.57 a	115.63 a
	(29.11)	(84.10)	(102.91)	(265.44)	(154.05)
April	745.33 a	669.73 a	1119.73 a	781.83 a	928.60 a
	(134.20)	(90.35)	(234.20)	(127.35)	(183.03)
May	1595.27 a	1160.50 a,b	574.87 b	1414.80 a,b	1061.40 a,b
	(216.13)	(68.55)	(349.15)	(237.67)	(148.24)

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix O. Mean monthly utilization (kg/ha) of three cool-season forages established in the Coastal Plain in November 2002 and sampled from February – December 2003.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
February	43.47	a,b	49.67	a,b	283.03	a	72.73	a,b	28.30	b
	(22.38)		(20.56)		(77.43)		(30.25)		(5.61)	
March	567.93	a	567.43	a	216.53	a	220.33	a	386.80	a
	(82.00)		(87.35)		(108.52)		(30.26)		(109.60)	
April	448.17	a	622.47	a	802.97	a	669.07	a	366.13	a
	(187.04)		(123.76)		(84.25)		(163.83)		(116.05)	
May	1095.77	a	1242.33	a	819.93	a	1196.07	a	1157.30	a
	(194.90)		(168.89)		(234.93)		(66.36)		(92.13)	
June	411.07	b	679.37	a,b	177.83	b	1178.43	a	1156.13	a
	(108.84)		(107.61)		(118.68)		(64.57)		(282.35)	
July	585.30	a,b	1098.10	a	19.17	b	666.90	a,b	423.57	a,b
	(145.86)		(61.49)		(4.36)		(279.76)		(159.17)	
August	336.40	a	672.40	a	44.30	a	434.63	a	503.53	a
	(79.85)		(96.22)		(15.35)		(110.96)		(171.25)	
September	362.07	a,b	438.90	a	28.37	b	140.03	a,b	250.60	a,b
	(126.47)		(134.20)		(9.67)		(58.84)		(80.27)	
October	63.80	a	13.87	a	162.43	a	213.70	a	126.63	a
	(15.38)		(7.77)		(80.34)		(101.30)		(29.86)	
November	193.03	a	51.40	a	320.27	a	205.60	a	151.33	a
	(57.89)		(8.15)		(150.83)		(51.25)		(45.65)	
December	345.13	a	372.90	a	95.30	a	552.73	a	619.73	a
	(135.84)		(105.86)		(36.76)		(44.49)		(135.50)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix P. Mean monthly utilization (kg/ha) of three cool-season forages established in the Coastal Plain in November 2002 and sampled from January – May 2004.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
January	558.37	a	148.67	a	82.67	a	469.33	a	516.07	a
	(59.65)		(23.81)		(24.92)		(87.80)		(136.46)	
February	328.50	a	221.13	a	94.03	a	225.93	a	209.87	a
	(118.92)		(41.20)		(21.09)		(90.64)		(70.29)	
March	287.10	a	452.00	a	100.93	a	275.83	a	362.10	a
	(86.66)		(63.64)		(35.17)		(88.71)		(167.24)	
April	642.03	a	394.37	a,b	50.20	b	105.97	b	567.50	a
	(82.91)		(117.60)		(16.91)		(22.56)		(86.81)	
May	169.63	a	444.50	a	88.30	a	62.00	a	276.30	a
	(65.78)		(229.04)		(23.06)		(18.29)		(92.16)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix Q. Mean monthly utilization (kg/ha) of three cool-season forages established in the Piedmont in November 2002 and sampled from February – December 2003.
Standard errors are presented parenthetically.*

SAMPLE PERIOD	Forage Species: DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
February	5.17	a	12.73	a	5.80	a	9.30	a	6.97	a
	(2.40)		(8.42)		(3.17)		(4.77)		(3.23)	
March	115.03	a	239.77	a	36.27	a	117.73	a	123.77	a
	(30.27)		(83.24)		(4.89)		(38.84)		(46.71)	
April	524.30	a	577.63	a	72.93	a	570.77	a	552.67	a
	(169.88)		(68.85)		(18.46)		(165.12)		(227.43)	
May	1106.70	a	773.60	a	426.20	a	1138.33	a	832.13	a
	(156.34)		(206.09)		(122.68)		(208.15)		(314.15)	
June	2056.87	a,b	1359.83	a,b,c	499.60	c	1805.43	b	1040.03	b,c
	(78.17)		(189.58)		(106.60)		(148.52)		(287.99)	
July	903.37	a	705.27	a	153.10	a	608.63	a	523.63	a
	(127.34)		(80.85)		(72.20)		(74.66)		(203.45)	
August	290.93	a	122.80	a	100.40	a	235.93	a	71.07	a
	(111.78)		(36.80)		(43.92)		(27.78)		(37.20)	
September	36.63	a	16.73	a	21.13	a	13.87	a	64.67	a
	(11.40)		(7.35)		(5.95)		(5.22)		(13.78)	
October	20.13	b	43.60	b	388.53	a,b	504.53	a	330.23	a,b
	(5.97)		(18.00)		(131.41)		(49.79)		(37.13)	
November	13.57	a	20.20	a	678.67	b	533.80	b	980.33	b
	(5.54)		(5.89)		(83.91)		(94.12)		(126.36)	
December	23.77	a	10.43	a	276.10	a	395.97	a	392.93	a
	(4.75)		(2.19)		(59.00)		(140.94)		(157.04)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix R. Mean monthly utilization (kg/ha) of three cool-season forages established in the Piedmont in November 2002 and sampled from January – May 2004.
Standard errors are presented parenthetically.*

	Forage Species				
SAMPLE PERIOD	DURANA CLOVER	REGAL LADINO CLOVER	MAXQ FESCUE	MAXQ FESCUE/ REGAL LADINO CLOVER	MAXQ FESCUE/ DURANA LADINO CLOVER
January	43.27 a	30.67 a	117.17 a	62.10 a	140.87 a
	(9.74)	(7.75)	(37.22)	(31.37)	(61.07)
February	34.07 a	39.90 a	313.00 a	286.13 a	104.73 a
	(11.56)	(9.05)	(91.51)	(54.86)	(36.34)
March	260.27 a	256.73 a	250.50 a	166.53 a	204.40 a
	(77.66)	(74.31)	(102.93)	(74.07)	(40.28)
April	231.23 a	93.87 a	43.13 a	460.77 a	430.60 a
	(118.81)	(34.55)	(13.88)	(153.40)	(122.50)
May	97.37 a	63.33 a	35.07 a	94.30 a	69.90 a
	(17.42)	(7.09)	(11.78)	(41.35)	(18.55)

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix S. Mean monthly utilization (kg/ha) of three cool-season forages established in the Blue Ridge in November 2002 and sampled from April – December 2003.
Standard errors are presented parenthetically.*

SAMPLE PERIOD	Forage Species: DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
April	88.93	a	246.13	a	143.13	a	329.33	a	114.27	a
	(22.53)		(81.12)		(48.77)		(82.61)		(54.40)	
May	573.83	a	552.13	a	426.90	a	789.80	a	663.77	a
	(141.57)		(147.97)		(151.00)		(262.48)		(193.28)	
June	1131.03	a,b	929.97	a,b	278.20	b	1487.33	a	616.60	a,b
	(223.87)		(194.28)		(133.57)		(127.76)		(110.62)	
July	1042.70	a,b	1035.13	a,b	95.33	c	1358.43	a	716.13	b
	(83.05)		(129.29)		(35.51)		(141.43)		(97.83)	
August	445.80	a	438.37	a	213.53	a	668.13	a	462.93	a
	(146.53)		(188.86)		(51.90)		(153.61)		(192.61)	
September	66.47	a	155.53	a	54.97	a	72.83	a	37.43	a
	(21.82)		(46.01)		(128.92)		(42.77)		(21.89)	
October	274.16	a	338.50	a	344.30	a	332.33	a	617.32	a
	(52.51)		(71.98)		(71.31)		(40.86)		(279.62)	
November	413.63	a	466.07	a	1427.53	a	1391.10	a	877.03	a
	(49.61)		(54.51)		(173.32)		(284.99)		(171.63)	
December	241.23	a	260.17	a	58.23	a	180.20	a	301.13	a
	(81.03)		(49.85)		(27.05)		(68.59)		(125.12)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix T. Mean monthly utilization (kg/ha) of three cool-season forages established in the Blue Ridge in November 2002 and sampled from January – May 2004.
Standard errors are presented parenthetically.*

	Forage Species				
SAMPLE PERIOD	DURANA CLOVER	REGAL LADINO CLOVER	MAXQ FESCUE	MAXQ FESCUE/ REGAL LADINO CLOVER	MAXQ FESCUE/ DURANA LADINO CLOVER
January	64.13 a	107.30 a	492.73 a	543.13 a	314.57 a
	(14.30)	(24.33)	(140.51)	(88.03)	(99.50)
February	20.73 b	60.17 b	66.77 b	106.03 b	290.87 a
	(6.64)	(16.29)	(9.46)	(22.80)	(40.79)
March	85.37 a	207.60 a	154.57 a	200.40 a	117.80 a
	(17.36)	(33.49)	(32.14)	(60.14)	(24.76)
April	204.57 a	209.40 a	97.27 a	369.53 a	196.33 a
	(12.90)	(39.37)	(26.41)	(107.23)	(99.18)
May	461.40 a	142.10 a	51.20 a	296.47 a	73.30 a
	(118.84)	(52.58)	(13.75)	(120.35)	(16.26)

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix U. Mean monthly utilization rates (%) of three cool-season forages established in the Coastal Plain in November 2002 and sampled from February – December 2003.
Standard errors are presented parenthetically.*

SAMPLE PERIOD	Forage Species: DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
February	56.36	a	73.52	a	68.79	a	54.66	a	36.67	a
	(7.77)		(5.38)		(10.10)		(8.01)		(2.97)	
March	55.22	a	50.47	a	28.27	a	30.72	a	42.41	a
	(3.32)		(5.88)		(6.70)		(5.91)		(6.85)	
April	12.91	a	19.39	a	24.90	a	20.30	a	9.60	a
	(4.51)		(3.56)		(4.14)		(2.93)		(2.63)	
May	26.53	a	37.62	a	24.57	a	31.98	a	24.44	a
	(3.14)		(2.45)		(7.05)		(6.18)		(2.08)	
June	36.34	a,b	52.92	a	5.48	b	60.92	a	55.17	a
	(6.03)		(5.12)		(3.60)		(4.01)		(9.56)	
July	41.68	a,b,c	67.10	a,b	0.85	d	41.12	b,c	25.79	c,d
	(3.96)		(3.70)		(0.23)		(11.90)		(7.04)	
August	38.12	a,b	65.06	a	1.73	c	36.77	b,c	32.15	b,c
	(7.92)		(3.52)		(0.49)		(6.21)		(6.67)	
September	50.18	a,b,c	63.78	a,b	3.38	d	20.82	c,d	28.32	b,d
	(12.23)		(5.05)		(0.75)		(14.39)		(6.71)	
October	40.47	a	15.56	a	18.38	a	37.03	a	29.30	a
	(5.31)		(0.38)		(0.36)		(13.67)		(12.41)	
November	30.91	a	18.47	a	19.84	a	19.70	a	17.70	a
	(3.19)		(6.18)		(7.94)		(9.63)		(7.79)	
December	53.55	a,b	74.52	a	5.29	b	51.62	a	58.32	a
	(13.13)		(5.05)		(1.82)		(9.43)		(7.40)	

*Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix V. Mean monthly utilization rates (%) of three cool-season forages established in the Coastal Plain in November 2002 and sampled from January – May 2004.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
January	60.83	a	49.22	a	4.82	b	42.94	a,b	36.64	a,b
	(7.83)		(4.42)		(1.72)		(4.60)		(9.17)	
February	29.83	a,b	44.21	a	4.86	b	14.65	a,b	17.28	a,b
	(5.22)		(5.32)		(0.80)		(9.03)		(4.29)	
March	18.13	a	36.92	a	4.41	a	20.66	a	19.67	a
	(6.09)		(3.26)		(1.57)		(4.67)		(6.18)	
April	30.12	a	32.29	a	1.78	b	7.21	b,c	23.07	a,c
	(2.44)		(4.24)		(0.64)		(3.03)		(3.31)	
May	8.06	a	27.27	a	3.48	a	2.82	a	9.01	a
	(1.69)		(10.07)		(0.77)		(0.65)		(3.46)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix W. Mean monthly utilization rates (%) of three cool-season forages established in the Piedmont in November 2002 and sampled from February – December 2003.
Standard errors are presented parenthetically.*

	Forage Species				
SAMPLE PERIOD	DURANA CLOVER	REGAL LADINO CLOVER	MAXQ FESCUE	MAXQ FESCUE/ REGAL LADINO CLOVER	MAXQ FESCUE/ DURANA LADINO CLOVER
February	69.53 a	71.05 a	48.59 a	76.02 a	47.18 a
	(5.44)	(6.02)	(9.77)	(12.14)	(10.26)
March	71.06 a,b	92.22 a	51.93 b	74.77 a,b	78.98 a,b
	(3.88)	(5.23)	(5.19)	(3.87)	(7.33)
April	56.03 a	68.23 a	23.59 a	49.58 a	55.00 a
	(12.78)	(3.67)	(4.37)	(5.91)	(7.83)
May	64.37 a	56.73 a	36.20 a	48.51 a	56.61 a
	(3.34)	(4.91)	(8.37)	(1.57)	(9.27)
June	92.38 a	93.62 a	25.35 c	68.81 b	68.53 b
	(2.22)	(1.37)	(4.46)	(1.38)	(5.78)
July	59.35 a	48.76 a,b	9.76 b	45.73 a,b	37.44 a,b
	(8.77)	(2.94)	(4.56)	(4.86)	(7.01)
August	58.60 a,b	55.84 a,b	9.42 c	24.54 b,c	9.53 c
	(18.39)	(9.68)	(8.61)	(0.46)	(1.46)
September	34.74 a	31.75 a	4.81 a	4.73 a	22.78 a
	(9.88)	(9.49)	(1.02)	(1.89)	(5.86)
October	31.82 a	68.20 a	46.09 a	54.51 a	46.57 a
	(7.34)	(9.97)	(9.14)	(7.23)	(6.11)
November	21.32 b	54.93 a,b	76.42 a	54.26 a,b	73.37 a
	(8.01)	(10.68)	(2.69)	(6.29)	(8.24)
December	38.60 a	30.68 a	34.17 a	37.33 a	42.24 a
	(8.69)	(7.05)	(5.37)	(5.58)	(5.10)

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix X. Mean monthly utilization rates (%) of three cool-season forages established in the Piedmont in November 2002 and sampled from January – May 2004.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
January	34.63	a,b	77.51	a	23.59	b	8.63	b	18.50	b
	(6.16)		(11.19)		(9.00)		(6.27)		(3.94)	
February	48.09	a,b	77.90	a	29.97	a,b	29.33	a,b	16.87	b
	(11.45)		(6.59)		(6.69)		(5.75)		(5.39)	
March	52.90	a,b	71.11	a	22.92	b,c	18.17	c	19.98	b,c
	(6.93)		(3.37)		(7.12)		(4.78)		(7.07)	
April	38.32	a	42.15	a	3.49	a	33.62	a	35.41	a
	(15.18)		(4.25)		(0.94)		(5.09)		(6.87)	
May	74.75	a	71.44	a	3.54	b	9.38	b	7.28	b
	(2.79)		(4.90)		(1.00)		(2.86)		(1.30)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix Y. Mean monthly utilization rates (%) of three cool-season forages established in the Blue Ridge in November 2002 and sampled from April – December 2003.
Standard errors are presented parenthetically.*

SAMPLE PERIOD	Forage Species: DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
April	61.64	a	70.03	a	28.80	a,b	58.35	a,b	27.39	a.b
	(4.05)		(5.93)		(6.04)		(3.99)		(4.71)	
May	36.43	a	40.01	a	28.84	a	27.42	a	31.33	a
	(6.39)		(3.80)		(5.79)		(2.47)		(5.13)	
June	41.51	a	42.68	a	15.07	a	35.55	a	16.86	a
	(4.10)		(9.40)		(5.95)		(5.34)		(4.68)	
July	50.21	a	50.45	a	3.36	b	35.97	a,b	20.30	b
	(2.65)		(7.18)		(1.46)		(4.48)		(5.50)	
August	26.06	a	33.71	a	9.78	a	29.78	a	16.09	a
	(7.15)		(13.41)		(2.98)		(5.78)		(5.25)	
September	12.09	a	22.43	a	19.71	a	11.94	a	5.71	a
	(2.78)		(7.27)		(6.43)		(5.49)		(2.42)	
October	30.00	a	23.84	a	5.61	a	23.00	a	33.82	a
	(8.16)		(7.97)		(2.30)		(2.12)		(14.42)	
November	52.48	a	52.62	a	43.28	a	61.49	a	45.83	a
	(8.15)		(5.75)		(5.58)		(4.29)		(6.71)	
December	61.50	a	55.88	a	2.96	b	11.81	b	16.90	b
	(6.48)		(8.59)		(1.46)		(4.58)		(3.71)	

*Means followed by the same letter within rows are not significantly different from each other at the P ≤ 0.05 level, Tukey's Mixed Model Test.

Appendix Z. Mean monthly utilization rates (%) of three cool-season forages established in the Blue Ridge in November 2002 and sampled from January – May 2004.
Standard errors are presented parenthetically.*

	Forage Species									
SAMPLE PERIOD	DURANA CLOVER		REGAL LADINO CLOVER		MAXQ FESCUE		MAXQ FESCUE/ REGAL LADINO CLOVER		MAXQ FESCUE/ DURANA LADINO CLOVER	
January	50.13	a,b	66.57	a	25.32	b	39.22	a,b	19.65	b
	(6.61)		(2.86)		(8.03)		(5.16)		(8.34)	
February	28.73	a,b	65.10	a	4.43	b	7.38	b	19.35	b
	(6.55)		(6.19)		(0.81)		(3.31)		(6.14)	
March	39.43	a,b	61.13	a	8.96	b	15.96	b	8.87	b
	(12.19)		(7.14)		(1.67)		(4.68)		(2.30)	
April	26.15	a	25.36	a	3.57	a	20.12	a	9.18	a
	(4.49)		(3.50)		(0.93)		(5.80)		(4.73)	
May	18.71	a	7.68	a	1.68	a	10.29	a	2.44	a
	(4.49)		(2.56)		(0.38)		(3.65)		(0.55)	

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix AA. Monthly crude protein (%) of forages established in the Coastal Plain in November 2002 and sampled from April 2003 – January 2004.
Standard errors are presented parenthetically.*

	Forage Species		
SAMPLE PERIOD	DURANA CLOVER	REGAL LADINO CLOVER	MAXQ FESCUE
January	24.56 a	21.14 a,b	12.76 b
	(0.43)	(0.22)	(2.02)
February	28.99 a	25.08 a,b	13.79 b
	(0.79)	(1.54)	(1.31)
March	28.40 a	24.05 a,b	16.52 b
	(0.83)	(1.19)	(1.03)
April	20.13 a	18.15 a	13.23 a
	(0.13)	(1.45)	(0.15)
May	17.72 a	16.94 a	9.01 b
	(0.51)	(0.85)	(0.36)
June	25.34 a	24.65 a	11.07 b
	(0.04)	(2.12)	(0.19)
July	20.61 a	18.04 a	10.25 b
	(0.41)	(0.20)	(1.32)
August	24.44 a	20.59 b	11.06 c
	(0.26)	(0.32)	(0.38)
September	21.12 a	20.72 a,b	12.89 b
	(0.69)	(0.51)	(1.35)
October	21.62 a	20.32 a	18.24 b
	(0.25)	(0.37)	(0.75)
November	22.76 a	20.50 a,b	18.04 b
	(0.24)	(0.99)	(0.37)
December	23.29 a	21.35 a	16.20 a
	(0.19)	(0.34)	(2.05)

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

Appendix AB. Monthly crude protein (%) of forages established in the Piedmont in November 2002 and sampled from April 2003 – January 2004.
Standard errors are presented parenthetically.*

	Forage Species		
SAMPLE PERIOD	DURANA CLOVER	REGAL LADINO CLOVER	MAXQ FESCUE
January	18.53 a	17.05 a	8.15 b
	(0.76)	(0.26)	(0.50)
February	20.58 a	23.69 a	8.66 b
	(1.88)	(1.81)	(0.02)
March	21.78 a	21.74 a	10.50 b
	(0.06)	(0.02)	(0.87)
April	18.79 a	19.93 a	8.57 b
	(0.80)	(1.42)	(1.15)
May	21.81 a	20.29 a,b	10.76 b
	(0.90)	(0.87)	(1.73)
June	18.69 a	24.36 a	9.41 a
	(4.17)	(0.09)	(0.18)
July	18.91 a	20.51 a	9.78 b
	(0.32)	(1.04)	(0.28)
August	21.22 a	20.85 a,b	11.30 b
	(1.25)	(0.75)	(0.52)
September	19.56 a	20.74 a	10.35 b
	(0.74)	(1.73)	(0.84)
October	21.26 b	26.31 a	16.83 c
	(1.48)	(1.25)	(1.54)
November	22.54 a	24.05 a	12.98 a
	(1.93)	(0.08)	(1.77)
December	18.32 a	13.16 a	8.68 a
	(0.23)	(2.79)	(0.04)

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

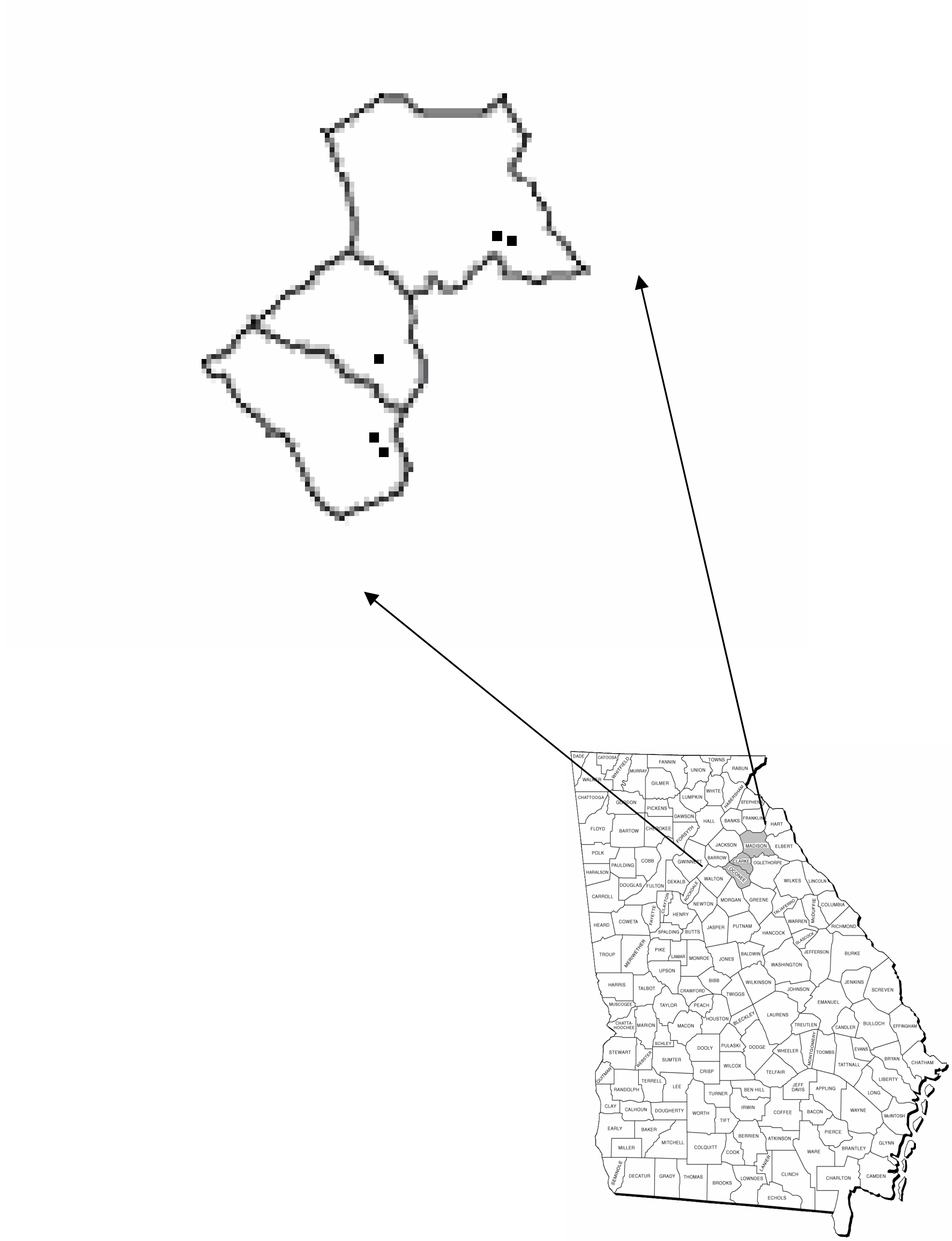
Appendix AC. Monthly crude protein (%) of forages established in the Piedmont in November 2002 and sampled from April 2003 – January 2004.
Standard errors are presented parenthetically.*

	Forage Species		
SAMPLE PERIOD	DURANA CLOVER	REGAL LADINO CLOVER	MAXQ FESCUE
January	22.50 a	22.24 a	8.67 b
	(0.07)	(1.61)	(0.08)
February	22.61 a	22.82 a	8.87 b
	(0.60)	(2.04)	(0.02)
March	23.10 a	23.14 a	8.40 b
	(0.51)	(2.01)	(0.91)
April	22.72 a	22.86 a	9.11 b
	(0.72)	(2.08)	(0.28)
May	23.29 a	23.78 a	10.01 b
	(0.86)	(2.00)	(0.55)
June	23.50 a	23.21 a	9.76 b
	(0.24)	(1.25)	(0.45)
July	22.72 a	20.30 a	8.72 b
	(0.55)	(0.63)	(0.97)
August	24.47 a	24.91 a	11.52 b
	(0.65)	(1.46)	(0.14)
September	24.74 a	25.22 a	11.64 b
	(0.91)	(1.77)	(0.33)
October	23.76 a	25.06 a	9.72 b
	(0.55)	(1.74)	(2.14)
November	21.27 a	20.80 a	9.52 b
	(0.34)	(1.27)	(1.24)
December	20.28 a	21.92 a	8.81 b
	(0.89)	(0.03)	(0.71)

* Means followed by the same letter within rows are not significantly different from each other at the $P \leq 0.05$ level, Tukey's Mixed Model Test.

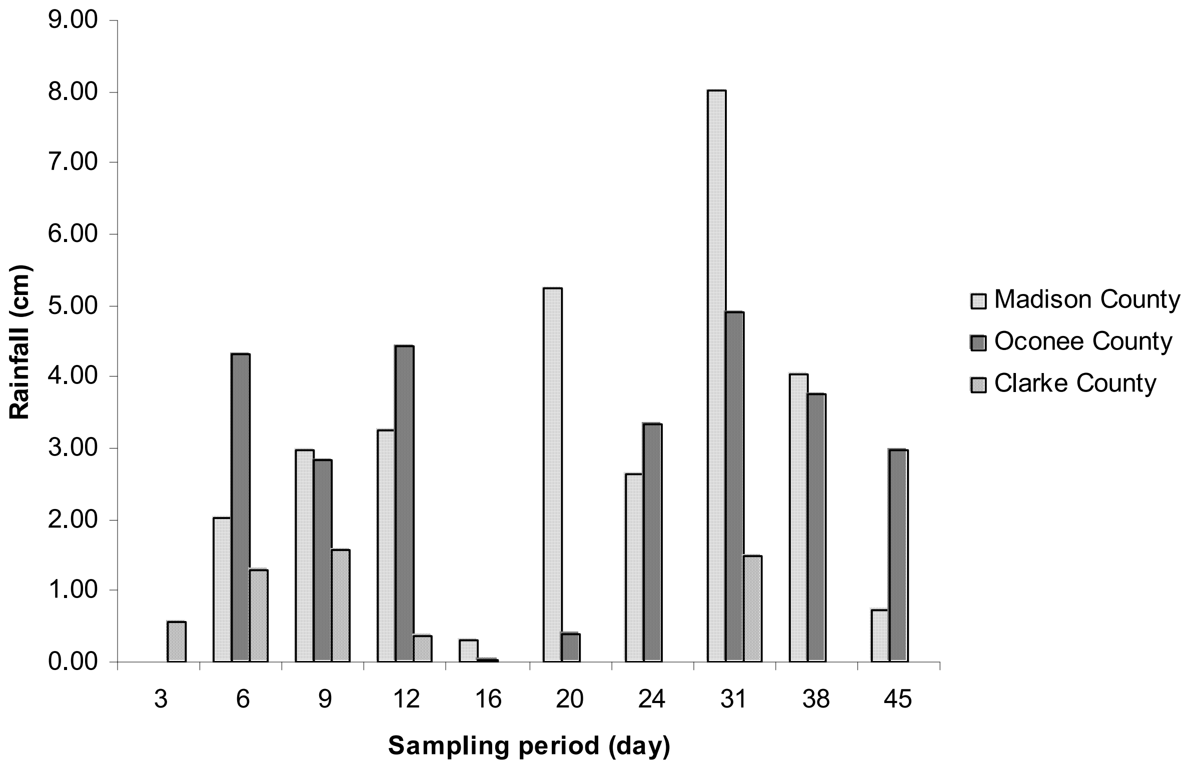
APPENDIX AD

Location of study sites in the Piedmont physiographic region of Georgia for the repellent study described in Chapter 3.



APPENDIX AE

Precipitation data among sampling periods for research sites for the repellent study described in Chapter 3.


9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Rainfall (cm)
3
6
9
12
16
20
24
31
38
45
Sampling period (day)
Madison County
Oconee County
Clarke County

Appendix AF. Mean number of soybeans, within each browse rating category, on site 1 in Madison County during July -August 2003. Standard errors are presented parenthetically.*

	BROWSE RATING					
SAMPLE	Control			Treatment		
PERIOD (DAYS)	0	1	2	0	1	2
3	15.40*	21.80	62.80*	78.20*	13.00	8.40*
	(1.81)	(4.59)	(4.79)	(3.65)	(2.85)	(1.96)
6	4.80	20.60	74.60*	34.40	51.80	19.80*
	(1.85)	(5.15)	(5.15)	(10.86)	(11.07)	(5.38)
9	1.20	17.20*	81.60*	5.20	49.80*	45.00*
	(0.73)	(3.18)	(3.20)	(2.71)	(1.85)	(2.76)
12	1.00	15.60*	83.40*	3.40	50.00*	46.60*
	(0.63)	(2.73)	(2.99)	(1.91)	(1.05)	(2.40)
16	0.20	12.00*	87.80*	0.60	45.00*	54.40*
	(0.20)	(1.38)	(1.39)	(0.40)	(2.21)	(2.18)
20	-	-	-	-	-	-
	-	-	-	-	-	-
24	-	-	-	-	-	-
	-	-	-	-	-	-
31	-	-	-	-	-	-
	-	-	-	-	-	-
38	-	-	-	-	-	-
	-	-	-	-	-	-
45	-	-	-	-	-	-
	-	-	-	-	-	-

[1] Browse rating category: 0 = no browse, 1 = partly browsed, 2 = completely browsed.
*indicates a significant difference between means within browse rating category during each sampling period at the $P \leq 0.05$ level.

Appendix AG. Mean number of soybeans, within each browse rating category, on site 2 in Madison County during July-August 2003. Standard errors are presented parenthetically.*

	BROWSE RATING					
SAMPLE	Control			Treatment		
PERIOD (DAYS)	0	1	2	0	1	2
3	65.60*	26.80*	7.60	99.60*	0.40*	0.00
	(8.68)	(6.32)	(3.44)	(0.40)	(0.40)	(0.00)
6	21.80*	62.60*	15.60	99.60*	0.40*	0.00
	(8.15)	(6.92)	(1.72)	(0.40)	(0.40)	(0.00)
9	0.80*	76.00*	23.20*	99.60*	0.40*	0.00*
	(0.20)	(4.66)	(4.84)	(0.40)	(0.40)	(0.00)
12	0.80*	74.60*	24.60*	99.60*	0.40*	0.00*
	(0.20)	(4.62)	(4.80)	(0.40)	(0.40)	(0.00)
16	0.00*	69.60*	30.40*	99.60*	0.40*	0.00*
	(0.00)	(5.74)	(5.74)	(0.40)	(0.40)	(0.00)
20	0.00	53.40	46.60*	71.20*	28.80	0.00*
	(0.00)	(5.41)	(5.41)	(9.74)	(9.74)	(0.00)
24	0.00	45.20*	54.80*	5.60	94.40*	0.00*
	(0.00)	(4.10)	(4.10)	(4.62)	(4.62)	(0.00)
31	0.00	29.40*	70.60*	0.00	96.20*	3.80*
	(0.00)	(1.81)	(1.81)	(0.00)	(1.96)	(1.96)
38	0.00	21.00*	79.00*	0.00	96.20*	3.80*
	(0.00)	(1.87)	(1.87)	(0.00)	(1.96)	(1.96)
45	0.00	15.20*	84.80*	0.00	96.20*	3.80*
	(0.00)	(1.46)	(1.46)	(0.00)	(1.96)	(1.96)

[1] Browse rating category: 0 = no browse, 1 = partly browsed, 2 = completely browsed.

* indicates a significant difference between means within browse rating category during each sampling period at the $P \leq 0.05$ level.

Appendix AH. Mean number of soybeans, within each browse rating category, on site 1 in Oconee County during July-August 2003. Standard errors are presented parenthetically.*

	BROWSE RATING					
SAMPLE	Control			Treatment		
PERIOD (DAYS)	0	1	2	0	1	2
3	81.80	0.40	17.80	100.00	0.00	0.00
	(7.83)	(0.24)	(7.89)	(0.00)	(0.00)	(0.00)
6	50.80*	7.00	42.20*	99.00*	0.80	0.20*
	(15.24)	(2.17)	(14.89)	(0.63)	(0.49)	(0.20)
9	41.60*	9.60	48.80*	99.00*	0.80	0.20*
	(15.01)	(4.12)	(15.46)	(0.63)	(0.49)	(0.20)
12	8.20*	43.00*	48.80*	98.60*	1.20*	0.20*
	(2.99)	(12.68)	(15.46)	(0.51)	(0.37)	(0.20)
16	4.00*	40.60*	55.40*	98.40*	1.40*	0.20*
	(1.45)	(10.85)	(12.16)	(0.40)	(0.24)	(0.20)
20	2.40*	37.20*	60.40*	98.20*	1.60*	0.20*
	(1.12)	(9.50)	(10.37)	(0.37)	(0.24)	(0.20)
24	2.20*	35.00*	62.80*	97.00*	2.80*	0.20*
	(0.97)	(9.07)	(9.81)	(1.30)	(1.32)	(0.20)
31	0.00*	36.20*	63.80*	97.00*	2.80*	0.20*
	(0.00)	(9.33)	(9.33)	(1.30)	(1.32)	(0.20)
38	0.00	35.20	64.80*	44.20	55.20	0.60*
	(0.00)	(8.96)	(8.96)	(21.24)	(21.16)	(0.40)
45	0.00	34.80*	65.20*	0.00	98.80*	1.20*
	(0.00)	(9.02)	(9.02)	(0.00)	(0.58)	(0.58)

[1] Browse rating category: 0 = no browse, 1 = partly browsed, 2 = completely browsed.
* indicates a significant difference between means within browse rating category during each sampling period at the $P \leq 0.05$ level.

Appendix AI. Mean number of soybeans, within each browse rating category, on site 2 in Oconee County during July-August 2003. Standard errors are presented parenthetically.*

	BROWSE RATING					
SAMPLE	Control			Treatment		
PERIOD (DAYS)	0	1	2	0	1	2
3	63.60*	5.60	30.80*	99.60*	0.20	0.20*
	(8.18)	(1.33)	(7.65)	(0.24)	(0.20)	(0.20)
6	10.20*	25.20*	64.60*	99.00*	0.00*	1.00*
	(2.22)	(5.88)	(7.26)	(0.55)	(0.00)	(0.55)
9	9.80*	24.80*	65.40*	97.80*	0.80*	1.40*
	(2.03)	(5.69)	(7.54)	(0.37)	(0.37)	(0.51)
12	7.20*	22.20*	70.60*	96.60*	2.20*	1.20*
	(0.66)	(2.80)	(3.17)	(1.03)	(0.73)	(0.37)
16	2.00*	22.00	76.00*	87.60*	11.00	1.40*
	(0.55)	(3.29)	(3.70)	(4.74)	(4.69)	(0.40)
20	0.40*	13.60*	86.00*	34.20*	64.40*	1.40*
	(0.24)	(2.25)	(2.43)	(5.31)	(5.22)	(0.40)
24	0.20	12.80*	87.00*	1.20	97.40*	1.40*
	(0.20)	(2.46)	(2.59)	(0.73)	(1.03)	(0.40)
31	0.00	13.00*	87.00*	0.00	83.40*	16.60*
	(0.00)	(2.59)	(2.59)	(0.00)	(3.82)	(3.82)
38	0.00	10.80*	89.20*	0.00	65.80*	34.20*
	(0.00)	(2.67)	(2.67)	(0.00)	(1.83)	(1.83)
45	0.00	10.40*	89.60*	0.00	63.40*	36.60*
	(0.00)	(2.69)	(2.69)	(0.00)	(1.50)	(1.50)

[1] Browse rating category: 0 = no browse, 1 = partly browsed, 2 = completely browsed.
* indicates a significant difference between means within browse rating category during each sampling period at the $P \leq 0.05$ level.

Appendix AJ. Mean number of soybeans, within each browse rating category, Clarke County during August 2003-September 2003. Standard errors are presented parenthetically.*

	BROWSE RATING					
SAMPLE	Control			Treatment		
PERIOD (DAYS)	0	1	2	0	1	2
3	1.60	0.20*	98.20*	2.80	8.80*	88.40*
	(0.60)	(0.20)	(0.73)	(0.73)	(2.75)	(3.36)
6	0.80	0.80*	98.40*	1.40	12.40*	86.20*
	(0.37)	(0.20)	(0.40)	(0.75)	(3.50)	(3.93)
9	0.20	1.60*	98.20*	1.40	12.40*	86.20*
	(0.20)	(0.24)	(0.37)	(0.75)	(3.70)	(4.18)
12	0.00	1.20*	98.80*	0.60	12.60*	86.80*
	(0.00)	(0.49)	(0.49)	(0.24)	(3.79)	(3.99)
16	0.00	0.80*	99.20*	0.60	12.80*	86.60*
	(0.00)	(0.20)	(0.20)	(0.24)	(3.71)	(3.91)
20	0.00	0.60*	99.40*	0.40	10.60*	89.00*
	(0.00)	(0.24)	(0.24)	(0.24)	(3.88)	(4.00)
24	0.00	0.00	100.00	0.00	7.00	93.00
	(0.00)	(0.00)	(0.00)	(0.00)	(3.03)	(3.03)
31	-	-	-	-	-	-
	-	-	-	-	-	-
38	-	-	-	-	-	-
	-	-	-	-	-	-
45	-	-	-	-	-	-
	-	-	-	-	-	-

[1] Browse rating category: 0 = no browse, 1 = partly browsed, 2 = completely browsed.
* indicates a significant difference between means within browse rating category during each sampling period at the $P \leq 0.05$ level.