Turfgrass Research, Education and Extension Endowment
2007 progress reports for funded projects

The Effects of Three-Dimensional Canopy Management on Overseeded Warm-Season Fairway Turf

Scientist: Kurt Steinke, Department of Soil and Crop Sciences

Funding: $7,000

The objectives are to 1) discover the main physiological and morphological effects of three-dimensional canopy management (3DCM) on turf species performance, 2) evaluate 3DCM frequency intervals on turf surface quality, and 3) assess the need and severity for autumn overseeding when differential 3DCM intervals are practiced in combination with improved varieties of perennial and annual ryegrass. Preliminary data indicate frequent 3DCM (3 x week) may be too aggressive and remove excessive verdure. However, regular 3DCM may aid in the transition process during overseeding and may eliminate the excessive stemminess that has given many warm-season turfgrasses the perception of being difficult to maintain. The configuration of a three-dimensional mower, with the vertical cutting unit, is shown in the image below.

The research differs from previous work because we are comparing the effects of 3DCM on the fairway industry standard turf ('Tifway' bermudagrass) to fine-textured zoysiagrass ('Cavalier') and seashore paspalum ('Sea Isle I'). Seashore paspalum demonstrates much potential as a sustainable warm-season turfgrass but a lack of cultural management data has hindered its acceptance. Fine textured zoysiagrass has shown promise due to aesthetic appeal, but thatch accumulation and management have become obstacles with this species. The project is also unique because it compares the fall and spring transition of winter overseeded grass systems using perennial, improved annual, and a 50/50 perennial/improved annual combination. Potential Benefits The data will be especially useful for turf managers in the southern and southwestern United States who routinely overseed their golf courses and struggle with turf performance during the autumn and spring transitional periods.

Summary: Three dimensional canopy management may enhance turf color/quality and further extend prime playing conditions during the transitional period without additional inputs. Additionally, this project has initiated $10,750 in matching support from Jacobsen, Inc.

New Approaches for Controlling Organic Matter Accumulation - Interaction Between Aerification Type, Frequency, Density in the Cultural Management of Ultradwarf Bermudagrasses

Scientists: Kurt Steinke and M. Engleke, Texas AgriLife Research

Funding: $5,400

The objectives are to 1) determine the benefits and limitations of new venting aerification technology in managing organic matter accumulation in high, moderate, and low growth rate bermudagrass varieties, and 2) compare venting aerification with the industry standard practices of organic matter extraction (conventional aerification) and organic matter dilution (topdressing). Preliminary data indicate Planetair® venting technology may decrease fungicide usage by 70%, eliminate the need for wetting agents, eliminate the need for verticutting, and reduce or eliminate the need for core aerification.

The research differs from previous work because the new venting aerification technology has not been compared directly with conventional aerification and topdressing methods, and scientific information on ways to successfully manage aggressive varieties of bermudagrass putting greens does not exist. We will monitor thatch reduction/accumulation in a previously established (1997) bermudagrass putting green varieties (Tifdwarf, Tifeagle and Mini-Verde).

The Planetair® venting machine demonstration (above left) and pattern of surface disruption from the Planetair® venting machine (above right).

Summary The data will be useful for providing a new potentially more effective way to manage these varieties of bermudagrass. This project has initiated $63,895 in matching support from Jacobsen Inc. and Planetair®. An additional $2,500 from the South Texas Golf Course Superintendents Association and $2,000 from the Turfgrass Producers of Texas has been gathered in support of this project.

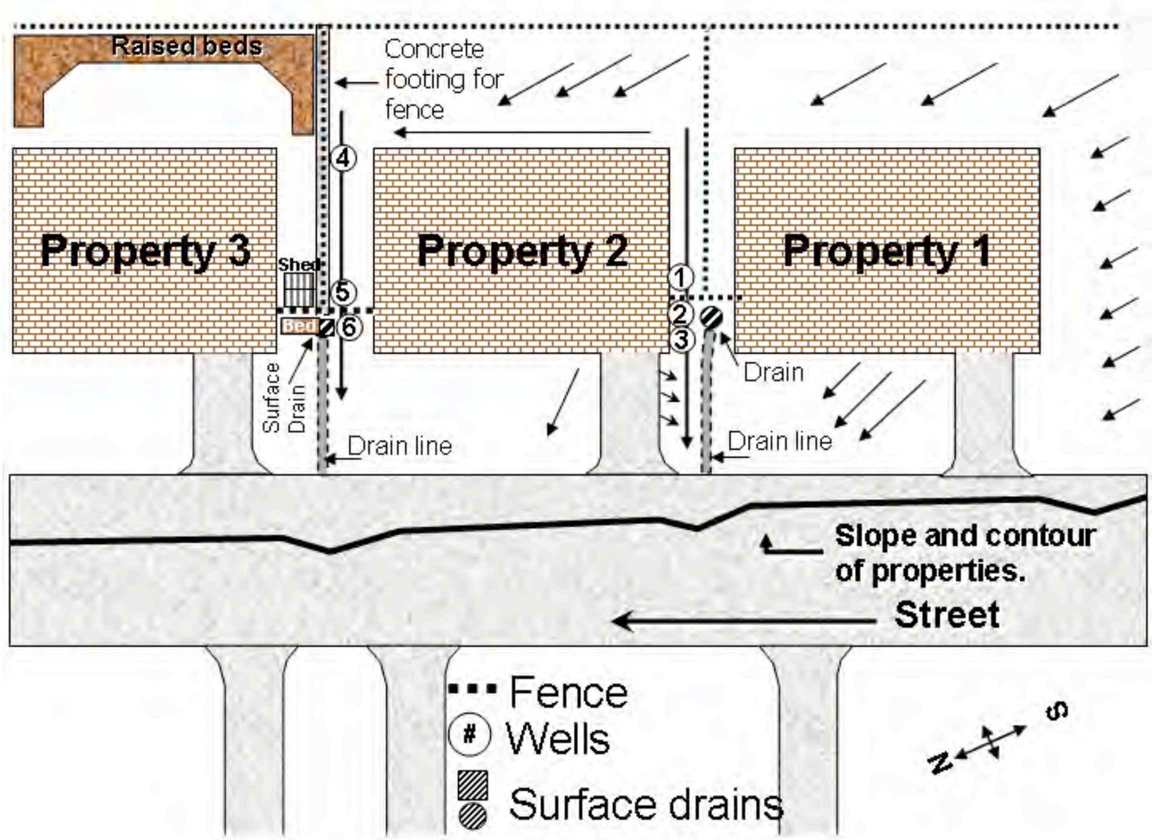
Characterization of turfgrass soil solutions and runoff with respect to nutrients and microbiological quality

Scientists: D.A. Zuberer. T.J. Gentry, F.M Hons and T. Provin, Department of Soil and Crop Sciences

Funding: $4,300

The principal objective of the project has been to continue characterization of the soil solutions in turfgrass systems with respect to nutrients, in particular nitrogen, phosphorus and dissolved organic carbon, and to initiate a longer term monitoring of the microbiological quality of the soil solution and storm-water runoff in an urban landscape.

Shallow wells (12 inch – slotted PVC well-screen points) were installed in homeowner lawns in College Station and in experimental turfgrass plots at the Texas A&M Turfgrass research center. The general layout of the residential watershed is shown below. and a sample well-screen point is illustrated in Figure 2. Wells were inserted to a soil depth of 30 cm. Slits above ground were sealed with a polyester resin to keep out surface runoff. The second year of



sampling the shallow wells is completed. Thus we have two full years of intensive sampling to delineate seasonal effects on dissolved organic

Continued: *Characterization of turfgrass soil solutions and runoff with respect to nutrients and microbiological quality*

carbon (DOC) and nutrients (especially N and P) in soil solutions from homeowner St Augustine grass lawns. DOC concentrations reached their seasonal maxima during the peak growing season (July to September) of the St. Augustine grass. The high values of DOC are likely due to the high productivity of the St. Augustine grass coupled with the fact that lawns at the two properties located upslope of the wells are mowed with mulching mowers so that all clippings are returned. Thus, the DOC pool represents carbon released from decomposing clippings as well as exudates from active roots and decomposition of root tissues. The high concentrations of DOC suggest that adsorption sites on soil particles are probably saturated with bound C and this has implications for loss of organic chemicals (fungicides, insecticides, etc.) applied to control lawn pests in soil solution lost through runoff and leaching. Nitrate concentrations in soil solutions were generally very low. The elevated nitrate levels generally occurred within a few days of fertilizer applications. Phosphorus concentrations were generally low, but like nitrate, they increased transiently following fertilizer applications. The consistent small pool of dissolved P is perhaps due to the prevalence of reducing conditions in the soil profile and also due to mineralization/immobilization turnover of P from grass clippings and microbial biomass. Runoff of this dissolved P has the potential to adversely affect water quality in receiving bodies downstream of the urban landscape.

In addition to the yard-well samples, we have collected samples from other points in the landscape including roof runoff, rainwater, surface runoff in the yard as well as at curb drains and water collecting in a subsurface concrete meter box to more fully characterize nutrient movement in and off the landscape.

Work on the microbiological characterization of the soil solutions and runoff is not yet complete. Preliminary findings indicate that the soil solutions contain high numbers of bacteria ranging from 80 to 155 million cells per ml. Coliform counts done on two separate occasions indicated high number of Total Coliforms 926 to 760 thousand / 100 ml) as wells a Fecal Coliforms (0 to 900 / 100ml). Preliminary data suggest that domestic (cats and dogs) and wild animals (birds, rabbits, and squirrels) contribute significantly to the bacterial populations in the urban landscape.

Summary: The approach and information is important in understanding the sources of nutrient movement and potentially pathogenic microbes in the urban watershed and what if any practices might be put in place to reduce any negative environmental consequences. These data also serve as an indicator of what might be expected in a typical urban watershed.

Development of Insect Resistance in St. Augustinegrass

Scientists: James A. Reinert, M.C. Engelke & A.D. Genovesi, Texas AgriLife Research

Funding: $5,000

The objective of this Project was to evaluate germplasm from the St. Augustinegrass breeding program at TAMUS-Dallas along with existing commercial cultivars for insect resistance and incorporate the resistance into new cultivars for the turf industry. During the first two years of this project we have characterize the commercial cultivars of St. Augustinegrass for their potential resistance or susceptibility to the Southern Chinch Bug. Each of the commercial cultivars evaluated were highly susceptible, including ‘Floratam’ and ‘FX-10’, which had high levels of Southern Chinch Bug resistance in previous years. Additionally, ‘NUF-76’, being developed by the University of Florida (resistant to Florida strains of SCB) was also susceptible to several strains of Texas Southern Chinch Bug. Many of the hybrids from the St. Augustinegrass Breeding Program at TAMUS-Dallas were also highly susceptible. Several hybrids, however, have been identified with varying levels of resistance to confined Southern Chinch Bug (no-choice tests) within 7 days in replicated experiments. Based upon these results, we have the potential to develop a new resistant cultivar to replace Floratam and FX-10 for the turfgrass industry to help manage the highly virulent VTSCB-2005 strain of Southern Chinch Bug in Texas.

Earlier studies showed that Southern Chinch Bug in Texas has overcome the resistance in Floratam and FX-10. Studies this past year confirm the loss of resistance expressed by Floratam and FX-10, and also show that NUF-76, a new cultivar that exhibits resistance to the Florida strain of Southern Chinch Bug that is being developed by the University of Florida, is not resistant to the Texas VTSCB-2005 strain of SCB. Among the “Resistant Cultivars”, including Floratam, FX-10 and NUF-76, a mean mortality of only 38.5, 35.3 and 23.4%, respectively, was produced with a mean of 9.1% mortality for Texas Common. This data shows that there is considerable variation is susceptibility to the various populations evaluated but the maximum level of mortality is usually well below 50% for these cultivars that had exhibited resistance in the past or in Florida. Based upon these findings, there is a good indication that SCB populations in Texas have only recently overcome the resistance in Floratam and that the resistance level is still declining. All future evaluations of our hybrids will be conducted with a mix of several SCB populations to insure a more uniform response from test to test and to decrease the inherent variability that is apparent from our evaluations so far.

Numerous additional hybrids of St. Augustinegrass were evaluated but only a few exhibited promising levels of resistance to this virulent strain of southern chinch bug. Five of the hybrids, showed the highest antibiosis with 95.0, 70.0, 66.2, 62.5 and 60.0%, respectively, level of Southern Chinch Bug mortality.

Summary: Chinch bug resistance has changed among St. Augustinegrass cultivars once thought to be resistant. Testing old and new breeding lines of St. Augustinegrass for resistance enhances the TAMUS St. Augustinegrass breeding program.

Improving Nitrogen Recommendations for Turfgrasses: Availability of Residual Soil Nitrate

Scientists: Frank M. Hons, Tony L. Provin, Richard H. White, and Hamid Shahandeh
Department of Soil and Crop Sciences, Texas AgriLife Research and Texas AgriLife Extension Service

Funding: $3,900

Nitrogen (N) has more effect on turfgrass growth rate and quality than any other plant essential element. Residual soil nitrate is routinely determined for agronomic crop production, with the quantity being subtracted from the normally recommended fertilizer amount. Turfgrass managers, however, generally have not accounted for residual soil nitrate in modifying N fertilizer recommendations. Because of potential regulations to decrease negative environmental consequences associated with nutrients, research is needed to determine whether residual soil nitrate should be accounted for in turfgrass systems. Objectives of this research were to: 1) evaluate effects of added N and residual soil nitrate on zoysiagrass quality, 2) determine the optimum depth for nitrate sampling, and 3) modify turfgrass N recommendations as necessary to account for residual nitrate.

Research plots of zoysiagrass near the Texas A&M University Turfgrass Field Lab were used. Soil samples to a 6-in. depth were taken on March 3rd before fertilizer application. Samples were again taken at 0 to 6 and 6 to 12”-in. depths on April 4th following N application in mid-March. Treatments were 0, 0.5, 1, 2, and 3 lbs N/1000 ft^2 as calcium nitrate broadcasted by hand. Visual quality ratings of grass color and vigor were made on an approximately weekly basis from April 19th through the end of June. Residual soil nitrate in samples taken prior to fertilization was very low, averaging only 1 ppm. About three weeks after fertilization, residual nitrate-N in 0 to 6-in. soil samples ranged from less than 1 to greater than 40 ppm and correlated with N fertilizer application rate. Fertilization had no effect on residual nitrate in 6 to 12-in. samples.

Quality ratings of zoysia grass taken from April 19th to the end of June were significantly affected by N application rate and residual soil nitrate. Grass color in plots receiving either 2 or 3 lbs N/1000 ft^2 was significantly better than the control treatments where nitrogen was not applied from the first rating until about 60 days later on June 21st. Grass receiving 3 lbs N/ 1000 ft^2 was greener than that having additions of either 0.5 or 1 lb N/1000 ft^2 over this same time period. Grass color associated with rates of 0.5 and 1 lb N/1000 ft^2 was statistically better than controls until about 41 days later on May 30th. Vigor results were similar except that fewer differences were observed between rates of 0.5 and 1.0 lbs N/1000 ft^2 and untreated controls, and differences between the two highest N rates and controls ended on June 13th.

Summary: Results from this short duration study, using single early season nitrogen application, found a rise in soil nitrate levels associated with increased nitrogen rates. The authors indicate that residual soil nitrate in 0 to 6-in. samples should be considered in making fertilizer N recommendations for turfgrasses.

Fate of Carbon and Nutrients in Response to N and Clippings Management of Warm-Season Turf Established With and Without Composted Biosolids

Scientists: X. Dai, D.M. Vietor, T.L. Provin, R.H. White, F.M. Hons, T.W. Boutton. Soil and Crop Sciences & Rangeland Ecology & Management, Texas AgriLife Research and Texas AgriLife Extension Service

Funding: $5,000

Municipal biosolids can be composted and incorporated to improve soil physical and chemical properties and increase carbon (C) sequestration during turf establishment and maintenance. Previous sampling and analysis during 9 mos. after sprigging of Tifway bermudagrass indicated volume-based rates of composted municipal biosolids (CMB) increased concentrations of organic C (SOC), total N and P, and extractable P in soil mixed with CMB. In contrast, application of fertilizer N (134 lb N/acre) and return of clippings did not alter SOC or soil nutrient concentration over 9 mos. compared to turf without fertilizer N or return of clippings. A lower ^{13}C value for CMB than for Tifway bermudagrass offered an opportunity to quantify the relative contributions of CMB and turfgrass to SOC and dissolved organic C (DOC) during and after turfgrass establishment. Yet, the short duration of the experiment limited deposition of organic C and nutrients from turfgrass and potential responses of SOC, DOC, and mineral nutrients to N and clippings management. Sampling of the treatments with and without CMB amendments, fertilizer N, and return of clippings was continued during an additional year to achieve three objectives:

1. *Quantify effects of fertilizer N and clippings management on SOC, soil DOC, and total and extractable N and P during maintenance of bermudagrass established with and without composted CMB.*

Concentrations of SOC and total and extractable N and P within the 0- to 6-cm depth remained constant and more than 2 times greater for turf grown in soil with compared to without CMB over the two years of sampling. Similarly, clipping yields were 2 to 4 times greater for turf grown in soil with rather than without CMB. In contrast, soil variables and clipping yield were not consistently different between treatments with or without return of clippings or annual topdressing of 134 lb fertilizer N per acre. The positive response of Tifway bermudagrass to CMB applied before sprigging during June 2005 remained evident during green-up after the final sampling date in Spring, 2007. The positive response of bermudagrass turf to CMB was due, in part, to a 15 to 20% reduction of soil bulk density and a soil water content 2 to 3 times higher within the 0- to 6-cm depth of soil with than without CMB.

2. *Use ^{13}C values to evaluate the dynamics of SOC and DOC in response to return of clippings and fertilizer N management during maintenance of bermudagrass turf established with and without CMB.*

Continued: *Fate of Carbon and Nutrients in Response to N and Clippings Management of Warm-Season Turf Established With and Without Composted Biosolids*

Both the volume-based CB rate and turfgrass biomass contributed to SOC and potential C storage or sequestration. Analysis of the ^{13}C enrichment in CMB revealed a value much lower value (–27‰) than that of Tifway bermudagrass biomass (–15‰), which presented an opportunity for quantifying the relative contribution of CMB and Tifway biomass to SOC and C sequestration. Similar increases in the ^{13}C value of SOC for treatments with and without CMB provided evidence of turfgrass contributions to SOC and carbon sequestration. The increases in ^{13}C values could have been due to net additions of turfgrass biomass to SOC or to tradeoffs between biomass deposition and degradation and loss of SOC. It is noteworthy that both CMB amendments and turfgrass biomass contributed to stable SOC concentrations and C sequestration over the period of Tifway establishment and maintenance in this study

3. *Monitor and analyze relationships among seasonal variation of SOC, soil DOC, total and extractable soil N and P, and 13C values within and below the CMB-amended soil layer during turfgrass maintenance.*

Although concentrations of SOC and total and extractable soil N and P forms remained relatively constant, DOC concentration increased over the two years of this study within the 0- to 6-cm depth. Despite large differences in SOC concentration between treatments with and without without CMB over five sampling dates, soil DOC concentrations were similar among treatments during the second year of sampling. The trend of DOC concentration over time was similar to those reported previously during establishment of common bermudagrass turf amended with large, volume-based rates of CMB. Comparable increases of soil DOC concentration over sampling dates for treatments with and without incorporation of CMB indicated turfgrass clippings and biomass were the principal source for increasing DOC concentrations. In addition, soil DOC concentration remained relatively constant for seven of the eight treatment combinations between the second and third sampling dates, a period in which low winter temperatures limited turfgrass growth.

Summary: The slight increase of ^{13}C values of SOC over time is consistent with the conclusion that turfgrass clippings and biomass were the principal source of increases in soil DOC concentration during the second year of this study. Although previous studies have hypothesized that DOC associates with and contributes to transport of nutrients in soil, variation of concentrations of soil DOC and of total and extractable N and P forms were not related in the present study. Additional research is needed to relate leaching and runoff loss of DOC to that of nutrient ions in turfgrass systems with and without CMB amendments.

Evaluating Herbicidal Control of Three Problematic Weeds in Texas Turf

Scientist: W. James Grichar, Texas AgriLife Research, Beeville, TX

Funding: $2,000

Herbicides were evaluated in the fall of 2006 and the spring/summer of 2007 at several locations across south and south-central Texas. Texas panicum was evaluated with a preemergence and postemergence study at the Dell Turf Farm location near Pearsall on Tifway 419 bermudagrass, K.R.bluestem was evaluated postemergence at the Texas AgriLife Research Station near Beeville in a monoculture situation, and sprangletop was evaluated postemergence at the Glen Rod farm near El Campo on buffalograss. Each study was replicated three times in a randomized complete block design and ratings were taken during the evaluation phase of the project.

Weed control and bermudagrass response to preemergence herbicides: Texas panicum pressure was light while yellow thistle pressure was moderate. All herbicides controlled Texas panicum at least 98% when rated 51 days after herbicide treatment (DAT). Yellow thistle control was less than 90% with Kerb at 1.5 lb/A, Pennant Magnum at 1.0 qt/A, and Dimension at 1.0 and 2.0 pt/A. Princep, atrazine, Monument, and the high rates of Sencor and Ronstar provided perfect thistle control. Only Pennant Magnum at 2.0 qt/A caused significant turfgrass injury.

Weed control and bermudagrass response to postemergence herbicides: Texas panicum pressure was light and no other weeds developed sufficiently to allow for evaluation. When rated 53 DAT, Asulam and MSMA plus Drive provided perfect control. Only Manor and Prograss failed to provide at least 80% Texas panicum control. Turf injury (chlorosis), 7 DAT, was greatest with herbicide treatments which included Sencor or Sencor alone. When rated 53 DAT, Sencor injury (stunting) to bermudagrass was 2% or less in combination with other herbicides and there was no turf stunting when Sencor was used alone. Prograss and Acclaim Extra caused 22 and 17% stunting, respectively.

K.R. Bluestem control using postemergence herbicides: Herbicides were applied in the fall (Oct 18), late spring (May 16), and early summer (June 26) to determine most effective herbicide for bluestem control. Since this study was conducted in an area that had been in K.R. Bluestem production for a number of years and a large number of seed had been produced, it was felt that to best observe the activity of the postemergence herbicides, Pennant Magnum should be used to control any bluestem that emerged from seed. When plots were evaluated approximately 30 days after the initial fall herbicide application, glyphosate without Pennant Magnum and MSMA plus Revolver with or without Pennant Magnum controlled bluestem greater than 90%. Accent at 0.83 oz/a controlled K.R. bluestem 73 to 83% while Accent at 1.25 oz/A controlled bluestem 77 to 80%. When rated after greenup in the spring (April 4), only MSMA plus Revolver without Pennant Magnum or glyphosate with Pennant Magnum controlled K.R. Bluestem greater than 70%. When rated 40 days after the initial spring application (May 16), glyphosate without Pennant Magnum, controlled K.R.

Continued: *Evaluating Herbicidal Control of Three Problematic Weeds in Texas Turf*

Bluestem 96% and glyphosate with Pennant Magnum controlled bluestem 85%. MSMA alone and MSMA plus Revolver alone controlled K.R. Bluestem at least 70%. After the second

herbicide application (early summer, June 26), glyphosate with or without Pennant Magnum provided 100% K.R. Bluestem control. MSMA plus Revolver, without Pennant Magnum, controlled bluestem 85% while either MSMA or Accent plus Acclaim Extra with or without Pennant Magnum controlled K.R. Bluestem at least 70%.

Sprangletop and turfgrass response to postemergence herbicides: The initial herbicide application was on May 8 followed by the second herbicide application on June 7. Sprangletop control across all rating dates was greatest with Accent at 1.25 oz/A. Accent controlled 85 to 98% sprangletop at each rating. Accent plus Acclaim Extra controlled sprangletop 58 to 88% depending on application timing. The best sprangeltop control with Accent plus Acclaim Extra was approximately 40 days after the second herbicide application (69 days after initial treatment). None of the other herbicide treatments controlled sprangletop better than 67%. Accent plus either MSMA or the three-way tank-mix of Accent plus Acclaim Extra plus MSMA controlled sprangletop no better than 67%. Buffalograss injury (chlorosis) 7 days after the initial herbicide treatment was at least 50% with MSMA, Acclaim Extra plus MSMA, Accent plus MSMA, or Accent plus Acclaim Extra plus MSMA. Accent plus Acclaim Extra did not cause any chlorosis. When rated 30 DAT, turf injury was at least 30% with Prograss, Acclaim Extra plus MSMA, or Accent plus Acclaim Extra. Accent, MSMA at 4.0 pt/A, Accent plus MSMA, and the 3-way combination of Accent plus Acclaim Extra plus MSMA resulted in 12 to 18 % turf injury. When rated approximately 40 days after the 2nd herbicide application, Prograss resulted in 92% stand loss while Acclaim Extra plus MSMA and Accent plus MSMA caused 73 and 77% stand loss, respectively. The 3-way combination of Accent plus Acclaim Extra plus MSMA reduced buffalograss stand 63% while MSMA reduced grass stand 20 to 37% depending on rate. Accent reduced buffalograss stand 20%.

Summary: Several preemergence and postemergence herbicides controlled Texas panicum and yellow thistle when applied under conditions of low weed pressure. K.R. bluestem control was best with glyphosate (100%) while MSMA plus Revolver controlled this weed 85%. Accent plus Acclaim Extra and MSMA controlled bluestem 70 to 78%. No other herbicides provided effective control. Sprangletop control was best with Accent at 1.25 oz/A (98%) while Accent plus Acclaim Extra controlled this weed 88%. Preemergence herbicide injury on Tifway 419 was greatest with Pennant Magnum at 2.0 qt/A while postemergence applications of Sencor alone or in combination with any other herbicide caused the most injury. On buffalograss, the postemergence applications of Prograss, Acclaim Extra plus MSMA, or Accent plus MSMA caused the greatest stand reduction.

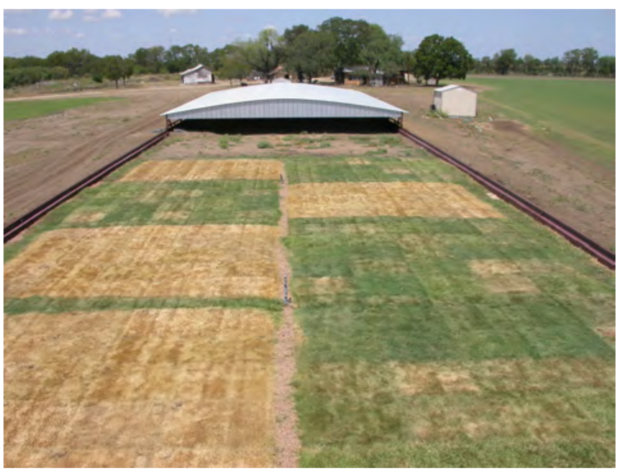
Note: Appreciation is extended to the cooperators on this research: Glen Rod Farms and Dell Turf Farms for their time and effort in these studies; and Peter McGuill (Wharton County CEA) for his help in herbicide application and evaluations.

Travel Support to Service the Ongoing Research Project: "The Evaluation of Sixty-Day Drought Survival in San Antonio of Established Turfgrass Species and Cultivars.

Scientists: D. R. Chalmers, Texas AgriLife Extension Service and R. White, Texas AgriLife Research.

Funding: $4,000

The research project entitled "The Evaluation of Sixty-Day Drought Survival in San Antonio of Established Turfgrass Species and Cultivars" was co-funded in 2005 by the San Antonio Water System and the Turfgrass producers of Texas. The project was coordinated through the Department of Soil and Crop Sciences for the agronomic studies and through the Biological and Agricultural Engineering Department. The project established 25 grass varieties on two soil depths (4-inches and native soil depth) in San Antonio in September 2005 and again in September 2006. The grasses were exposed to 60-day drought treatments (using a 5,000 sq ft drought simulator constructed under the guidance of Extension Agricultural Engineering) in 2006 and 2007. Drought treatments were followed by a 60-day recovery periods in 2006 and 2007.



The original research grant was planned and budgeted, using the proximity of San Antonio grant cooperator, so that much of the servicing of the plots (maintenance and data) would be done by staff in San Antonio. Only occasional site visits were budgeted for College Station Faculty. The San Antonio staff person left that job to pursue another career opportunity. This resulted in the need to service the plots by College Station faculty and resulted in greater travel than had been originally planned to gather data every 7 to 10 days over the 120 day dought/recovery periods in 2006 and 2007. The travel funds supplemented increased site visits by College Station Soil and Crop Science faculty to service and collect data. The above image displays the blocks of 4-inch soil depth being off color 20 days into the 2006 drought.

Summary: This project was completed in 2007. The outcome of the research enables the City of San Antonio will use the data to compile a list of acceptable drought tolerant grasses for use in new home construction. Therefore, the project has great importance to San Antonio, Bexar County and other water agencies/municipalities that may consider the project outcomes in their water conservation efforts. The entire 60-page final research report can be viewed on the web at: http://itc.tamu.edu/documents/2008FinalReportSAWS&TPT_s.pdf