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Warm-Season Forage Responses to Nitrogen, Phosphorus, and Potassium Fertilization

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Warm-season grasses, like bermudagrass [*Cynodon dactylon*], require relatively high nutrient rates for production of high forage yields and maintenance of soil nutrient levels. In western Arkansas, poultry litter has been one of the primary nutrient sources used to fertilize grass forages. Concerns regarding high soil-test P and water quality have resulted in regulations that restrict or prohibit poultry litter applications (DeLaune et al., 2006). In many fields, farmers must now rely on inorganic fertilizers to provide sufficient nitrogen (N), phosphorus (P), and potassium (K) to optimize forage production. This presentation will summarize published and ongoing research from Arkansas pertaining to warm-season forage response to 1) N-fertilizer rate and source, 2) P-fertilizer rate, and 3) K-fertilizer rate.

Bermudagrass Yield Response to Nitrogen Rate and Source

A summary of 15 site-years of published and unpublished N-fertilization trials conducted in northwestern Arkansas illustrates the responsiveness of bermudagrass to N fertilization (Table 1). Non-irrigated bermudagrass receiving no N fertilizer generally yields <2 ton (dry matter)/acre. Sites that produced relatively high yields with no N had generally received high rates of manure in previous years or were first year production fields. Near maximal forage yields were produced with <170 lbs N/acre at these high yielding sites during the first year, but afterwards relative yields declined and responsiveness to N increased. Data indicate that adequate N fertilizer is needed to produce high bermudagrass yields that can serve to sustain the cattle industry as well as maintain lush ground cover which may reduce runoff.

Table 1. Typical yield of non-irrigated bermudagrass receiving no N fertilizer at 14 site-years in Washington and Benton counties of Arkansas.

Yield Range	Site years	Relative Yield
tons/acre	#	% of maximum
<1	5	10
1-2	3	26
2-3	4	39
3-4	2	52
4-5	1	77

Data from seven site-years having maximum N rates >400 lb N/acre were used to calibrate N rates for bermudagrass production in northwestern Arkansas. Relative yields increased nonlinearly (quadratic) as N rate increased. The mean of bermudagrass yields receiving no N was 1.6 ton/acre and the highest yielding treatment averaged 7.5 ton/acre. The quadratic relationship predicted a maximum relative yield of 98% with ~550 lbs N/acre. Nitrogen-fertilizer rates of 274 and 364 lbs N/acre were predicted to produce 80 and 90% relative yields, respectively.

The N-fertilizer value of fresh poultry litter (FPL) has been researched and debated within Arkansas as well as other poultry-producing states. Bitzer and Sims (1988) reported that, on average, 67% (range 21-100%) of the organic N in 20 poultry litter sources mineralized during a 140 day incubation. State recommendations often generalize that 50-60% of the organic N in poultry litter is mineralized during the first year of application. Few published studies have compared yield (or N uptake) of warm-season forage receiving N from inorganic N fertilizers and FPL across a range of N rates. To estimate the N availability in FPL relative to NH_4NO_3 (applied at rates up to 400 lbs N/acre) we calculated relative forage yield (season total) and regressed it against total N rate using data from a 5-year study reported by Honeycutt et al. (1988). The rate of yield increase per unit of applied total N (i.e., slope values) was numerically higher (not statistically compared) for NH_4NO_3 than FPL, but the intercepts were quite different (Fig. 1). The relationships suggest that FPL must be applied at nearly twice the total-N rate as NH_4NO_3 to produce similar relative forage yields. Thus, an estimate of 50% plant available N in FPL for warm-season forage appears reasonable when calibrated against yields produced with inorganic-N fertilizer.

Ammonium nitrate, the preferred inorganic N fertilizer for forage, has become increasingly difficult to obtain during the last five years due to safety and national security regulations concerning its explosive properties. The lack of available NH_4NO_3 requires growers use other inorganic-N fertilizers and various N-fertilizer amendments to satisfy the forage N requirement and maximize N use efficiency. We have ongoing studies comparing NH_4NO_3, urea, urea amended with the urease inhibitor NBPT (Agrotain, 4 qt/ton urea), and pelleted poultry litter (PPL; Slaton et al., 2007; Massey et al., 2008). Three site-years of research indicate that i) urea produces 90-100% of the season total yield as NH_4NO_3, ii) amending urea with Agrotain provided no season-total yield benefit compared with urea alone, and iii) PPL produces, on average, 85% of the yield of inorganic-N fertilizer per unit of applied N. These are preliminary results from an ongoing study and conclusions may change as more data is gathered.

Forage receiving urea with Agrotain produced significantly greater yields than urea alone for only 1 of 10 individual harvests at three site-years. Fertilization with Agrotain treated urea increased total N uptake for 3 of 7 individual harvests at two site-years where total N uptake was measured. The lone harvest that Agrotain treated urea provided a yield advantage over urea was for the third harvest when N fertilizer was applied in July and it did not rain for more than 10 days. Sufficient rainfall occurred within 24 to 48 hours after 4 of 8 N applications where Agrotain treated urea and urea produced similar forage yields, averaged across N rates.

The potential benefits of Agrotain are further illustrated by examining its influence on NH_3 volatilization. We measured NH_3 volatilization for 15 days following each application of 120 lbs N/acre (360 lbs N/acre/year) using the method described by Griggs et al. (2006). By 15 days after fertilizer application, cumulative NH_3-N losses, expressed as the percentage of applied

N and averaged across three N application times, averaged <0.5% for NH_4NO_3, 1% for PPL, 3% for Agrotain treated urea, and 14% for urea (Fig. 2). For urea, 82% (~12% of applied N) of the cumulative NH_3-N loss occurred during the first 3 days and was essentially complete by 6 days. In comparison, for Agrotain treated urea, only 14 and 66% (0.5 and 2% of applied N) of the cumulative NH_3-N loss occurred after 3 and 6 days, respectively, indicating the urease inhibitor successfully delayed urea hydrolysis. It should be noted the method used to determine NH_3 volatilization from applied N fertilizer indicates the potential for NH_3-N loss and not actual losses under field conditions. Although forage yield and N uptake were not always increased by amending urea with Agrotain, the potential for NH_3 volatilization loss from urea is significant and can be reduced by use of the urease inhibitor. Based on our data, treating urea with Agrotain should be considered when i) the chance for rainfall within 24-48 hours after urea application is low and ii) air temperature is high enough for rapid urea hydrolysis (e.g., mid- and late-summer N applications).

The low amount of NH_3-N loss from PPL was surprising, but very consistent across N application times. We performed another NH_3-N volatilization study in late August 2007 to compare two fresh litter sources against PPL. Results showed all litter sources had relatively low cumulative (15 day) NH_3-N losses with fresh litter losing about 3% of total applied N and PPL losing only 1% of the total applied N. When NH_3-N losses were calculated using only the total NH_4-N content of each litter source, which comprised about 10% of the total N, the values were about 30% and 10% of the total applied NH_4-N for fresh litter and PPL, respectively. The differences in cumulative NH_3 losses are likely linked to the pH of fresh (pH = 8.6) and pelleted litter (7.2) with the greater pH resulting in greater NH_3 loss.

Management of Other Nutrients

Nutrient management recommendations for sites without high soil-test P should involve, or at least consider, poultry litter or other available animal manures as a nutrient source. In Arkansas, moist broiler litter contains, on average, 61 lbs N, 70 lbs P_2O_5, and 60 lbs K_2O/ton with an average pH of 8.3 and moisture of 31% (unpublished data, University of Arkansas Diagnostic Laboratory 2005-2007). Based on retail prices of \$0.76/lb P_2O_5 and \$0.42/lb K_2O in the first quarter of 2008 the broiler litter has P and K fertilizer value of \$78.40/ton. Furthermore, broiler litter has some value as a lime material. After two-years of N fertilization, soil receiving 360 lbs N/acre/year had average soil pH (1:2 soil weight:water volume) values of 4.8 for NH_4NO_3, 4.9 for urea and Agrotain treated urea, and 5.9 for PPL compared with a pH of 5.5 for soil receiving no N (Massey, unpublished data, 2008). Feed ration differences among poultry types and/or changes across time (i.e., decades) have likely altered its the elemental composition and reaction in soil. For example, Hileman (1965) reported annual application of 2 and 8 tons broiler litter/acre/year reduced the pH of a silt loam from 6.6 for the no N control to 6.2 and 5.8, respectively. Thus, changes in animal feed rations and manure processing (e.g., Alum and pelletizing) in response to environmental concerns involving poultry litter and its nutrient content, availability, and behavior in soil may also change which requires continuous research to document its value as a fertilizer and soil amendment.

Two years of research evaluating bermudagrass response to P fertilization on a Captina silt loam (116 ppm) shows that, on average, 12.5 lbs P_2O_5/ton is removed by harvested forage, Mehlich-3 extractable P changes by ! 1 ppm/! 4 lbs net P_2O_5 added or removed/acre (note the ! symbol indicates either a net increase or decrease based on nutrient balance), and season total bermudagrass yields have not responded to P fertilization. Yields for the first and second harvests each year have been unaffected by P fertilization, but, third harvest yields have increased significantly (10-25%) from P fertilization each year. These findings suggest that bermudagrass grown on some soils with an 'Above Optimum' soil-test P (>50 ppm Mehlich-3 P) may benefit from P fertilization, which warrants further study to determine the consistency and magnitude of late-season yield responses to P-fertilization strategies.

Forage yield responses to K fertilization of a Captina silt loam with an initial soil-test K of 115 ppm (Mehlich-3) have been consistent and significant. Season total yields were increased by 14-18% for the first year and 36-69% for the second year with annual K rates of 200 to 500 lbs K_2O/acre/yr required to maximize yields. On average, 45-50 lbs K_2O/ton were removed by harvested bermudagrass receiving sufficient K to produce near maximum yields. After 2-years of cropping Mehlich-3 extractable K (0-to 4-inch depth) changed by !1 ppm/! 2.5 lbs net K_2O/acre. These data highlight the need for frequent soil analysis for K and sufficient K fertilization to maintain productivity of soil managed for moderate to high forage yields which remove large quantities of K.

Summary

Nutrient management strategies developed for warm-season grasses grown for hay are changing rapidly in response to environmental quality and national security issues and require additional research to insure that agronomic efficiency is not being compromised. Agronomic research is needed to develop and update nutrient management recommendations that are agronomically sound, environmentally friendly, and economically sustainable. For example, slow- or controlled-release N sources such as polymer-coated urea, and urease (e.g., Agrotain) and nitrification inhibitors (e.g., DCD) warrant further investigation as to their potential to minimize N transformation and loss from the soil and their utility to optimize N efficiency in forage systems.

References

Bitzer, C.C., and J.T. Sims. 1988. Estimating the nitrogen availability in poultry litter through laboratory and field studies. J. Envir. Qual. 17:47-54.

DeLaune, P.B., B.E. Haggard, T.C. Daniel, I. Chaubey, and M.J. Cochran. 2006. The Eucha/Spavinaw phosphorus index: a court mandated index for litter management. J. Soil Water Cons. 61:96-105.

Griggs, B.R., R.J. Norman, C.E. Wilson, and N.A. Slaton. 2006. Ammonia volatilization and nitrogen uptake by conservation and conventional tilled delayed flood rice. Soil Sci. Soc. Amer. J. 70:745-751.

Hileman, L.H. 1965. The effect of broiler litter on soil under orchardgrass sod. Ark. Farm. Res. 14(1):6.

Honeycutt, H.J., West, C.P., and Phillips, J.M. 1988. Responses of bermudagrass, tall fescue and tall fescue-clover to broiler litter and commercial fertilizer. Ark. Agric. Exp. Stn. Bull. 913. Fayetteville, AR.

Figure 1. Predicted bermudagrass yield response to N rate applied as fresh broiler litter or NH_4NO_3 from data reported by Honeycutt et al. (1988). Symbols: ● NH_4NO_3 applied at 100- 400 lbs N/acre (used for linear regression); ○ NH_4NO_3 applied at 500-600 lbs N/acre; G Fresh poultry litter.

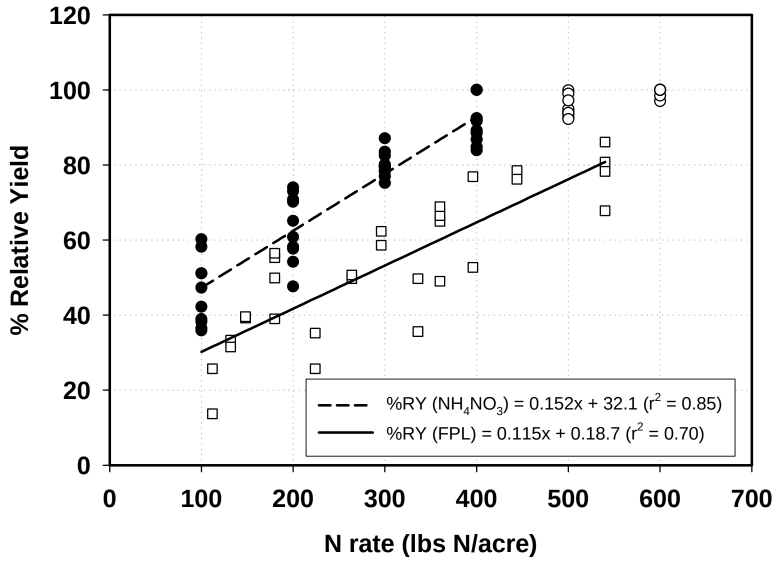
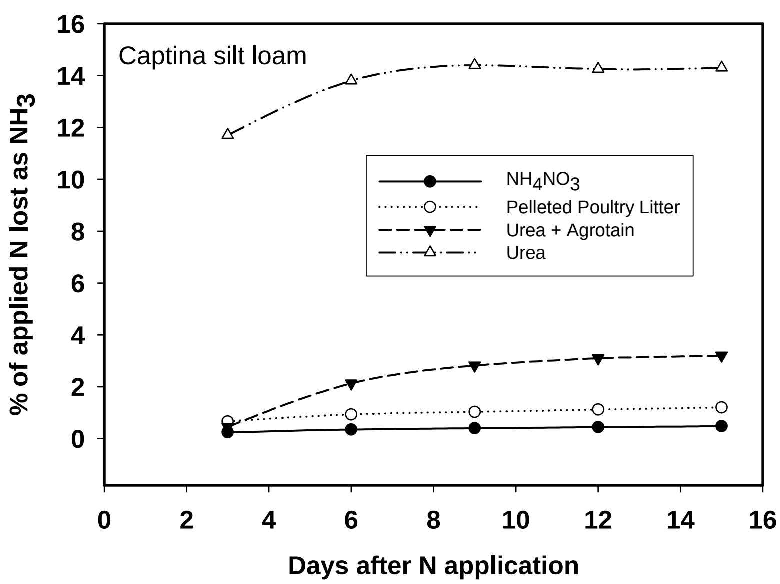


Figure 2. Cumulative NH_3-N losses from four N sources applied at 120 lbs N/acre/application averaged across three N applications in May, June, and July 2007.



Progress in Legume Breeding and Genomics at the Noble Foundation

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Introduction

Legumes have the ability to fix atmospheric nitrogen, are a good source of dietary protein, and account for a significant part of the world's crop production. In addition, the price increase of commercial nitrogen fertilizer has sparked renewed interest in utilizing legumes in agricultural production systems to offset nitrogen costs of grass-driven biofuel systems. The overall goals of the forage legume breeding and genomics program at the Noble Foundation are to identify genetic solutions for abiotic and biotic limitations in forage legume productivity and to develop molecular technologies to improve the efficiency of cultivar development.

Alfalfa

Alfalfa (*Medicago sativa* L.) is the most important forage legume crop species in the U.S. (Barnes et al., 1988) and is recognized as one of the best forage crops for feeding ruminant animals (Barnes and Sheaffer, 1995; Engels and Jung, 1998). Some of the main abiotic and biotic stress factors limiting alfalfa productivity include drought and aluminum toxicity, and alfalfa potato leafhopper and cotton root rot, respectively. Additional target traits for improvement include increased biomass yield, nutritional quality and persistence.

Abiotic stress

Drought is considered the most important cause of yield reduction in crop plants (Bohnert and Jensen, 1996). Soils with low water availability constitute about 45% of the U.S. land surface and drought alone accounted for 41% of the insurance indemnities for crop losses between 1940 and 1978 (Boyer, 1982). In most of the Southern Great Plains and western U.S., inadequate surface water supplies, declining water tables, and high water pumping costs limit alfalfa production (Ray et al., 1999). The regulation of drought tolerance in plants is genetically and physiologically complex (Valliyodan and Nguyen, 2006). Drought stress on perennial forages is a regular feature in this region and reduces forage yield and limits persistence. A collaborative project with New Mexico State University aims to identify genetic mechanisms associated with drought tolerance and forage biomass production in two tetraploid alfalfa populations derived from a cross between genotypes of *M. sativa* subsp. *sativa* var. Chilean (low water-use efficiency) and *Medicago sativa* subsp. *falcata*, var. Wisfal (high water-use efficiency). Forage biomass yield was evaluated under both irrigated and drought conditions at two locations (NM and OK) and used to identify molecular markers associated with increased yields under both water regimens. Current efforts include evaluating a core collection of alfalfa germplasm including various subspecies and genotypes collected from arid regions to identify additional sources of useful genetic variation in the drought-stress response. Approaches to enhance drought tolerance in alfalfa using biotechnology are also being considered.

Worldwide, aluminum (Al) is one of the most important factors limiting crop production in acid soils (Foy et al., 1978). A reduction in yields due to inhibited root growth and nutrient uptake are some of the symptoms caused by Al toxicity (Kochian et al., 2005). The mechanisms underlying resistance to Al toxicity in forage legumes have yet to be determined and to date, no alfalfa germplasm with Al tolerance is commercially available. Our strategy is to utilize a combination of tissue culture, nutrient solution and soil-based assays to evaluate mapping populations developed at Noble and at The University of Georgia using the tetraploid Al-tolerant germplasm, Altet-4. The objective is to identify molecular markers associated with Al tolerance in alfalfa. Microsatellites and markers developed from candidate genes previously associated with the Al tolerance response in other crops are being used to genotype the populations and to construct linkage maps. The expected outcome of this research is to develop Al tolerant alfalfa cultivars using markers to identify desirable genotypes with favorable alleles for Al tolerance.

Biotic stress

Potato leafhopper (PLH) feeding in alfalfa causes losses in biomass yield and nutritive quality (Hutchins and Pedigo, 1990; Sulc et al., 2004). A collaborative effort with Forage Genetics International using bulk segregant analysis is underway to identify molecular markers associated with alfalfa potato leafhopper resistance. The goal is to use these markers in an applied breeding program to develop alfalfa cultivars with durable PLH resistance. Cotton root rot (CRR), caused by the soil-borne fungus *Phymatotrichopsis omnivora*, is a devastating disease in alfalfa. No effective cultural or chemical control system and no sources of natural resistance have been identified. One of the research targets of the Oklahoma Consortium for Legume Research is to identify a solution to the cotton root rot problem in alfalfa. The disease affects various plant species grown in Oklahoma, Texas, New Mexico, Arizona, southern California and Mexico. Anti-fungal compounds that are effective against cotton root rot have been identified and genotypes of *Medicago truncatula,* a close relative of alfalfa, with some level of natural tolerance have been identified. Current efforts include screening diverse alfalfa germplasm with the goal of identifying useful sources of CRR tolerance.

Nutritional quality

Lignin content is a key factor affecting forage digestibility and the conversion of biomass to biofuels (Chen and Dixon, 2007). Alfalfa lines independently down-regulated in all key enzymatic steps of the monolignol biosynthetic pathway have been developed. The objectives of this research are to better understand the biological mechanisms underlying agronomic traits of alfalfa lines with altered lignin composition to enhance the efficiency of the lignocellulosic biomass conversion process while maintaining good agronomic performance.

White clover

White clover (*Trifolium repens* L.) is a major cool-season forage legume species often utilized as a companion species in grass pastures (Brink et al., 1999). The focus of most white clover breeding programs in the USA has been developing ladino white clover due to their large leaves and high yields. However, intermediate types have a higher stolon density and have good persistence (Hoveland and Bouton, 2000). When tested as a renovation legume for grass pastures in the Southeastern USA, the intermediate-type white clover experimental line GA-43, registered as 'Durana', possessed better stand persistence than currently used ladino cultivars (Bouton et al., 2005). A white clover population developed from a cross between a single clone each from Durana and SRVR (Gibson et al., 1989) was used to identify genomic regions associated with desirable traits including persistence under grazing and grass competition, plant spreading, and stolon density. We have established a pipeline to identify additional molecular markers which are currently being used to enhance the resolution of the genetic linkage map and to identify regions associated with drought tolerance and ornamental traits.

Other legumes

The approaches described and the genomic resources developed can be utilized to enhance progress in other forage legume species with none or limited genomic resources. As an example, the molecular markers developed for our target forage legume species are being utilized to assess the genetic diversity of perennial native legume populations under consideration for use in rangeland restoration applications by researchers at the USDA-ARS in Logan, UT.

Overall, a combination of high-throughput genotyping technologies, the identification of genes underlying complex traits of agronomic importance, and traditional breeding strategies has the potential to accelerate the development of forage legume cultivars enhanced for traits with a high impact potential for farmers and ranchers.

References

Barnes, D.K., B.P Goplen, and J.E. Baylor. 1988. Highlights in the USA and Canada. p.1-24. *In* A.A. Hanson, D.K. Barnes, and R.R. Hill (ed) Alfalfa and alfalfa improvement. ASA, CSSA, and SSSA. Madison, WI, USA.

Barnes, D.K., and C.C. Sheaffer. 1995. Alfalfa. p. 205-216. *In* Barnes, R.F., Miller, D.A., and C.J. Nelson. Forages Vol.1: An introduction to grassland agriculture. Ames, IA, USA. Iowa State Univ. Press. p. 205-216.

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

Bouton, J.H., D.R. Woodfield, J.R. Caradus, and D.T. Wood. 2005. Registration of ‘Durana’ white clover. Crop Sci. 45:797.

Bohnert, R.H., and R.G. Jensen. 1996. Strategies for engineering water-stress tolerance in plants. Trends in Biotech. 14:89-97.

Boyer, J.S. 1982. Plant productivity and environment. Science 218:444-448.

Chen, F., and R.A. Dixon. 2007. Lignin modification improves fermentable sugar yields for biofuel production. Nature Biotech. 25:759-761.

Engels, F.M. and H.G. Jung. 1998. Alfalfa stem tissues: Cell-wall development and lignification. Ann. of Botany 82:561-568.

Foy, C.D., R.L. Cheny, and M.C. White. 1978. The physiology of metal toxicity in plants. Ann. Rev. Plant Physiol. 29:511-566.

Gibson, P.B., O.W. Barnett, G.A. Pederson, M.R. McLaughlin, W.E. Knight, J.D. Miller, W.A. Cope, and S.A. Tolin. 1989. Registration of southern regional virus resistant white clover germplasm. Crop Sci 29:241–242.

Hoveland, C.S., and J.H. Bouton. 2000. Persistence of selected white clovers in closely grazed tall fescue and bermudagrass sods. p. 11. *In* Proc XVI Trifolium Conference. Pipestem, WV. 20-22 June 2000.

Hutchins, S.H., and L.P. Pedigo. 1990. Phenological disruption and economic consequence of injury to alfalfa induced by potato leafhopper (Homoptera: Cicadellidae). J. Econ. Entomol. 83:1587-1594.

Kochian, L.V., M.A. Piñeros, and O.A. Hoekenga. 2005. The physiology, genetics and molecular biology of plant aluminum resistance and toxicity. Plant Soil 274:175-195.

Ray, I.M., S.M. Townsend, C.M. Muncy, and J.A. Henning. 1999. Heritabilities of water-use efficiency traits and correlations with agronomic traits in water-stressed alfalfa. Crop Sci. 39:494-498.

Sulc, R.M., K.D. Johnson, C.C. Sheaffer, D.J. Undersander, and E. van Santen. 2004. Forage quality of potato leafhopper resistant and susceptible alfalfa cultivars. Agron. J. 96:337-343.

Valliyodan, B., and H.T. Nguyen. 2006. Understanding regulatory networks and engineering for enhanced drought tolerance in plants. Curr. Opin. Plant Biol. 9:1-7.

A legume testing program for the southern US: Proposed research and funding opportunities

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The utilization of legumes in forage and grazing systems has declined during past decades in the Unites States and overseas resulting from widespread use of inexpensive inorganic N fertilizer (Taylor, 2008; Rochon et al., 2004). Consequently, several breeding programs, particularly those addressing clovers (*Trifolium* spp.), have been closed in the southern US during the past 25 years (Quesenberry, 2002), while some strong breeding programs are still being maintained by universities, federal agencies, and private institutions.

A recent sharp increase in energy prices has prompted stakeholders to reconsider legumes as an alternative to traditional forage and pasture management procedures. This renewed interest is largely based on the perceived economic benefits legumes may generate as part of agro-ecosystems. Besides documented nutritional advantages of legumes as pure stands or in pasture mixes, emphasis is now placed on potential savings through biological N fixation and positive environmental effects, including improved water quality through reduced N loss, erosion control, and a reduction in greenhouse gas emissions due to savings of fossil fuels used for industrial N synthesis.

However, there are several practical constraints present that hamper the widespread renewed adaptation of legumes. Besides biotic stresses such as pest pressure and diseases which have been addressed in breeding programs (Taylor, 2008), abiotic stresses are more difficult to overcome in the long term. These stresses include unfavorable soil conditions such as low pH, low water holding capacity, and low fertility of P and K. Major difficulties could also arise in the future from shifts in climatic patters that could result in magnified abiotic stresses such as prolonged periods of drought or heat in currently more temperate areas. Moreover, a major problem remains the poor natural reseeding ability of some species, including crimson clover (*T. incarnatum* L.), berseem clover (*T. alexandrinum* L.), and subterranean clover (*T. subterraneum* L.; Barnes et al., 2003). This results in recurring establishment costs that may put the overall sustainability of particular forage or grazing systems into question. Unfortunately, lack of skills among producers with respect to management of legume-grass swards does not simplify the agronomic challenges resulting from environmental stresses.

To address some of these challenges, a group of agronomists, breeders, animal scientists, ecologists, and plant physiologists started in spring of 2008 a concerted effort to secure funding with the goal to evaluate existing improved legume varieties under a range of soils and climates prevalent in the southern US encompassing 13 test locations in 10 states. The objective of this initial project is to screen varieties of annual winter legumes including arrowleaf clover (*T. vesiculosum* Savi), crimson clover, hairy vetch (*Vica villosa* Roth), common vetch (*V. sativa* L.), ball clover (*T. nigrescens* Viv.), berseem clover, rose clover (*T. hirtum* All.), and black medic (*Medicago lupulina* L.) regarding their adaptability, N-fixation rate, and percentage of hard-seed production. This study has ecologic and economic implications for grassland agriculture in the southern United States. First, testing legume species across a wide spectrum of climates and soils will result in greater confidence for choosing appropriate species for particular situations in this region. Further, identifying the N fixation rates and reseeding potential of selected annual legumes will have positive effects on the economic sustainability of livestock operations. Ideally, this project will provide comprehensive information on legume species and variety performance under differing environmental conditions that will close a major gap of missing information required by agricultural professionals to improve existing forage and grazing systems.

In the long term, above-mentioned constraints imply further research in the following areas: a) Soil-plant-animal interrelationships for a broad range of legume species under differing soils and climates; and b) Sustainable livestock production systems under which legume persistence is maintained despite environmental stress. Both of these topics should ideally be addressed using an interdisciplinary approach. Traditional funding programs for this type of research are available through USDA-Southern SARE (Sustainable agriculture research and education program), and the National Research Initiative (NRI) Competitive Grants Program. The SARE program offers mainly research and education grants, producer grants, and on-farm research grants, and has a strong emphasis on sustainable agriculture research based on a systems approach linked to producer education. The NRI program offers grants in specific emphasis areas that are suitable for focused and basic research on specific topics related to plant performance. This includes the Plant Biology program with a plant breeding emphasis, but also the Biobased Products and Bioenergy Production Research program that offers opportunities for research on alternative uses of legumes. Research across a wide spectrum of issues is possible with the Managed Ecosystems program within the Agroecosystems and Rural Prosperity cluster of NRI. The success of future interdisciplinary research endeavors in forage breeding and utilization will depend on the ability of involved researchers to formulate focused research questions, identify existing funding opportunities, and communicate future funding needs to policy makers.

References:

Barnes, R.F, C.J. Nelson, M. Collins, and K.J. Moore. 2003. Forages. 6th ed., Iowa State Press, Ames.

Quesenberry, K.H. 2002. Red, white, crimson, and other southern clovers: Where have they gone and why? Proc. 57th Southern Pasture and Forage Crop Improvement Conference, Athens, GA April 23-25.

Rochon, J.J., J.J. Doyle, J.M. Greef, A. Hopkins, G. Molle, M. Sitzia, D. Scholefield, and C.J. Smith. 2004. Grazing legumes in Europe: a review of their status, management, benefits, research needs and future prospects. Grass Forage Sci., 59:197-214.

Taylor, N.L. 2008. A century of clover breeding developments in the United States. Crop Sci. 48:1-13.

Effect of Sericea Lespedeza on Growth Performance and Carcass Characteristics in Goats

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Abstract

Twenty four Kiko X Boer intact bucks were stratified by BW and randomly assigned into 4 experimental groups and fed diets with different levels of SL, diet A: 0% SL (control), diet B: 10% SL, diet C: 20% SL and diet D: 30% SL. All animals were fed 70% (of the total diet) SL mix and 30% bermudagrass hay, adjusted every 3 - 4 days so that 4 – 6 % was refused (in total) daily. Body weights were taken every 2-4 wk and blood was collected at the beginning and end of the study for complete analysis. At the completion of the study, all goats were harvested and carcass measurements taken. There was no difference in initial or final BW of goats; however, ADG was higher (quadratic, $P = 0.01$) in goats consuming either alfalfa or sericea lespedeza. Average daily feed intake increased (linear, $P = 0.03$) as the level of SL increased in the diet and G:F decreased (linear, $P = 0.09$) as level of SL increased and it was lower for 10 or 20% SL diets (quadratic, $P = 0.002$). Scrotal circumference tended to decrease (quadratic, p = 0.07) and height decreased (linear, P = 0.05) with addition of SL. Adjusted fat decreased (linear, P = 0.02) with added SL and dressing percentages ranged from 37.6 to 39.1 $\pm$ 1.5 were low for all diets. White blood cells decreased (linear, $P = 0.05$) and lymphocytes % increased (linear, $P = 0.05$). Serum Alanine Aminotransferase increased (linear, $P = 0.0002$) and serum amylase decreased (linear, $P = 0.01$) as the level of SL increased. Thee was no effect of added SL on fecal egg count. In conclusion, addition of SL up to 30% in the diet adversely affected the growth performance and gain efficiency and produced low quality carcasses.

Introduction

As the production of goat meat increases throughout the US, infection with gastrointestinal nematodes (GIN), particularly *Haemonchus contortus*, is the biggest concern to farmers and a profitable goat production (Shaik, 2006). Common solutions to the parasite problems include anthelmintics, however, due to an increased anthelmintic resistance a preferable non-chemical alternative is needed to increase profitability of small ruminant and maintain the health of animals. Sericea lespedeza (SL) contains condensed tannins, which are responsible for decreasing the amount of GIN in sheep and goats, as reported by Paolini et al. (2003) and has been considered an effective method of controlling parasites (Shaik, 2006). Condensed tannin containing forages are responsible for decreasing the amount of GIN in sheep and goats (Paolini, 2003). The condensed tannin forage, sericea lespedeza, fed as hay or pellet has been investigated as to reduce the number of common GIN in goats (Shaik, 2006). However, the effects of sericea lespedeza on the carcass characteristics and growth performance had not been investigated. This study will sought to determine the effects of, the condensed tannin containing forage, sericea lespedeza on the growth performance and carcass characteristics of Boer Bucks.

Methodology

After the acclamation period, goats were weighed and 24 of the 27 goats were stratified by BW and were randomly assigned to four experimental diets (n = 6); diet A, the control group – 0% sericea lespedeza (SL), B – 10% SL, C – 20% SL, and D – 30% SL. Sericea lespedeza was incorporated in the grain mix portion of the diet (Table 1). Goats were housed individually indoors in pens of approximately 4' X 6'. An adjustment period of 2 weeks allowed goats to become acclimated to pen living, routine feeding and to allot time of proper diet adjustment before the start of the study.

Goats were fed 70% grain mix with varying amounts of SL and 30% bermudagrass hay (Table 1) once daily. Animals had accesses to feed and water ad libitum. Refusals for grain mix and hay were recorded daily. Projected daily refusal was 4 – 6%, so diets were adjusted every forth day to maintain the preferred daily refusal rate. Goats were weighed monthly and fecal egg counts collected twice during the study, at middle and end. Blood was collected in vacutainer tube via jugular vein for complete analysis, twice throughout the study.

At the completion of the study, goats were weighed again for final weight and slaughter at the Auburn University Meat Lab and carcass characteristics were measured after 24 hour.

Table 1. Ingredients composition of different experimental diets containing different levels of sericea lespedeza

	Sericea Lespedeza, %			
Item	0	10	20	30
Ingredient, % of dry matter (DM)				
Concentrate mix	71.3	70.1	70.1	71.9
Bermudagrass hay	28.7	29.9	29.9	28.1
Composition of concentrate mix, %				
Sericea Lespedeza	0	14.2	28.8	43
Alfalfa pellets	43	28.8	14.2	0
Cracked corn	23.6	20.8	17.2	14
Whole Oats	11	11	11	11
Soybean meal (48% Crude Protein)	8.4	11.2	14.8	18
Soy hulls	8.8	8.8	8.8	8.8
Molasses	3	3	3	3
Vitamin. Mineral Mix	1.2	1.2	1.2	1.2
Salt	0.5	0.5	0.5	0.5
NH4Cl	0.5	0.5	0.5	0.5

Results

Growth performance of goats consuming diets containing different levels of SL are present in Table 2. As indicated in this Table, there was no difference in initial or final BW of goats; however, ADG was higher (quadratic, $P = 0.01$) in goats consuming either 30% alfalfa or 30%

sericea lespedeza in their diet. Average daily feed intake increased (linear, $P = 0.03$) as the level of SL increased in the diets and G:F decreased (linear, $P = 0.09$) as level of SL increased and it was lower for goats consuming 10 or 20% SL diets (quadratic, $P = 0.002$). Scrotal circumference tended to decrease (quadratic, p = 0.07) and height decreased (linear, P = 0.05) with addition of SL.

Table 2. Growth performance of goats consuming various levels of sericea lespedeza

	Sericea Lespedeza %					*P-value* [a]		
Item	0	10	20	30	SEM	Linear	Quadratic	Cubic
BW, kg								
Initial	27.9	27.4	28.7	27.5	2.2	0.99	0.82	0.54
Final	36.1	32.2	34.7	35.6	1.9	0.89	0.24	0.4
Average daily gain, g	129.6	77	94.9	129.9	14.1	0.77	0.01	0.45
Average daily feed intake, g	1064.8	1082.4	1195.4	1414.5	111.5	0.03	0.4	0.98
Grain DM Intake, g	760.1	761.5	841.7	1017.7	81.7	0.03	0.32	0.96
Hay DM Intake, g	304.8	320.9	353.7	396.7	30.5	0.04	0.68	0.96
Gain: Feed (G:F)	0.12	0.07	0.07	0.09	0.009	0.09	0.002	0.32
Body Measurements								
Scrotal circumference, in	10.3	8.95	9.62	9.48	0.3	0.21	0.07	0.96
Height, in	26.1	24.3	24.6	25.5	0.5	0.05	0.01	0.53
Girth, in	38.9	36.7	38.7	37.6	0.91	0.68	0.57	0.11

[a] Based on orthogonal contrast for equally spaced treatments.

Carcass characteristics of goats consuming different levels of SL in their diet are presented in Table 3. As indicated, there was no difference in hot carcass weight, cold carcass weight, shrink or dressing %. However, adjusted fat decreased (linear, P = 0.02) with increasing levels of SL in

Table 3. Carcass characteristics of goats consuming various levels of sericea lespedeza

	Sericea Lespedeza %					*P*-value [b]		
Characteristic [a]	0	10	20	30	SEM	Linear	Quadratic	Cubic
Live wt., kg	38	33.5	33.9	35.9	1.98	0.52	0.13	0.73
HCW (kg)	14.3	13.2	13	13.8	0.99	0.73	0.35	0.98
CCW, kg	14.2	12.9	12.6	13.6	0.95	0.67	0.27	0.95
Shrink, %	1.18	1.74	2.89	1.51	0.89	0.6	0.31	0.47
Dressing, %	37.6	39.1	38.4	38.6	1.5	0.72	0.67	0.65
ADF, cm	0.085	0.088	0.069	0.062	0.007	0.02	0.53	0.38
BF, cm	0.03	0.02	0.02	0.017	0.005	0.09	0.92	0.99
LM area, cm^2	16.8	14.6	15.9	15.8	0.9	0.69	0.25	0.26
BCS	4.41	4.5	4.6	4.08	0.17	0.25	0.1	0.45

[a] HCW, hot carcass weight; CCW, cold carcass weight; ADF, Adjusted Fat; BF, body fat; LM, longissimus muscle.

[b] Based on orthogonal contrast for equally spaced treatments.

the diet. Dressing percentages ranged from 37.6 to 39.1 ± 1.5, were low for all diets and lower for those reported by Solaiman et al. (2006) for goats on higher grain diets (dressing percentage about 45%).

Hemogram of goats consuming different levels of SL in their diet is presented in Table 4. As it is indicated, most of the parameters are similar in goats consuming different experimental diets; however, white blood cells decreased (linear, $P = 0.05$) and lymphocytes % increased (linear, $P = 0.05$) as the level of SL increased in the diets.

Table 4. Hemogram of goat kids consuming various levels of sericea lespedeza

	Sericea Lespedeza %					*P*-value [b]		
Blood Characteristic [a]	0	10	20	30	SEM	Linear	Quadratic	Cubic
RBC, 10^6/µL	7.85	7.89	8.47	8.18	0.36	0.32	0.64	0.4
Hemoglobin, g/dL	9.81	10.1	9.88	10.7	0.3	0.078	0.4	0.29
Hematocrit, %	16.9	17.2	18.8	17.2	1.2	0.62	0.42	0.4
MCV, fL	21.4	21.7	22.1	22	0.26	0.07	0.42	0.72
MCH, pg	12.8	12.9	11.9	13.1	0.55	0.99	0.29	0.19
MCHC, %	60.1	59.6	54	59.8	2.96	0.63	0.29	0.24
WBC, 10^3/uL	12.5	11.3	10.4	10.5	0.8	0.054	0.441	0.377
As a % of WBC								
Neutrophils	52	46.9	52.3	45	4.5	0.43	0.81	0.27
Lymphocyte	32.9	38.5	37.1	41	2.6	0.053	0.76	0.32

[a] RBC, red blood cell; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin %; WBC, white blood cells.

[b] Based on orthogonal contrast for equally spaced treatments.

Blood serum chemistry of goats consuming SL diets are in Table 5. Blood serum enzymes Alkaline phosphatase tended to decrease (linear, *P* = 0.09) while Creatinine kinase and Alanine aminotransferase increased (linear, *P* = 0.001 and *P* = 0.0002, respectively). No changes were observed in blood serum metabolite as SL increased in the diets, however, serum Ca decreased (linear, *P* = 0.0002).

Table 5. Blood serum chemistry of goat kids consuming various levels of sericea lespedeza

	Sericea Lespedeza %					*P*-value [a]		
Blood serum enzymes, (IU / L)	0	10	20	30	SEM	Linear	Quadratic	Cubic
Alkaline phosphatase	229.3	196.2	191.7	180.1	19.4	0.09	0.6	0.7
Aspartate aminotransferase	62.6	65.8	69	64.3	2.7	0.5	0.17	0.55
Creatinine kinase	155.7	162	180.3	222.9	19.1	0.01	0.08	0.89
Gama glutamyletransferase	43.7	44.2	40.2	42.9	1.59	0.37	0.5	0.16
Alanine aminotransferase	12.4	11.1	15.8	15.6	0.8	0.0002	0.52	0.006
Amylase	29.6	31	20.5	25.7	1.8	0.01	0.32	0.003
Blood serum protein (g / dL)								
Total protein	6.17	6.41	6.3	6.28	0.16	0.7	0.45	0.57
Albumin	2.52	2.54	2.49	2.58	0.06	0.047	0.76	0.78
Blood serum metabolites (mg/dL)								
Total bilirubin	0.22	0.17	0.23	0.21	0.03	0.83	0.74	0.28
Creatinine	0.6	0.61	0.69	0.64	0.002	0.09	0.3	0.13
Blood urea nitrogen	15.5	17.3	14.5	15.3	1.07	0.5	0.67	0.12
Glucose	66.2	64	65	64.7	1.7	0.62	0.58	0.57
Triglyceride	35.9	28.9	35.1	28.1	2.5	0.14	0.98	0.04
Blood serum minerals (mg / dL)								
Calcium	9.97	9.84	9.44	9.27	0.13	0.0002	0.91	0.44
Phosphorous	7.47	6.6	6.49	6.56	0.41	0.51	0.31	0.64
Blood serum electrolytes, mEq / L								
Sodium	143.7	143.7	143.3	143.2	0.73	0.52	0.95	0.86
Chloride	109.1	108.1	107.8	107.7	0.64	0.13	0.53	0.87
Potassium	4.94	4.96	5.12	4.9	0.16	0.96	0.49	0.52

[a] Based on orthogonal contrast for equally spaced treatments.

Fecal egg count table

Table 6 presents fecal egg count in goats consuming different SL diets. There were no differences in fecal egg count of goats consuming up to 30% of SL in their diets. Condense tannin (Table 7) in sericea lespedeza did not reduce parasite load in goats as indicated by fecal egg counts.

Table 6. Fecal egg counts of goat kids consuming various levels of sericea lespedeza

Fecal Egg Counts (Eggs / g)[a]	Sericea Lespedeza %				SEM	*P*-value [b]		
	0	10	20	30		Linear	Quadratic	Cubic
Period 1 (P1), 28-Nov-07	2550	1360	2990	1316	638	0.48	0.72	0.06
Period 2 (P2), 10-Jan-08	142	230	290	140	78.5	0.89	0.17	0.64
Average	1346	795	1640	728	326	0.51	0.6	0.05

[a] P1, goats not treated for internal parasites; P2, goats were treated; Average, data analyzed using both period as repeated measure.

[b] Based on orthogonal contrast for equally spaced treatments

Table 7. Condensed tannin (CT) analysis of sericea lespedeza Hay*

Sample	Extractable CT	Protein Bound CT	Fiber-Bound CT	Total CT
1	1.31	4.62	0.44	6.37
2	1.38	4.74	0.43	6.55

* Values are relative to a purified Sericea Lespedeza standard (on an as-fed basis)

Conclusions

Addition of up to 30% sericea lespedeza in the diet aversely affected average daily gain and gain efficiency. Animals consuming SL had lower scrotal circumference and lower height and feeding high forage diets produced low dressing percentage and quality carcasses.

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References

Poalini, V., A. Frayssines, F. De La Farge, P. Dorchies and H. Hoste. 2003. Effects of condensed tannins on established populations and on incoming larvae of *Trichostrongylus colubriformis* and *Teladorsagia circumcinta* in goats. Vet. Res. 34: 331 – 339.

Shaik, S. A., T. H. Terrill, J. E. Miller, B. Kouakou, G. Kannan, R. M. Kaplan, J. M. Burke and J. A. Mosjidis. 2006. Sericea lespedeza hay as a natural deworming agent against gastrointestinal nematode infection in goats. Vet Parasitol. 139: 150 – 157.

Solaiman, S. G, C. E. Shoemaker, W. R. Jones and C. R. Kerth. 2006. The effect of high levels of Cu on serum lipid profile and carcass characteristics in goat kids. J. Anim. Sci. 84:171–177.

Finishing Lambs and Kids on Pasture in Appalachia

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Introduction

Traditional sheep, hair sheep and meat goat industries are growing rapidly in the Appalachian Region, particularly on small farms, to help produce meats for ethnic markets. This niche market offers an economic opportunity for small farms in the U.S., but the viability of meat goat and sheep finishing systems depends upon the ability to manage enterprise costs and market a consistent, high quality product.

Efforts are underway in the US to define breeds and refine crossbreeding programs to improve growth rate and carcass yield of meat-type goats. Particular interest has been placed on crosses with the Boer goat that was specifically developed for meat production in South Africa and introduced into the U.S. about 20 years ago. The Kiko goat introduced into the U.S. from New Zealand is another meat-type goat that is used for meat production in the southeastern U.S. (Browning et al., 2006). Traditional sheep breeds are used for meat production (i.e. Suffolk, Hampshire, etc). The Katahdin is a hair sheep composite breed that was developed in the Northeastern U.S. (Wildeus, 1997) and is gaining in popularity in the eastern hill-land pasture region of the U.S. as they perform well in low-input, sustainable production systems, do not need to be sheared (Jones, 2004), are able to utilize low to moderate quality forages, and have better resistance to gastrointestinal parasites (Burke and Miller, 2004).

Meat packers desire lambs and goat kids under a year of age and weighing 60 –70 pounds without excessive fat for ethnic markets, especially the Halal market. Site of fat deposition within the carcass and fat composition are related to breed of animal and the diet. In general, hair sheep (Horton and Burgher, 1992), and meat goats (Warmington and Kirton, 1990) yield lightweight carcasses with less subcutaneous fat cover and more internal (kidney) fat compared to traditional sheep breeds of the same age. Forages traditionally are energy limiting and animals finished on pasture without energy supplementation should produce leaner carcasses than animal finished in the feedlot on high concentrate diets.

Numerous forage types are used in small ruminant finishing systems. Alfalfa (*Medicago sativa* L.) is a tall-growing, winter-hardy plant that produces high yields and quality forage (Hoveland, 1992) and supports superior weight gains in goat (Gelaye et al., 1990) and sheep (ref) systems. Red clover (*Trifolium pratense* L.) grows well on fertile and moderately acidic soils, thrives with rotational grazing (Taylor and Smith, 1995), and has higher rumen escape protein compared to alfalfa (Jones et al., 1995). Orchardgrass (*Dactylis glomerata* L.) is a major pasture grass in the northeastern United States (Hoveland, 1992) that works well in grass-legume combinations.

White clover (*Trifolium repens* L.) is a common component of hill-land pastures in much of the eastern US and predominately grown for pasture throughout the U.S. (Pederson, 1995).

With the expansion of non-traditional lamb markets that accept smaller and leaner carcasses, there is need to evaluate traditional sheep, hair sheep, and meat goat growth and carcass characteristics when finished on pasture for the ethnic markets.

We summarize performance and carcass parameters from two grazing projects conducted in 2007 with lambs and meat goat kids finished on pastures in Appalachia.

Trial 1. Meat Goats Finished on Alfalfa, Red Clover, or Orchardgrass Without Supplementation

In 2007, seventy-two growing meat goat wethers (at least 75% or greater Boer breeding) were randomly assigned to three pasture treatments: alfalfa (ALF), red clover (RCL) or orchardgrass (OGR) that were each replicated three times, resulting in a stocking density of 16 kids/ac (8 kids/pasture). Each pasture contained 0.5 ac subdivided into ten 0.05-acre paddocks for rotational stocking management based on a target 4-d occupation period.

Grazing was initiated on 6 June and continued until 11 Sept 2007. Animals had access to water and mineral supplement at all times and were dewormed every 30 d with a combination (one from each anthelmintic class: benzimidazole, tetrahydropyrimidine and macrocyclic lactone) of orally administered anthelmintics as prescribed by a collaborating veterinarian.

At the end of the grazing season, animals were processed according to traditional Halal protocol. Carcasses were stored overnight for 12 hr in a walk-in cooler maintained at 34^{o} F prior to recording carcass data. The REA and BF were recorded from the right and left sides of the carcass and averaged. Chilled carcass wt and leg, lean quality, and overall conformation scores were recorded. Dressing percentage was calculated using the chilled carcass wt divided by final shrunk BW.

Trial 2. Traditional lambs, Hair-sheep lambs and meat goats finished on pasture with and without supplementation.

A mixed sward of OGR, RCL, and white clover was used for this experiment in 2007. Hay was harvested from all pastures in May 2007, and nitrogen fertilizer (33 lb N/ac) was broadcast after haying. The area was divided into six grazing pastures (each 1.5 acres) using electrical polywire fencing; each of the six 1.5-acre pastures was subdivided into three grazing paddocks each containing 0.5 ac.

Thirty-six Suffolk crossbred lambs (SX), 36 Katahdin lambs (KA), and 36 Boer x Kiko meat goat kids (GX) were used. All kids and lambs were wethers of the same age (born 1-15 March 2007). Lambs and kids were weighed and assigned to six groups; each grazing group contained 6 SX, 6 KA, and 6 GX wethers. A group of lambs and kids grazed pastures together at a stocking density of 18 animals per 1.5-acre pasture (12 animals per acre). Each pasture was 1.5 ac in size and was subdivided into three 0.5-ac paddocks for rotational stocking management based on a target 21-d occupation period. Paddocks were mowed to a 4-in stubble height immediately after each occupation.

Three of the animal groups were supplemented (SUP) with whole cottonseed (WCS) at 0.5% body weight (BW) daily throughout the experiment whereas the other three animal groups were not offered WCS supplement (UNSUP). Animals were weighed every 14 d, BW recorded, and supplement adjusted after each weigh day.

Grazing began on 29 June until 25 Sept 2007. Animals had access to water and mineral supplement at all times and were dewormed only at the beginning of the study each year with a combination (one from each anthelmintic class: benzimidazole, tetrahydropyrimidine and macrocyclic lactone) of orally administered anthelmintics prescribed by a collaborating veterinarian. Individual animals were administered anthelmintics when FAMACHA© eyelid score was 3 or greater; eyelid scores were determined every two wk.

At the end of the grazing season, animals were processed and carcass data collected and calculated as state above. Data in both experiments was analyzed using SAS (Cary, NC).

Trial 1. Meat Goats Finished on Alfalfa, Red Clover, or Orchardgrass Without Supplementation

Performance and carcass data are presented in Table 1. Final BW were greater for ALF and RCL compared to OGR. Overall ADG was greater for ALF compared to RCL and OGR which were similar. Chilled carcass wt was ALF > RCL > OGR. Dressing percentage of RCL and OGR was similar, and both were greater than ALF. Ribeye area and backfat was higher for kids finished on ALF compared to RCL and OGR. Leg score and conformation score followed a trend of ALF > RCL > OGR; lean score was greater for ALF compared to OGR; RCL was intermediate.

Trial 2. Traditional lambs, Hair-sheep lambs and meat goats finished on pasture with and without supplementation.

Performance and carcass data are presented in Table 2. Overall as the season progressed, final BW and ADG were greater for SUP than UNSUP animals and followed a trend of SX > KA > GX. There were no treatment effects on carcass wt., dressing %, REA, BF, or leg, lean, or conformation scores. There was a breed effect on all parameters that followed a trend of SX > KA > GX.

Discussion

There are many factors that affect ruminant performance and carcass characteristics when grazing pasture. Forage mass influences intake and ultimately performance. Lambs had greater intake of alfalfa or red clover in comparison to perennial ryegrass (*Lolium perenne* L.) (Fraser et al., 2004). In addition, Fraser et al. (2004) reported lambs grazing red clover had higher weight gain than those grazing alfalfa or perennial ryegrass. Red clover contains phytoestrogens (i.e. equol) that can increase weight gain (Moorby et al., 2004). Red clover also may improve weight gains via a polyphenol oxidase-mediated increase in rumen escape protein (Jones et al., 1995).

In the present study, WCS offered as a supplement to SX and KA lambs and GX kids improved BW and ADG when grazing a mixed grass-legume pasture. Kandylis et al. (1998) reported that liveweight gain and carcass internal fat was greater for lambs offered diets containing 15 or 30% WCS compared to lambs offered diets without WCS. Fat is deposited internally in hair compared to wool breeds of sheep (Horton and Burgher, 1992). Subcutaneous fat deposition in goats is slow compared to traditional sheep (Warmington and Kirton, 1990).

Implications

Goats finished on ALF, RCL, and OGR produced desirable BW and carcasses for the Halal ethnic market. Katahdin lambs and Boer x Kiko meat goat kids finished on pasture with and without whole cottonseed supplementation produced desirable BW and carcasses for the Halal ethnic market. Heavier weight (> 100 lbs) Suffolk lambs finished on pasture with and without supplementation may fit better into the traditional or Kosher meat markets.

Literature cited

Browning, Jr., R., T., Payton, B. Donnelly, M.L. Leite-Browning, P. Pandya, W. Hendrixson, and M. Byars. 2006. Evaluation of three meat goat breeds for doe fitness and reproductive performance in the southeastern United States. *In:* 8th World Congress on Genetics Applied to Livestock Production. 13-18 August 2006, Belo Horizonte, MG, Brasil. http://www.wcgalp8.org.br/wcgalp8/articles/abstract/4_873-1904_abstract.pdf Accessed Mar. 28, 2008.

Burke, J.M, and J.E. Miller. 2004. Relative resistance to gastrointestinal nematode parasites in Dorper, Katahdin, and St. Croix lambs under conditions encountered in the southeastern region of the United States. Small Rumin. Res. 54:43-51

Fraser, M.D., M.H.M Speijers, V.J. Theobald, R. Fychan, and R. Jones. 2004. Production performance and meat quality of grazing lambs finished on red clover, lucerne, or perennial ryegrass swards. Grass Forage Sci. 59:345-356.

Gelaye, S., E.A. Amoh, and P. Guthrie. 1990. Performance of yearling goats fed alfalfa and florigraze rhizoma peanut hay. Small Rumin. Res. 3:353-361.

Horton, G.M.J., and C.C. Burgher. 1992. Physiological and carcass characteristics of hair sheep and wool breeds of sheep. Small Rumin. Res. 7:51-60.

Hoveland, C.S. 1992. Grazing systems for humid regions. J. Prod. Agric. 5:23-27.

Jones, B.A., R.D. Hatfield, and R.E. Muck. 1995. Crop quality and utilization: Characterization of proteolysis in alfalfa and red clover. Crop Sci. 35:537-541.

Jones, K.G. 2004. Trends in the U.S. Sheep Industry. AIB-787. Econ. Res. Serv., USDA.

Kandylis, K., P.N. Nikokyris, and K. Deligiannis. 1998. Performance of growing-fattening lambs fed whole cottonseed. J. Sci. Food Agric. 78:281-289.

Karnezos, T.P., A.G. Matches, and C.P. Brown. 1994. Spring lamb production on alfalfa, sainfoin, and wheatgrass pastures. Agron. J. 83:278-286.

McGregor, B.A., 1985. Growth, development, and carcass composition of goats: A review. Pp. 82-89. *In:* Copland, J.W. (Ed.) Goat Production and Research in the Tropics. Univ. of Queensland, Brisbane, ACIAR.

Moorby, J.M., M.D. Fraser, V.J. Theobald, J.D. Wood, and W. Haresign. 2004. The effect of red clover formonetin content on live weight gain, carcass characteristics, and muscle equol content of finishing lambs. Anim. Sci. 79:303-313.

Pederson, G.A. 1995. White clover and other perennial clovers. Pp. 227-236. *In:* R.F Barnes, D.A. Miller, and C.J. Nelson (ed.) Forages. Vol. 1. 5th Ed. An Introduction to Grassland Agriculture. Iowa State Univ. Press, Ames.

Taylor, N.L. and R.R. Smith. 1995. Red Clover. Pp 217-226. *In*: R.F Barnes, D.A. Miller, and C.J. Nelson (Eds.) Forages. Vol. 1. An Introduction to Grassland Agriculture. Iowa State Univ. Press, Ames, IA.

Van Keuren, R.W., and A.G. Matches. 1988. Pasture production and utilization. Agron. 29:515-538.

Warmington, B.G., and A.H. Kirton. 1990. Genetic and non-genetic influence of growth and carcass traits of goats. Small Rumin. Res. 3:147-165.

Wildeus, S. 1997. Hair sheep genetic resources and their contribution to diversified small ruminant production in the United States. J. Anim. Sci. 75:630-640.

Table 1. Trial 1. Performance and carcass data of meat goat wethers finished on alfalfa (ALF), red clover (RCL), or orchardgrass (OGR) pastures in 2007.

Item	ALF	RCL	OGR	P value
Begin BW, lb	49.2	49.8	49.2	>0.10
Final BW, lb	63.7a	59.9a	54.8b	<0.001
ADG, lb/d	0.22a	0.15b	0.13b	<0.001
Carcass Wt, lb	29.6a	26.5b	23.7c	<0.001
Dressing %	46.4a	44.2b	43.0b	<0.001
REA, sq. in.	1.40a	1.23b	1.13b	<0.001
BF, in.	0.07a	0.06b	0.05b	<0.01
Leg Score	10.4a	10.2a	9.6b	<0.001
Lean Score	11.0a	11.3a,b	10.7b	<0.05
Conformation Score	10.7a	10.5a	10.0b	<0.01

[a,b]Means in the same row without common letters differ by the P Level listed.

Table 2. Trial 2. Performance and carcass data when Suffolk (SX) lambs, Katahdin (KA) lambs and meat goat (GX) kids were finished on pasture with and without whole cottonseed supplement in 2007.

	--No Supplement--			---Supplement----			Supplement Effect	Breed Effect
Item	SX	KA	GX	SX	KA	GX	P value	P value
Begin BW, lb	58.3	54.8	33.9	57.1	53.5	32.2	>0.10	<0.001
Final BW, lb	76.5	71.2	40.5	85.3	71.7	42.5	<0.01	<0.001
ADG, lb/d	0.20	0.18	0.07	0.32	0.20	0.12	<0.001	<0.001
Carcass Wt., lb	39.6	38.4	19.0	42.7	36.5	20.6	>0.10	<0.001
Dressing %	51.7	54.0	47.0	49.9	50.9	48.5	>0.10	<0.001
REA, sq. in.	1.92	1.72	0.97	1.97	1.70	0.99	>0.10	<0.001
BF, in	0.05	0.10	0.03	0.06	0.09	0.03	>0.10	<0.001
Leg Score	11.4	12.3	9.8	12.0	11.9	9.7	>0.10	<0.001
Lean Score	12.3	12.3	10.7	12.4	12.7	10.7	>0.10	<0.001
Conformation Score	11.3	12.1	9.8	11.9	11.8	9.7	>0.10	<0.001

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Integration of Meat Goat Production into Pine Silvopasture Systems

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INTRODUCTION:

Very limited information is available on guidelines for proper management of meat goats on pine silvopasture systems in the Southeastern U. S. Goats could be used as management tools to design pine silvopasture systems to provide economic returns to pine growers during early years of pine growth while creating a sustainable, biologically diverse system long-term. In silvopasture, livestock and trees are combined to form a carefully designed practice that is an integration of intensive forage management, animal husbandry, and silviculture (Clason and Sharrow, 2000). Silvopasture is practiced with most success in regions with mild, moist climates suited for commercial timber and livestock production (Rietveld and Francis, 2000). Pine growers are seeking alternative enterprises to earn incomes, while waiting for the long-term profits from pine plantations. Meat goat production can provide an alternative source of income especially for limited resource famers and landowners as there is an increased demand of goat meat due to influx of goat meat eating ethnic populations and niche markets in the U.S. (Solaiman, 2005). The objectives of the current study were to evaluate stocking rate effects on changes in understory vegetation quantity, quality and botanical composition and the effects on growth rates of meat goats foraging in a pine silvopasture system. The ultimate goal is to find out optimum equilibrium point between maximum stocking rate, sustainable vegetation (browse, forbs and grass) and loblolly pine growth.

MATERIALS AND METHODS:

The experiment was a collaborative study conducted on property of the Federation of Southern Cooperatives in Epes, Alabama. An existing 6-acre, 7-year old loblolly pine plantation was thinned and pruned and divided into 12 paddocks of approximately 0.5-acre each. The four treatments included: control (no grazing; Trt1), 0.2 Animal Unit Equivalent (AUE/acre; Trt2), 0.3 AUE/acre (Trt3) and 0.4 AUE/acre (Trt4) (equivalent to 4, 6 and 8 goats/acre, respectively). Each treatment was replicated three times. The ungrazed plots were used for baseline data. The existing vegetation consisting of grasses, browse and forbs were characterized for species composition and available biomass at the beginning (baseline) and at the end of the experiment.

The Shannon-Weiner diversity index was calculated for understory, midstory and overstory plant species present at the beginning and at the end of the foraging period. Initial evaluation of data indicated that the experimental plots were similar in plant species composition.

For plant species composition determination, three levels were designated: level 1 (0 to 36 inches from ground level); level 2 (36 to 60 inches), and level 3 (above 60 inches from ground level) and 300 points were read for each level. Herbaceous biomass was determined by hand clipping 10 0.25-m^2 quadrats/paddock and dried samples were analyzed for crude protein, acid detergent fiber, neutral detergent fiber and acid detergent lignin (AOAC, 1990). The forage biomass data were transformed to the power of $^{0.4}$ to achieve the normality assumption; forage biomass and quality data were compared across treatments and between May and October using the Mixed procedure in SAS 9.1 with replication as a random factor (Littell *et al.*, 2006).

Goats were dewormed for the control of internal parasites. Goats were also weighed prior to stocking the paddocks and were then weighed monthly to measure liveweight changes. Fecal samples were taken at weekly intervals to conduct NIRS to determine the quality of diets selected by goats. Blood samples were taken at monthly intervals to determine blood urea nitrogen (BUN) concentrations. Body condition scores were recorded at monthly intervals. Goats were stocked onto the paddocks in early June 2007 and remained until the end of the grazing season (30 September 2007). No supplemental feeds were provided except trace mineralized salts which were provided ad libitum. Goats had access to clean water and temporary sheds.

RESULTS AND DISCUSSION:

The fence prevented any entry of predators from June 2007 through the end of September, 2007. This was one of the driest years in Epes, Alabama. Typically, parasitic larva infection is low during dry, hot summer periods. However, fecal egg counts were not determined because goats were browsing off the ground in late spring and early summer.

Grasses and sedge species were dominated by bahiagrass, carex species and tickle grass in May and the trend continued in October for bahiagrass but cool-season grass species and carex species decreased dramatically (Table 1). Warm-season forbs increased across treatments from May to October, especially white heath aster and ragweed, while cool-season species such as buttercup and rubus species decreased (Table 1). The understory cover was dominated by litter (unidentified dead plant materials and pine needles) both in May and October but more so in October across treatments.

The midstory cover was predominantly open in May and October (Table 2). Blackberry was completely defoliated by goats probably as a result of their preference for this species. Vere (1979), Luginbuhl et al. (1999) and Escobar et al. (2000) observed that goats were effective at controlling blackberries. Goldenrod and groundsel trees increased across treatments from May to October. The increase was dramatic on ungrazed plots (control). Treatment effects were not evident in midstory cover categories.

The overstory was dominated by open sky. The values were 78, 81, 71 and 82 percent (Table 3) for treatments 1 to 4 in May and the corresponding values were 72, 75, 61 and 76 percents for October, respectively. There was an increase in pine proportion from May to October across all treatments (Table 3).

The plant biomass (average of 10 quadrats) were 15.5, 13.9, and 15.3 kg/ha (transformed to $^{0.4}$) in May 2007 prior to the start of the experiment in Trt2, Trt3, and Trt4, respectively (Table 4). The ungrazed (control) plots contained an average of 15.3 $(kg/ha)^{0.4}$. After three months of grazing, the corresponding values for Trts 2, 3, and 4 were 17.5, 11.6, and 14.0 $(kg/ha)^{0.4}$, respectively. Dry matter declined as the season progressed on plots with high stocking rates. The percent changes were +82.8, +35.0, -35.1, and -21.3 for the control, low stocking rate (Trt2), medium stocking rate (Trt3), and high stocking rate (Trt4), respectively. There were significant differences (P<0.05) between May and October values for treatment one and three (Table 4). The differences were also evident among treatments in October (P < 0.05).

Acid detergent fiber (ADF), neutral detergent fiber (NDF) and acid detergent lignin (ADL) levels were similar (P>0.05) among treatments at the beginning of the trial (May; Table 5) but crude protein (CP) levels were highest (P<0.05) at the highest stocking rate compared to control and low stocking rate. The CP levels were not different among treatments in October and were numerically higher than the values observed in May (Table 6). The ADF and NDF levels were highest for the highest stocking rate (P<0.05), most likely as a result of more digestible (less mature) species being grazed off. The lignin values were numerically higher in October across all treatments compared to May values.

The body condition scores were not different across treatments (P>0.05). There were no differences in BUN concentrations between treatments at day 0 and at day 30 (table 7). By day 60, BUN concentration for the highest stocking rate was significantly higher compared to the lowest stocking rate (P<0.06). Similarly, BUN concentration at day 90, differed between the lowest stocking rate goats and the medium stocking rate goats (P<0.06; Table 7). When BUN concentrations were compared across time and treatments, there was a definite trend. As stocking rates increased so did BUN concentrations. The relatively high concentrations of BUN are indicative of excess dietary protein (nitrogen) relative to digestible energy intake (Hammond et al., 1994). The protein degradability and level of protein intake can also affect BUN.

Goats gained less weight as the season progressed regardless of stocking rates (Table 8). Gains dropped off dramatically at the end of period 3 (third month). The average daily gains (ADG) were determined at monthly intervals and for the entire period (Table 8). The average daily gains for the first month were not different among treatments (P>0.05) but the highest stocking rate gained the most (32.8 g/head/day) followed by the medium stocking rate (25.2 g/head/day) and the lowest stocking rate (12.6 g/head/day). This was an interesting observation because one would expect the lowest stocking rate to gain the most. Perhaps, goats at higher stocking rates selected more nutritious parts of the plants and could also have caused more severe defoliation.

The trend was reversed in the following month. It is likely that goats learned to penetrate some of the browse and forbs species, but gains were still not significantly different (P>0.05) between treatments. Gains dropped off after the first two months (day 60 to 90).

Escobar et al. (1998) reported similar gain drops for goats grazing a mature stands of Shinnery oak where there were little grass or forbs available. However, the lowest stocking rate still gained weight (17.6 g/hg/day). When daily gains were compared for the entire period, the daily gains decreased as stocking rates increased but the differences were not significant ($P>0.05$). Gains were not as good as expected because these were yearling wethers put in a new environment with no previous experience in eating these plants.

Table 1. Understory (0-36 inches) cover categories for different stocking rates observed in May and October 2007, Epes, AL.

Cover category		May				October			
		Trt1	Trt2	Trt3	Trt4	Trt1	Trt2	Trt3	Trt4
		---%---							
Grass	Bahiagrass	8.12	10.40	5.87	17.79	15.07	22.53	18.67	25.73
	Carpet grass	0.13	0.27	0.13	0.55	2.27	2.00	1.20	3.47
	Carex spp.	14.78	9.87	10.13	8.83	3.07	0.53	4.00	0.67
	Tall fescue	0.93	3.47	5.47	0.97	0.27	4.13	2.40	0.53
	Tickle grass	7.32	8.00	4.80	5.93	0.00	0.00	0.00	0.00
	Other grasses	3.33	8.00	2.80	4.41	3.73	1.73	1.60	3.47
Forbs	White heath aster	3.99	1.87	2.80	1.79	10.13	3.47	1.07	2.13
	Buttercup	5.19	4.53	4.80	1.79	0.00	0.00	0.00	0.00
	Goldenrod	5.99	6.93	4.67	4.00	4.53	4.93	2.53	2.53
	Groundsel	1.07	2.80	1.07	2.34	1.20	0.93	0.13	0.27
	Ragweed	0.00	0.00	0.00	0.00	5.07	3.20	5.07	0.67
	Rubus spp.	7.06	6.67	8.40	5.79	3.47	4.80	5.47	2.53
	Trumpet creeper	0.13	0.27	0.67	0.28	1.60	0.40	0.27	0.00
	Verbena	0.27	0.13	0.13	0.14	0.93	0.67	0.67	0.40
	Other forbs	7.59	5.07	11.07	9.52	7.33	2.80	3.33	2.00
Other	Bare ground	2.00	0.00	0.40	0.41	0.27	0.67	1.47	2.27
	Litter	26.63	24.13	26.27	30.21	34.27	38.27	41.07	46.13
	Pine needles	5.46	7.60	10.53	5.24	6.80	8.93	11.07	7.20

Table 2. Midstory (36-60 inches) cover categories for different stocking rates observed in May and October 2007, Epes AL.

Cover category	May				October			
	Trt1	Trt2	Trt3	Trt4	Trt1	Trt2	Trt3	Trt4
	--%--							
Open sky	69.91	75.13	74.93	80.53	58.59	67.99	85.90	83.47
Blackberry	6.07	4.92	4.79	3.33	0.00	0.00	0.00	0.00
Goldenrod	3.91	5.85	2.33	2.13	10.12	9.43	6.65	3.60
Groundsel tree	6.75	6.52	3.97	7.33	10.25	11.29	2.53	7.33
Multiflora rose	0.81	0.13	1.23	0.00	0.27	0.00	0.13	0.00
Pecan	6.07	2.66	3.56	3.07	1.73	0.93	0.53	2.13
Ragweed	0.00	0.00	0.00	0.00	7.86	6.91	0.27	0.53
Rubusspp.	0.00	0.00	0.00	0.00	0.67	0.93	1.20	0.27
Trumpet creeper	0.81	0.40	2.47	0.13	0.13	0.40	0.27	0.00
Verbena	2.16	1.60	1.92	1.47	5.06	0.66	1.73	0.80
White heath aster	1.08	1.20	1.23	0.13	1.07	0.53	0.13	1.20
Other	2.43	1.60	3.56	1.87	4.26	0.93	0.66	0.67

Table 3. Overstory (>60 inches) cover categories for different stocking rates observed in May and October 2007, Epes, AL.

Observation month	Overstory category	Trt1	Trt2	Trt3	Trt4
		-----------------------	------- %	-------	-----------------------
May	Open sky	78.26	81.07	70.53	82.44
	Pine	18.66	17.60	24.93	13.40
	Groundsel tree	0.54	0.40	2.27	0.94
	Gum	0.00	0.13	0.00	0.00
	Milkweed	0.13	0.00	0.00	0.00
	Pecan	2.28	0.67	2.13	3.22
	Elm	0.00	0.13	0.13	0.00
	Wild plum	0.13	0.00	0.00	0.00
October	Open sky	72.13	75.07	60.93	76.00
	Pine	26.13	21.20	36.00	20.53
	Groundsel tree	1.07	2.67	2.00	1.73
	Oak	0.13	0.00	0.00	0.00
	Pecan	0.53	1.07	1.07	1.73

Table 4. Shoot biomass of forage (LS means ± SE) sampled from different stocking rates, May and October 2007, Epes, AL.

Treatment (trt)	May	October
	--------------------($kg\ ha^{-1})^{0.4\dagger}$	---------------------
Trt1	$15.3 \pm 0.97^{\ddagger}_{x}$	$19.4 \pm 1.15^{a}_{y}$
Trt2	15.5 ± 0.95	17.5 ± 1.10^{a}
Trt3	$13.9 \pm 1.06_{x}$	$11.6 \pm 1.05^{b}_{y}$
Trt4	15.3 ± 1.02	14.0 ± 0.94^{c}

†Transformed data

‡LS means within a row with different subscript are different (Trt 1: $P < 0.001$; trt 3: $P < 0.05$); LS means within a column with different superscripts are different (trt 1& trt 3, trt 1 & trt 4, and trt 2 & trt 3: $P < 0.0001$; trt 2 & trt 4: $P < 0.01$; trt 3 & trt 4: $P < 0.05$).

Table 5. Effects of grazing goats with different stocking rates on quality parameters (LS means ± SE) of forages sampled in May 2007, Epes, AL.

Treatment	Forage quality parameters			
	CP	NDF	ADF	ADL
	------------------------	------------ %	------------	------------------------
Trt1	$8.4 \pm 0.31^{\dagger a}$	57.4 ± 1.96	38.4 ± 0.86	7.5 ± 0.60
Trt2	8.1 ± 0.26^{a}	60.9 ± 1.69	39.6 ± 0.60	7.8 ± 0.35
Trt3	8.8 ± 0.34^{ab}	58.6 ± 2.15	38.9 ± 0.83	8.2 ± 0.60
Trt4	9.4 ± 0.37^{b}	58.9 ± 1.97	38.4 ± 0.44	7.6 ± 0.70

†LS means within a column with different superscripts are different (trt 1 & trt 4: $P < 0.05$; trt 2 & trt 4: $P < 0.01$).

Table 6. Effects of grazing goats with different stocking rates on quality parameters (LS means ± SE) of forages sampled in October 2007, Epes, AL.

Treatment	Forage quality parameters			
	CP	NDF	ADF	ADL
	----------------------------------	---------%---------	----------------------------------	
Trt1	9.3 ± 0.36	57.5 ± 2.26[†a]	38.6 ± 1.15[a]	9.1 ± 0.28[a]
Trt2	9.4 ± 0.46	57.6 ± 2.46[a]	38.6 ± 1.43[a]	8.8 ± 0.32[ab]
Trt3	9.9 ± 0.42	56.9 ± 2.24[a]	38.5 ± 1.19[a]	8.8 ± 0.31[ab]
Trt4	9.3 ± 0.38	61.8 ± 2.57[b]	41.6 ± 1.28[b]	8.3 ± 0.32[b]

[†]LS means within a column with different superscripts are different (NDF: trt 3 & trt 4 - P < 0.01, others – P < 0.05; ADF: P < 0.05; ADL: P < 0.01).

Table 7. Effects of different stocking rates on blood urea nitrogen (BUN ± SE) levels of meat goats grazed under pine silvopasture system, Epes, AL.

Stocking rate	BUN (mg/dL) at Day 0	BUN (mg/dL) at Day 30	BUN (mg/dL) at Day 60	BUN (mg/dL) at Day 90
Trt2	10.08 ± 1.34[a]	10.17 ± 0.73[a]	10.72 ± 0.80[a]	13.35 ± 2.28[a]
Trt3	11.61 ± 1.09[a]	9.29 ± 0.63[a]	11.79 ± 0.66[a]	18.53 ± 1.61[b]
Trt4	12.50 ± 0.94[a]	10.16 ± 0.58[a]	12.77 ± 0.57[b]	17.02 ± 1.55[a]
Means within a column with unlike superscripts differ (P<0.08).				

Table 8. Effects of grazing goats with different stocking rates on average daily gains (ADG ± SE) under pine silvopasture system, Epes, AL.

Stocking rate	ADG (g/d) (0-30 days)	ADG (g/d) (30-60 days)	ADG (g/d) (60-90 days)	ADG (g/d) (0-90 days)
Trt2	12.60 ± 0.04[a]	42.83 ± 0.02[a]	17.63 ± 0.02[a]	24.36 ± 0.02[a]
Trt3	25.20 ± 0.04[a]	28.55 ± 0.01[a]	- 10.08 ± 0.01[a]	14.56 ± 0.02[a]
Trt4	32.75 ± 0.03[a]	8.82 ± 0.01[b]	- 21.83 ± 0.01[b]	9.52 ± 0.01[a]
Means within a column with unlike superscripts differ (P<0.10).				

SUMMARY AND CONCLUSIONS:

The liveweight gains of goats were not satisfactory for any stocking rates. This could be due to unseasonably dry conditions experienced during the 2007 grazing period. The goats should have been supplemented with energy sources because the BUN values indicated that the protein intakes were adequate. At least three years of study are required to affect any changes in vegetation, especially woody and perennial species. The long-term effects on woody and herbaceous vegetation, soil nutrients and tree health need to be evaluated. The very preliminary results observed for changes in herbaceous biomass over the grazing period suggest that, from the standpoint of browse maintenance, 0.3AUE/acre may be a reasonable initial stocking rate in this system.

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REFERENCES:

1. AOAC, 1990. Official Methods of Analysis (15th Ed.). Association of Official Analytical Chemists, Arlington, VA.
2. Clason, T. R. and Sharrow, S. H. 2000. Silvopasture practices. P. 119-147. In H. E. Garrett, W. J. Rietveld and R. F. Fisher (eds.) North American Forestry: An integrated science and practice. ASA, Inc., Madison, WI.
3. Escobar, E. N., F. Pinkerton, and T. N. McKinney. 1998. Use of goats as a vegetation management tool. Mimeo Report of E. (kika) de la Garza Institute of Goat Research, Langston University, Langston, OK.
4. Luginbuhl J.M., T.E. Harvey, J.T. Green, M.H. Poore, and J.P. Mueller. 1999. Use of goats as biological agents for the renovation of pastures in the Appalachian region of the United States. Agroforestry Systems. 44:241–252.
5. Rietviled, W. J., and C. A. Francis. 2000. The future of agroforestry in the USA. P. 387-402. In H. E. Garrett, W. J. Rietviled and R. H. Fisher (ed.) North American Agroforestry: An integrated science and practice. ASA, Inc., Madison, WI.
6. Littell, R.C., G.A. Milliken, W.W. Stroup, R.D. Wolfinger, O. Schabenberger. 2006. SAS® for Mixed Models. SAS Institute Inc., Cary, NC.
7. SAS. (1998). Statistical Analysis System, Version 6.12. SAS Institute: Cary, NC.
8. Solaiman, S. G. 2005. Meat Goat Industry Outlook for Small Farms in Alabama and Surrounding States. George Washington Carver Agricultural Experiment Station, Tuskegee University. Publication No. 112-605.
9. Vere, D.T. and P.J. Holst. 1979. Using goats to control blackberries and briars. Agricultural Gazette of New South Wales 90:11-13.

The Role of Unconventional Forages in Lamb and Goat Production Systems in Georgia.

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Sheep and goats have consistently been able to utilize forages that cattle or horses regularly refuse or reserve for consumption during difficult times. Both species and especially sheep have made good use of broadleaf weeds, while goats are known to actively seek the plant parts of browse. These tendencies allow sheep and goats to be used in the same grazing areas as cattle or horses to enhance the total utilization of forage resources in the area. At the same time they recycle nutrients and enrich the soil resource.

Recent experience with sheep in kudzu and meat goats in a silvopasture system has provided evidence of these animal species ability to utilize unconventional forages. When speaking of high quality diets and forages nutritionally it is appropriate to include the several forbs, weed and browse species that are eaten with relish. While sheep and to some extent goats can survive and thrive on improved domesticated perennials such as Bermuda grass, Bahia grass, Ryegrass and Fescue they often prefer other choices. Stage of growth of some forage species determines the relative relish with which small ruminants consume them. Texas panicum (*Panicum texanum*) will largely be ignored during the vegetative stages of growth but actively eaten by goats and sheep as it approaches maturity and the seed head stage.

"High quality" forages for meat goats means a totally different thing as compared to high quality forages for beef or dairy cattle. A further factor that has an influence in the nutrient value of various unconventional forages for goats or sheep is the grazing habit and mouth configuration of those animals. The following table contains crude protein values for several unconventional forages utilized by goats and sheep.

Plant Species	**Crude Protein (%)**
Pig weed (Amaranthus spp.) vegetative	24%
Honeysuckle (*Lonicera japonica*) buds and leaves	16%
Curly dock (*Rumex crispus)* leaves	30%
Blackberry leaves	15%
Buckhorn plantain leaves	18%
Buckhorn plantain heads	16%
Greenbriar (*Smilax laurifolia*) tips	18%
Mimosa (*Albizzia julibrissin*) leaves	23%
Puna chicory Forage chicory (*Cichorium intybus.*)	20%

Several studies at the Small Ruminant Center at Fort Valley State University have validated the notion that goats and sheep will be productive on a diet composed primarily of these kinds of unconventional forages. The outlines and preliminary results of two on-going studies are shared here.

Silvopasture Systems. In a current study being conducted on an unimproved site in collaboration with M. Goodman (Auburn University), two stocking rates of mature female goats have been allocated to an established volunteer stand of pine trees, hardwoods, and softwood deciduous trees. The two stocking rates were the equivalent of 15-16 goats per hectare and 30-31 animals per hectare, respectively. A baseline survey established that there were 36 species of plant growing naturally in the understory. There were 11 tree species of varying height growing as part of the overstory. Survey points of bare ground, leaf litter, pine needles, moss and open sky were recorded. Paddocks were allocated to grazing group within categories/degree of open sky on a vertical plane.

Among the several paddocks in the wooded experimental area blackberry was consistently high in prevalence. Other plant species of note in one or several paddocks included Carolina jesamine, goldenrod, honeysuckle, spleenwart fern, hairy aster, other asters, horsenettle, and mare's tail. The predominate species in the overstory included pine trees and sweet gum trees. Wild cherry and privet were other prevailing woody species.

The goats were allowed to stay in each designated area until all edible vegetation was removed as determined by ocular judgment. Goats were then removed to a non-experimental site where they remained until the experimental site had reestablished to a state of cover sufficient for supporting grazing for at least another two weeks. Annual weather play a major role in the extent of re-growth and frequency of defoliation. Visual evidence confirmed that goats consumed both understory vegetation to ground level and overstory vegetation to a height equivalent to goats standing on rear legs while foraging.

Plant species consumption preference was designed to be determined through microhistological analysis of fecal samples collected twice per week while goats were on experimental plots. While analysis of outcome data are yet to be completed, eventually only three species of plants remained in the understory. They included sickle pod (*Senna obtusifolia*), horse nettle (*Solanum carolinense*), and spleenwart fern (*Asplenium spp*). The goats refused to consume these species during each of the first two years of the study which continues for a third and final year.

Sheep in Kudzu. There is ample anecdotal evidence that sheep and kudzu make a good combination nutritionally. There is even evidence that sheep make an appropriate animal for the biological control or management of the aggressive vine. In middle Georgia the growth habit of kudzu allows it to be grazed from about mid-May through the first frost which is usually in November. Earlier work by Terrill et al. at Fort Valley State suggested the yield and quality of kudzu when harvested as hay would make it a suitable dried forage. When consumed fresh as a grazed product dry matter level will be much lower and could be of some concern if rapid growth is the objective. Nonetheless grazing kudzu on a regular and repeated basis adds to and overall expanded seasonal yield. Using the plant as a protein bank for a large number of animals for a short periods of time holds potential for the crop to compliment the more common pasture species during times of drought or low nutritive value.

During early summer 2007, 192 head sheep were placed in sequence on a series of .5 hectare paddocks in an established volunteer area of kudzu. The flock was composed of 94 adult sheep weighing an average of 59.8 kg, and 98 spring-born lambs weighing an average of 29.8 kg. Total weigh of the flock was 8539.4 kg for a grazing intensity of 6832 kg per hectare. The experimental protocol required that the sheep remain on any particular grazing area until the kudzu appeared to be 95% harvested.

In additional to the kudzu, common ragweed (*Ambrosia artemisiifolia*) was growing in the area with some vigor. Curiously the ragweed had not been especially prevalent in the area prior to 2007. It is speculated that an intentional winter season burn of dead kudzu vines may have encouraged the ragweed to grow vigorously early in the 2007 season and to become well established. The sheep were reluctant to consume the ragweed and voluntarily consumed very little. Later in the grazing season consumption of ragweed increased either in response to a more mature crop with some seed, or following the lead of a herd of meat goats that were added to increase grazing intensity after the lambs were removed for other research needs. Other plant species of some significant presence were Lambs quarter (*Chenopodium album*) and Aster spp.

A total of nine paddocks were constructed utilizing a commercially available electrified plastic wire netting. The study included three treatments: (1) No grazing, (2) Grazing once relatively early in the season, (3) Grazing repeatedly during the season as soon as complete ground cover was established. The aim was to establish the relative merits of each approach to kudzu elimination. Because adequate permanent fencing was not available, each "Once grazed" paddock and an adjacent "Repeated grazed" paddock were grazed simultaneously. At the end of each grazing session the kudzu was completely defoliated. By the end of the season the "once grazed" paddocks resembled the ungrazed control, and the "repeatedly grazed paddocks were completely defoliated including the invasive ragweed. A total of 92 grazing days were obtained utilizing sheep primarily and for one two-week period 94 adult sheep and 45 adult goats were grazing together.

Summary. The evidence suggests that several unconventional forages can be effectively used in commercial small ruminant production systems. Challenges include the matter of planting method and animal management. Portable electric fencing allows these relatively small animals to be moved to sites where these forages already exist. In additional to the examples shared, opportunities include utilization of weed growth and residues from crop production, forages growing in marginal areas, and weeds that are beginning to develop herbicide resistance.

References:

Burner, D., D. Carrier, D. Belesky, D. Pote, A. Ares, and E. Clausen. 2008. Yield components and nutritive value of Robinia pseudoacacia and Albizia julibrissin in Arkansas, USA. Agroforestry Systems. 72:51.

Luginbuhl, J-M,, J. T. Green, J. P. Mueller, and M. H. Poore. 1996. Meat goats in land and forage management. In: Proceedings-Southeast Regional Meat Goat Production Symposium. Florida A&M University. Tallahassee.

Luginbuhl, J-M., J. T. Green, M. H. Poore, and J. P. Mueller. 1996. Use of goats as biological agents for the control of unwanted vegetation. In: Proceedings – Workshop on Use of Trees in Animal Production Systems. Pasture and Forage Experiment Station. Matanzas, Cuba. November 26-29.

Terrill, T. H., W. F. Whitehead, G. Durham, C. S. Hoveland, B. P. Singh, and S. Gelaye. 2004. Preference of grazing goats for cool-season annual clovers. South African J. Anim. Sci. 34:92.

Terrill, T., S. Gelaye, M. Mahotiere, E. Amoah, S. Miller, and R. Windham. 2003. Effect of cutting date and frequency on yield and quality of kudzu in the southern United States. Grass and Forage Science 58: 173.

Climate Variability and Forage Extension Programs

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In the southern United States, it is not a matter of IF drought conditions will occur; it is a matter of WHEN and HOW BAD. Forage utilization and grazing herd management are typically prone to drought conditions. Rapid-response forage extension programs are needed so that Extension Faculty and local staff can quickly identify drought conditions and implement timely programs.

Much of the Southeast experienced severe drought during 2007. For Georgia, this drought was the worst on record. This paper reports on how the Forage Extension Program at the University of Georgia recognized and responded to this drought. Recommendations are also offered herein on how others can prepare for and respond to severe drought conditions.

Early Recognition

Early in April 2007, forecasts from the Southeast Climate Consortium (www.agclimate.org) and the National Weather Service's Climate Prediction Center (http://www.cpc.ncep.noaa.gov/index.htm) predicted that La Nina conditions in the Pacific were developing. These conditions usually set up jet stream flows that prevent moisture in the upper atmosphere from being directed toward the Southeast. As a result, their precipitation forecasts predicted (what was at that time) a potentially disastrous drought.

Response

Beginning in April, Extension personnel began to develop educational fact sheets and to organize meetings to present management tactics and strategies to forage-based livestock farmers in Georgia. In addition to existing publications, nine Extension Special Bulletins, one computerized decision-aid, and two Extension Circulars where written: "Forage Use and Grazing Herd Management during a Drought" and "Nitrate Toxicity." These publications, along with eight popular-press articles, detailed specific pasture and hay production practices that producers could put into place that would minimize the long-term effects of a severe drought and could prevent livestock-poisonings resulting from the accumulation of toxins in some forage species.

These materials were assembled and posted to (or linked from) a special drought information page on the Georgia Forages webpage. Site counters for the website indicate that this special drought information webpage (http://www.caes.uga.edu/commodities/fieldcrops/forages/drought.html) has been accessed over 6000 times by nearly 1000 unique visitors since it was developed in July 2007.

Beginning in June and continuing through early August, eight meetings were planned and implemented throughout Georgia. The purpose for these 2 ½ hr meetings was to present and discuss best management practices for grazing herd management and safe forage utilization during a drought. Specific topics covered at the meetings included: i) the weather situation and outlook; ii) economic considerations and marketing strategies; iii) tax implications of weather-forced sales; iv) forage management issues (i.e., summer annuals as emergency forage, effects of overgrazing, planning for fall/winter grazing, etc.); and v) feeding options and management considerations that stretch forage supplies. These meetings were strategically located so that nearly all producers within the hardest hit areas would be within a 90-min. driving radius of these meetings (Figure 1). As a result, over 430 producers attended these meetings.

Members of the response team also presented these drought-mitigation recommendations to over 27 local livestock organizations and stakeholder groups throughout the state. In addition,

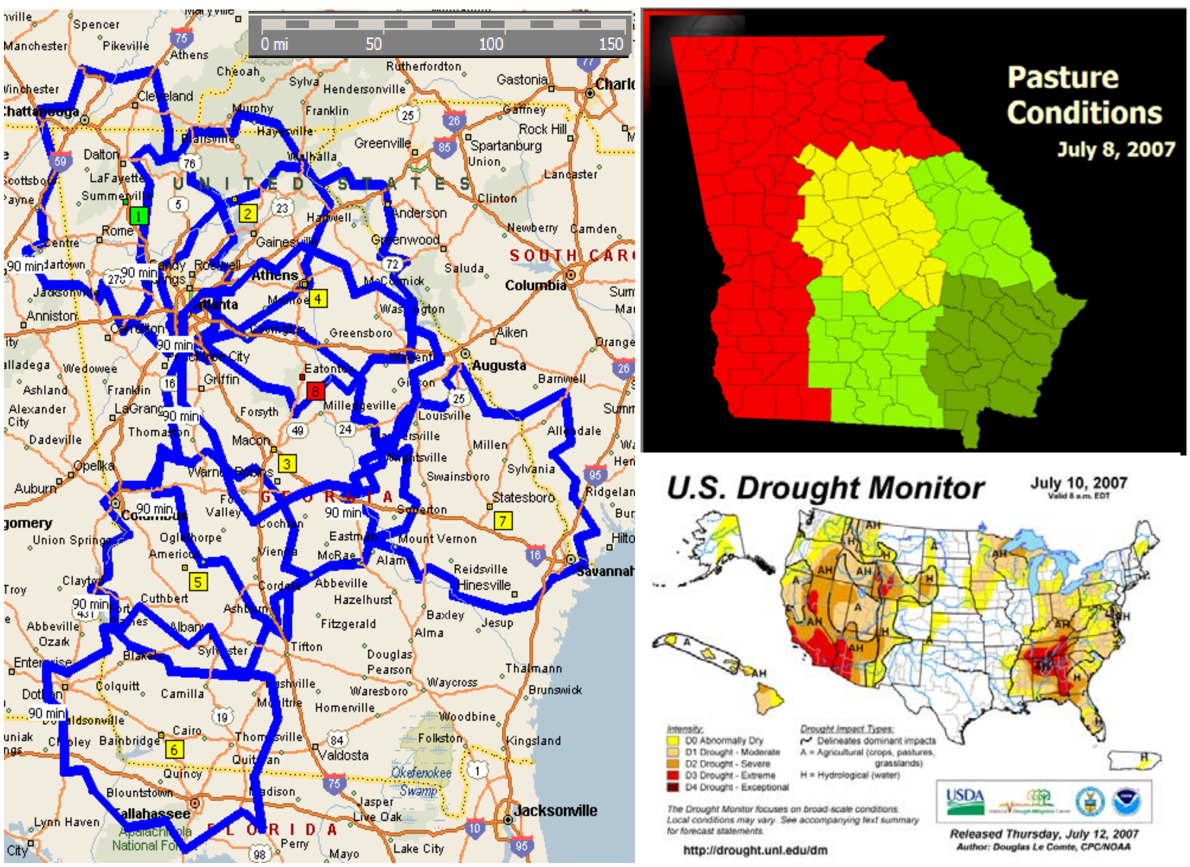

Figure 1. A) Locations of the eight regional meetings on "Grazing Herd Management During Drought" held in Georgia in 2007. Blue polygons indicate a 90-min drive-time radius from the eight locations. B) Graph of pasture conditions in early July, as reported by the USDA-NASS Georgia Field Office's "Crop Progress & Condition Report." Districts are colored based on the percentage of pasture conditions reported as poor or very poor (Red: more than 50%; yellow: 30-50%; light green: 10-30%; dark green: less than 10%). C) U.S. Drought Monitor report showing the severity of drought on July 10. At the peak of the 2007 drought, over 56% of Georgia was in exceptional drought (1st percentile, 1 in 100 yr).

the handouts and presentation notes from the regional meetings were posted on a special webpage (http://www.caes.uga.edu/commodities/fieldcrops/forages/droughtmtgs.html) dedicated to these meetings. This page registered over 1900 page-loads by over 480 unique visitors.

Immediately preceding seven of these eight regional meetings, trainings were performed for local Extension Agents. Agents attending these trainings were presented a preview of the information to be presented at the producer meetings, given more detailed training on drought-mitigation strategies, and informed on how to better counsel with individual producers as they struggle to deal with specific forage management issues related to the drought.

Impact

Post-meeting surveys indicate that nearly all of the producers improved their knowledge about the practices presented at these meetings and how the practices could be implemented on their farm. Nearly 75% of the producers in attendance stated they better understood how to properly meet the nutritional demands of their animals during drought. Nearly 78% of the respondents indicated they would be making specific management changes as a result of these meetings. For example, 91% of respondents who do not routinely grow winter annuals for winter/spring grazing indicated that they planned to do so in the fall/winter of 2007-08.

These meetings may also have mitigated another source of potential economic loss: nitrate poisoning. Approximately 80% of respondents indicated that, as a result of these meetings, they intended to sample forages they suspect to be high in nitrates. Records at the CAES's Agricultural and Environmental Services Labs (AESL) indicate that these producers followed through on their intentions to sample their forages for an analysis of quality and toxin content. In the first five months of fiscal year 2007-08, over 2100 forage samples were received, whereas only 2075 samples were processed through the lab during the entire 2006-07 fiscal year. Of those samples received from forage species prone to having toxic nitrate concentrations, nearly 20% were above the 4500 ppm threshold. By submitting through the AESL, forages high in nitrates or other toxins and anti-quality factors could be flagged and local County Extension Agents could consult with individual producers to mitigate these issues.

Recommendations

Prior to drought:

- Develop an inventory of publications, fact sheets, web pages, and other resources with your Forage Extension program and related disciplines.
- Identify areas were new information is needed or old information needs to be updated.
- Identify Extension Specialists from other disciplines that would be able to help present a well-rounded program.
- Pre-assemble materials on a centralized website (does not have to be "live" until needed).
- Occasionally check short-, medium-, and long-term range precipitation and temperature forecasts from National Weather Service's Climate Prediction Center (http://www.cpc.ncep.noaa.gov/index.htm) and climate predictions from the Southeast Climate Consortium (www.agclimate.org).
- Regularly monitor the U.S. Drought Monitor (http://www.drought.unl.edu/dm/monitor.html)

- Sign up for a weekly summary of soil moisture and pasture conditions by subscribing to your state's NASS field office's "Crop Progress & Condition Report" (e.g., http://www.nass.usda.gov/Statistics_by_State/Georgia/Subscribe_to_GA_Reports/index.asp).
- Monitor precipitation maps and evapotranspiration data for trends that indicate soil moisture shortages.

If conditions for a drought appear imminent or are on-going:

- Identify the severity of the drought. See guidelines here: http://pubs.caes.uga.edu/caespubs/pubcd/C914.htm.
- Make your drought information page "live" and notify the Extension Agents or your stakeholders of this resource.
- Encourage Extension Agents or appropriate stakeholders to acquire nitrate test kits or refresh out-of-date materials (e.g., http://aesl.ces.uga.edu/publications/ForageNitrate.htm, http://www.nitrate.com/nittest4.htm).
- Plan and implement regional extension programs in coordination with local Agents. (For state-wide coverage, it is usually best to solicit for volunteers that are willing to host regional trainings. However, be sure to identify drive-time requirements and priorities based on thresholds of drought severity).
- Communicate with seed suppliers to determine the availability of summer annual forages.
- If you have access to forage quality test results, track the percentage of samples that have high concentrations of nitrate. Focus on those that will commonly have high nitrate levels (e.g., browntop millet, sorghums/sorghum family, pearl millet, bermudagrass, etc.).
- Develop news articles, radio programs, and other mass media programs to provide real-time information.

SWITCHGRASS: FORAGE AND BIOMASS CROSSROADS

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Switchgrass is a warm-season perennial grass native to much of the United States. Over the last few years it has received renewed interest as a renewable fuel source, since it produces large amounts of cellulose that can be digested and converted to ethanol. The high yields and environmental adaptability of switchgrass make it an excellent choice for biofuel production.

While there has been a great deal of media attention on the merits of switchgrass as a biofuel feedstock, many are less familiar with the potential of switchgrass as a forage crop. Switchgrass, like a number of other native warm-season grasses (NWSG), can actually produce high-quality forage. Yields of 2-5 tons per acre can be expected, depending on rainfall, soil type, as well as other environmental conditions. The nutrient content of this forage can be as high as 16-17 percent crude protein, if harvested correctly.

Characteristics that make switchgrass attractive as forage crop

► High yields – Switchgrass grown for forage can produce up to twice as much as tall fescue on an acre of land. Research in Tennessee has shown that, if grown exclusively for hay, 4-5 tons per acre are not uncommon. If switchgrass is planted primarily for biofuels production, there is potential to harvest the early growth through haying or grazing, then managing the remainder of the season's growth for biofuels.

► Summer production - Since switchgrass is a warm-season grass, it is adapted to hot, summer conditions. As peak growth occurs from May through September, it is easy to produce hay because of better drying conditions. It is not unusual to find switchgrass hay that is better quality than the average tall fescue hay This is not because switchgrass as a species is better than tall fescue, but because hay making conditions are better during the switchgrass growing season and because rain and cool temperatures often delay cutting tall fescue. Delayed tall fescue harvest results in decreased protein and energy.

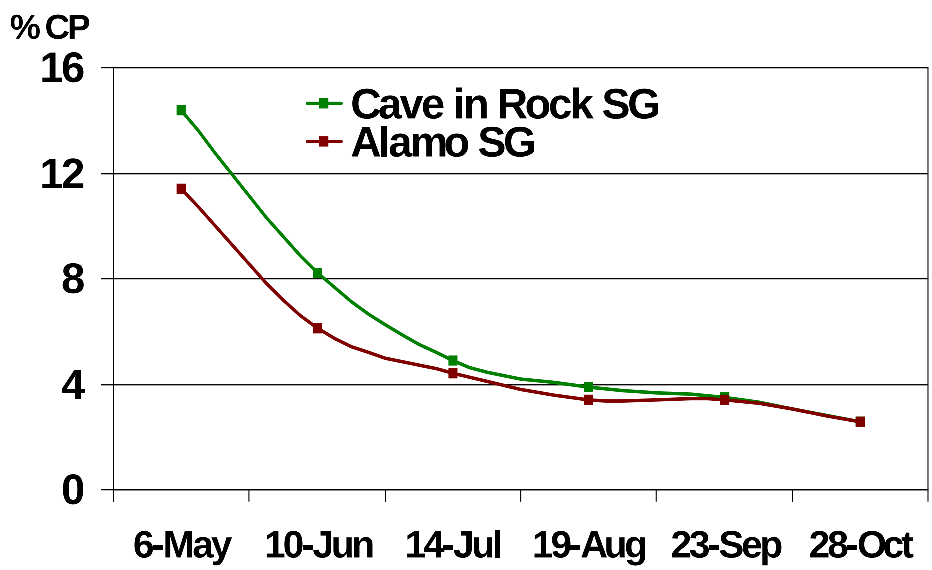
► The summer growth of switchgrass also makes switchgrass an excellent forage for grazing. Since most cattle operations in the mid-South use tall fescue as their primary pasture grass, there is limited forage production during summer. This limited production reduces the performance of grazing cattle, and may lead to overgrazing and weakened stands of tall fescue. Switchgrass can provide good quality forage for grazing animals and provide the opportunity to rest tall fescue pastures during a stressful time of the year.

Research has shown switchgrass can be grown successfully as both a biofuel and forage crop. There is no need, however, to grow it as only one or the other. There is the possibility of having switchgrass as a "dual purpose" crop. The early growth of the forage, which is generally the highest quality, can be hayed or grazed. The later growth can be allowed to mature and harvested after frost as a biomass crop. Biomass production will be lower under this scenario, but, depending on the objectives and needs of the producer, may be a useful strategy.

Keys to using switchgrass as a hay crop

Early-season production (late April – late May for switchgrass) produces the highest quality forage and can be easily diverted for hay. Crude protein levels could easily range from 14 - 20% at this time of the year. However, forage yields will be relatively low (e.g., 2 tons/ac depending on the timing of harvest). As with any hay crop, waiting a few weeks will increase yield and decrease quality (Fig 1.). The later the forage is harvested, the greater reduction in the final biofuel harvest for that season. Most biomass accumulation in switchgrass occurs in the first half of the growing season. In one southeastern study, 56% of annual biomass accumulation was obtained by late June each year. Obviously, delaying the forage harvest too late (past late boot stage) would also be counterproductive for forage production because of drop in forage quality in the maturing stand.

Figure 1. Crude protein changes with maturity in two switchgrass cultivars. (Sladden and co-workers. 1994. AFGC proceedings p. 242).



Unlike dormant-season harvests, these early forage harvests (haying or grazing) should leave a minimum 8-inch residual height to ensure rapid regrowth and an adequate final biofuels harvest. Producers must realize that leaving high residual heights is very important to quick recovery of the plant because of the elevated growing point on switchgrass (often > 5" above the soil surface) and the minimal leaf surface area present below 8 – 10". Removing the growing point and all leaves will result in delayed regrowth that will substantially reduce final yields and, in the long run, stand vigor.

Because biorefineries will require switchgrass on a year-round basis, producers would have the opportunity to sell switchgrass harvested for hay later as biofuels if they find they do not need as much as hay. While dormant-season harvested material is considered better quality for biofuels as a result of reduced mineral concentrations, there is no reason to believe mid-summer "hay" crops will not be acceptable for biofuels. Following guidelines for proper hay storage will help ensure the material will be valuable for hay or biofuels in the future.

Caution About Horses and Switchgrass Hay: While switchgrass hay has excellent value for beef and/or dairy cattle, as well as other livestock, there is evidence that horses fed switchgrass hay may have a phototoxic reaction. In short, horses may lose some hair and suffer sunburns. Although it is not common, this problem is something horse owners should be aware of. At this time, switchgrass is not recommended for horse hay.

Grazing Switchgrass

Because early-season switchgrass has good nutritive value for cattle, the material could be removed through controlled grazing rather than haying. Grazing, of course, requires adequate fencing, access to water and shade. Where this infrastructure is lacking, the investment may not be cost-effective, given the relatively short grazing season that would be available in an integrated system where a good deal of growth will be reserved for biofuels. On the other hand, temporary fencing and leaving gates open back to water on other pastures could be effective; this will be more effective later in the spring when the quality and production difference between cool-season grasses and switchgrass is more pronounced.

Because of the reasons given above under haying guidelines, it is important not to graze switchgrass it too closely. Leaving a residual stand height of at least 8 inches, and preferably as high as 12 inches, will result in more rapid regrowth and greater yields for biofuels at the end of the season. While most producers managing switchgrass strictly as a forage crop will practice rotational grazing to accommodate this growth, it is unnecessary when attempting to integrate grazing and biofuels production. That is because only 2 – 4 weeks of grazing should be planned, which would be a single rotation. Switchgrass could be grazed later into the season, but as with haying, increased consumption as a forage crop will reduce final biomass yields.

Initial entry into switchgrass in the spring should occur once the stand is 18 – 24 inches tall, typically mid-May. Stocking at lower rates or creep grazing calves will make it possible to begin sooner. Stocking rates of 3 – 5 steers/ac will probably be best under normal circumstances. This should allow enough animals to remove the available forage within a 2 – 4 week period, freeing up the remainder of the growing season for accumulation of biofuels. Experience will dictate how to adjust these stocking rates to achieve desired results. Keep in mind, during the establishment year, no grazing should be planned unless it is a brief period of high stocking to remove a weed canopy. During the second year of the stand, there will be production, but it will likely be only 50 – 70 percent of the stand's potential. It is important to not overgraze the stand this second year to enable the root system to fully develop. Such a system will ensure full production levels in future years and promote considerable stand longevity typical of switchgrass (> 15 years).

Fertilization of Switchgrass for Forage Production

Even though these grasses are adapted to poor soil fertility, in order to produce large amounts of high quality forage, adequate levels of potash, phosphate and nitrogen should be provided. Also, best production will occur when soil pH is kept above 6.0. This can be monitored through soil testing once every 2-3 years. Nitrogen should be only be applied to native grasses if soil moisture is not limiting, and if extra forage production is desired (Table 1).

Table 1. Nitrogen fertilization recommendations for switchgrass used for forage.

use	early summer	mid-summer
	---------------- *lb actual N per acre* ---------------	
hay *mid-summer application should be eliminated if soil moisture is limited	45-60	45-60
grazing * apply N only if extra forage growth is needed.	45-60	up to 60 lb N

Summary

Even though many people are currently focused on switchgrass as a biofuel, it should be kept in mind that switchgrass can also be used as a forage crop. High yields and good quality forage can be produced during summer, if it is managed correctly. If switchgrass is cut while it is young and leafy, the nutrient content will be equal to other grasses. If switchgrass is allowed to mature and become fibrous, forage quality will suffer drastically. Of course, the tendency of switchgrass to produce high amounts of fiber when mature is what makes it desirable for biofuel production.

It should also be kept in mind that this crop does not have to be used only for forage or only for biomass. It can be harvested as a dual purpose crop, so early growth can be used for forage, and later growth can be used for biomass. Haying early may reduce biomass production, but the ability to use some of the growth for cattle production will add flexibility to a producer's operation, and the opportunity to increase profitability.

UK Horse Pasture Evaluation Program: A Success Story

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Overview

Since 2001-2002 and the outbreak of Mare Reproductive Loss Syndrome (MLRS) the University of Kentucky has been developing stronger ties with the state's equine industry. Approximately 30% of the foal crop was lost in the Central Bluegrass region during this period with a devastating impact on the industry. Traditionally, many Thoroughbred farms have functioned as independent entities, but MLRS helped them to realize that the University of Kentucky had tremendous amount of expertise that they could provide in the areas of animal health, forage management, and other areas. Initially, there were many theories as to the cause of MLRS with tall fescue and other potential toxic plant species often mentioned. In the end, MLRS was found to be caused by the accidental ingestion of eastern tent caterpillars, but one of the positive outcomes was that farms realized the need to better understand the composition of their pastures.

Horse farms in the Central Kentucky are interested in UK's assistance with pasture evaluation. Although some farms rely on the expertise of their county agents or independent consultants, during the fall of 2005 a team from the UK Forage Extension Program conducted a pilot project to provide an extensive evaluation of horse pastures on 14 Central Kentucky farms. One of the focuses of the pilot project was the evaluation of pastures for percent tall fescue and the potential for stands with significant fescue to cause fescue toxicity in pregnant broodmares. In 2006 and 2007, the program was continued with tremendous success and now almost 50 farms have been enrolled in the program totaling almost 10,000 acres.

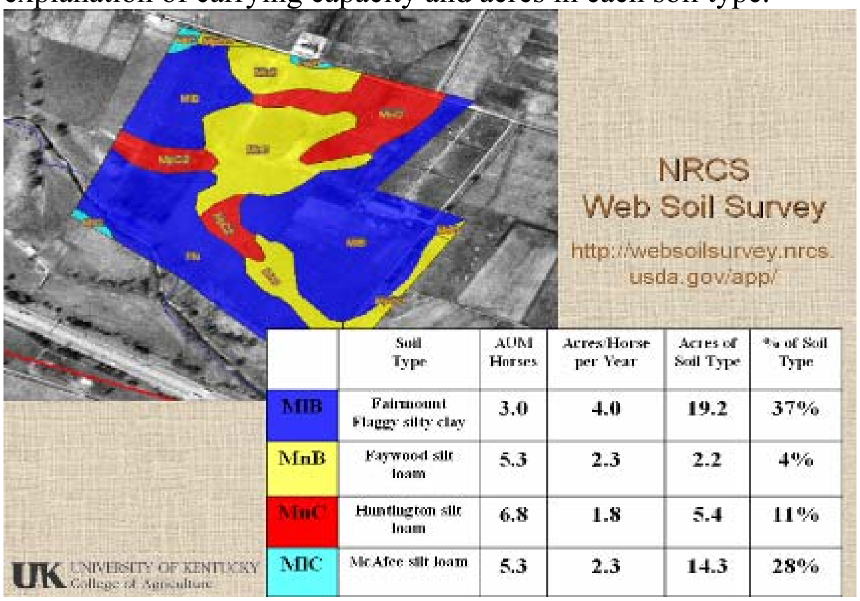
Evaluations from participants in the program have been very positive. Mike Owens, past president of the Kentucky Thoroughbred Farm Managers Club (KTFMC) and a program participant said, "UK's Pasture Evaluation project has proved to be a very useful tool in pasture management on the farm. The project identifies and gives the percentage of grasses and weeds in any given pasture, along with the ergovaline levels. Their identification and recommendations are presented in a professional package with a CD that makes for a quick reference tool." Another former KTFMC president, Steve Johnson, states that the "equine industry sorely needs the monitoring and consultation being provided with this service." Steve goes on to add that "It's very gratifying to know that UK is addressing the issues that are important on horse farms in Central Kentucky." A recent participant adds, "I cannot imagine having access to a program that will have as much overall impact on the quality of the horses that we are producing here in the Bluegrass. This program is long overdue!"

With the success of the program, we are offering an expanded pasture evaluation service to horse farms in the Central Bluegrass area in 2008. At the end of this paper an excerpt of the registration form provided to farm owners and managers is included.

Information Provided to Farms

After the pasture evaluation is completed, the program leader and coordinator sit down for 1 to 2 hours with the farm manager and/or owner and explain the data obtained from their farm evaluation. Each farm receives a notebook containing an overall farm map, a soils map taken from web soil survey, detailed species composition charts from each paddock (20 quadrat samples per paddock), photographs of all quadrat areas, individualized pasture management recommendations, additional publications, and other information on their farm. Since many horse farms do not have a strong agronomic background, a complete explanation of soil types and carrying has proved very useful (Figure 1).

Figure 1. Horse farm soil map taken from web soil survey with explanation of carrying capacity and acres in each soil type.



	Soil Type	AUM Horses	Acres/Horse per Year	Acres of Soil Type	% of Soil Type
MIB	Fairmount Flaggy silty clay	3.0	4.0	19.2	37%
MnB	Faywood silt loam	5.3	2.3	2.2	4%
MnC	Huntington silt loam	6.8	1.8	5.4	11%
MIC	McAfee silt loam	5.3	2.3	14.3	28%

Although there are many pages of data provided to each farm one of the most useful tables is the average species composition from the evaluated pastures, including the percentage of tall fescue, endophyte infection rate, and ergovaline levels at the time of sampling (Figure 2). Part of the discussion includes an explanation of tall fescue consumption by broodmares grazing mixed species pastures and the potential health risks during the last trimester. Microhistological analysis conducted by Morrison (2008) showed that tall fescue consumption is closely correlated with botanical composition in the pasture (Figure 3).

Figure 2. Average species composition, endophyte percentage, and ergovaline (ppb), from 47 horse farms evaluated in Central Kentucky during 2005-2007.

Tall Fescue	Blue Grass	Orchard Grass	White Clover	Weeds	Bare Soil	Ergovaline ppb	Endophyte Infection %
24	26	12	8	20	10	301	71

Amount of Available Forage = 70%

Amount of Tall Fescue in Forage = 34%

Ergovaline Conc. of Available Forage = 102 ppb

The results from each farm make up the majority of information presented, but some time is spent discussing the principles of pasture management based on research findings in other studies. A number of researchers have shown variation in ergovaline levels over the growing season, but most horse farm owners and managers are not aware of these findings. They are surprised to learn that ergovaline levels are low in Central Kentucky from December into early April (Bush and Long, unpublished data). Since the goal for Thoroughbred births is early January and the majority are born by early April, then there is a wide window of opportunity for safe late term gestation even on pastures with high percentages of tall fescue. The take home message is that tall fescue is a good cool season forage grass for pasture cover, non-pregnant mares and other classes of horses, but care should be taken when grazing broodmares on fescue pastures.

Figure 3. The percentage of tall fescue consumed by grazing broodmares compared to the percentage of tall fescue in the pastures based on microhistological analysis of fecal samples taken from mixed season grass species mixtures (Morrison, 2008).

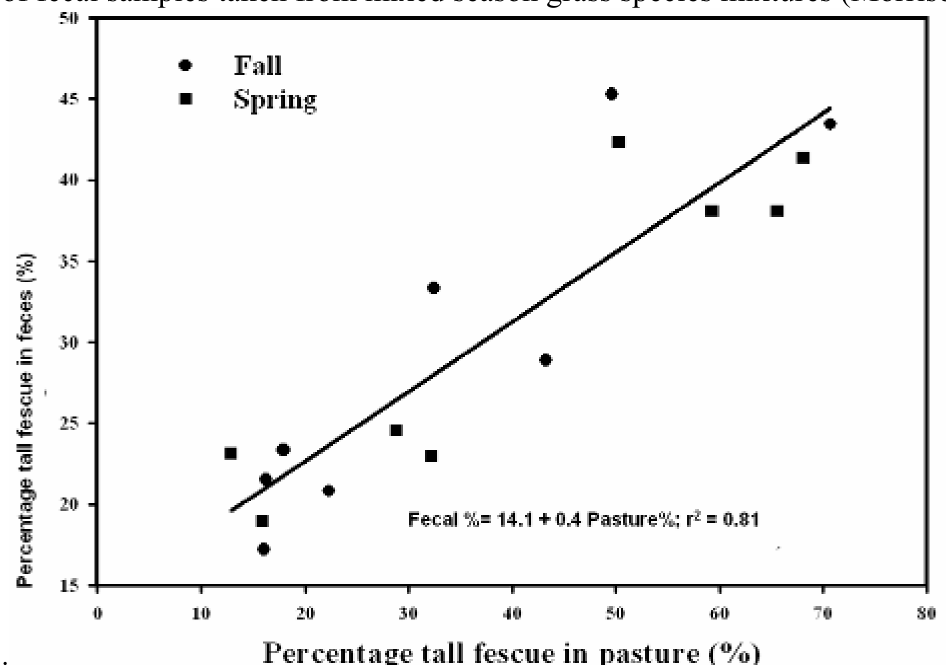


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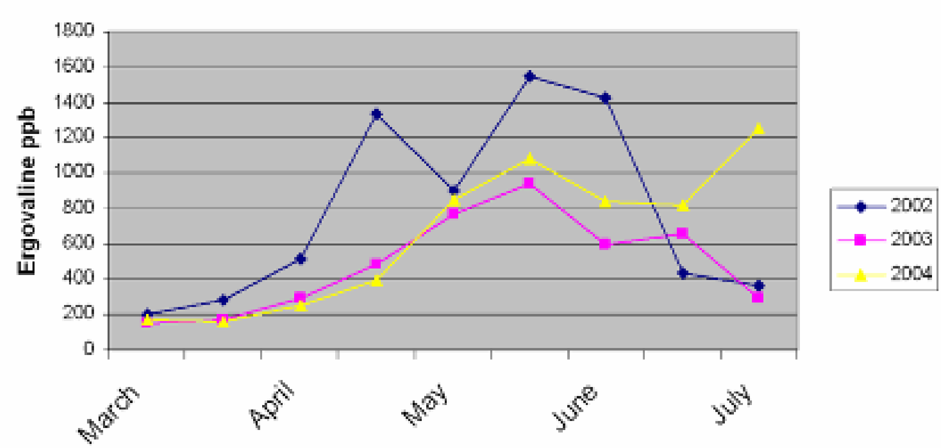
Figure 4. Ergovaline levels (ppb) from all farms monitored during the spring and summer of 2002-2004 (Bush and Long, unpublished data). Levels represent the average of the maximum levels from each farm.



Example of Recommendations to Farms

Fields 19, 26, 27
Weed Control
Most prominent weeds: Narrowleaf (Buckhorn) Plantain, Nimblewill and Dandelion.

We commend you on an excellent job of weed control in these fields. Field 19 had the most weeds at 15%, so spraying would be an option against narrowleaf plantain and dandelion. The most effective herbicides for these broadleaf weeds are Cimarron Max, 2,4-D, Crossbow, Redeem, and Forefront. See the herbicide charts (Green et al., 2007) for more details and costs of application.

There were several small patches of nimblewill in fields 19 and 26. Since there are not available herbicides for this weed, the only control method (without complete spraydown and replanting) is good pasture management to maximize competition of desirable grasses.

Seeding
Seeding recommendations are based on percent bare soil in fields and since these field were between **10-25% bare soil** Seeding is an option (Field 19 -13%, Field 26 – 14%, and Field 27 – 11%. Since each of these fields contains more than 20% bluegrass, there is a good chance that it will fill in and provide a good cover.

Fertility
Soil test these pastures every 3 years, submit the samples to your local county agent, and apply recommended levels of lime, phosphorus, potassium, and micronutrients. We recommend Nitrogen should only be applied in the fall at rates not to exceed 40 – 60 lbs of actual nitrogen per acre. See page 6 of these recommendations or the "Fall Nitrogen Fertilization of Horse Pastures" publication at the end of this notebook.

Sample Registration Information for Horse Pasture Evaluation Program

Overview

The University of Kentucky is developing stronger ties with the state's equine industry in the areas of research, extension and teaching. Many horse farms in the Bluegrass Region are interested in UK's assistance with pasture evaluation and we are continuing to offer our pasture evaluation program to horse farm in the region during 2008. Please read through the options below. If interested in this year's program, please complete and submit the attached information form; farms will be contacted in the order in which we receive the forms. We look forward to the program this year, and plan to continue expanding the number of farms and services in coming years.

Farm Enrollment:

Simply fill out the enclosed enrollment form and fax or mail it to Dr. Ray Smith. You may also email the requested information to tom.keene@uky.edu. If you have any questions on the program call Tom Keene at 859-257-3144 or Dr. Ray Smith at 859-257-3358 or visit the U.K. Forage Website at http://www.uky.edu/Ag/Forage/HorseLinks.htm. We will first make an initial visit to your farm to explain the complete details of the evaluation program before the actual sampling date. The basic evaluation service ***includes up to 6 paddocks per farm, but no more than 80 acres*** (for example, if all of your paddocks are 25 acres in size we could only sample 3 paddocks). See the following pages for additional options. For farms ***less than 20 acres***, feel free to contact the program coordinator for alternate pricing.

Basic Service: 6 paddocks or 80 acres (as described above): $750

- Assessment of pasture species composition
    - Tall fescue
    - KY Bluegrass
    - Orchardgrass
    - Clover
    - Weeds
    - Bare Soil
- Percent of tall fescue plants infected with fungal endophyte
- Concentration of ergovaline (toxin) in tall fescue at date of sampling
- Estimate of ergovaline intake for horses grazing each paddock
- Comprehensive soil map of entire farm
    - Carrying capacity based on each soil type present on farm
    - Recommended acres per horse per year for each soil type present on farm
    - Explanation of soils on farm with total acres of each type
- We will link you with your county agent to provide consultation for soil sampling and analysis.
- Satellite photo of your farm
- GPS map of each sampled field, useful for tracking improvements in pasture management
- Printed digital photographs of individual pasture areas sampled
- "Pasture and Paddock Action Log" for keeping records in each field
- General guidelines on management of pastures, including options for: weed control, soil fertility, grazing management, pasture renovation and reestablishment, grass species and variety choices, tall fescue management, interpreting ergovaline levels, and options for removal of tall fescue from Central Kentucky pastures

- CD ROM containing all data, photographs, analysis, and an electronic version of "Pasture and Paddock action Log" in Microsoft Excel
- Complete set of University of Kentucky extension publications related to horse pastures and selected national and international publications
- *Survey* of the evaluation of your farm. Your input, suggestions and ideas are vital for our program as we try to make it as beneficial as possible and expand services in coming years.

Final delivery of comprehensive report issued to each farm:
We will have a personal follow-up consultation, lasting about one hour, with forage experts from UK to interpret and explain all of the information gathered for your farm. This will be an opportunity to discuss your farm's pasture management in detail, and ask any questions concerning your farm.

Additional options:
- Pilot Study Measuring Ascarid Egg Contamination Optional pilot study. If preliminary research is successful, we will collect soil and plant samples from one pasture, examine ascarid egg contamination microscopically, and report any concerns and recommendations for that pasture. No charge this year for the pilot study.
- Whole farm service or additional fields If you would like more than 6 fields or 80 acres sampled, we will do so for $10 per acre.
- Follow-up ergovaline measurements We will re-sample your fields at a later date and report the ergovaline levels. Cost: $75 for each field sampled.

References

Morrison, J.I. 2008. Using Microhistological Techniques to Predict Botanical Composition of Horse Diets on Central Kentucky Cool-Season Grass Pasture. MSc. Thesis, University of Kentucky.

Smith, S.R. and T.C. Keene. 2008. Fescue Toxicity for Horses: Historical Overview and Kentucky's Successful Pasture Evaluation Program. *In* Proceedings of the Amer. Forage and Grassland Council and Society for Range Management Annual Meeting. 26-31 Jan. 2008. Louisville, KY. Amer. Forage and Grassland Council. Chicago, IL.

Green, J.D., W.W. Witt, and J.R. Martin. 2007. Weed management in grass pastures, hayfields, and other farmstead sites. UK Agricultural Experiment Station Publication AGR-172. www.ext.edu/Ag/Forage/Publications/AGR-172.pdf

Role of the Extension Service in Addressing Needs of Hispanic Farmers

Rocky Lemus
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The number of Hispanic farmers and ranchers are increasing in the southeastern US (Texas, Arkansas, Tennessee, Kentucky, Louisiana, Mississippi, Alabama, Georgia, Florida, North Carolina, and South Carolina). They are the largest and fastest growing farmer minority group in the United States because they are in a transition from "farm work to farm ownership." In many of these states, agriculture is the sole source of income for most Hispanic residents. About 40% of the cattle farms (beef and dairy) in the Southeast are operated by Hispanic owners (USDA, 2000). Today, this community's agricultural survival is threatened, in part due to a lack of information of where to find outreach support and cooperation from the Extension service, USDA agencies, and community-based agricultural organizations.

Educating Hispanic farmers about information and services that are available through their local Extension service is one of the major obstacles to overcome. This is especially true when they are new immigrants and they are not familiar with the information and services that Extension could provide to them. Other possible barriers such as limited English language skills, possibly, cultural barriers to seeking assistance and illiteracy may keep some Hispanic farmers from seeking out and participating in Extension programs. It can be challenging for Extension agents to demonstrate the need for such programs in their counties if they are not able to identify potential participants. Obviously this can lead to low numbers of participants in programs that could support and assist this target audience. Including more of these producers in the county mailing lists would help the county Extension faculty to reach out and interact more closely with the clientele and integrate them into some of the programs and newsletters they offer. When Extension agents view cultural differences as an opportunity, they are more likely to find ways to reach and work with varied groups.

The Extension service has worked with Hispanic farmers in the Southeast in many ways over the years. For example, Texas and Florida have developed educational curricula, translated materials, hosted Spanish language radio programs, and created videotapes in Spanish to better serve their clientele. The extent of this programming varies from state to state, depending on the population and training of the Extension agents and specialists. Other important factors to consider when working with Hispanic farmers are to identify the subgroups to be served (Cubans, Mexicans, and South or Central Americans, etc.) to provide appropriate outreach and assistance to these groups.

The development of an educational network system between the University's Cooperative Extension Service and the different states is necessary to provide outreach assistance to minority farm and ranch producers. An excellent resource for Extension personnel who work with Hispanic farmers could be web pages that could be linked institutionally to webpages by each state's Extension Web site dedicated to providing information in Spanish and written by Extension specialists from across the Southeast. These webpages could be a great asset for serving this minority group since the Southeast is fortunate to have a number of specialists who are bilingual and can aid in this task. The recruitment of volunteer leaders in the different Hispanic communities also could be an important tool to disseminate information about Extension education programs. Interaction with high schools and community colleges that are engaged in agricultural production is another way to consider reaching out into the Hispanic communities.

Some of the ways that the Extension service could increase Hispanic involvement in agricultural programs include the following strategies:

1. Develop a mailing list of Hispanics in the area and invite them to participate in other Extension programs.
2. Translate flyers and registration materials about field days into Spanish to increase attendance.
3. Know which Hispanic subgroup and commodity groups Extension agents are working with to provide the necessary information.
4. Organize focus groups with Hispanic farmers to determine topics for future programs.
5. Place a Hispanic representative on the Extension Advisory Committee to make producers aware of the efforts Extension specialists are involved across the southeast.
6. Extension specialists could conduct diversity training with staff members in an effort to broaden their knowledge and involve them in more programming with Hispanic clientele.
7. Ask professionals who speak Spanish to present training sessions. There might be professionals across some states at other universities that will be willing to network, providing more services to the Hispanic clientele.

Summary

Agricultural training is needed by the growing Hispanic farmer population. Extension agents need to understand cultural and language barriers in order to develop effective training programs that will empower Hispanic farmers and provide them with the skills to function in the agricultural business. Providing basic agricultural and business education to farmers and ranchers will guide them to acquire the knowledge and skills necessary to successfully operate their farm and business enterprises. It is important to make sure that Hispanic farmers view the Extension service as a user-friendly agency that meets their agricultural needs.

References

NRCS, 2007. Natural Resources Conservation Service (NRCS) Support for Hispanics in Agriculture. http://www.economics.nrcs.usda.gov/technical/hispanics/

U.S. Department of Agriculture. 2000. *Quick facts. Characteristics of Hispanic farm operators*. National Agricultural Statistics Service and Secretary's Hispanic Advisory Council.

Brandsberg, G. T. 1991. How Extension is serving Spanish- speaking clients in the United States. Paper presented at the National Extension Technology Conference, Hershey, PA.

EXTENSION FORAGE SPECIALIST LESSONS AND OBSERVATIONS

Don Ball
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It has been said that, "The only constant is change," and also, "The more things change, the more they stay the same." There is some truth in each of these statements. In the 32 years I have worked as Extension Forage Crop Agronomist at Auburn University, many things have indeed changed, while others have stayed the same (or nearly so).

During the past 5 to 10 years there have probably been more personnel changes in Extension Forage Specialist positions in the Southeast than occurred in 25 years before that. In view of this, I was asked to reflect on some things I have observed and learned during my career, the idea being that this might be of interest and value to some of the younger extension forage workers (including County and Regional Agents). I agreed to do so, but there is a great deal of subjectivity in such an exercise. Thus, the topics I choose to mention and some of the statements I will make regarding my impressions and attitudes might differ considerably from those someone else might provide.

Forage/Livestock Situation

Livestock production is in some ways similar to what it was in 1976, but different in other ways. The total number of beef cows on farms within the state has declined by about 35% as pine trees, urban sprawl, rural home sites, etc. have displaced pastures and cattle in many areas. As was the case 32 years ago, the average beef cattle herd in Alabama is between 25 and 30 animals, but we have more people who own livestock on what might be termed "hobby farms." Most livestock producers, both then and now, either have off-farm sources of income or have diversified farming operations.

Beef cow/calf production is still overwhelmingly the most common type of livestock enterprise. Stocker cattle production, which thirty years ago we thought was likely to greatly increase, has declined as far as the number of animals in stocker programs, although the average stocker operator now runs more animals. Despite there being increased interest in grassfed animal products recently, beef finishing is still a very small part of the picture in terms of overall income for beef producers.

Milk production per dairy cow has increased by about 65%, but today there are less than one-fourth as many dairy operations in Alabama and about one-seventh as many dairy cows (though at present the outlook for irrigated grazing-oriented dairies seems bright in the Southeast). The number of horses in the state is estimated to be about the same as in 1976. We still have almost no sheep, but meat goat numbers have increased dramatically, and will probably continue to increase in the future.

During the past 32 years there has been substantial scientific and technological progress, including the development, release, and commercial availability of numerous improved forage cultivars. In the 1970's there were relatively few no-tillage drills on farms, but many producers now own or have access to such equipment, and no-till planting of forage crops is common. Numerous new herbicides have been developed that facilitate control of various weeds in pastures and hayfields. Near infrared reflectance spectroscopy (NIRS) has made it easier and cheaper to assess forage nutritional value in samples associated with research studies as well as producer-submitted samples.

Probably the single most important scientific development pertaining to forage/livestock production during my career has been the knowledge and insights and production strategies that have resulted from tall fescue endophyte work. While contributions have been made by workers in many disciplines, in many states, and in numerous countries, much of this important work has been done by people involved with the Southern Pasture and Forage Crop Improvement Conference (SPFCIC).

Method Of Operation Of Extension Workers

In the 1970's, most Extension Forage Specialists had 100% extension appointments. However, most Specialists hired in recent years have split appointments. Thus, more applied research is being done by Extension Specialists than used to be the case (County and Regional Agents are also more often involved in applied research today). Along with this trend has come increased pressure to seek funding for research.

Technology has impacted greatly on day-to-day extension work. This includes use of cell phones, voice mail, and fax machines. But the most dramatic and important development is widespread use of computers, including laptops that many extension workers take virtually everywhere, and availability of the internet. Most extension workers use this tool to both receive and disseminate a great deal of information, and spend many hours each week reading and responding to e-mail messages. Power Point presentations and LCD projectors have made slides and slide projectors obsolete.

The number of people doing forage research and extension work has declined during the past three decades. This has made it essential that there be more dissemination of forage information via non-face-to-face methods. Distance learning equipment is used widely, and much forage information is provided via web sites. The number of students taking forage courses has declined, but there is a definite trend in extension to offer more intensive training sessions to producers. The membership of, and the numbers of people participating in, forage-oriented organizations has declined, SPFCIC being one of them.

There are fewer county-level, but more multi-county extension meetings held today, and many extension workers now attend more Experiment Station field days, statewide commodity meetings, and industry events of various types. Overall travel requirements may have declined slightly for some extension forage workers (though it has increased for others), but position-related travel funding by universities and extension organizations is generally much less than it used to be, or is even non-existent.

Extension Programming

A development during my career is that several states now offer grazing schools or other programs that provide in-depth training on grazing management. One reason is that many producers are more concerned about the cost of stored feed, and thus are interested in extending grazing. This is probably a direct result of the efforts of many extension workers who have recognized that this is a key to profitability in livestock production. One strategy for lowering hay requirements is to minimize hay storage and feeding losses, another area that has been a focus of extension programs in many states.

In the 1970's, most producers recognized the value of forage legumes, but many were not willing to expend much effort to grow them. Evidence that circumstances can greatly influence attitudes in a relatively short period of time has been demonstrated in just the past three years or so, mainly as a result of skyrocketing fertilizer costs. Today there is more interest in forage legumes than I have seen before in my career. Producers are also seeking other means of lowering their fertilizer costs where possible.

Forage quality and forage testing have been a focus of extension workers in the Southern region during the past 30 years, but despite the advent of NIRS testing, progress in this area has been slow. However, efforts such as the Southeastern Hay Contest and hay shows (local, area, and statewide) are beneficial.

A few topics that were rarely mentioned in the mid-1970's now get a significant amount of attention by extension forage workers. Some Southern Region extension workers at the state, area, or county level spend a substantial amount of time advising wildlife enthusiasts on planting forage crops in wildlife food plots. Concern about the environment has increased greatly, and the role of forages in issues such as disposal of organic wastes or erosion control is discussed more frequently.

The demographics of extension clientele has changed and continues to change, which has also impacted on extension programming. Given the large number of people who have moved from urban areas to live on small acreages, several states have initiated educational programs to meet their unique educational needs. Some extension programs are now oriented toward Spanish-speaking people.

Lessons Learned

I have saved until last the "Lessons Learned" portion of this paper. To a young extension worker this could potentially be the most important part. It is also the part that probably is most subjective and thus is most subject to criticism and/or to being misunderstood. Many of the statements I will make are simply common sense. A number of them are not unique to extension work. I probably would have agreed with most or all of them on the first day I was on the job. However, through the years I have had experiences (or observed experiences of others) that have made me realize just how true and important they really are. Therefore, I feel strongly that they are worthy of mention.

*Throughout my career I have heard the statement, "People don't care how much you know until they know how much you care." I have observed that people really can sense very quickly (even over the phone) how concerned you are about helping them. The lesson here is that one's tone, demeanor, and approach have a huge effect on how well a message is received. In particular, anyone who "talks down" to people or tries to impress them with how smart they are will largely nullify the value of information they present.

*Within reason, an extension worker should strive to treat all clients with equal respect. Regardless of the size or economic impact of an operation, the concerns a producer has are important to him or her. I think it is also worthwhile to mention that I have learned that profit is not the only (and surprisingly often not even the primary) motivating factor for many livestock producers, especially beef producers.

*It is helpful to critically assess your personal strong and weak points. Don't kid yourself on this. When possible, one should choose to do the things he or she does best.

*You can get more done working with other people than you can get done working alone. People stimulate ideas in each other, and they are more likely to stay motivated when others are depending on them. Also, working together facilitates various people having the opportunity to focus on tasks they can do well.

*To the extent possible, one should strive to work and associate as frequently as possible with the best and most productive people at one's location or within one's organization and profession.

*Professional success requires lots of work, but there is a limit to how much you can do. Learning to prioritize effectively is one of the most valuable skills an extension worker can develop. Learning to tactfully say "no" is another. There is a fine line between outstanding and laudable professional commitment and insane workaholism. If a good honest effort has been made, one should not feel badly about what didn't get done.

*Enthusiasm for, and a sense of excitement associated with, a project go a long way toward it being successfully achieved. If you are able to view a task as fun, it is much more likely to turn out well.

*Staying organized is a never-ending struggle, but is worth the effort. As one example, maintaining a good filing system in which articles and publications on various topics can be readily accessed will pay off.

*If you don't know the answer, say so. People realize that you can't know everything. Being able to find an answer quickly (see example above) is almost as good as knowing the answer.

*Professional visibility is important in an extension position. There is a strong correlation between visibility and perceived credibility.

*You get paid for doing a job, not for putting in hours. If you can find a more effective way to get the job done in some unorthodox way, do it.

*A picture (image) sometimes can be worth a thousand words, so it makes sense for an extension worker to carry a camera whenever he or she leaves the office to visit a farm or Experiment Station. If a good shot is available, it is important to take the time to get it.

*Credit from a successful project can be divided an infinite number of times without diminishing the value. If someone deserves credit, they should be given credit. Failure to give credit where it's due decreases the likelihood of future cooperation.

*Anytime some educational product is developed, one should consider whether it might be used in another way. Any product developed should be saved as it may be useful later.

*One should never put someone's name on a paper or other product (regardless of how certain one is that they wouldn't mind) without getting their approval.

*Before criticizing a commercial product one should have data to back up the statements.

*With regard to interaction with other people, you tend to get back what you give out. This is an argument for being positive, polite, and cooperative.

*Technicians, secretaries, and other support personnel are generally the people who actually get things done. It isn't smart to treat them badly.

*Being against an idea or approach tends to make people mad and is not conducive to progress or cooperation. However, stating that you like two or more ideas or approaches but favoring one more than another is rarely a problem.

*Consider whether criticism is valid and if not, don't take it too seriously. Some people who feel their poor performance is becoming too obvious in comparison to others try to remedy this by criticizing those who outperform them.

Conclusion

Based on what I have observed during my career, I think it is likely that during the next 32 years some things will change a great deal and others will change very little (but predicting which things will change is tough). There will likely be many scientific advances, there will be technological changes that will radically affect the way extension workers do their jobs, and there will be important changes in producer demographics and expectations that will necessitate changes in the areas of focus of extension workers. ***However, the statements included in the "Lessons Learned" section of this paper were true in 1976, they are true today, and I expect they will be equally true in 2040.***

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Forage Ecology/Physiology Work Group

Plant Growth promoting rhizobacteria as inoculants for cereals: recent developments and future prospects

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Achieving sustainable agriculture is a current challenge in modern agriculture in order to meet the increasing worldwide demands for food while minimizing the long-term impact on the environment. Since their introduction in farming practices in the early to mid 20th century, chemical fertilizers have been responsible for a constant increase in crop production. However, the low cost of these chemicals have led to their widespread excessive use leading to several adverse effects including persistence of recalcitrant pesticides in the soil, decreased soil biodiversity and groundwater pollution. In developed countries, the rising costs of petroleum-derived products together with the social demand for environmentally-friendly agricultural practices have stimulated research for alternative solutions. Beneficial microorganisms (bacteria and fungi), that are natural soil inhabitants, have been used as biofertilizers for improving soil fertility and crop production.

Plant-growth promoting rhizobacteria, so called PGPR, that form beneficial associations with the roots of a variety of crops represent such a promising alternative. The rhizosphere, which corresponds to a region in the soil in contact with the roots (and under the influence of the root exudates) harbors a very active community of microorganisms. Microorganisms present in this environment include some that have beneficial effects on plant growth via their activity on the roots. An overview of how beneficial microorganisms are currently used to promoter plant growth and crop production will be presented and the different mechanisms involved in plant growth promotion will also be briefly discussed.

Bacteria of the genus *Azospirillum* are free-living nitrogen-fixing bacteria that are found in association with the roots of cereals and grasses including important crops such as corn, sorghum, rice or wheat. These bacteria have been found to exert beneficial effects on plant growth and yield of many important crops with positive effects ranging from 5 to 30% yield increase in 60% to 70% of the reported experimental sites. Several biofertilizer-containing *Azospirillum* spp. are commercially available worldwide. This presentation will describe examples of the use of *Azospirillum*-containing bioinoculant in long-term field experiments. In addition, this presentation will also include recent field data obtained with a bioinoculant containing a combination of beneficial microorganisms in rice in Vietnam.
Finally, current challenges and issues to be resolved in the field of bioinoculant and biofertilizer production will be discussed.

Applications of *Rhizobium* in Forage Pastures Down Under: New Approaches to Legume Inoculation

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The annual value of biological N_2 fixation to Australia's pastoral industries has been estimated as worth $AUD2-3 billion in N-fertilizer cost equivalents from moderately productive land, often limited by lack of reliable rainfall. This figure is increasing rapidly as the price of oil and N and P fertilisers rise. This value is built on long conducted practices in the past century of applying appropriate rhizobia produced in peat cultures with pasture legumes such as subterranean clover, medics, serradella and newer legume species such as *Biserrula* (Deaker et al. 2004) To a large extent, the application of superphosphate with certain trace elements including molybdenum was an essential ingredient for this success, but some unwanted consequences of better N supply in soils such as acidification as a result of nitrate leaching has occurred in winter rainfall areas.

In recent years several new approaches in the application of legumes have been attempted, to help overcome problems that have limited forage production, either because of poor survival of rhizobia after application to seed, poor survival of rhizobia in soil and inadequate pasture legume species, particularly in tropical Queensland. These new approaches include:

- Variation in methods of inoculation, using liquid or granulated inoculants that can be applied more readily by farm machinery than by using the more laborious coating of seed with peat cultures with sticking agents
- The demonstration that synthetic polymers controlling the rate of wetting or drying of *Rhizobium* cultures can significantly improve the survival rate of bacteria coated on seed
- The development of integrated systems for tropical legume forage pastures, with documented live weight gains as feedback for free range livestock, validating and allowing improvement of the effectiveness of particular farming practices and better use of biodiversity.

In this presentation, some details associated with laboratory and field research in these areas will be presented for discussion. While much of this experience may be specific to Australian conditions, there are some lessons that can be applied more broadly for the benefit of forage pasture production worldwide.

Deaker, R., Roughley, R.J. and Kennedy, I.R. (2005) A review of legume-seed inoculation technology. *Soil Biol. Biochem.* 36, 1275-1288.