Eastern Gamagrass

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PREFACE

The Plant Materials Program of the USDA-Natural Resources Conservation Service (NRCS) has spent a considerable amount of time and effort in collecting, evaluating and selecting genotypes of eastern gamagrass [*Tripsacum dactyloides* L. (L.)] for various conservation use. Because of the natural range of occurrence of this grass, much of the current research has been concentrated at plant materials centers (PMC) in the southern U.S. These Plant Materials Centers include Brooksville, Florida; Americus, Georgia; Coffeeville, Mississippi; Booneville, Arkansas; Nacogdoches and Knox City, Texas.

This publication contains studies that address essential issues relevant to the cultivation and production of eastern gamagrass and its use for livestock forage, erosion control and other conservation uses. The Eastern Gamagrass Technology Update was developed as a technology transfer tool to provide information to our partners.

Cover Photo: Eastern gamagrass hay production on a farm near Como, Mississippi.

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Seasonal Seed Ripening of Florida Native Eastern Gamagrass

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INTRODUCTION

The Brooksville, Florida Plant Materials Center has been working to develop superior native strains of eastern gamagrass [*Tripsacum dactyloides* (L.) L.] for range and pasture improvement, as well as buffer and wildlife use. Viable seed production was included in the selection criteria, since direct seeding is the most economical method of establishment. A study was implemented to identify those accessions that produce the highest quantity of viable seed. Although it had not been one of the original objectives, the period of highest viable seed production for the selected accessions was also determined in this study. No work of this nature had been documented, especially as it relates to Florida ecotypes.

PROCEDURE

In 1996, an assembly of eastern gamagrass established at the PMC was initially screened for viable seed production and other desirable traits. Nine accessions were selected for further testing. Study protocol was developed through consultation with Chet Dewald, Research Agronomist at the USDA ARS in Woodward, OK. Dewald recommended that ripe seed be collected every 7 to 10 days during the flowering and seed set period. Ripe seed is dark bronze to brown in color, and separates easily from other spikelets. Gamagrass seed typically ripens from the top down. Once the upper tassel (male spikelets) mature and shatter, the lower female spikelets (fruitcases) begin ripening in succession. Mature seed shatters easily. Seed was hand collected in June through August 1996 and 1997. Collected seed was immediately stored in a cooler at approximately 45^{o} C and 45% humidity for several weeks. The number of seed gathered from each plot at each collection date was recorded. Viability was determined by dissecting the fruitcase to determine the presence or absence of a healthy caryopsis. One hundred seed were dissected in each sample if they were available.

Selected accessions were located on two diverse sites at the PMC. Both sites are composed of sandy coarse soils, however, the first site is well drained, and tends to be droughty and infertile. Supplemental irrigation was applied at bare subsistence rates. The second site is poorly drained with the water table being within six inches of the soil surface during the growing season. Fertility is also much higher on this site. Plots were replicated two times per site. Plot size was used to determine production per acre.

CONCLUSIONS

The eastern gamagrass accessions used in this study varied in ploidy level. Two of the accessions (9059264 and 9059283) are triploid; five (9059213, 9059215, 9059266, 9059287, 9059338) are tetraploid, 2n=4x=72; and the ploidy level of one accession (9059286) is unknown. However, based on the size of seed, it is most likely a tetraploid. Chet Dewald and his staff performed the chromosome counts. Seed from two additional accessions (9056069 and 9059278) was collected in 1997 only. Both accessions are diploid, 2n=2x=36. It was observed that diploid strains produce smaller seeds than strains with multiple ploidy levels.

Flowering generally began in May and tapered off in August. Most seed ripened between mid June and late August. Seed weight varied between accessions and between collection date (Table 1). Lower viability would be expected to decrease seed weight. However, initial seed stalks were observed to have two or more rachis, while seed stalks ripening later in the season (mid July) tended to have only a single rachis. Seeds from a multiple rachis tended to be smaller in size and weight than those coming from a single rachis. For example, seed collected from 9059213 on 6/28 with a purity of 52%, weighed 10.86 g/100 seed, while seed collected on 8/20 with a purity of 55% weighed 15.84 g/100 seed. The added weight was most likely due to larger fruitcases with heavier walls. At highest purity in 1996 on the wet site, a pound of 9059213 contained 2,638 seed; 9059264 contained 4,239 seed; 9059266 contained 3,380; and 9059287 contained 2,885 seed. Ahring and Frank (1968) reported a pound of pure seed used in their experiments contained 5928 to 6387 seed. It is possible they were using diploid strains for their work, since diploids tend to produce smaller seeds. Number of seed per pound varied widely between 1996 and 1997 and between sites, but never approached the amounts reported by Ahring and Frank (1968). Since initial seed viability is lower than that obtained later in the season, it would be interesting to explore whether clipping off the first seed stalks would increase the viability of the later maturing seed stalks. Early clipping would allow the plant to save reserves for later seed production.

Table 1. Weight per 100 seed of four eastern gamagrass accessions collected from a wet site in 1996.

Accession		1996 Collection Date								
		6/21	6/28	7/5	7/15	7/24	8/2	8/9	8/20	8/29
9059213	100 Sd. Wt. (g)	8.29	10.86	14.43	14.84	15.89	17.21	16.07	15.84	16.04
	% Viable	30	52	63	72	74	80	31	55	39
9059264	100 Sd. Wt. (g)	0.00	7.55	10.26	10.71	13.13	13.78	13.92	14.79	12.99
	% Viable		51	63	68	40	49	39	36	31
9059266	100 Sd. Wt. (g)	0.00	0.00	16.67	13.43	15.56	13.75	13.45	14.21	12.96
	% Viable			58	81	78	58	56	40	16
9059287	100 Sd. Wt. (g)	4.76	8.82	12.96	13.95	13.85	15.74	14.05	13.60	13.40
	% Viable	0	68	72	23	75	83	58	44	36

The date of peak viable seed production for eight accessions collected from both sites in 1996 and 1997 is shown in Figure 1. For most accessions, peak production fell between 7/23 and 8/11 both years. Number of viable seed was used rather than pounds, because of differences in seed weight and purity. The two diploid accessions collected in 1997 had peak production between 6/16 and 6/26.

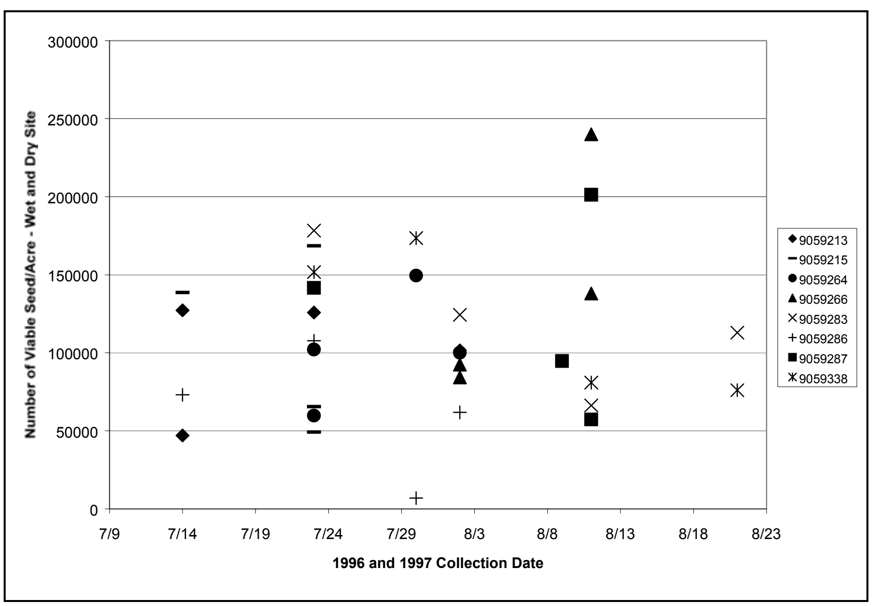

Figure 1. Peak number of viable seed produced per acre by eight accessions in 1996 and 1997 on a wet and dry site.

Figures 2 through 5 show viable seed produced per acre for the four highest producing accessions in the study. Even though viable seed was being produced as early as mid June, production typically rose sharply after July 1, and fell sharply after August 15. Early in the season, seed was observed to come ripe one at a time on the raceme. However, at the time of peak production, several seeds would ripen simultaneously on all four accessions. Accession 9059213 tended to mature the earliest of the four accessions with peak production occurring before August 1. The other three accessions tended to experience peak production on August 1 or later. Further studies need to be conducted to determine the influence of fertility and precipitation on seed production. It would also be interesting to explore whether harvesting seed twice (e.g. July 15 and August 15) would increase yields over harvesting once around August 1.

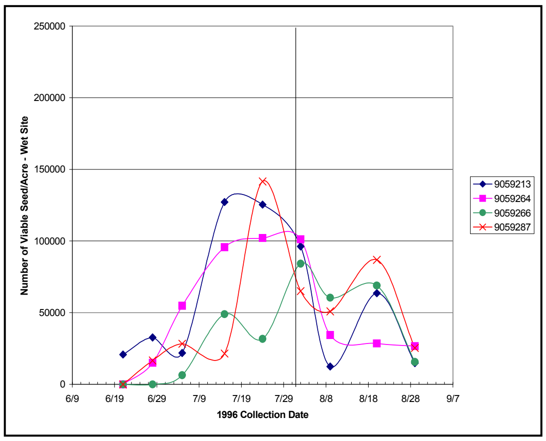

Figure 2. Number of viable seed produced by four accessions in 1996 on a wet site.

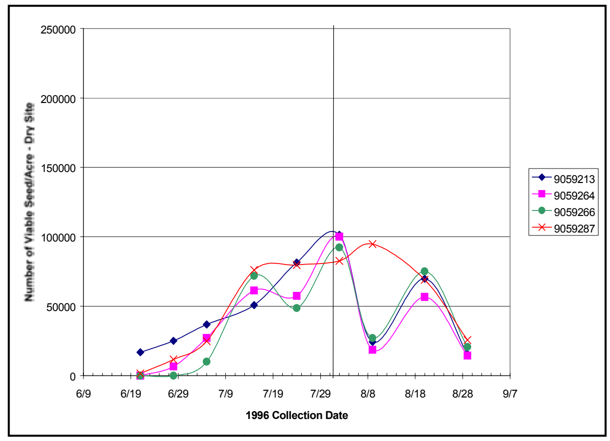

Figure 3. Number of viable seed produced by four accessions in 1996 on a dry site.

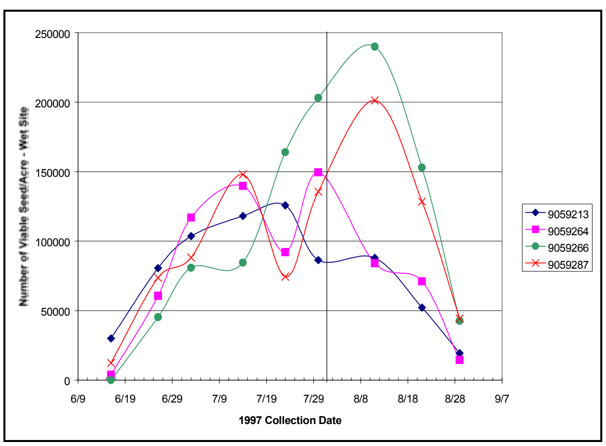

Figure 4. Number of viable seed produced by four accessions in 1997 on a wet site.

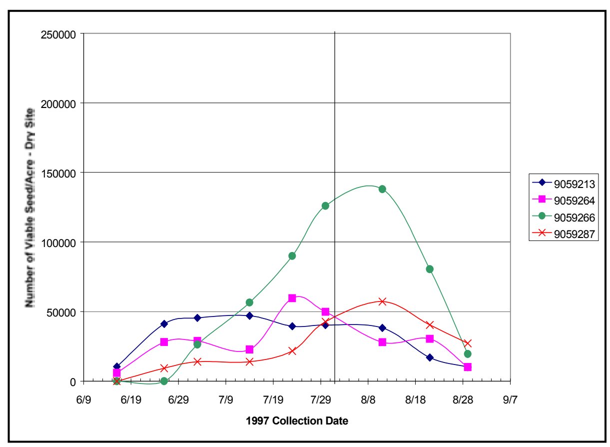

Figure 5. Number of viable seed produced by four accessions in 1997 on a dry site.

APPLICATION

The four Florida accessions with the highest viable seed production were identified in this study. Although eastern gamagrass produces viable seed over a period of two months, it was discovered that peak production for most accessions generally occurred within 15 days of August 1. This information will allow seed producers to time harvests to obtain the maximum amount of viable seed.

FUTURE RESEARCH NEEDS

The four superior accessions of eastern gamagrass selected in this study need to undergo advanced evaluation on multiple sites, to determine performance and adaptation to a variety of conditions. More information is needed to obtain maximum viable seed production from stands of eastern gamagrass, including:

- Determine the role of fertility and soil moisture in viable seed production
- Determine the role of fertility and soil moisture on the date of peak viable seed production
- Study the effect of suppressing early seedhead production on later viability
- Determine whether clipping July 15 and Aug. 15 would produce higher yields than a single clipping at the time of peak production.

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Evaluation of Hot Water Treatments to Overcome Dormancy of Eastern Gamagrass Seeds

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INTRODUCTION

Eastern gamagrass [*Tripsacum dactyloides* (L.) L.] is a warm season perennial grass, native to the eastern and central portions of the United States and the West Indies (Hitchcock, 1951). It has been recognized as a highly palatable forage species (Polk and Adcock, 1964; Rechenthin, 1951); however, its utilization in forage systems has largely been hampered by seed production and establishment problems (Ahring and Frank, 1968; Anderson, 1990).

The planting unit of eastern gamagrass consists of a caryopsis surrounded by a hard, indurate, fruit case (Anderson, 1985). Many years ago, researchers such as Crocker (1916) recognized that hard seed or fruit coats could prevent germination by restricting the absorption of water or oxygen or by physically restricting growth of the embryo. Seed coverings of many species will also contain chemical inhibitors that prevent germination from occurring (Hartmann and Kester, 1975). Anderson (1985) found that germination inhibitors were not present in the fruit coverings of eastern gamagrass and that the fruit case did not restrict germination by preventing the passage of respired carbon dioxide out of the fruit. Since the coverings do not act as a barrier to movement of carbon dioxide, they likely would not impose any restrictions on the absorption of oxygen. Removal of the fruit case promoted germination (Anderson, 1985) but there is no effective way for seed producers to accomplish this for large seed lots without causing a significant amount of damage to the seeds (Anderson, 1990). Anderson (1985) suggested that the fruit case mainly affected germination by imposing limits on the environmental conditions under which germination could occur. The restrictive effect of the fruit case can be overcome by a period of cold, moist stratification (Ahring and Frank, 1968; Anderson, 1985). Ahring and Frank (1968) tested various stratification intervals ranging from 1 to 9 weeks and obtained best germination for the two seed lots tested with 6 weeks of stratification at 5 to 10°C.

This stratification requirement presents several agronomic problems for potential growers. The seed producer must have facilities for providing the stratification treatment. Current recommendations are to hydrate seeds by soaking overnight in a 0.5 percent solution of Thiram 42S fungicide to control seed pathogens, and stratifying for 6 to 12 weeks at 1 to 4°C (Row, 1998). If stratified seeds are subsequently exposed to environmental conditions that are not conducive to germination, then seeds may enter secondary dormancy (Hartmann and Kester, 1975; Simpson, 1990) and will not germinate until the following year. This problem is most severe when adequate soil moisture is not available after planting, and in many cases, would require irrigation to ensure establishment (Row, 1998). Also, many growers are not accustomed to handling and planting stratified seeds. They should be refrigerated before planting and protected from high temperatures during the planting operation. For these reasons, an alternative seed treatment that could simplify seed production and planting operations would be desirable.

Hot water treatments have been used to modify hard seed coats and promote germination (Hartmann and Kester, 1975). Keith (1981) successfully treated a hard-seeded cotton (*Gossypium hirsutum* L.) breeding line by soaking seeds in a hot water bath for 60 seconds at 85°C. Seeds are usually planted immediately following hot water treatment, but seeds of certain species have been allowed to dry and were then stored without greatly affecting germination percentages (Hartmann and Kester, 1975). If eastern gamagrass seeds responded to hot water treatment, they might be less likely to encounter the potential secondary dormancy problems associated with stratification and would therefore become more attractive to potential growers.

PROCEDURE

Seeds from two accessions of eastern gamagrass were tested for the efficacy of hot water soaking, 9058543, which was originally collected in Pushmataha County, Oklahoma, and 9062708, from Williamsburg County, South Carolina. Seeds were hand collected from plants growing at the Jamie L. Whitten Plant Materials Center (PMC) in Coffeeville, Mississippi during the months of July and August 1997. Eastern gamagrass seed lots often contain a fairly high and variable percentage of unfilled seeds, either without a caryopsis or with a shriveled, non-viable caryopsis (Ahring and Frank, 1968; Douglas et al., 2000). To determine seed fill, 30 seeds of each lot were opened and examined for the presence of a healthy caryopsis. It was found that 9058543 contained an average of 87% filled seed and 9062708 averaged 80% filled seed. Seed fill was fairly high because seeds were collected by hand, not combine harvested.

To determine appropriate hot water temperatures for testing, a non-replicated preliminary study was conducted using a seed lot from a previous experiment containing a mixture of accessions cleaned to 90% fill. Temperatures used were 70, 80, 90, and 100°C and soaking duration ranged from 60 to 240 seconds in increments of 30 seconds using the methods outlined below. Seeds from both the 90 and 100°C treatments did not germinate. Because of this result, the 100°C temperature was dropped from further testing and 90°C was retained as the upper testing limit. Treatment intervals for final testing were not altered from those used in the preliminary test.

Seed treatments used in this study were the hot water treatments outlined above, plus stratification, and an untreated control. Twenty-five seeds were used for each treatment. Samples were hot water treated by placing seeds in a basket constructed of hardware cloth (6 mm square openings) lined with aluminum window screen; an attached wire handle facilitated placement in and removal from the water bath. A cover was made from similar window screen to prevent seeds from floating out of the basket during treatment. The basket containing the seeds was submerged in a 1 liter beaker containing distilled water placed on a multiple setting hot plate that was previously calibrated to provide the appropriate water bath temperatures. Care was taken to ensure that temperatures did not vary by more than 2°C from the target temperature during the treatment period. After hot water treatment, seed samples were placed in a greenhouse and allowed to dry before planting. A quantity of seeds was prepared for stratification by soaking overnight in tap water. Seeds were then enclosed in a self-closing plastic bag with a minimal amount of free water, and put in a cooler maintained at 6°C with no humidity control.

The experiment was conducted twice. For the first treatment run, seeds of both accessions were stratified on 24 February 1998. Seeds of 9058543 were hot water treated on 25 March 1998 and all seed treatments for that accession were planted the following day. Accession 9062708 was hot water treated on 26 March 1998 and all treatments were also planted the following day. For the second run, seeds were stratified on 24 April 1998, 9062708 was hot water treated on 26 May 1998, and 9058543 was hot water treated on 27 May 1998 with all treatments planted the day after hot water treatment as before. Germination containers used were 17.8 cm x 13.3 cm x 5.9 cm plastic bedding plant liners and seeds were planted 0.6 to 1.3 cm deep in a commercial potting medium. The test was arranged as a randomized complete block with three replications in a split plot design with accessions as the main plot and seed treatments as the split plot. Germination containers were placed in a germinator maintained at 20/30°C night/day regime, with an eight-hour day period when the internal lights were on. There is no Association of Official Seed Analysts recommendation for eastern gamagrass germination testing; however, seed laboratory personnel experienced in testing this species recommended this temperature regime (J. Franklin, personal communication). All containers were irrigated thoroughly following planting and watered throughout the testing period as necessary. Germination counts were made every seven days over a five week period and a total germination percentage was determined for each treatment. This data was subjected to an analysis of variance (ANOVA) using MSTAT-C (Michigan State Univ., 1988) and appropriate mean separations were performed at the five percent level of probability ($P<0.05$) using a least significant difference test.

A non-replicated field trial using seeds of both accessions was planted on 28 May 1998 at the PMC on an Oaklimiter silt loam soil. Seed treatments used were stratification (seeds placed in stratification on 24 April 1998), untreated seeds, and the highest ranking of the hot water treatments from the first run of the germinator experiment. Hot water treatments used were 70°C for 60, 90, 120, 150,180, 210, 240 sec, and 80°C for 60 sec. Sample size was 25 seeds as in the germinator test. Hot water treated seeds were dried in the greenhouse for one to two days before planting. Seed samples were planted by forming a shallow row with a hoe, hand sowing the seeds, and covering to a depth of about 2.5 cm. Germination counts were made every three or four days until 9 July 1998.

CONCLUSIONS

The germination percentages for each accession and each trial run were first analyzed separately to determine trends in responses to the treatments. The accessions responded in a similar manner to the seed treatments in each run of the experiment, so the data for each accession was averaged across the two runs (Tables 1 and 2). Germination rates were fairly low as is typical of eastern gamagrass. It appears that all 90°C treatments and the 80°C treatments soaked for 150 sec or longer may have been lethal or otherwise prevented germinaton. The true cause for this lack of germination was not determined, because it was apparent that such treatments would be unacceptable and further examination was irrelevant.

Table 1. Total germination percentages of eastern gamagrass accession 9058543 exposed to various seed treatments averaged over two trial runs.

Seed Treatment	Soaking Time (Sec)	Water Temperature (°C) 70	80	90
		--------------------------%	----------------------	
Hot Water Soak	60	11	19	0
	90	7	6	0
	120	13	1	0
	150	9	0	0
	180	12	0	0
	210	17	0	0
	240	22	0	0
Untreated		11		
Stratified		57		

Table 2. Total germination percentages of eastern gamagrass accession 9062708 exposed to various seed treatments averaged over two trial runs.

Seed Treatment	Soaking Time (Sec)	Water Temperature (°C) 70	80	90
		--------------------------%	----------------------	
Hot Water Soak	60	27	21	0
	90	29	5	0
	120	28	1	0
	150	25	0	0
	180	28	0	0
	210	30	0	0
	240	30	0	0
Untreated		24		
Stratified		42		

Those treatments that yielded zero germination were dropped from the final ANOVA. The resulting data analysis showed that there was a significant interaction effect between accession and seed treatment (Figure 1). There are several factors that could have contributed to this interaction. First, germination percentages for all seed treatments, except the stratification treatment and the 80°C treatments, were much higher for 9062708. Secondly, germination of stratified 9058543 was much greater than all other treatments, but for 9062708, several of the hot water treatments had germination percentages more closely similar in magnitude to that of the stratification treatment. In fact, the germination percentage of the stratification treatment for 9058543 was significantly higher than that of same treatment for 9062708. Anderson (1985) noted variability in stratification responses between genotypes of eastern gamagrass from different locations. From these results, it seems likely that 9062708 is not as dependent as 9058543 on stratification for optimum germination. The collection location of 9058543 is in USDA plant hardiness zone 7a and 9062708 in 8a, so 9062708 would be subjected to more moderate winter conditions. This could explain the variation in stratification response between the two accessions. Also, the two accessions did not respond in a similar manner to the hot water treatments. The 70°C 240 sec treatment provided the best germination of the hot water treatments for both accessions. However, the 80°C 60 sec treatment would be ranked as the second best hot water treatment for 9058543, whereas this treatment would have ranked as the eighth best hot water treatment for 9062708, below even the control treatment. Germination percentages of the 80°C 90 and 120 sec treatments were very low, which indicates that there may have been damage to the seeds.

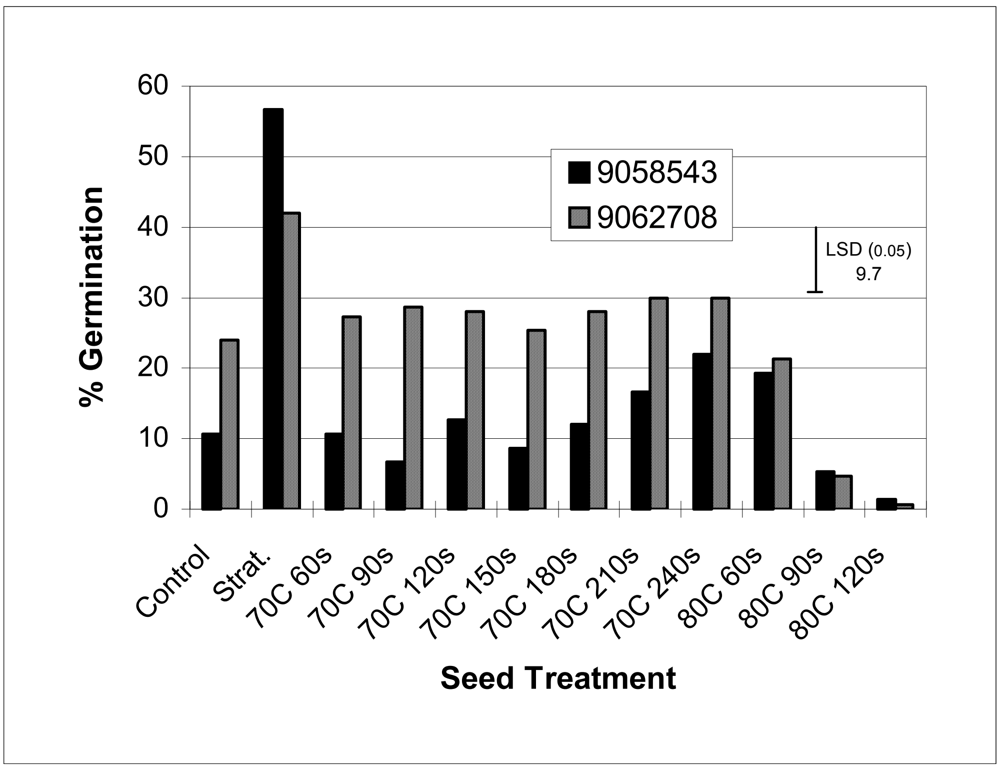

Figure 1. Interaction effect of selected seed treatments on total germination percentages of eastern gamagrass seeds.

Figure 2 illustrates differences in the rate of germination for selected treatments by graphing the germination percentage mean over both accessions at each evaluation interval. Stratified seeds germinated much more quickly than the other treatments. Anderson (1985) found that stratified seeds exposed to appropriate temperatures germinated very rapidly, with several treatments showing relatively high germination percentages within five days. In this experiment, none of the treatments germinated by the first count at seven days. The germination medium used by Anderson (1985) was filter paper and he therefore could have detected germination much more quickly than in this study where seeds were planted in a potting medium. The germination rate of the hot water treated seeds was somewhat similar to that of the control, although final germination percentages were higher than those of the control. This response has profound agronomic implications. Even if final germination percentage of the hot water treated seeds were equal to that of stratified seeds, the fact that hot water treated seeds germinate more slowly subjects the seedlings to increased competition from other plant species, which could prevent establishment.

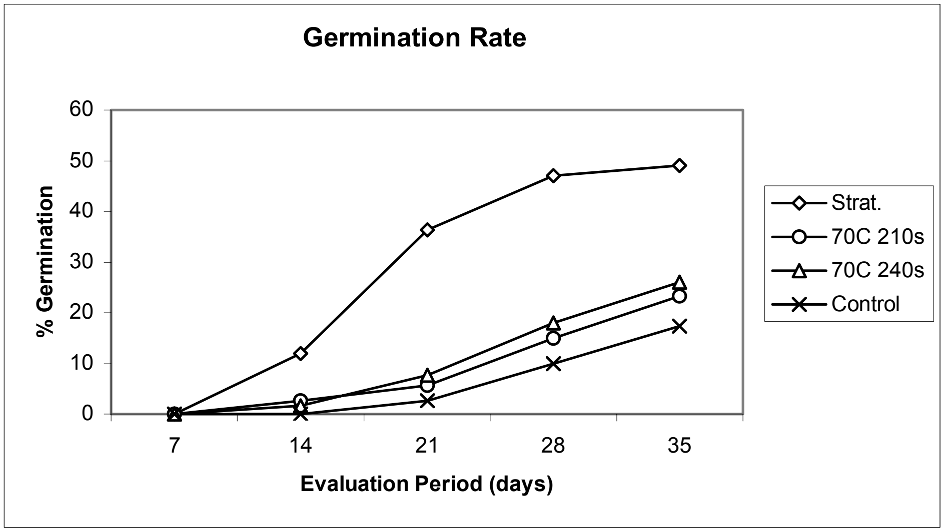

Figure 2. Mean germination percentages of stratified (Strat.), two selected hot water treatments, and untreated seeds (Control).

No herbicides were used for the preliminary field planting, so locating the seedlings for germination counts was somewhat difficult and this probably affected counts made on several evaluation dates. The data presented (Table 3) is the maximum count recorded for each treatment, and may not be the true total germination percentage. Field response of the hot water treated seeds was disappointing; however, weather conditions during the treatment period were unusually hot and dry. There was almost no germination recorded for any of the hot water treated seeds of accession 9062708, the same accession that showed a more favorable response in the germinator. Those hot water treatments with the highest germination percentages for 9058543 in the field were not those that performed best in the germinator. Keith (1981) found a similar disparity in the hard-seeded cotton line between those hot water treatments with the best germination percentages in the laboratory as opposed to those in the field. Final recommendations for treating this cotton seed line were based on those treatments that performed best in the field. Due to the unusual environmental conditions experienced during this study, such conclusions would not be appropriate in this case. It is interesting to note the high germination percentages recorded for stratified seeds. Several researchers have documented that secondary dormancy can be induced in stratified eastern gamagrass seeds by drought (Row, 1998); however, germination percentages for these accessions were higher in the hot dry conditions in the field than they were for the more ideal conditions in the germinator. This could possibly be an instance of the seeds responding favorably to high temperatures. Anderson (1985) noted that germination of stratified seeds was better at a higher temperature (32°C) than at a lower temperature (25°C). Possibly the 20/30°C temperature regime used in the germinator test was not appropriate for optimum germination. The need for high germination temperatures might need to be further documented so it can be taken into account if seed testing recommendations are developed for this species.

Table 3. Total germination percentages for a preliminary field test of two eastern gamagrass accessions exposed to various seed treatment regimes.

Seed Treatment	Germination	
	9058543	9062708
	---------------------------%---------------------------	
Untreated	0	0
Stratified	68	84
70°C 60 sec	0	0
70°C 90 sec	4	0
70°C 120 sec	16	0
70°C 150 sec	0	0
70°C 180 sec	24	4
70°C 210 sec	0	0
70°C 240 sec	0	0
80°C 60 sec	0	0

APPLICATION

Hot water treatment was tested because theoretically it offered potential as a commercially feasible treatment for growers to use to overcome dormancy of eastern gamagrass seeds. However, results of this study did not support this theory. Stratification is the treatment that produced best germination of eastern gamagrass seeds.

FUTURE RESEARCH NEEDS

Due to the poor results of hot water treated seeds in the preliminary study and in additional studies conducted in 1999 (see accompanying paper in this publication), it does not appear that hot water treatment warrants further testing. Future testing will examine other seed treatments and planting methods that can be used to improve establishment of stratified seeds.

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Comparison of Chemical Stimulants for Improving Germination of Eastern Gamagrass Seed – 1999 Field and Germinator Studies

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INTRODUCTION

The hard, indurate fruit case of eastern gamagrass [*Tripsacum dactyloides* (L.) L.] imposes restrictions on germination of the caryopsis held within (Anderson, 1985). These restrictive effects can be overcome by a period of cold, moist stratification (Ahring and Frank, 1968; Anderson, 1985). However, stratified seeds can be subject to secondary dormancy if exposed to environmental conditions in the field that are not conducive to germination (Hartmann and Kester, 1975; Simpson, 1990). The need for reliable field establishment methods has led to interest in determining the efficacy of alternative treatments to overcome dormancy of eastern gamagrass seeds.

Hot water treatments have been used to modify hard seed coats and promote germination (Hartmann and Kester, 1975; Keith, 1981). Previous testing at the PMC has shown hot water treatments to have a slight effect on germination of eastern gamagrass, but germination percentages were lower than those of stratified seeds (Grabowski and Douglas, 1999).

Various types of chemical stimulants have been shown to promote germination. Soaking in a potassium nitrate (KNO_3) solution is one method commonly used to improve germination of freshly harvested seeds (Hartmann and Kester, 1975). Ahring and Frank (1968) found that soaking eastern gamagrass seeds in KNO_3 or sodium hypochlorite solutions had no effect on germination. Soaking in a solution of ethylene chlorohydrin slightly increased germination, but the effect was not significant and germination percentages were much lower than for stratified seeds. Row (1998) found that soaking in KNO_3 or Thiram solutions did not improve germination over soaking seeds in water alone. Exogenous applications of gibberellins and cytokinins have been used to stimulate germination of various types of seeds (Hartmann and Kester, 1975) and it has been reported that eastern gamagrass seeds are deficient in gibberellins and cytokinins (Anderson, 1985). Treatment with gibberellic acid (GA) has been shown to overcome dormancy of perennial teosinte [*Zea perennis* (A.S. Hitchc.) Reeves & Manglesdorf] seeds (Mondrus-Engle, 1981); however, for eastern gamagrass, GA treatments improved early, but not total germination (Anderson, 1985). This study conducted at the Jamie L. Whitten Plant Materials Center (PMC) examined the effect of KNO_3 or GA treatments on germination of hot water treated and stratified seeds.

PROCEDURE

Three accessions of eastern gamagrass were tested: 9058543, which was originally collected in Pushmataha County, Oklahoma, 9062680 from Montgomery County, Tennessee, and 9062708 from Williamsburg County, South Carolina. Seeds were harvested by hand from plants growing at the PMC in Coffeeville, Mississippi during the months of July and August 1998. Seed fill of eastern gamagrass is often quite variable (Ahring and Frank, 1968; Douglas et al., 2000). Seed lot quality was improved for this test by separating out heavier seeds using a South Dakota Seed Blower (Seedburo Equipment Co., Chicago, Ill.) (Ahring and Frank, 1968). Thirty seeds of each lot were opened and examined for the presence of a healthy caryopsis to determine seed fill. It was found that 9058543 contained an average of 83%, 9062708 averaged 87%, and 9062680 averaged 87% filled seed.

Stratification treatments consisted of soaking seeds in a 0.2% KNO_3 solution, 1000 mg L^{-1} GA solution, or distilled water for 24 hours prior to cold treatment. Sample sizes used were 25 seeds for the field test and ten seeds for the germinator test. ProGibb, a commercial formulation of gibberellic acid was used as the GA source. After soaking, seeds were rinsed with distilled water before being placed in the cooler (6°C) on 9 March 1999. Seed samples were hot water treated at 70°C for 240 sec and then soaked in the same treatments described for stratification. Seeds were then rinsed with distilled water and kept moist until planting in the field or germinator. An untreated control was also included. Seed samples for the field test were hot water treated on 3 May 1999 and all treatments planted the following day. Stratification treatments were placed in an insulated container to limit heat exposure while being transported to and prior to planting in the field. Seeds for the germinator test were hot water treated on 5 May 1999 and planted 6 May 1999.

The tests were arranged as a two factor (accession and seed treatment) randomized complete block with six replications in the field test and four in the germinator test. Seeds for the field test were planted in an Oaklimiter silt loam soil in shallow rows formed with a hoe, covering the seeds to a depth of about 2.5 cm. After planting, the study area was sprayed with 1.68 kg ha^{-1} of atrazine for weed control. Seeds planted in the germinator were sown 0.6 to 1.3 cm deep in a commercial potting medium in 17.8 cm x 13.3 cm x 5.9 cm plastic bedding plant liners. The germinator was maintained at 20/30°C night/day regime, with an eight-hour day period when the internal lights were on. Germination counts were made weekly for 42 days, when the germinator study was terminated; counting seedlings in the field test became difficult at this time due to reduced activity from the atrazine treatment, but the study was left in place to do a final survival count in the fall. Data from these tests were subjected to an analysis of variance (ANOVA) using MSTAT-C (Michigan State Univ., 1988) and appropriate mean separations were performed at the five percent level of probability ($P<0.05$) using a least significant difference test.

CONCLUSIONS

The ANOVA indicated that there was an interaction effect between accession and seed treatment in both testing locations. This interaction can be attributed to differential responses of the three accessions to the various seed treatments (Table 1) as will be discussed below. Germination of hot water treated seeds was much higher in the germinator than in the field, which concurs with previous results at the PMC (Grabowski and Douglas, 1999). It appears that hot water soaking does not provide sufficient seed coat modification to permit successful field establishment of eastern gamagrass seed. The low germination percentage of seeds in the control treatment indicates that all three accessions required stratification to overcome dormancy. Germination of stratified 9062680 seeds was reduced compared to the other two accessions in both environments. Seed fill data shows that this germination reduction cannot be attributed to seed quality differences between the accessions. Perhaps this accession has a more pronounced level of seed dormancy. Soaking in KNO_3 or GA slightly improved germination of hot water treated seeds of accessions 9058543 and 9062680 in the germinator; however, neither of these chemicals consistently improved germination of stratified seeds in either location. Row (1998) reported that a 24-hour exposure to KNO_3 reduced germination of some seed lots, but no such reduction was noted in this study. Response to KNO_3 appeared to be greater under field conditions.

Table 1. Total germination percentages for stratified and hot water treated seeds of three eastern gamagrass accessions treated with KNO_3 and gibberellic acid (GA).

Accession	Seed Treatment	Germination	
		Germinator	Field
		----------------------%----------------------	
9058543	Stratified	63	49
	GA + Stratified	60	57
	KNO_3 + Stratified	58	62
	Hot Water	8	2
	Hot Water + GA	23	3
	Hot Water + KNO_3	13	4
	Untreated	3	1
9062680	Stratified	51	38
	GA + Stratified	27	47
	KNO_3 + Stratified	21	36
	Hot Water	8	3
	Hot Water + GA	21	5
	Hot Water + KNO_3	21	1
	Untreated	8	1
9062708	Stratified	70	49
	GA + Stratified	58	45
	KNO_3 + Stratified	43	49
	Hot Water	20	2
	Hot Water + GA	23	0
	Hot Water + KNO_3	13	1
	Untreated	5	2
LSD (0.05)		19	10

The GA treatment did have a noticeable effect on the speed or rate of germination of stratified seeds as illustrated by mean seedling counts made in the germinator at each evaluation date (Figure 1). Data from the field test is not presented graphically because interference from weeds prevented accurate counts during later evaluation dates, however, germination counts from the first evaluation date are presented in Table 2. Early germination (7 days after planting) was improved by GA treatment; however, the difference was not significantly different from stratification alone in the germinator. In the field, early germination was significantly greater for 9058543 and 9062680. These findings are in agreement with Anderson (1985), who reported that GA increased early but not total germination percentages of seeds with intact fruit cases. In this study, the GA treatment caused abnormal elongation and chlorosis of the seedlings, which made the shoots highly susceptible to being broken by wind or physical contact. Although Anderson (1985) also used a 1000 mg L^{-1} concentration of GA, abnormal growth was not reported in that study. Anderson (1985) did not specify the length of the GA treatment period or what formulation of GA was used. In this study, GA was added to the 24-hour pre-stratification soak, which would appear to be a commercially acceptable treatment method. Reduced concentrations may be required to effectively treat seeds with the GA formulation and treatment duration used in this study. KNO_3 had no effect on germination rate of stratified seeds.

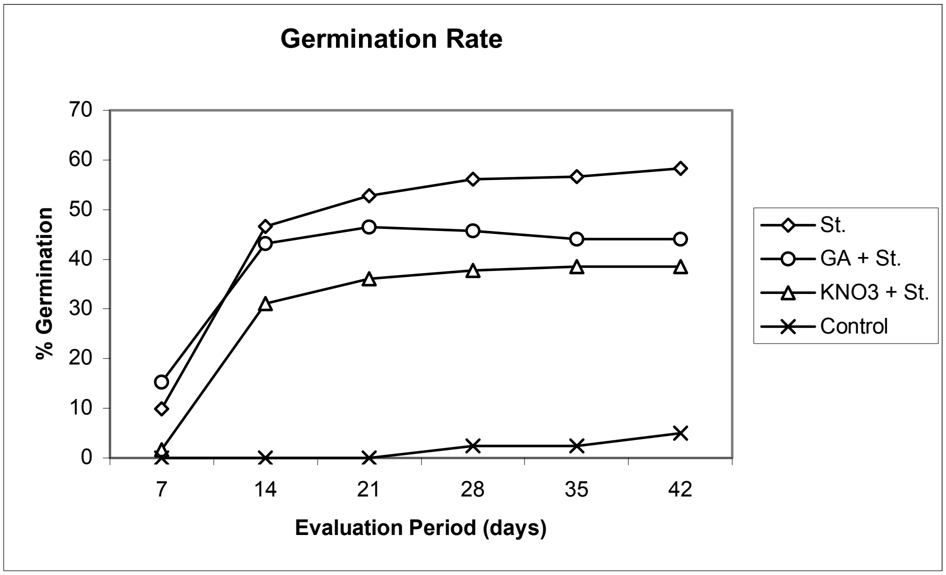

Figure 1. Mean germination percentages of stratified (St.) seeds with or without pretreatment with chemical stimulants (GA or KNO_3) and untreated seeds (Control) in the germinator.

Table 2. Early germination of stratified seeds treated with gibberellic acid (GA) and KNO_3 and untreated seeds in the field.

Accession	Seed Treatment	Germination
		---------------%---------------
9058543	Stratified	2
	GA + Stratified	34
	KNO_3 + Stratified	0
	Untreated	0
9062680	Stratified	9
	GA + Stratified	34
	KNO_3 + Stratified	7
	Untreated	0
9062708	Stratified	8
	GA + Stratified	5
	KNO_3 + Stratified	0
	Untreated	0
LSD (0.05)		8

APPLICATION

This study did not indicate that hot water treatment would be an acceptable treatment for eastern gamagrass seeds, however, chemical stimulant treatments appeared to show promise. Early germination is important in the field because it reduces the amount of time that seeds might be exposed to unfavorable environmental conditions and it allows seedlings to be more competitive with weeds. Pre-stratification soaks in GA should be easy to incorporate in seed production schemes because current practice is for producers to soak seeds in water for 24 hours to hydrate them prior to the cold treatment (Row, 1998). It would be a simple matter for the GA solution to be substituted for water in the soaking treatment.

FUTURE RESEARCH NEEDS

If GA treatments are to be used commercially, additional research is needed to determine treatment rates that do not cause abnormal seedling elongation. Also, examination of the effect of various forms of GA and treatment durations may be required. The effect of other chemical stimulants, especially cytokinins, which are also deficient in eastern gamagrass seeds, needs to be studied as well as the effect of various combinations of chemical stimulants to test for any potential synergistic effects.

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A Comparison of Seed Cleaning Techniques for Improving Quality of Eastern Gamagrass Seed

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INTRODUCTION

Eastern gamagrass [*Tripsacum dactyloides* (L.) L.] is a native warm-season perennial bunchgrass with potential for livestock forage and cropland erosion control in the Southeast (Ball et al., 1991; Dewald et al., 1996). Attempts to establish stands from seed have given inconsistent results. The seed of eastern gamagrass is protected between a rachis internode and an outer glume association known as a cupulate fruitcase (Galinat, 1956). The cupulate fruitcase has shown to inhibit germination in some genotypes of eastern gamagrass, but germination can be enhanced with cold-moist stratification for 60 days followed by exposure to temperatures of at least 30° C (Anderson, 1990). Indeterminate seed maturity is another factor that indirectly affects seed quality. A typical combine-run harvest consists of complete seed units (cupulate fruitcase with filled seed), incomplete seed units (cupulate fruitcase with unfilled seed) and other non-viable inert matter. Inability to adequately separate filled seeds from unfilled seeds may lead to poor establishment (Ahring and Franks, 1968).

Air screen cleaners (ASC) are commonly used for cleaning eastern gamagrass seed. They remove most of the inert matter and a portion of immature seed units, but are not capable of separating complete seed units from incomplete ones. Similarities in size and shape, and the inability of the system's air flow mechanism to separate complete units from incomplete units complicates cleaning operations, thus both types are included in the final product. A South Dakota Seed Blower has been shown to improve separation of complete seed units from incomplete seed units of eastern gamagrass and increase germination potential 73 to 95% (Ahring and Franks,1968). However, the South Dakota Seed Blower was designed for processing limited seed quantities and does not have the capacity to accommodate large seed lots**.**

There is no published literature on the use of an air fractionating aspirator (AFA) or gravity separator (GS) to improve seed quality of eastern gamagrass once the seed has been partially cleaned with an air screen cleaner. Therefore, the objective of this study was to compare percent fill and percent germination of fractions separated by an AFA and GS, and contrast these results to those for a single fraction from an ASC.

PROCEDURE

Three lots were chosen for the experiment. Lots A, B, and C were harvested with a John Deere 4400 conventional combine in September 1992, 1993, and 1995, respectively, from a stand of eastern gamagrass at the USDA-Natural Resources Conservation Service, Jamie L. Whitten Plant Materials Center (PMC) near Coffeeville, Mississippi. Seed units and other components of the harvest were spread evenly on a concrete floor and allowed to air dry in a ventilated warehouse for approximately one week. An ASC (Clipper M2B, A. T. Ferrell and Co., Saginaw, MI), equipped with an upper and lower screen, was used for cleaning. Seed units were stored in cloth bags and placed in a storage vault maintained at 13° C and 45% relative humidity. In January 1997, a 4.5 kg random sub-sample was collected from each lot.

A 200 gram random sub-sub-sample was obtained from each 4.5 kg sub-sample and separated into four fractions with an AFA (Carter-Day Model No. CF 21, Minneapolis, MN). Each fraction was weighed to determine its percentage relative to the sample size. A GS (Oliver MFG, Rocky Ford, CO) was used to separate a 3.5 kg sub sample of lot C into two fractions. Weight or percentage of the two fractions was not determined due to the excessive loss of seed units that fell from the GS to the floor during the cleaning operation.

Percent filled seed was determined by hand dissecting three replicates of 10 randomly selected seed units to determine the presence or absence of a seed. A single fraction from each lot separated by an ASC served as a control. Four replications of 25 seed units were randomly selected from each fraction and control, and planted in 17.5 cm x 13.3 cm x 5.9 cm containers filled with a commercial potting medium. Containers were placed in a cooler maintained at 5° C with no humidity control on 15 April 1997 for cold-moist stratification. Containers were watered regularly to keep potting medium moistened.

Containers were removed from the cooler and placed in a greenhouse on 27 May 1997. Germination counts were made 7, 14, and 21 days after placement in the greenhouse. Total germination was determined by summing germination counts at the end of 21 days.

Filled seed and germination percentages by fraction and lot were subjected to an analysis of variance procedure in MSTAT-C (Michigan State Univ., 1988) and significant means were determined by least significant difference (LSD) at $P<0.05$ (Gomez and Gomez, 1984).

CONCLUSIONS

Differences in percentage of seed units in each fraction indicate that an AFA has the capability to make discreet separations between seed components not obtainable with an ASC (Table 1).

Table 1. Percent seed units accounted for in each lot by fraction as determined by AFA.

	Seed Lot		
Fraction	A	B	C
	------------------------%	--------------------------	
1	20	11	20
2	17	17	20
3	35	35	30
4	28	37	30

Seed fill of fractions by lot and cleaning technique was defined by determining the presence or absence of a seed. Fractions one and two of lot A, B and C separated by the AFA, and fraction one of lot C separated by the GS, had significantly increased seed fill compared to the other fractions and control (Table 2). This indicates that the heaviest seed units associated with these fractions contained a filled seed determined to be of good quality based on size and visual appearance. Compared to the control, fractions one and two in lot A, B, and C from the AFA were found to increase germination potential 44, 67 and 61%, respectively. Fraction one from the GS increased germination potential 67% when compared to the control.

Table 2. Percent seed fill by lot and fraction for two cleaning techniques.

	AFA			GS
	Seed Lot			
Fraction	**A**	**B**	**C**	**C**
	-----------------------------------%	-------------------------------------		
1	93	90	87	90
2	90	90	80	30
3	57	73	43	--
4	10	20	20	--
Control	47	23	23	23
LSD (0.05)	22	12	25	30

Percent germination for each fraction by lot and cleaning technique is presented in Table 3. Percent germination of fractions one and two of lot A and B separated by the AFA was found to be significantly higher than fractions three and four. Typically the first fractions had the highest germination percentages because they had a higher seed fill and thus a greater germination potential.

Table 3. Percent germination by lot and fraction for two cleaning techniques.

	AFA			GS
	Seed Lot			
Fraction	**A**	**B**	**C**	**C**
	------------------------------------%------------------------------------			
1	43	21	24	48
2	35	29	25	15
3	15	15	18	--
4	3	3	3	--
Control	22	22	16	22
LSD (0.05)	12	12	10	13

APPLICATION

Potential implications of such cleaning techniques include improving uniformity of stands of eastern gamagrass, pricing of seed lots based on seed quality and selecting for seedling vigor. This information has been passed on to several gamagrass seed growers. The technique of a GS to clean eastern gamagrass is being used by Shepherd Farms in Clifton Hills, Missouri and will soon be part of the cleaning process for a gamagrass seed grower in eastern Kentucky.

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Influence of Seeding Depth on Seedling Emergence of Accession 9062680 and PMK-24

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INTRODUCTION

Stratification is a germination enhancement method used to overcome physiological dormancy in various types of seeds. Stratification, also known as prechill, involves storing seeds at temperatures between 35° and 42° F with moist sand, peat or other mediums for different time intervals (Beinz, 1980). Stratification has shown to be effective in improving germination of eastern gamagrass [*Tripsacum dactyloides* (L.) L.] (Anderson, 1990). Many commercial seed growers offer stratified eastern gamagrass seed for spring plantings. However, placing spring-planted stratified seed at the proper seeding depth is critical for optimum germination and subsequent seedling growth. Planting stratified seed too shallowly increases the potential for the seed to dry out before germinating, resulting in the loss of stratification and initiating secondary seed dormancy (Martin et al., 1976). If secondary dormancy occurs, germination may be delayed until the seed undergoes a natural stratification process and will likely not germinate until the next spring. Although fall planting has been considered as an alternative to artificial stratification this strategy has given mixed results in the Midwest due to fluctuations in winter weather patterns from year to year (Row, 1998). Because of the negative impact drying has on stratified seed and the potential for secondary dormancy, many producers will often disk up the planting assuming that it was a failure. On the other hand if the seed is planted too deeply emergence may be decreased or may not occur at all. A seeding depth of 1.0 to 1.5 inches has been recommended for eastern gamagrass (Dewald et al., 1996). Placing stratified eastern gamagrass seed deeper into a higher soil moisture retention zone may give the seed an opportunity to germinate and emerge before dehydration. Objectives of this study were to compare seedling emergence of PMK-24 and accession 9062680 (680) at various depths to determine if seed planted deeper than 1.5 inch will significantly reduce seedling emergence and at which depths provide the highest potential for seedling emergence and development.

PROCEDURE

Seed of accession 680 and PMK-24 (accession 421612; released as 'Pete' in 1988) was cleaned with a South Dakota Seed Blower (Ahring and Franks, 1968), stratified for nine months, and planted in single rows in replicated plots at the PMC in April 1999 and 2000. Seed planted in 1999 were harvested in August 1998 and seed planted in 2000 were harvested in August 1999. Seed was planted in an Oaklimeter silt loam at depths of 0.5, 1, 1.5, 2, 2.5, and 3 inches. Seedling emergence was recorded 7, 14 and 21 days after planting.

PRELIMINARY FINDINGS

There were no significant differences in 680 and PMK-24 for seedling emergence at 7, 14 and 21 days after planting in either year (Figure 1 and 2). For unknown reasons, none of the seed emerged 7 days after planting in 2000 (data not shown), however, by 14 days 50% of the seedlings had emerged.

Seeding depths significantly influenced seedling emergence in 1999 and 2000 (Fig. 3 and 4). As depth increased, seedling emergence decreased. The 0.5 inch depth significantly increased early emergence over the other depths in 1999 which may indicate that shallow planted seed may germinate and emerge rapidly given favorable soil moisture and soil temperature at planting time. In both years, soil moisture was at a moderate level according to an Aquateer [200] soil moisture and soil temperature monitoring probe. Soil temperature was 75-78° F at one inch at planting.

Supplemental water was not used in this study. However, if irrigation is an option, it could be used in a dry spring to maintain adequate soil moisture within shallow seeding depth zones to prevent dehydration and prolong stratification until seed germinate and emerge. Another approach would be to refrain from planting stratified seed unless soil moisture is evident or until measurable rainfall is forecasted. Over 60% of the seed planted at 0.5 inch had emerged in 21 days compared to 58, 53 and 50% at 1.0, 1.5 and 2.0 inches, respectively, but these differences were not significant. The relatively low number of seedlings that emerged at the 2.5 and 3.0 inch depths were slightly chlorotic but recovered in 7-10 days suggesting that planting seed deeper than 2.5 inches in a silt loam soil should be avoided.

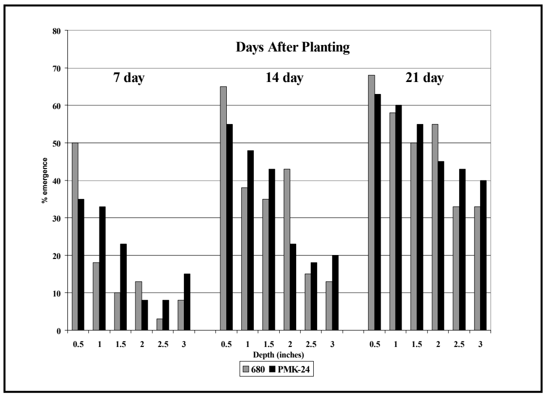

Fig.1. Percent emergence of gamagrass entry by depth at 7, 14 and 21 days after planting in 1999, Coffeeville, MS.

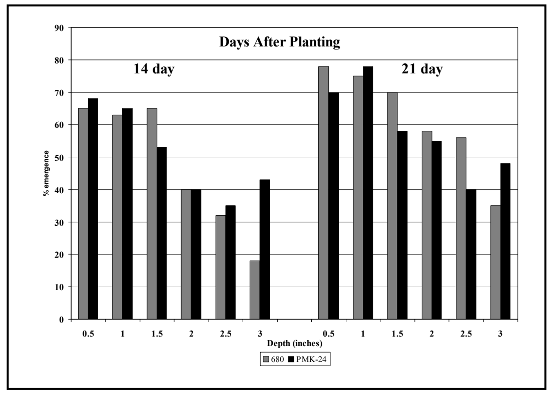

Fig . 2. Percent emergence of gamagrass entry by depth at 14 and 21 days after planting in 2000, Coffeeville, MS.

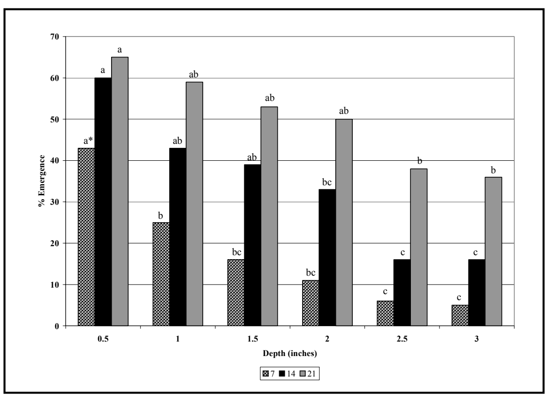

Fig. 3. Percent emergence at 7, 14 and 21 days after planting as a function of planting depth in 1999, Coffeeville, MS.

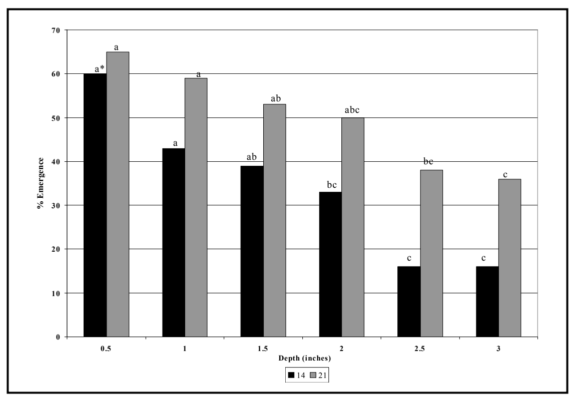

Fig. 4. Percent emergence at 14 and 21 days after planting as a function of planting depth in 2000, Coffeeville, MS.

* Bars labeled with the same letters for a given day at each depth is not significantly different at P<0.05.

APPLICATION

From these preliminary results it appears that stratified seed planted at 0.5 inch are capable of producing a quicker stand but the risks associated with planting seed this shallowly must be considered. Planting stratified seed at 1.0 - 2.0 inches provided reasonable stands after 21 days. Seed planted at these depths are less likely to dry out as quickly as those planted in shallower depths; thus, providing the seed with a greater opportunity to germinate and emerge before dehydration occurs. This study will be completed in 2001.

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Response of Perennial Forages and a Forb as Filter Strips for Nitrogen and Phosphorus Uptake

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OBJECTIVE

Determine biomass production and nutrient accumulation of selected perennial grasses and a forb species for filter strips.

PROCEDURE

The study was conducted over a six year period from 1991 until 1996. Sixty 14 m^2 plots divided among 3 replications and consisting of six warm season grasses 'Alamo' switchgrass, 'Lometa' Indiangrass, T-587 old world bluestem, 434493 eastern gamagrass, 'Coastal' Bermudagrass, 'Earl' big bluestem; two cool season grasses 'Jose' tall wheatgrass, 'Rebel II' tall fescue; and one forb 'Aztec' maximilian sunflower were established. Each replication was divided into two treatments (clipped or unclipped). Clipped plots were harvested periodically during the growing season and forage was removed from each plot. Unclipped plots were harvested when the material was dormant and forage was removed from each plot. Yields were based on dry weight of a sample (1 m^2) from each plot. Clipping height and frequency were based on species and plant growth stage. One replication consisting of 20 plots were equipped with plate lysimeters.

Management of each plot consisted of some supplemental irrigation applied during the growing period and after each fertilizer application. Warm-season species plots were burned before the start of spring growth. Plots were fertilized at a predetermined rate as outlined in the following schedule.

Spring Fertilizer Application	Midsummer Fertilizer Application	Fall Fertilizer Application
1992: 45 Kg N /ha	1992: 45 Kg N /ha	1992: 45 Kg N /ha
1993: 90 Kg N /ha	1993: 90 Kg N /ha	1993: 90 Kg N /ha
1994: 90 Kg N /ha	1994: none	1994: 90 Kg N /ha
23 Kg P /ha	1995: 90 Kg N /ha	1995: none
23 Kg K /ha	1996: 90 Kg N /ha	1996: 45 Kg P /ha
1995: 90 Kg N /ha		45 Kg K /ha
1996: 90 Kg N /ha		

CONCLUSION

Plant tissue analysis, 1992 through 1996, shows 'Aztec' maximilian sunflower, 'Coastal' bermudagrass, and 'Alamo' switchgrass as the best species in overall yields (biomass production), and nitrogen and phosphorus accumulation. The two cool-season grasses had very low establishment rates and did not provide sufficient amounts to sample. Leachate collection in lysimeters was insufficient for analysis due to malfunctions in the tubing and a lack of uniform water distributions. Biomass production in clipped versus unclipped plots tended to approach similar values by the end of the last year.

Biomass Yield (lb./ac.) of Clipped and Unclipped Plots

	1992		1993		1994		1995		1996	
	C*	U**	C	U	C	U	C	U	C	U
Aztec	11763	?	18191	4494	6672	4726	12940	14561	14367	5840
Alamo	9965	20226	7185	9258	5176	5366	17366	8210	6494	3992
Lometa	8756	7271	2840	4047	4311	4320	9595	11994	4658	3158
Earl	8635	5550	5789	2917	4032	4726	10642	8717	4329	2324
Coastal	9508	10204	9902	9347	8657	7966	14764	10676	9166	7031
434493	6641	3796	6285	2197	4076	6008	10304	9190	8614	3069
T-587	9142	8846	5876	5165	4019	4996	11791	11217	8602	6137

*C = Cut
**U = Uncut

Nutrient Accumulation of N (lb./ac.) of Clipped and Unclipped Plots

	1992		1993		1994		1995		1996	
	C*	U**	C	U	C	U	C	U	C	U
Aztec	285.1	128.7	274.0	24.9	75.7	43.4	207.2	128.4	206.1	73.4
Alamo	85.6	45.6	102.4	54.5	51.6	41.3	239.0	44.9	60.6	45.5
Lometa	59.3	24.7	31.4	29.9	40.5	36.4	101.7	88.0	51.6	36.0
Earl	65.8	17.1	61.7	21.9	36.6	45.6	127.7	72.0	49.0	36.2
Coastal	91.9	47.4	169.5	45.2	88.6	67.3	127.1	96.1	106.3	93.6
434493	55.4	16.3	88.0	21.1	43.9	56.7	158.5	103.1	85.4	51.3
T-587	56.9	33.2	83.5	38.2	34.4	36.3	139.3	71.6	84.2	72.3

*C = Cut
**U = Uncut

Nutrient Accumulation of P (lb./ac.) of Clipped and Unclipped Plots

	1992		1993		1994		1995		1996	
	C*	U**	C	U	C	U	C	U	C	U
Aztec	27.3	11.4	22.4	2.4	7.8	3.4	17.1	10.3	24.7	5.7
Alamo	10.4	3.3	11.1	4.2	5.4	3.9	23.8	3.8	11.0	3.4
Lometa	6.5	2.0	2.4	1.9	3.5	2.8	11.8	8.2	7.7	3.4
Earl	6.6	1.2	7.4	1.5	3.0	3.1	11.6	4.7	5.8	2.7
Coastal	10.2	5.5	14.8	5.0	9.0	6.5	12.8	7.6	17.0	7.9
434493	6.7	1.7	9.5	1.8	4.1	5.9	18.3	8.5	16.7	4.3
T-587	7.5	3.2	9.0	3.2	3.4	3.0	15.4	6.1	16.7	5.5

*C = Cut
**U = Uncut

Nitrogen and phosphorus uptake by most species was much greater on clipped plots; indicating preferential species for filter strip planting. The three warm-season species 'Lometa' Indiangrass, 434493 eastern gamagrass, and 'Earl' big bluestem from 1992-1996 showed the lowest yields compared to the other three species. Field observations indicated that these species did not seem to recover as fast as the other species after each clipping each year, even though all species received the same treatment.

Nutrient Utilization and Dry Matter Production of Eastern Gamagrass, Switchgrass and Old World Bluestem

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INTRODUCTION

Many of the native warm-season grass (WSG) species are being recommended by the Natural Resources Conservation Service for Conservation Reserve, Wildlife Habitat Incentive, and Stewardship Incentive Programs. These WSGs are also being incorporated into riparian buffers, field borders, filter and buffer strips for animal waste and commercial fertilizer nutrient runoff and other potential pollutant traps.

Several of the WSGs have the ability to produce considerable dry-matter (Sanderson et al., 1996 and Jung et al., 1990) and develop extensive root systems (Moser and Vogel, 1995 and Huang, 1994). A study was conducted to assess which WSG species may be better adapted in the accumulation of nutrients from applied poultry litter and be considered for inclusion in a filter or buffer strip as a nutrient trap. The second objective was to assess the dry-matter production potential of WSGs with broadcast poultry litter.

PROCEDURE

The study was located at the Booneville Plant Materials Center, Booneville, AR. The level site is classified as a Taft silt loam soil (fine-silty, siliceous, thermic Glossaquic Fragiudults). Average precipitation is 45.1 in./yr. Total precipitation received prior and during the active growing season (March-August) was about 21.02 and 26.8 in./yr. for 1995 and 1996, respectively. This summary will report findings on three of the eight grass species studied; 'Alamo' switchgrass (*Panicum virgatum* L.), 'T-587' Old World bluestem (*Bothriochloa ischaemum* L.), and 'Pete' eastern gamagrass [*Tripsacum dactyloides* (L). L.]. The 10' x 20' plots were arranged in a randomized complete block design with split plots and three replications. Three poultry litter treatments were applied to main plots; 0- (control), 4-, and 8-tons/acre (t/ac) on a dry-weight basis. Grass species were allocated to sub-plots. The 4 t/ac litter rate was broadcast applied as a single application in April and the 8 t/ac litter rate was applied as two 4 t/ac split applications in April and June. Nutrient analysis for the poultry litter was approximately 65, 35, and 50 pounds/ton (lbs/ton) for nitrogen (N), phosphorus (P), and potassium (K), respectively. Grass plots were harvested at a 6 in. height three times during the growing season. Harvest weights for each plot were obtained and a grab sample was collected for nutrient analysis. Samples were dried at 140°F and dry-matter (DM) was calculated on a pounds-per-acre (lb/ac) basis. The samples were ground and analyzed for nitrogen, phosphorus, and potassium.

CONCLUSIONS

Eastern gamagrass accumulated more N, P, and K (0 t/ac rate) and a greater amount of N at the 4 t/ac rate than Old World bluestem or switchgrass in the above ground plant portion (Table 1). Switchgrass accumulated more P (44.0 lb/ac) at the 4 t/ac rate than other species and at the 8 t/ac litter rate the quantity of P removed was similar to other species evaluated. Potassium accumulation rates for Old World bluestem (294.7 lb/ac) were higher at the 4 t/ac rate than other species and similar to and higher than switchgrass and eastern gamagrass, respectively, at the 8 t/ac rate. Nitrogen accumulation at the 8 t/ac rate was greater for switchgrass (388.6 lb/ac) than other species. Another observation (Table 1) is that the increase in N, P, and K accumulation was greater between 0 and 4 t/ac than between the 4 and 8 t/ac application rate. Nitrogen accumulation for switchgrass increased 6.5 times from the 0 to 4 t/ac rate compared to 1.4 times between the 4 and 8 t/ac litter rate. These differences were similar for Old World bluestem at comparable litter rates and lower for eastern gamagrass.

Seasonal averages for protein content increased for grass species with increasing levels of poultry litter. Protein content for eastern gamagrass (data not shown) averaged 9.8, 12.9, and 13.6 percent for 0, 4, and 8 t/ac litter rate. Switchgrass protein content with 0, 4, and 8 t/ac applied litter was 8.0, 10.8, and 13.4 percent, respectively. Generally, protein content was higher at the first harvest and declined during the second and third harvest. The protein produced on a per acre basis may be calculated by multiplying the N content (Table 1) by a factor of 6.25. For example, switchgrass accumulated 228.5 lb/ac N at the 4 t/ac rate, multiplying 228.5 x 6.25=1428 lb. of protein harvested per acre.

A 4 and 8 t/ac litter application rate would result in the equivalent of 140 and 280 lb/ac, respectively, of P applied each year. The increase in applied P would require approximately 3 (140 lb/ac) and 6 (280 lb/ac) years for removal by switchgrass with no additional poultry litter applications. This is an example of how quickly P is accumulated in the soil and the length of time required to lower this nutrient to a manageable level.

Dry-matter for all species increased with increasing levels of applied poultry litter (Table 2). Increases in DM production were greater between 0 and 4 t/ac than between the 4 and 8 t/ac litter rate for all species. Dry-matter production was greater for eastern gamagrass in 1995 with 0 and 4 t/ac and in 1996 at the 0 t/ac rate compared to other species and similar litter rates. Switchgrass produced more DM at the higher litter rate (8 t/ac) in 1995 (15,652 lb/ac) and 1996 (19,312 lb/ac) than other species evaluated. Edwards et al., (2000) reported DM production (3 year average) of 12,450 and 7,780 lb/ac for eastern gamagrass and switchgrass, respectively, with 240 lb/ac N fertilizer.

Eastern gamagrass initiates growth much earlier than the other WSG species studied. This species also produced the majority of seasonal DM production at the initial harvest. Eastern gamagrass produced 58.6 and 83.0 percent of the seasonal DM production at the first harvest in 1995 (24 May) and 1996 (5 Jun), respectively, with 0 t/ac litter (data not shown). This observation was similar for the 4 and 8 t/ac litter rates in 1995 and 1996.

During the four years this study was conducted 12 batches (3 per year) of poultry litter were analyzed for nutrient (N, P, and K) content. All of the batches had varying amounts of the three nutrients, and the range (low to high) for each nutrient (lb/ton) was quite large. Four t/ac is the annual poultry litter application rate that is recommended by the state extension service. There was wide variation in the results of the analyses for N, P, and K in this study. There is also considerable variation in manure nutrients of other types of operations (i.e. livestock, layers, and swine, etc.) documented in literature. This is an indication that it is imperative to know the nutrient content of each load of animal waste prior to field application.

A consideration that will facilitate the timing of nutrient accumulation in filter strips would be the selection of a grass species that is actively growing during the time of field fertilization. An example would be to select a warm-season species for the filter strip to coincide with summer crop fertilization. Eastern gamagrass may be a consideration for incorporation into filter strips because of its early spring growth pattern.

Table 1. Nitrogen, phosphorus and potassium uptake by grass species with 0,4, and 8 tons/ac of applied poultry litter.

	Litter applied – tons/ac								
	0			4			8		
Species	N	P	K	N	P	K	N	P	K
	lbs/ac								
Old World Bluestem	29.4	4.8	36.3	207.5	31.5	294.7	317.3	44.6	374.0
Eastern gamagrass	61.2	10.0	68.0	256.6	35.0	244.7	318.4	42.3	335.8
Switchgrass	35.3	6.3	35.7	228.5	44.0	255.2	388.6	46.5	375.4

Table 2. Dry matter production for grass species influenced by 0, 4 and 8 tons/ac of applied poultry litter in 1995 and 1996.

	Litter applied – tons/ac					
	0		4		8	
Species	1995	1996	1995	1996	1995	1996
	lbs/ac					
Old World Bluestem	1006	2278	9955	11447	13355	13802
Eastern gamagrass	8357	5310	15867	14504	13045	15987
Switchgrass	2897	2883	11716	14627	15652	19312

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Seasonal Grazing of Eastern Gamagrass in the Southeastern USA

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INTRODUCTION

Eastern gamagrass [*Tripsacum dactyloides* (L) L.] is a warm-season, native, perennial grass suited to most of the eastern United States. One of its potential uses is forage for livestock. The Jimmy Carter Plant Materials Center in Americus, Georgia is demonstrating intensive grazing management of this plant. The Lamar County Soil and Water Conservation District is cooperating in this demonstration by providing the cattle for the demonstration.

PROCEDURES

In the spring of 1993, a 4.5 ac field of eastern gamagrass, (variety 'Pete'), was planted in 36 in rows using a corn planter. A planting rate similar to rates discussed by Dewald et al. (1991) was utilized. This 4.5-ac pasture was allowed to establish from 1994 to 1995. This demonstration is located in the upper Coastal Plains on the northwest side of the town of Americus, Georgia, where annual precipitation mean is 125 cm (about 49"), and the annual mean temperature is 18.5 degrees Celsius (about 65.3 degrees Fahrenheit).

The demonstration site is divided into ten paddocks, approximately 0.2 hectares (about 0.45 acre) each, using a single strand of electric fence wire about 90 cm high. Water was provided in each paddock. On April 1, 1999, 12 steers, provided by the Lamar County Soil and Water Conservation District, weighing about 575 pounds were brought to the plant materials center. April 22, 1999 the steers were weighed, vaccinated, wormed, fly control applied, and ear tags attached. On May 5, 1999 the steers were moved into the first eastern gamagrass paddock to begin a 3.5 day grazing period in each paddock. Approximately 150 pounds of ammonium nitrate (34-0-0) was applied to each paddock after the cattle completed grazing each paddock. Manure samples were taken on a periodic basis to determine crude protein and digestible organic matter of the eastern gamagrass consumed by the animals. The Grazing Animal Nutrition Laboratory at Texas A&M University was utilized to determine these readings. The NUTBAL Nutritional Balancer software was used to predict animal nutritional needs.

PRELIMINARY FINDINGS

This is the first year of the study and will continue until 2004. Cattle were rotated successively through the ten paddocks with the 3.5 days grazing period in each paddock. This rotation period was based on maintaining a 10-12 in stubble height. The cattle were rotated through the ten paddocks three times and then on the fourth cycle the grazing time in the paddocks was shortened two days per paddock. The exact number of days per paddock is not concrete, but determined by the amount of grass available. When grazing was terminated (Sept. 15), eastern gamagrass stubble height was approximately 8-14 in. This should ensure persistence of the eastern gamagrass stand (Aiken and Springer, 1998).

Table 1. Crude protein and digestible organic matter in fecal samples, Americus, GA, 1999.

Date	Crude Protein	Digestible Organic Matter
05-27	8.02	62.62
06-07	9.55	63.00
06-24	10.72	63.02
07-06	12.65	63.83
08-23	10.71	62.14
09-15	10.85	62.84

Table 2. 1999 Average and Total Animal Weight Gain, Americus, GA.

Beginning Weight	Ending Weight	Total Gain	Avg. Daily Gain
(April 1)	(Sept. 15)		
573	866	293	1.74 lbs/day

The steers showed a total average weight gain of 293 pounds in 168 days of grazing the eastern gamagrass at the Jimmy Carter Plant Materials Center in Americus, Georgia. These gains were similar to Burns et al. (1992).

SUMMARY

Observations and results of NIRS analysis of fecal samples for crude protein suggest that forage quality is adequate for typical livestock operations in this region. Vegetation observations suggest that the quantity of forage produced compared to the fertilizer inputs is adequate for practicable use of eastern gamagrass as a forage crop in this region.

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Clipping Effect on Yield and Quality of Eastern gamagrass, Switchgrass, and Bermudagrass

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INTRODUCTION

In the southeastern United States, forage producers have relied on the introduced species bermudagrass [*Cynodon dactylon* (L.) Pers.] as a major component in their forage programs (Ball et al., 1991). Numerous cultivars have been released through plant breeding and selection to increase forage production and quality (USDA, 1994). Bermudagrass should be harvested every 4 to 5 weeks to maintain optimum quality. The stage of maturity at harvest influences the palatability, crude protein content, and especially the digestible energy level. Forage quality deteriorates rapidly with advancing maturity even though yield will continue to increase (Ball et al., 1991).

Eastern gamagrass [*Tripsacum dactyloides* (L.) L.] and switchgrass (*Panicum virgatum* L.), both perennial warm-season grasses native to the southeastern United States, have potential as forage crops. Eastern gamagrass is adapted from Massachusetts to Michigan, Iowa and Nebraska, south to Florida and Texas. Switchgrass has an even larger distribution from Maine to North Dakota and Wyoming, south to Florida, Arizona and Mexico (Hitchcock, 1951).

The increased demand for native forage species for summer grazing (Burns et al., 1992), hay production (Hall et al., 1982) and silage (Brejda et al., 1994) have resulted in many advances in seed production, seed quality and stand establishment techniques. However, limited information is available on production potential of native grasses under management conditions used for introduced species (i.e., frequent clipping). The objective of this study was to evaluate clipping effects on yield and quality of eastern gamagrass, switchgrass, and bermudagrass.

PROCEDURES

The study was conducted over a 3-y period from 1996 to 1998 at the USDA-NRCS-Jamie L. Whitten Plant Materials Center near Coffeeville, MS, on an Oaklimeter silt loam (Coarse-silty, mixed, thermic Fluvaquentic Dystrochrepts). Plots were established from transplants and sprigs and allowed to grow for 2 yr before clipping treatments were introduced in May 1996.

During establishment phase, 60 lbs N, 26 lbs P, and 36 lbs K were applied. All species were burned each spring prior to green-up. Thirty days after green-up all plots received 60 lbs N, 39 lbs P, and 48 lbs K. After initial harvest, 180 lb N and 120 lb K were applied in split applications. Study design was a split plot in a randomized complete block with 5 replications. Plots were split by 30 d and 45 d clipping frequency into 10 by 20-ft plots.

Bermudagrass and switchgrass were harvested from a 3-ft by 20-ft strip in each plot at a 4 inch cutting height using a sickle bar mower. Five eastern gamagrass plants were harvested from each plot to a 4 inch cutting height with a hand held sickle bar trimmer. Harvested material was weighed green in the field before a subsample was collected from each plot. Samples collected for dry matter, %N, ADF, NDF, were dried at 55°C for 16 hours (Undersander et al., 1993). Percent N was determined from Kjeldahl N digest using flow injection analysis on a Lachat Quick Chem Automated Ion Analyzer (Lachat Instruments, Milwaukee, WI). Crude protein was estimated by multiplying %N by 6.25. Acid detergent fiber and NDF were determined using an ANKOM$^{200/220}$ FIBER ANALYZER (Cherney et al., 1997). In 1996, 30 d plots were harvested 14 June, 15 July and 12 August; 45 d were harvested 28 June and 12 August. In 1997, 30 d plots were harvested 14 May, 19 June, 18 July and 18 August; 45 d plots 19 May, 30 June, and 11 August. In 1998, 30 d were harvested 22 May, 18 June, 24 July and 3 September; 45 d 22 May, 30 June, and 25 August. Precipitation was recorded on-site at the PMC for each year of the study (Table 1).

Table 1. Growing season precipitation totals for 1996 – 1998 and 20 y average, Coffeeville, Mississippi.

	Precipitation			
Month	1996	1997	1998	20-yr avg.
	------------------------------------inches-------------------------------			
March	5.20	7.83	6.57	5.75
April	5.94	3.15	5.59	5.47
May	3.90	7.17	4.53	5.75
June	11.77	12.32	1.97	4.84
July	4.80	4.09	4.09	4.33
August	3.50	3.15	3.62	3.27
September	7.52	5.59	0.28	4.17
Total	42.64	43.31	26.65	33.58

Harvested material was weighed green in the field and random samples collected for dry matter (DM) yield, %N, ADF, and NDF. Samples were dried at 55°C for 16 hours. Percent N was determined from Kjeldahl N digest using flow injection analysis on a Lachat Quick Chem Automated Ion Analyzer (Lachat Instruments, Milwaukee, WI). Acid detergent fiber and NDF were analyzed with an ANKOM$^{200/220}$ FIBER ANALYZER (Cherney et al., 1997). Data was subjected to analysis of variance in SAS (v 6.12) (1996) (SAS Institute Inc., Cary, NC). Duncan's multiple range test (DMRT) at the 5% level of probability separated significant differences between means.

CONCLUSIONS

There was a significant year x frequency x specie interaction, therefore each frequency was analyzed separately. Bermudagrass produced relatively consistent yields each year for both clipping frequencies with no differences in 1996 and 1998 (Table 2). These bermudagrass yields agree with Fisher and Caldwell (1958) but are higher than 4 yr average yield for 'Tifton 44' reported by Hearn (1999).

Eastern gamagrass responded early to a 30 d frequency but decreased 71% to 3707 lb/acre in 1998 (Table 3). In 1998, eastern gamagrass clipped on 30 d was slow to recover from winter dormancy and excessive weed competition became a problem as the stand declined under the frequent clipping regime. Brakie (1998) reported that a 30 d clipping frequency weakened plants of southern ecotypes of eastern gamagrass in eastern Texas. Kinsinger and Hopkins (1961) found that frequent defoliation in big bluestem (*Andropogon gerardii* Vitman) and western wheat grass [*Pascopyrum smithii* (Rydb.) A. Love] depleted root reserves. These food reserves are important for growth and regrowth following dormancy, defoliation, and other stressful conditions (Sosebee and Wiebe, 1971).

Table 2. Influence of clipping frequency on season total dry matter yield of 3 warm season grasses, 1996-1998, Coffeeville, Mississippi.

Frequency	Year 1996	1997	1998	Mean
---Bermudagrass---				
	---lbs / acre---			
30 day	11561	10221	10542	10775
45 day	11092	7905	10860	9952
LSD (0.05)	NS*	1602	NS	693
---Eastern gamagrass---				
30 day	12494	13123	3707	9775
45 day	10361	14652	12329	12447
LSD (0.05)	NS	NS	2235	2517
---Switchgrass---				
30 day	5681	5675	8594	6650
45 day	3130	7914	12300	7781
LSD (0.05)	989	1915	1297	933

* Not significant

Brejda (1997) reported significant variation in eastern gamagrass forage yield between years because of wide variation in growing season precipitation amounts. In this study, it appears that clipping frequency had more of an effect on yield for eastern gamagrass than precipitation. During this study precipitation received during the growing season was more than 21% above the 20 yr average in 1996 and 23% above average in 1997. In 1998, growing season precipitation was 21% below the 20 yr average. During 1998, with limited precipitation, there was no significant difference in yield for 45 d as compared to 1996 and 1997. Eastern gamagrass yields reported in this study for 45 d clipping frequency are consistent with yields reported by Brejda (1997) but are lower than those reported by Brakie (1998).

Table 3. Season total dry matter yield comparison of 3 warm season grasses clipped on 30 and 45d frequency, 1996 – 1998, Coffeeville, Mississippi.

Year	Bermudagrass	Eastern gama	Switchgrass	LSD (0.05)
	---30 d Clipping Frequency---			
	---lbs / acre---			
1996	11561	12494	5682	1983
1997	10221	13123	5675	2560
1998	10541	3707	8597	1214
LSD (0.05)	1065	3088	1136	
	---45 d Clipping Frequency---			
	---lbs / acre---			
1996	11092	10361	3130	1377
1997	7905	14652	7914	3654
1998	10860	12329	12300	NS
LSD (0.05)	1381	NS*	1573	

* Not significant

Bermudagrass and eastern gamagrass produced significantly higher yields than switchgrass in 1996 and 1997 when clipped on 30 d. In 1998, there was a significant increase in switchgrass yield. This is somewhat misleading because over half of the season total yield for 1998 30 d clipping frequency was produced in the third cutting (data not shown). Switchgrass clipped on 30 d began to show signs of decline similar to the eastern gamagrass with increased weed competition following winter dormancy which severely limited yield in the first and second cutting. Beaty and Powell (1975) reported that switchgrass yield and stand decreased under frequent defoliation resulting in an increase in weed growth.

Switchgrass yields increased significantly each year under 45 d clipping frequency. There was a 9170 lb/acre increase from 1996 to 1998. In 1998, there was no significant difference between species clipped on 45 d. Switchgrass yields reported in this study are 3 times larger than those reported by Beaty and Powell (1975).

There were significant differences in crude protein, ADF and NDF for species clipped on a 30 d frequency (Table 4). Percent crude protein content ranged from 6 to 11% in bermudagrass, 8 to 12% in eastern gamagrass and 7 to 13% in switchgrass. Crude protein contents for eastern gamagrass are in agreement with Brakie (1998). Protein content increased with each cutting in all three years peaking in the third or fourth cutting except in 1998. The highest crude protein content was in the 1998 second cutting during an extremely low precipitation period. Kamstra (1973) and Perry and Baltensperger (1979) reported that higher crude protein levels in switchgrass during drought years are associated with a higher leaf to stem ratio.

Percent ADF ranged from 33 to 40% in bermudagrass which was significantly lower than eastern gamagrass (36 to 41%) in all cuttings in 1996 and 1997. In 1998, there was no significant difference in %ADF. Eastern gamagrass and switchgrass had significantly lower %NDF per cutting as compared to bermudagrass for all years on a 30 d clipping frequency.

Table 4. Quality estimates by cutting and species for 30 d clipping frequency in 1996 – 1998, Coffeeville, Mississippi.

Species	% Protein				% ADF				% NDF			
	------------Cutting------------				------------Cutting------------				------------Cutting------------			
	1	2	3	4	1	2	3	4	1	2	3	4
	-------1996-------											
Bermudagrass	8	9	8	10	38	33	37	36	72	71	72	71
Eastern gama	10	10	10	12	41	38	39	37	67	69	67	67
Switchgrass	10	9	7	9	34	34	38	36	71	69	69	66
	-------1997-------											
Bermudagrass	6	12	10	11	33	34	35	33	72	70	70	70
Eastern gama	10	8	12	12	37	38	38	38	69	70	68	67
Switchgrass	10	8	12	12	34	33	35	35	67	70	66	65
	-------1998-------											
Bermudagrass	9	11	9	8	38	35	38	40	74	71	71	70
Eastern gama	9	12	10	N/A*	36	36	38	N/A	67	66	68	N/A
Switchgrass	8	13	10	N/A	37	34	38	N/A	68	65	67	N/A

LSD (0.05) for differences in species and cutting for Protein = 1.5
LSD (0.05) for differences in species and cutting for ADF = 2.0
LSD (0.05) for differences in species and cutting for NDF = 2.0

* N/A = Eastern gamagrass and Switchgrass were only clipped three times in 1998.

In 1997, bermudagrass was only clipped twice on a 45 d clipping frequency. Bermudagrass did not respond well to a late 45 d harvest in 1996. Bermudagrass clipped on 45 d produced lower % crude protein than both eastern gamagrass and switchgrass (Table 5). Protein levels remained more consistent across cuttings for eastern gamagrass and switchgrass unlike the 30 d frequency ranging from 6 to 11% and 6 to 10% respectively.

There was no significant difference in %ADF across cuttings or species in 1998 on a 45 d cutting frequency. Percent NDF also remained constant from first to last cutting each year with no significant difference within species.

Table 5. Quality estimates by cutting and species for 45 d clipping frequency in 1996 – 1998, Coffeeville, Mississippi.

Species	% Protein			% ADF			% NDF		
	Cutting			Cutting			Cutting		
	1	2	3	1	2	3	1	2	3
	1996								
Bermudagrass	8	6	7	37	38	38	72	74	72
Eastern gama	10	6	9	37	41	40	71	70	70
Switchgrass	10	6	7	33	40	38	71	71	68
	1997								
Bermudagrass	5	6	N/A*	35	38	N/A	74	74	N/A
Eastern gama	11	10	10	38	40	39	69	72	68
Switchgrass	10	8	8	34	36	39	67	71	70
	1998								
Bermudagrass	9	9	7	37	38	39	75	73	71
Eastern gama	10	10	10	37	38	38	68	68	70
Switchgrass	8	10	7	36	37	38	68	68	65

LSD (0.05) for differences in species and cutting for Protein = 1.5
LSD (0.05) for differences in species and cutting for ADF = 2.5
LSD (0.05) for differences in species and cutting for NDF = 4.0

* N/A = Bermudagrass was only clipped twice in 1997.

APPLICATIONS

A 45 d clipping frequency typically represents two to three harvests per growing season in the lower southern states, but is greatly influenced by moisture and length of growing season. Eastern gamagrass clipped on 45 d had a 3 yr average dry matter yield of 12 447 lb/acre with no significant variation between years. Bermudagrass clipped on 30 d had one more clipping per year but only had a 3 yr average dry matter yield of 10 775. Clipping on a 30 d frequency reduced stands allowing weeds to invade both eastern gamagrass and switchgrass. A 45 d clipping frequency appears to be more suited for eastern gamagrass, as indicated by the sustained yield across years.

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Estimating Digestibility of Eastern Gamagrass

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INTRODUCTION

Equations to predict total digestible nutrients (TDN) were developed for a variety of introduced perennial forage grasses and legumes, and annual small grain forages (Undersander et al., 1993). Livestock producers and forage specialists use TDN equations to estimate the feed value of different forages and determine nutrient supplement needs. Quality estimates for crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF) are used in various equations to predict TDN. Age of forage at harvest is among several factors influencing quality estimates that will ultimately effect TDN. Because many TDN equations give emphasis to introduced forages, they have limited use for predicting TDN of native forage grasses such as eastern gamagrass [*Tripsacum dactyloides* (L.) L.]. Objectives of this study were to determine the effect of a 30 and 45 day clipping frequency (CF) on forage quality estimates of accession 9062680 for ADF, NDF, CP and lignin (L), and determine if these estimates could be used to estimate the digestibility of the grass.

PROCEDURE

The 118 samples used in this study were collected from replicated plots clipped on a 30 and 45 day clipping frequency. For specific details on yield response, harvest dates, fertilization experimental design refer to paper by Edwards et al. contained in this publication.

Samples collected for dry matter, %N, ADF, NDF, L, and IVDMD were dried at 55°C for 16 hours (Undersander et al., 1993). Percent N was determined from Kjeldahl N digest using flow injection analysis on a Lachat Quick Chem Automated Ion Analyzer (Lachat Instruments, Milwaukee, WI). Crude protein was estimated by multiplying %N by 6.25. Acid detergent fiber, NDF, L, IVDMD were determined by the procedures of Goering and Van Soest (1970) with IVDMD utilizing a Daisy ^{II} Incubator and an ANKOM$^{200/220}$ FIBER ANALYZER (Cherney et al., 1997). Data was subjected to analysis of variance and step wise regression procedures for general linear models in SAS (v 6.12) (1996) (SAS Institute Inc., Cary, NC). A multiple range test separated significant means at the 5% level of probability.

CONCLUSIONS

Forage Quality Estimates

The 30 day CF typically produced lower fiber, higher protein and IVDMD than the 45 day CF in 1996-1998 (Table 1). In 1996 and 1998 the 30 day CF significantly increased IVDMD by 3% units and 6% units, respectively, compared to the 45 day clipping frequency. The IVDMD values for 9062680 for both clipping frequencies are higher than those reported for 'Coastal' bermudagrass [*Cynodon dactylon* (L.) Pers.] harvested at four weeks (Ball et al., 1991). The 30 day CF significantly decreased ADF by 6% units in 1996. In comparing the 3 year average, the 30 day CF produced a significantly lower ADF and a significantly higher protein and IVDMD than the 45 day CF but the magnitude of these differences were small. Brejda et al. (1994) and Horner et al. (1985) reported similar ADF, protein, and lignin but lower NDF for eastern gamagrass in their studies. The average IVDMD for 9062680 was 18% units higher than those reported for PMK-24 eastern gamagrass (Brejda, 1994; Faix et al., 1985). However, Burns et al. (1992) reported ingestive masticates of 'Pete' eastern gamagrass ranged from 64 to 80% IVDMD. True digestibility of eastern gamagrass may be higher than indicated by conventional Van Soest estimates. Horner et al. (1985) reported that eastern gamagrass was nearly equal to alfalfa (*Medicago sativa* L.) as a source of hay for lactating dairy cows.

Table 1. Quality estimates of 9062680 eastern gamagrass as influenced by CF in 1996-1998 and 3 year average, Coffeeville, MS.

	Quality estimates				
Frequency	ADF[1]	NDF[2]	CP[3]	L[4]	IVDMD[5]
1996			%		
30	38 a*	79 a	10 a	8 a	79 a
45	44 b	78 b	8 b	11 a	76 b
1997					
30	40 a	80 a	10 a	8 a	74 a
45	42 a	81 a	10 a	11 a	74 a
1998					
30	42 a	78 a	11 a	8 a	77 a
45	41 a	77 b	10 a	12 b	71 b
3 yr. Avg.					
30	40 a	79 a	10 a	8 a	77 a
45	42 b	79 a	9 b	11 a	74 a

1 - acid detergent fiber; 2 - neutral detergent fiber; 3 - crude protein; 4 - lignin; 5 - *in vitro* dry matter digestibility. Means in columns within year and 3 year average followed by the same case letters are not significantly different at $P \leq 0.05$.

Estimating Digestibility

Undersander et al. (1993) identify numerous digestibility equations for different regions of the U.S. utilizing ADF, CP, and NDF to predict TDN of various perennial and annual grasses, legumes, and other crops. In this study, regression analysis produced similar equations for the 30 and 45 day CF when ADF, NDF, CP and L estimates were regressed on IVDMD (data not shown). Therefore, data were pooled for final statistical analyses.

Regression analysis gave different equations each year (Table 2). Although the regression equations for 1996-1998 were highly significant, their correlation was weak. Reid et al. (1988) reported higher correlation coefficients between chemical components and IVDMD of warm season grasses. Bidlack et al. (1999) found that IVDMD was highly correlated with L and CP in some genotypes of eastern gamagrass. The equation produced in 1996 with NDF, CP and L gave the highest correlation. When combined over years, no combination of quality estimates produced a consistent equation. However, ADF and CP remained in the over all equation but was a weak primary influence. Many state and university forage testing laboratories in the southeastern U.S. use ADF and CP for predicting TDN of cool and warm season grasses and legumes, grass-legume combinations, and other forages (www.uark.edu/depts/agronomy/facpage/west/tdn). The overall equation has relevance for estimating digestibility of 9062680. Additional laboratory analysis may be necessary before an equation can be verified. In addition, *in vivo* digestibility studies need to be conducted.

Table 2. Regression equations, R^2 and P values for IVDMD (Y) vs. quality estimates (ADF[1], NDF[2], CP[3] and L[4]) of 9062680 eastern gamagrass for 1996-1998 and combined over years.

Year	Regression equation	R^2	P value
1996	$Y = 85.6 - 0.33 * NDF + 1.63 * CP + 0.24 * L$	0.63	0.0001
1997	$Y = 67.7 - 0.27 * ADF + 0.22 * NDF$	0.16	0.0242
1998	$Y = 77.3 - 0.43 * L$	0.19	0.0112
Combined	$Y = 77.9 - 0.21 * ADF + 0.56 * CP$	0.13	0.0004

1 - acid detergent fiber; 2- neutral detergent fiber; 3 - crude protein; 4 - lignin.

APPLICATION

A 45 day CF was found to be suited for persistence, sustainable yield (refer to paper by Edwards et al. in this publication) and favorable quality of 9062680 eastern gamagrass. There was no combination of quality estimates that produced a consistent equation to estimate digestibility. Crude protein and ADF estimates remained in the overall digestibility equation but were a weak influence; however, the equation has relevance for estimating the digestibility of 9062680.

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FUTURE RESEARCH NEEDS

Additional laboratory analysis will be conducted in 2000 and used to revise the equations. *In vivo* digestibility studies need to be conducted on accession 9062680.

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Yield, Quality and Persistence of 13 Accessions of Eastern Gamagrass in the Southern U.S.

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INTRODUCTION

Thirteen ecotypes of eastern gamagrass [*Tripsacum dactyloides* (L.) L.] were selected as superior forage accessions by Plant Materials Centers (PMC) in Knox City and Nacogdoches, Texas; Los Lunas, New Mexico; Booneville, Arkansas; Coffeeville, Mississippi and Brooksville, Florida. Maintaining 13 cultivars of eastern gamagrass in the commercial seed trade would be difficult; therefore, an inter-center strain trial was initiated to identify accessions that performed well over a broad environmental region. Therefore, the objectives of this study were to compare yield, quality and persistence of 13 accessions of eastern gamagrass at six locations in the southern U.S. and identify cultivars for release within a specific region.

PROCEDURE

The study was conducted at six locations (Table 1) from 1996-1998. Plots of the 13 accessions (Table 2) were established vegetatively in a randomized complete block with four replications in 1995 and allowed to establish one year. Phosphorus was maintained at a medium to high level. Nitrogen (N) and potash were applied at 200 lb/acre in equal split applications. First incremental rate of N was applied each year when plants began actively growing in the spring and after each harvest except for the last one. The initial harvest was made at the boot stage and subsequent harvests every 45 days thereafter. The final harvest was made 6-8 weeks prior to the average first frost date. Harvested material from each plot and grab samples were collected for dry matter (DM) yield determinations, acid detergent fiber (ADF), neutral detergent fiber (NDF), and percent N. Crude protein was estimated by multiplying percent N by 6.25. Quality estimates were determined on accessions with above average DM yields at the respective locations. Annual total DM yield by year for each accession was determined by summing yields of each harvest. A three-year average yield was calculated by dividing the total yield obtained in 1996-1998 by 3. Plots were only irrigated to accelerate establishment in 1995. However, additional irrigation water was applied at Knox City, TX and Brooksville, FL because of drought. Differences in accessions, locations, years and their interactions on yield and quality estimates were determined using an analysis of variance. Significant means were separated by least significance difference (LSD) at $P<0.05$.

CONCLUSIONS

Three year average yields range from 1.5 to 8.5 tons/acre depending on accession, number of harvests per location and rainfall (Table 3a-3e). Dry matter yield by accession, location and three year average are presented in Table 4a – 4f. Three to four harvests per year were common at most locations. Florida accessions performed poorly at all locations except for Brooksville and Americus. These accessions were winter killed at Booneville and Coffeeville and accession 9055975, also a Florida accession, did not survive after 1996 in Knox City. Conversely, accessions from Los Lunas, Nacogdoches, Coffeeville and Booneville performed poorly at Brooksville. Florida accessions and accession 434493 were the highest yielding (3 years) entries at Brooksville. Apparently, accessions from the more temperate zones of the U.S. are not as well adapted to the climate and growing conditions of central Florida as the local ecotypes and the opposite was true of Florida accessions in the more temperate zones.

Average yield (three year) for accessions was combined over four locations (Nacogdoches, Coffeeville, Americus and Booneville) because of the similarities in climate and growing season. Accession 9062680 was the highest yielding accession (> 7 tons/acre) but was not significantly higher than 9066165, 9043740 or 9058495 (Table 5).

Knox City and Brooksville locations represented two environmental extremes in this study. Dry matter yields at Knox City and Brooksville were favorable for accessions that persisted but their performance and persistence was greatly enhanced by irrigation water that was supplemented periodically due to prolonged drought conditions. Therefore, it seemed logical for Knox City and Brooksville to select the best performing accession at their respective locations for cultivar release.

After the plots were burned in 1998 at Coffeeville, it was evident that all accessions were either severely damaged or killed by disease (*Rhizoctonia* and *Pythium* complex) except 9062680. This accession exhibited resistance to this complex and continued to produce acceptable yields despite limited rainfall in 1998. This complex destroyed accession 9043762 in late 1996 and severely damaged accessions 434493, 9043740, 9058465, 9043708 and 9066165 following the second harvest in 1997. Consequently, these accessions did not recover after the second harvest. This disease was probably environmentally induced, with climate and moisture being key elements for their occurrence. James Robbins at the Mississippi Agricultural and Forestry Experiment Station in Stoneville, Mississippi is developing a treatment protocol for its control. Several accessions at Brooksville were infected with rust like organisms (*Colletotrichum* sp. and *Septoria* sp.) that caused them to die back.

Quality Estimates

Quality estimates (protein, ADF and NDF) were conducted on accessions that produced above average yield at each location by harvest. Quality estimates for accessions at Coffeeville, Americus and Knox City are presented in Tables 6, 7 and 8, respectively. Protein, ADF and NDF for these accessions were similar at each location but varied between harvests and years. Typically the first harvest was the highest quality because the plants were harvested at the boot stage. In subsequent harvests, particularly at Coffeeville, more reproductive stems coupled with high yields may have decreased N content resulting in lower forage quality estimates. Acid detergent fiber percentages for these eastern gamagrass accessions are similar to most introduced warm season perennial grasses (bermudagrass and bahiagrass) but NDF values are higher.

APPLICATION

Accession 9062680 will be released for the lower southeastern states with potential for use in northern Florida. Booneville plans to release accession 9058495 for Arkansas, eastern Oklahoma and southern Missouri. Accession 9043740 was released as ‘Jackson’ in 1998 for eastern Texas and western Louisiana. Knox City released accession 434493 in 2000 as San Marcos Germplasm for west central Texas and southern Oklahoma.

Table 1. Location and soil types of PMCs in the inter-center strain trial.

PMC	Soil type
Booneville, AR	Taft silt loam
Knox City, TX	Miles loamy fine sand
Nacogdoches, TX	Woden fine sandy loam
Coffeeville, MS	Oaklimeter silt loam
Americus, GA	Lucy fine sandy loam
Brooksville, FL	Kendrick fine sand

Table 2. Eastern gamagrass accessions and Plant Materials Center origin.

Accession	PMC Origin
9058465	Booneville, AR
9058495	Booneville, AR
9058569	Booneville, AR
9059213	Brooksville, FL
9059215	Brooksville, FL
9055975	Brooksville, FL
9062680	Coffeeville, MS
9062708	Coffeeville, MS
434493	Knox City, TX
9066165	Los Lunas, NM
9043629	Nacogdoches, TX
9043740	Nacogdoches, TX
9043762	Nacogdoches, TX

Table 3a. Monthly and total growing season rainfall for 1996-1998 at Coffeeville, MS.

Month	1996	1997	1998
March	5.20	7.83	6.57
April	5.94	3.15	5.59
May	3.90	7.17	4.53
June	11.77	12.32	1.97
July	4.80	4.09	4.09
August	3.50	3.15	3.62
September	7.52	5.59	0.28
Total	42.64	43.31	26.65

Table 3b. Monthly and total growing season rainfall for 1996-1998 at Nacogdoches, TX.

Month	1996	1997	1998
March	1.80	3.88	2.50
April	5.60	Missing data	1.50
May	1.60	6.31	0.17
June	1.60	4.40	0.80
July	1.60	3.78	0.58
August	6.67	19.04	4.69
September	5.55	2.72	5.30
Total	24.42	40.13	15.54

Table 3c. Monthly and total growing season rainfall for 1996-1998 at Booneville, AR.

Month	1996	1997	1998
March	3.17	3.42	7.03
April	6.11	5.26	2.27
May	4.18	1.73	7.54
June	6.13	6.42	2.43
July	5.75	0.92	2.31
August	1.49	2.24	2.94
September	5.85	2.71	4.39
Total	32.68	22.70	28.91

Table 3d. Monthly and total growing season rainfall for 1996-1998 at Americus, GA.

Month	1996	1997	1998
March	6.35	.50	6.22
April	2.74	4.10	8.68
May	4.16	3.46	2.46
June	3.40	3.65	.75
July	3.00	5.49	2.10
August	2.65	1.05	2.05
September	2.90	3.40	8.65
October	1.10	5.60	.20
Total	26.30	27.25	31.11

Table 4a. Total dry matter yield of eastern gamagrass accessions by year and 3 year average at Knox City, Texas.

	DM yield			
Accession	1996	1997	1998	Avg.
	---------------------------lb/acre-----------------------------			
434493	14 030	18 925	3664[1/]	12 206
9043629	6551	14 155	1720	7244
9043740	12 119	*	*	*
9043762	15 563	24 148	3942	14 652
9055975	2121	*	*	*
9059213	3548	3640	361	2516
9059215	5078	3880	500	3152
9058465	8876	18 156	3130	10 054
9058495	10 868	19 418	3310	11 199
9058569	6457	13 237	1752	7149
9062708	7773	13 466	1746	7662
9062680	10 820	16 041	2994	9952
9066165	13 873	17 346	3797	11 672
Mean	9052	14 565	2446	8592
LSD (0.05)	4286	4221	1028	3199

* dead.

1/ Plots were harvested only in May.

Table 4b. Total dry matter yield of eastern gamagrass accessions by year and 3year average at Nacogdoches, Texas.

Accession	DM yield 1996	1997	1998	Avg.
	---------------------------lb/acre------------------------------			
434493	12 594	7328	1952	7291
9043629	14 880	18 302	5488	12 890
9043740	16 354	18 122	4312	12 929
9043762	14 446	13 116	3819	10 460
9055975	3114	3644	507	2422
9059213	8171	12 403	3995	8189
9059215	6654	9301	2243	6066
9058465	13 522	15 048	3074	10 548
9058495	13 064	10 846	3551	9154
9058569	5169	3300	-------	4231
9062708	12 996	12 305	3313	9538
9062680	15 276	14 778	3996	11 350
9066165	14 044	10 410	5100	9851
Mean	11 560	11 454	3443	8840
LSD (0.05)	7702	8565	NS	6363

NS - Not significant.

Table 4c. Total dry matter yield of eastern gamagrass accessions by year and 3 year average at Booneville, Arkansas.

Accession	DM yield 1996	1997	1998	Avg.
	-------------------------lb/acre----------------------------			
434493	15 554	8805	9979	11 446
9043629	12 081	4936	7156	8058
9043740	9185	5098	6943	7075
9043762	13 581	11 020	11 061	11 887
9055975	4051	*	*	*
9059213	4999	*	*	*
9059215	4168	*	*	*
9058465	13 033	7730	9845	10 203
9058495	14 000	9916	12 657	12 191
9058569	12 332	5344	6985	8220
9062708	13 566	8400	9148	10 371
9062680	12 403	11 864	14 228	12 832
9066165	16 087	9048	11 551	12 229
Mean	12 229	8309	10 093	10 451
LSD (0.05)	4206	1592	2192	2590

* Plots were winter killed.

Table 4d. Total dry matter yield of eastern gamagrass accessions by year and 3 year average at Coffeeville, Mississippi.

	DM yield			
Accession	1996	1997	1998	Avg.
	------------------------lb/acre----------------------------			
434493	12 528	12 525	†	
9043629	9442	12 186	†	
9043740	8754	13 420	†	
9043762	11 311	†		
9055975	2032	*		
9059213	4971	*		
9059215	5950	*		
9058465	14 535	13 394	†	
9058495	12 877	20 019	†	
9058569	6859	12 101	†	
9062708	12 017	15 388	†	
9062680	12 747	23 604	12 000	16 117
9066165	14 149	12 120	†	
Mean	9859	10 366		
LSD (0.05)	3724	4525		

* Winter killed in 1996-1997.
† Plants killed by soil disease.

Table 4e. Total dry matter yield of eastern gamagrass accessions by year and 3 year average at Americus, Georgia.

	DM yield			
Accession	1996	1997	1998	Avg.
	--------------------------lb/acre--------------------------------			
434493	17 073	17 703	15 049	16 608
9043629	*	11 249	11 693	11 471
9043740	17 392	22 399	11 195	16 995
9043762	14 611	16 504	13 882	14 999
9055975	6535	7695	5722	6651
9059213	13 541	16 183	9863	13 196
9059215	15 318	17 953	2647	14 791
9058465	15 300	16 074	11 872	14 415
9058495	16 162	12 794	9873	12 943
9058569	10 717	5916	2647	6427
9062708	17 358	16 449	14 476	16 094
9062680	19 637	17 406	14 165	17 070
9066165	19 267	16 973	14 102	16 781
Mean	15 243	15 023	11 203	13 726
LSD (0.05)	2144	2910	4297	2623

* Not harvested in 1996.

Table 4f. Total dry matter yield of eastern gamagrass accessions by year and 3 year average at Brooksville, Florida.

	DM yield			
Accession	1996	1997	1998	Avg.
	------------------------lb/acre------------------------------			
434493	6883	10 133	17 507	11 507
9043629	2318	4966	12 515	6600
9043740	1149	1399	6020	2856
9043762	4540	5233	16 903	8892
9055975	9728	8923	10 674	9775
9059213	8399	11 074	16 141	11 871
9059215	10 790	14 780	14 926	13 499
9058465	5670	6065	13 440	8391
9058495	2475	*	*	*
9058569	2248	*	*	*
9062708	5007	6239	10 589	7278
9062680	3368	5780	10 984	6711
9066165	4252	3123	8528	5301
Mean	5141	7065	12 483	7712
LSD (0.05)	2788	4952	NS	5325

* Dead.

Table 5. Three year average dry matter yield by accession averaged over four southern locations.

Accession No.	DM Yield (lb/acre)
9062680	14 681
9066165	12 986
9043740	12 806
9058495	12 546
9062708	12 384
9043762	12 370
9058465	12 270
434493	11 917
9043629	10 741
9059213	9550
9059215	9414
9059569	7049
9055975	4178
LSD (0.05)	2150

Table 6a. Forage quality estimates of eastern gamagrass accessions by harvest date and average, Coffeeville, MS 1996.

	Forage quality estimates											
	Harvest dates											
Accession	05/20			07/03			08/19			Average		
	CP[1]	ADF[2]	NDF[3]	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
	---------- % ------------			--------- % -----------			--------- % ----------			-------- % ----------		
434493	12	34	66	7	43	72	9	39	68	9	39	69
9043762	12	31	66	7	38	69	8	38	65	9	36	67
9058465	11	31	59	7	39	70	7	39	67	8	36	65
9058495	12	32	65	7	38	71	7	39	68	9	36	68
9062708	13	33	60	5	42	72	7	39	68	8	38	67
9062680	11	33	66	7	39	71	7	39	67	8	37	68
9066165	14	33	67	7	39	71	7	40	69	9	37	69
Mean	12	32	64	7	40	71	7	39	67			
LSD (0.05)[4]	2	NS[5]	6	1	3	NS	NS	NS	1.3			

Table 6b. Forage quality estimates of eastern gamagrass accessions by harvest dates and average Coffeeville, MS 1997.

	Forage quality estimates											
	Harvest dates											
Accession	05/16			07/01			08/20			Average		
	CP[1]	ADF[2]	NDF[3]	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
	-----------% ----------			----------% ---------			---------- %- ---------			---------- % --------		
434493	15	35	66	11	38	67	---	---	---			
9043629	14	34	65	12	39	70	10	37	68	12	37	68
9043740	14	34	66	10	40	69	---	---	---			
9058465	13	35	66	9.5	42	71	---	---	---			
9058495	15	35	67	10	40	71	10	37	68	12	37	69
9058569	15	34	66	10	43	72	10	39	70	12	39	69
9062708	14	34	66	9	42	72	---	---	---			
9062680	14	36	67	10	42	71	9	40	68	11	39	69
9066165	15	35	66	9	39	69	---	---	---			
Mean	14	35	66	10	41	70	10	38	69			
LSD (0.05)[4]	1.4	NS[5]	NS	1.4	3	2	NS	2.4	NS			

1 – crude protein; 2 – acid detergent fiber; 3 – neutral detergent fiber; 4 – least significant difference; 5 – not significant.

Table 7a. Forage quality estimates of eastern gamagrass accessions by harvest dates and average Americus, GA 1996.

Accession	05/22			07/09			08/27			Average		
	CP[1]	ADF[2]	NDF[3]	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
	-----------% -----------			----------%----------			----------- % ---------			----------% --------		
434493	11	38.	70	6	43	74	9	42	70	8	41	71
9059215	11	36	70	6	45	76	7	44	72	8	42	72
9043740	10	36	66	6	40	71	7	39	70	7	39	69
9058465	9	36	68	6	41	70	8	41	68	8	39	69
9058495	11	37	71	6	42	74	7	42	72	8	40	72
9062708	12	36	69	6	43	73	7	44	70	8	41	70
9062680	8	39	70	6	42	72	8	40	68	8	40	70
9066165	10	39	74	7	42	73	7	43	70	8	42	72
Mean	10	37	70	6	42	73	7	42	70			
LSD (0.05)[4]	NS[5]	2	NS	NS	3	2	1	NS	2			

Forage quality estimates; Harvest dates

Table 7b. Forage quality estimates of eastern gamagrass accessions by harvest dates and average Americus, GA 1997.

Accession	05/20			07/15			09/04			Average		
	CP[1]	ADF[2]	NDF[3]	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
	---------- % ----------			----------% ----------			------------% ----------			----------- % --------		
434493	8	40	71	8	42	72	8	41	70	8	41	71
9059215	7	40	72	7	43	74	6	43	74	7	42	73
9043740	7	40	72	6	42	73	7	41	71	7	41	72
9058465	7	39	70	7	41	71	8	39	69	7	40	70
9043762	7	38	71	6	41	71	6	41	70	6	40	71
9062708	9	35	70	7	42	74	7	40	71	8	39	72
9062680	7	40	71	8	40	71	8	39	71	8	40	71
9066165	6	41	72	7	43	73	7	41	72	7	42	72
9059213	7	39	71	6	42	74	6	43	72	6	42	72
Mean	7	39	71	7	42	72	7	41	71			
LSD (0.05)[4]	1	2	2	1	2	1	1	2	2			

Forage quality estimates; Harvest dates

Table 7c. Forage quality estimates of eastern gamagrass accessions by harvest dates and average Americus, GA 1998.

Accession	06/17			07/29			09/10			10/20		
	CP[1]	ADF[2]	NDF[3]	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
	-----------%-----------			--------- %----------			-----------%-----------			-----------%----------		
434493	5	43	75	9	37	70	10	37	67	11	39	70
9043740	5	41	74	8	38	72	11	34	65	10	38	69
9058465	5	40	71	9	37	70	10	35	66	11	38	68
9043762	4	41	73	8	38	71	11	34	65	10	39	69
9062708	5	39	72	10	36	70	11	36	68	11	37	69
9062680	4	42	71	11	36	69	10	38	69	11	38	67
9066165	5	41	74	10	37	70	11	36	68	11	39	70
9043629	5	41	74	10	36	69	11.	34	65	11	38	68
Mean	5	41	73	9	37	70	11	35	66	11	38	69
LSD (0.05)[4]	NS[5]	NS	3	2	2	2	NS	3	2	NS	NS	NS

Forage quality estimates; Harvest dates

1 – crude protein; 2 – acid detergent fiber; 3 – neutral detergent fiber; 4 – least significant difference; 5 – not significant.

Table 7c (Con't). Average forage quality estimates of eastern gamagrass accessions, Americus, GA 1998

Accession	Average		
	CP[1]	ADF[2]	NDF[3]
	------------ % -----------		
434493	9	39	71
9043740	9	38	70
9058465	9	37	69
9043762	8	38	70
9062708	9	37	70
9062680	9	38	69
9066165	10	38	70
9043629	9	37	69

1 – crude protein; 2 – acid detergent fiber; 3 – neutral detergent fiber.

Table 8a. Forage quality estimates of eastern gamagrass accessions by harvest dates and average Knox City, TX 1997.

	Forage quality estimates											
	Harvest dates											
Accession	07/1			8/20			10/8			Average		
	CP[1]	ADF[2]	NDF[3]	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
	---------- % ----------			---------% ----------			--------- % ----------			--------- % ---------		
434493	11	33	65	6	37	69	13	38	68	10	36	67
9043740	11	33	64	5	34	66	13	36	66	10	34	65
90543762	8	33	64	8	34	65	13	36	68	10	34	66
9058495	11	33	64	9	35	67	13	36	66	11	35	66
9062680	12	31	62	9	35	66	14	34	65	12	33	64
9066165	9	31	66	9	38	70	12	38	71	10	36	69
Mean	10	32	64	8	36	67	13	36	67			

Table 8b. Forage quality estimates of eastern gamagrass accessions by harvest dates and average Knox City, TX 1998.

	Forage quality estimates											
	Harvest dates											
Accession	05/30			07/17			09/09			Average		
	CP[1]	ADF[2]	NDF[3]	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
	---------- % -----------			---------% ----------			--------- % -----------			---------- % ----------		
434493	10	40	70	10	42	71	11	37	67	10	40	69
9043629	9	37	66	9	44	72	12	36	63	10	39	67
9043740	12	37	66	---	---	---	---	---	---	---	---	---
9043762	11	39	69	9	42	70	10	37	65	10	39	68
9058465	9	40	67	10	41	68	11	36	63	10	39	66
9058495	11	35	69	9	40	71	10	37	67	10	37	69
9058569	11	37	66	10	42	71	11	36	66	11	38	68
9062708	12	35	59	8	37	69	11	37	66	10	36	65
9062680	12	37	62	10	40	68	12	35	63	11	37	64
9066165	10	39	70	9	41	71	10	38	68	10	39	70
Mean	11	38	66	9	41	70	11	37	65			

1 – crude protein; 2 – acid detergent fiber; 3 – neutral detergent fiber.

Table 8c. Forage quality estimates of eastern gamagrass accessions Knox City, TX 1998.

Accession	05/19/98		
	CP[1]	ADF[2]	NDF[3]
	-----------	%	------------
434493	10	37	66
9043762	10	35	65
9058465	9	35	64
9058496	11	35	66
9062680	10	35	67
9066165	9	37	67
Mean	10	36	66

1 – crude protein; 2 – acid detergent fiber; 3 – neutral detergent fiber.

Yield of Eastern Gamagrass Selections as Affected by Clipping Interval and N Rates

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INTRODUCTION

Eastern gamagrass [*Tripsacum dactyloides* (L.) L.] is a warm season perennial species indigenous to the Americas (Gould, 1983). It is adapted throughout the United States including the Great Plains and Texas (Gould, 1975) and grows in association with the tall warm season grasses.

The East Texas Plant Materials Center (ETPMC) began collections of eastern gamagrass accessions in 1985 and 1986. Evaluation of ninety-three collections from Texas began in 1987 and completed in 1990. In September 1990, three selections; PI#595896 (Jackson County), PI#595897 (Medina County), and PI#595898 (from Nacogdoches County) were chosen for advanced evaluation. At the time this study was initiated, there were no officially released southern cultivars of eastern gamagrass.

OBJECTIVES

Previous studies of warm season grasses indicated influence not only of geographic factors, but also management factors such as clipping interval and N rate. The objective of this study was to provide basic management information pertaining to southern selections of Eastern gamagrass. This objective included answering three important questions:

1. Evaluation of the plant's response to different clipping intervals
2. Determination of optimum amounts of N fertilizer for dry matter production and forage quality
3. Which selection(s) exhibited superior growth and production

PROCEDURE

The study was conducted from 1992 to 1994 at the ETPMC near Nacogdoches, Texas. The climate is temperate with an average rainfall for the growing season (April to September) of 22.76 inches. The study plots were a Woden fine sandy loam soil (coarse loamy siliceous thermic Typic Paleudalf).

The experimental design was a split-split plot randomized complete block with three replications. Each replication was divided into three clipping intervals of 30, 45, and 60 days. Each clipping interval was divided into four subplots representing rates of annual N application (0, 125, 250, and 500 lbs N/ac). Ammonium nitrate was applied in split applications on April 1 and after each clipping except the final one of each growing season. The N subplot was divided into five sub-subplots for the selections in the study. These selections were; PI#595896 from Jackson County, Texas; PI# 595897 from Medina County, Texas; PI# 595898 from Nacogdoches County, Texas; PI#434493 from Hays County, Texas; and #421612 ('Pete').

Clipping height was set at seven inches, based on a study conducted by Dewald (1991). Moist weight of the forage from each selection was measured in kilograms. Moisture content was calculated and the plot weights adjusted to dry matter yield in pounds per acre. A subsample was collected for later forage analysis of protein and ADF (acid detergent fiber) at the Stephen F. Austin State University Soils Laboratory.

CONCLUSIONS

Dry matter yields for 1993-1994 will be presented in this report (Table 1).
Throughout the study, longer clipping intervals produced significantly greater dry matter yields.

Table 1. Seasonal dry matter yield (lbs./ac) treatment means and main effects for each selection at each N rate and each clipping interval for 1993

	N Rate (lbs./ac.)				
	0	125	250	500	Mean
Selection	**30 day Clipping Interval**				
Medina	4,515	7,592	10,367	14,320	9,198
Jackson	6,952	9,468	14,006	14,893	11,329
Nacogdoches	6,851	10,198	11,018	11,872	9,984
Hays	3,582	8,614	9,299	9,131	7,656
Pete	2,673	4,975	5,975	5,357	4,745
Mean	4,914	8,169	10,133	11,114	8582 c
	45 day Clipping Interval				
Medina	9,052	11,220	14,174	16,713	12,789
Jackson	8,334	11,299	16,005	16,746	13,096
Nacogdoches	9,165	11,119	14,961	15,219	12,616
Hays	6,143	7,300	8,772	11,186	8,350
Pete	6,009	6,132	7,502	5,615	6,314
Mean	7,740	9,414	12,082	13,095	10633 b
	60 day Clipping Interval				
Medina	8,861	10,625	19,049	19,599	14,533
Jackson	10,546	17,027	21,104	17,117	16,448
Nacogdoches	13,860	14,848	18,757	18,229	16,423
Hays	5,627	5,717	11,198	10,984	8,381
Pete	6,413	8,423	7,446	8,277	7,639
Mean	9,061	11,328	15,510	14,841	12685 a
	N rate main effects				
	7239 c	9637 b	12642 a	13017 a	

Main effects followed by the same letter are not statistically different using the Duncan's Multiple Range Test at P=0.05
LSD for comparison of treatment means is equal to 3060 lbs./ac at P=0.05

Table 2. Seasonal dry matter yield treatment means (lbs./ac) and main effects for each selection at each N rate and each clipping interval for 1994

	N Rate (lbs./ac)				
	0	125	250	500	Mean
Selection	**30 day Clipping Interval**				
Medina	4,106	8,119	11,835	15,755	9,954
Jackson	3,838	9,327	15,089	14,430	10,671
Nacogdoches	4,714	10,192	12,229	13,691	10,207
Hays	3,194	9,065	12,231	9,975	8,616
Pete	2,052	3,862	5,350	4,968	4,058
Mean	3,581	8,113	11,347	11,764	8701 c
	45 day Clipping Interval				
Medina	6,926	13,241	17,467	19,123	14,189
Jackson	5,318	12,256	18,497	17,630	13,425
Nacogdoches	6,383	13,052	15,581	15,458	12,619
Hays	5,120	8,195	10,880	11,231	8,857
Pete	3,833	5,173	5,942	4,161	4,777
Mean	5,516	10,383	13,673	13,521	10773 b
	60 day Clipping Interval				
Medina	7,125	14,042	22,836	23,781	16,946
Jackson	7,847	20,105	25,834	23,491	19,319
Nacogdoches	9,340	17,035	20,352	23,507	17,559
Hays	5,615	6,270	12,878	9,734	8,624
Pete	4,313	8,666	7,193	5,914	6,522
Mean	6,848	13,224	17,819	17,285	13794 a
	N Rate Mean Effects				
	5315 c	10574 b	14280 a	14190 a	

Main effects followed by the same letter are not statistically different using the Duncan's Multiple Range Test at P=0.05

As noted in the above tables, the 60d clipping interval produced significantly more dry matter yield than the 45 or 30d clipping intervals. The selections from the ETPMC produced much more dry matter than Pete or Hays. Dry matter yields of 'Pete' were approximately half to one third of the dry matter amount of the selections of the ETPMC. The ETPMC selections were not significantly different in dry matter yield.

Nitrogen concentration decrease while ADF increased as clipping intervals increased. This was partly due to the increased amount of mature stems and leaves in the 45 and 60d clipping intervals.

APPLICATION

This study addressed fundamental management questions of proper clipping interval and fertilization response of southern selections of eastern gamagrass. Farmers and ranchers throughout the southeastern United States could use this information to better manage eastern gamagrass stands. Better management would then result in improved stand health and condition.

FUTURE RESEARCH NEEDS

The nutritional data in this study was analyzed only in a laboratory setting. The best way to fully understand the potential nutritional value of eastern gamagrass would be to conduct controlled animal grazing trials using a rotational grazing system. Nutritional data could be taken and more information gleaned about the response of eastern gamagrass as used in a rotational grazing system.

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Summary of Eastern Gamagrass Field Plantings in Texas

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INTRODUCTION

Nineteen field plantings were installed in Texas from 1994 through 1999 per the long-range plan for field plantings. Three genetic strains selected by the East Texas Plant Materials Center (PMC) and one strain from the James E. 'Bud' Smith PMC were compared to the commercial varieties 'Pete', 'Iuka', and 'Iuka IV'. Comparisons were conducted in twenty-three counties across ten Major Land Resource Areas (MLRAs). Four sites were in frequently flooded bottomlands. All other locations were on uplands. Average annual precipitation for the sites ranged from 14 inches to 52 inches. Irrigation was applied at the places with less than 22 inches.

None of the 19 field plantings included all 4 accessions from the PMCs and all three commercial varieties. Combinations of Eastern gamagrass strains and the number of times each combination occurs are:

9043629, 9043740, 9043762, Pete, and Iuka	1 planting
9043629, 9043672, and 9043740	4 plantings
9043629 and 9043672	2 plantings
9043629 and 434493	1 planting
434493, Pete, and Iuka	1 planting
434493 and Iuka	2 plantings
434493 and Iuka IV	1 planting
434493	6 plantings
9043762	1 planting

GENERAL OBSERVATIONS

Earlier field plantings of Pete and Iuka confirmed stratification of seed could be avoided by planting in late winter-early spring (January 1-March 30). Sixteen of the 1994-1999 field plantings were seeded between 1/1 and 3/30. Two were seeded between 12/15 and 12/31. One planting was made on 4/10. All but 2 of the 19 plantings successfully established.

One unsuccessful seeding was in an old rice field. Seedlings emerged and grew well until their roots reached a heavy plow pan. It did not rain from early May of 1999 until January of 2000 at this planting site. The young seedling roots were not able to penetrate the plow pan to get to deep moisture. A second planting that did not establish successfully suffered heavy competition from bahiagrass and vaseygrass and cattle grazing. Creek overflow may have also contributed to the failure.

Precipitation was 30-40 percent below the historical averages for all 19 sites during the growing seasons of 93-95 and 97-99. Weed competition was severe in 97-99 because of good moisture in the fall and again in late winter in 96-97; 97-98; and 98-99 following the dry summers of 96-98.

CONCLUSIONS

Eastern gamagrass varieties Pete, Iuka and Iuka IV are adapted to Texas. Strains originating from Texas and being evaluated by PMCs at Knox City and Nacogdoches grow taller and have wider leaves. It is possible to establish successful stands of all seven strains of eastern gamagrass in severe weedy competition without fertilizing prior to or at seeding. Established eastern gamagrass begins growth by March 10. Withholding fertilizer until late winter of the second year of the planting allows the eastern gamagrass to uptake the nutrients before summer weeds and perennial, warm-season grass competition start growth in April and May then compete for limited moisture supplies during the summer. Annual, cool-season weeds and grasses benefit from the fertilizer but present no competition to the eastern gamagrass seedlings. Herbicide use needs more study to develop strategies that give consistent, economic results.

What Lies Ahead for Accession 9062680?

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Accession 9062680, which originated from Montgomery County, Tennessee and selected by the USDA-NRCS Jamie L. Whitten Plant Materials Center (PMC), Coffeeville, Mississippi, will be released as a perennial forage crop and for other conservation uses in 2002. Its range of adaptation and performance is being documented using 'Pete' and 'Jackson' as standards for comparison. A 0.75 acre production field was established in 2000 with seed harvests to begin in 2001.

Nitrogen Effects on Biomass and Seed Production

Nitrogen is important for the production of grass crops and eastern gamagrass is no exception. Previous work has shown that some eastern gamagrass ecotypes respond to increased nitrogen rates (Brakie, 1998; Brejda, 1997). A cooperative study with Mississippi State University began in 2000 to evaluate the response of 9062680 to different nitrogen rates (0, 125, 250, 375 and 500 lb/acre) on Coastal Plains and Blackland Prairie soils in Mississippi. Plots were established at the PMC, Prairie, and Starkville in 2000 with the first harvests planned for 2001. A second nitrogen study was also initiated in 2000 to compare the effects of N rates on seed production of 9062680. The study will also be conducted at Starkville, PMC, and Prairie.

Improving Uniformity of Seed Ripening

Eastern gamagrass is indeterminate in its seed ripening, which can complicate timing of harvest. A study began in 2000 to evaluate the use of ethephon (Prep) to improve uniformity of seed ripening to increase harvesting efficiency of 9062680.

Silage Evaluation

Research has shown that eastern gamagrass has potential for utilization as a perennial silage crop (Bredja, 1994). A study is planned for 2001 with Mississippi Agriculture and Forestry Experiment Station at Holly Springs to compare silage characteristics of 9062680 to different corn silage varieties.

Bioenergy Crop

High yield potential is one of the major features of 9062680. This characteristic has made it a prime candidate as a bioenergy crop for marginal cropland in the southeastern states (USDA, 1992). A management system that optimizes biomass production is being evaluated at the PMC. This study is being funding by the Department of Energy.

Nutrient Management

Accession 9062680 is included in a study that compares seven other warm season perennial grasses for nutrient removal efficiency from land applied poultry litter. Plots were established in 2000 at the PMC, and with the Mississippi Agricultural and Forestry Experiment Stations at Prairie and Holly Springs. These locations represent three major soil types in Mississippi.

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