30th Milan No-Till

Crop Production Field Day

TOUR REPORT

with

Crop Variety Demonstrations

Hosted by UT AgResearch
Thursday, July 26, 2018
7 a.m.–2 p.m.

North Tract of the
AgResearch and Education Center
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UTIA Field Days are a cooperative effort of UT AgResearch and UT Extension.

Tour A: No-Till Corn Production

Planting Corn Behind Cover Crops

Angela McClure
Professor
UT Department of Plant Sciences

Winter cover crops may provide a number of environmental benefits, although their impact on cash crop performance can vary. Cover crops may positively influence a crop such as corn due to improved soil water conservation, improved soil aggregate stability, and weed suppression. Cover crops may compete with corn for resources, depending on termination time and method, resulting in reduced corn populations, soil nitrogen immobilization, and soil water depletion in a dry spring. Additionally, the interference between cover crop residual and planting equipment may create difficulty in seed furrow closer and reduce seed-to-soil contact. The preliminary results of three studies conducted in 2018 at Jackson (West Tennessee AgResearch and Education Center) and Milan AgResearch and Education Center will be shared. Studies were initiated in light to moderate cover residue in order to evaluate the impact of termination timing, use of a roller crimper, corn seeding rate, starter N use, and various row cleaner and closing wheel attachments on corn establishment and early and midseason growth and development.

Considerations for Moisture Sensors

Josh German
Extension Agent I
UT Extension Hardeman County

Tracey Sullivan
Extension Program Leader I
UT Extension Western Region Office

Considerations for Moisture Sensors will offer producers an overview of the key things to look for and consider when making management decisions with various moisture sensors. Presenters have multiyear experience with various models available to producers and share their West Tennessee field experiences. Key topics of discussion include "Why Use Moisture Sensors?" "Critical Water Periods," "Types of Sensors," "When and Where to Place Sensors," and "Management Level and User Experience." After attending this discussion, producers will have more insight to decide which moisture sensor may best fit their farm and an overview of how to.

"Why Use Moisture Sensors?" Producers will hear reasons why moisture sensors can be beneficial to their operation. Some key points are maintaining adequate soil water level, nutrient stewardship, visual misrepresentation from the plant of moisture availability, and moisture stress.

Learning to use moisture sensors as a management tool can help optimize crop yield and improve irrigation efficiency.

During the **"Critical Water Period"** is when moisture sensors are most beneficial. With sensors, the producer is able to set goals such as water use efficiency, higher yields, and cost savings. Having sensors at multiple depths in the root system allows a grower to determine how much water to apply and when to apply it. With sensors, a producer is irrigating based on predetermined goal and current available moisture and not visual appearances; therefore, water use thresholds, crop histories, and irrigation records are generated to aid in management decisions. Having these allows a grower to determine irrigation timing and amounts or establish trends based on specific field and crop conditions that can only be seen when using sensors.

"Types of Sensors" The industry is full of various models of moisture sensors and evolves daily. Sensors come in two major types and most have subtypes. The two major types used in row crops are volumetric water content, also known as VWC, and tension sensors. VWC sensors directly measure water content using electronic pulses, which allows them to indicate the amount of water reserves available to the plant, like a fuel gauge. These are used to predict irrigation events. They must be calibrated, are more expensive, and are usually microprocessor controlled. However, they have repeatable readings, are usually automated, and require little maintenance once installed. Tension sensors come in a variety of forms: primarily tensiometer and granular matrix sensor, or GMS. A tensiometer is the only direct measurement system available and works by reading the physical force at which water is being held in the soil. These must be purchased depth specific and are usually more costly. Granular matrix sensors measure the soil tension indirectly by generating values with a tensiometer. These are generally maintenance free, have a long lifespan, and are less expensive. Most tension sensors are usually manually checked.

"When and Where to Place Sensors" Sensor placement and management level required by each type of sensor will be discussed. Sensors should be placed based on topography and soil type along with field experience from the producer. Physical barriers, old road beds, harvest traffic lanes, and other factors such as producer or consultant access can affect placement as well.

"Management Level" and **"User Experience"** are the final topics included as considerations. With most management issues, the most valuable resource on a producer's operation is time. Time for install, time for maintenance, and time spent getting technical support and time to retrieve data varies among types of sensors and companies selling and supporting them.

Hybrid Selection for Unique Situations

Ryan Blair
Extension Area Specialist II
UT Extension

Ranson Goodman
Extension Agent III
UT Extension Henry County

As corn-based ethanol facilities strive to drive down production costs, they are taking a closer look at feedstocks. Breeders are now looking into hybrids designed specifically to reduce input cost for ethanol conversion. Future markets may be coming our way. We will discuss these new alpha amylase enzyme containing hybrids and their potential.

Corn is often used in wildlife food plots for various animals. The effects of corn hybrids on waterfowl feeding patterns demonstration was conducted in a Tennessee wildlife management area. The experiment was set up as a corn variety comparison to determine yield, plant height, ear height, standability after 30 days flooded, water depth, difference from water level to ear height, and a feed rating. Hybrid/variety selection along with ideal plant traits will be covered to assist land managers.

Other "unusual" corn production practices, white corn, and non-GMO options will be covered for their niche markets.

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Tour B: Soybean Breeding

Screening for Drought and Charcoal Rot Resistance

Alemu Mengistu
Research Plant Pathologist
USDA-ARS, Jackson, Tennessee

Jason Deffenbaugh
Biological Science Technician USDA-ARS

Charcoal rot is a disease of soybean that causes significant yield losses in production in the US as well as in many other countries around the world. This disease is exacerbated when plants are under stress, especially under heat and drought conditions. The effect of charcoal rot on drought tolerant genotypes is not well understood mainly because of the confounding effect of drought with the effect of disease severity from charcoal rot. Therefore, field experiments were conducted to determine the severity of charcoal rot on nine drought tolerant genotypes in MG IV and MG V under irrigated and nonirrigated treatments and compared their disease severities with two moderate resistance and two susceptible controls.

Disease was assessed over the growing season using the lower stem and root tissues to determine colony-forming units of the charcoal rot fungus. The population density of the fungus increased slowly from the V1 to R6 growth stages and rapidly increased from the R6 to R7 on all genotypes under both irrigated and nonirrigated treatments. Disease severity levels under irrigation resulted in less than half of the disease severity levels found in the nonirrigated regime, indicating that the nonirrigated treatment significantly increased the severity of charcoal rot. Among the nine drought tolerant genotypes, only four were identified as having moderate resistance under nonirrigation, indicating that not all drought tolerant genotypes were resistant to charcoal rot.

Yield gains of the drought tolerant lines over the moderately resistant controls under nonirrigation across years was not significantly different. Under irrigation environment, however, there was a 35-45 percent yield gain for all moderately resistant charcoal rot lines over the susceptible controls. Even though yield was significantly reduced under nonirrigation compared to yield in the irrigated environment, the yields for moderately resistant lines were significantly higher than the yields of the susceptible controls. The nonirrigation environment may be an appropriate environment for concurrent screening and identification of genotypes with resistance to both charcoal rot and drought resistance. The four moderately resistant drought tolerant genotypes that expressed moderate resistant may be valuable sources of resistance for charcoal rot that can be used in breeding programs. [Published in Crop Protection 105 (2018) 90-101]

New Genetic Sources of Soybean Cyst Nematode Resistance

Prakash Arelli
Supervisory Research Geneticist USDA-ARS
Adjunct Professor, University of Tennessee

Lisa Fritz
Biological Science Technician USDA-ARS

In 2017, Tennessee soybean farmers produced a record 83 million bushels of soybeans with a production value of $805.1 million. An additional 1.8 million bushels are estimated to have been lost due to soybean cyst nematode (SCN), valued at over $17 million. Resistant cultivars have been an effective means of nematode control, but they have also caused major shifts in nematode populations. For decades, soybean cultivars for sale in the US have primarily shared the same source of SCN resistance: a soybean called plant introduction (PI) 88788. This soybean line is native to China and was introduced into the US in the early 1900s for commercialization purposes. Over time, nematode populations in many farmer fields have shifted, rendering this source of nematode resistance much less effective than it once was.

Although soybean cultivars with the PI 88788 genetic resistance source still dominate the market because there is no yield drag, new alternatives are available for broader resistance, in part due to the USDA-ARS soybean breeding program located at the West Tennessee AgResearch and Education Center in Jackson. USDA-ARS in Jackson has released five varieties since 2005 with nematode resistance from a different genetic source: a soybean called 'Hartwig'. Hartwig is resistant to SCN Races 2 and 5, the most common populations in Tennessee fields. This technology has already been transferred to major seed companies and public universities, and varieties with the Hartwig genetic source of SCN resistance are commercially available for purchase from a variety of different companies.

In the future, we expect nematodes to adapt to and overcome the Hartwig genetic source of resistance, just as has occurred with the PI 88788 genetic source. In anticipation of this outcome, the USDA-ARS program in Jackson is developing soybean lines from several different new sources. Soybean lines JTN-5316, JTN-5416, and JTN-5516 combine the Hartwig genetic source with that of PI 567516C, for a broad base of SCN resistance. Soybeans JTN-4118, JTN-4218, and JTN-4318 are earlier maturing lines developed from the PI 494182 genetic source, and are undergoing their first round of regional yield testing in 2018. Soybean lines from genetic sources PI 437655 and 'Columbia' are also in the development pipeline.

Attendees will learn about the different genetic sources for SCN resistance available to them now and in the future, and why changing genetic sources is important. The presentation will also highlight resources that farmers can use to choose varieties with the best SCN resistance for their fields, and how to identify cultivars with genetic resistance from the Hartwig source versus the PI 88788 source.

Breeding New Varieties for the Southern US

Vince Pantalone
Professor
UT Department of Plant Sciences

Chris Wyman
Research Associate
UT Department of Plant Sciences

Ronnie Moore
Graduate Research Assistant
UT Department of Plant Sciences

We will focus our attention on three new varieties and a potential new variety developed recently by our program.

Ellis has been in commercial seed production for the past four years. It is a very high yielding, popular conventional variety that shows drought tolerance. It was developed from the cross between two high yielding University of Tennessee cultivars, '5601T' and '5002T'. In extensive field trials, Ellis has shown excellent adaptation and performance in Tennessee, the Mid-South region, and the Southeast region of USA. Ellis exhibits a relative maturity of 4.9, determinate growth habit, white flowers, gray pubescence, and tan pod wall. It is resistant to stem canker and southern root knot nematode. Ellis shows field tolerance to frogeye leaf spot. The protein and oil concentrations of Ellis seed enable it to produce high protein meal (greater than 48 percent protein in the meal fraction). The excellent seed yield of Ellis coupled with its ability to produce high protein meal have shown high estimated processor values for this new variety.

TN09-008 is a conventional variety released in 2017 and marketed as GoSoy 53C16. Its relative maturity is 5.3. It has high yield, which is protected by resistance to soybean cyst nematode (SCN) races 2, 3, and 5 along with resistance to stem canker and tolerance to sudden death syndrome (SDS) and frogeye leaf spot. TN09-008 was developed from the cross 'Fowler' × 'Anand' and each of its parents are resistant to SCN. SCN is the most damaging parasite of soybean in the USA. Estimates of losses from SCN exceed $1.2 billion annually. Planting resistant cultivars is the most effective means of SCN control. The release of TN09-008 provides a new high yielding resistant variety for nematode control. TN09-008 is resistant to SCN HG types 1.2.5.7 (race 2, score = 1), 5.7 (race 3, score = 1), and 2.5.7 (race 5, score = 1) showing the best possible score (1) for resistance in the USDA Southern Uniform Test. The new variety also had the best possible score (1) for resistance to stem canker. TN09-008 ranked 3rd highest for yield in the USDA Southern Uniform Test, among 27 entries including checks Asgrow AG 5332, Pioneer 95Y70, Osage, USG 5002T, and JTN-5203. TN09-008 has purple flowers, tawny pubescence, tan pod wall, and a determinate growth habit. The plants show good resistance to lodging. The seeds have black hila and are yellow with smooth seed coats. TN09-008 matures one day later than JTN-5203 and 3 days later than 5002T.

TN11-5102 is a conventional variety released in 2017. Its relative maturity is 5.4. The variety produces high yield and high protein meal. It is unusual for varieties that have high protein to have high yield because there is a negative genetic correlation between the traits. Over the decades as breeders have selected for higher yield the oil content has gone up, but the protein content has gone down. This is currently creating an issue with international buyers who prefer South American soybeans with higher protein content over US soybeans. TN11-5102 is resistant to southern root knot nematode and had the best possible score for resistance (1) in the USDA Southern Uniform Test. It also showed the best possible score (1) for resistance to stem canker in that test. It was the top yielding line in the United Soybean Board Quality Traits Test, and has performed well in many other field trials. In 3 years of the USDA Southern Uniform Test, TN11-5102 had seed protein concentration significantly higher than the test mean, and capable of producing a 49 percent meal protein.

TN13-5537R1 and TN13-5538R1 were sister lines that were composited to form the new variety released last year in 2017 and marketed as GoSoy 54G16. This variety has the off-patent glyphosate herbicide resistance gene. It has a relative maturity of 5.3. The plants have white flowers, gray pubescence, tan podwall, and a determinate growth habit. It is resistant to races 2 and 5 of soybean cyst nematode and show strong field tolerance to sudden death syndrome. The variety has performed competitively in yield trials in recent years.

TN16-520R1 is an off-patent glyphosate resistant variety released in 2018. Its relative maturity is 4.9. It is a backcross derived selection of its popular high yielding recurrent parent 'Ellis'. TN16-520R1 had the best possible score (1) for stem canker and for southern root knot nematode in the USDA Southern Uniform Test. TN16-520R1 ranked among the top 4 of 26 entries in the 2017 USDA Southern Uniform Test conducted over 13 locations. Its yield performance and adapted maturity will make it a valuable new variety for producers in Tennessee and the southern region. It has white flowers, gray pubescence, tan pod wall, and a determinate growth habit. The plants show good resistance to lodging. The seeds have buff hila and are yellow with smooth seed coats.

Ellis-HOLL is a potential new conventional variety that is a backcross derivative of Ellis with four recessive genes added to increase oleic acid and decrease linolenic acid. In June 2015 the FDA issued its final ruling that partially hydrogenated oils are now banned from the US food supply, due to health risks associated with the consumption of trans fat. Food processors must comply with the ruling by this year, and would no longer be permitted to sell partially hydrogenated oils either directly or as ingredients in another food product. Soybean oil is the most common partially hydrogenated oil on the market. Loss of market share of soybean oil would detrimentally affect the soybean industry. The creation of high oleic oil with low linolenic acid would eliminate the need for hydrogenation and would create a US vegetable oil supply akin to the quality of extra-virgin olive oil. This is what we have accomplished with Ellis-HOLL. The Ellis-HOLL soybean produces 82 percent oleic acid (approximately four times that of normal soybean) and approximately 2.6 percent linolenic acid (approximately four times lower than that of normal soybean) via recessive mutations in omega-6 and omega-3 desaturases. In its first year of field testing in a three-location field trial, Ellis-HOLL produced 60 bushels/acre which exceeded that of the check variety Ellis (58.6 bushels/acre). After extensive field trials are conducted in 2018, we may recommend Ellis-HOLL for release as a new variety.

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Tour C: No-Till Soybean Production

The Silent Yield Robbers: Soil Pathogens and Nematodes

Heather Kelly
Associate Professor
UT Department of Entomology and Plant Pathology

Rachel Guyer
Research Specialist III
UT Department of Entomology and Plant Pathology

While soilborne diseases can go unnoticed due to the lack of obvious symptoms, they still pose a significant threat to soybean yield. Detection and correct identification before high populations develop are critical for proper management and yield protection. Integrated management strategies that at least include seed treatments, resistant/tolerant varieties, and crop rotation are essential to sustainably manage soilborne diseases. Soilborne diseases are caused by fungi and nematodes, namely seedling disease pathogens Fusarium, Rhizoctonia, Pythium, and Phytophthora; charcoal rot caused by Macrophomina phaselina; and soybean cyst nematode (Heterodera glycines). Proper plant and soil sampling can be used to identify disease-causing pathogens as well as taking into consideration field and environmental conditions. Additional information on symptoms, sampling, and management options on seedling disease; charcoal rot; and pathogenic nematodes will be discussed.

Variable Rate Irrigation Water Management in Soybeans

Avat Shekoofa
Assistant Professor
UT Department of Plant Sciences

Soybean water use varies by growth stage and time of the year. Soybean plants lose gallons of water daily during hot, dry conditions through transpiration. Plants transpire, or lose more than 98 percent of water taken up by the roots, through leaf tissue. Therefore, selecting the right variety and maturity group along with having accurate rainfall or weather data are important factors for scheduling the best irrigation level to improve soybean yield. Also, positioning soil moisture sensors under irrigation systems may help with improving the scheduling of irrigation for row crops. The objectives of this study are to i) determine the latest effective growth stage to initiate irrigation to maximize yield for soybeans, and ii) determine the earliest effective growth stage to terminate irrigation to maximize soybean yield. This will be the fourth year of testing the initiation of irrigation at R1 (beginning of blooming), R3 (beginning pod development), and R5 (beginning seed), also the termination of irrigation at R6 (full seed) to compare, improve, and increase the efficiency of irrigation. Results from the past 3 years of this ongoing study funded by the Tennessee Soybean Promotion Board (TSPB) will be discussed during field tours.

The field trials were conducted at the Milan AgResearch and Education Center. The trial was planted with P47T36 soybean using a 30-inch row production planter. Irrigation treatments were delineated under a center pivot irrigation system equipped with variable rate technology. The trial was arranged in a randomized complete block design with irrigation treatments randomized within each replication. The irrigation regimes consisted of three initiations (R1, R3, and R5) and one termination of irrigation at R6. A zero irrigation treatment was included as a control. Four soil moisture sensor units were used at two depths (6 inches and 24 inches) to determine rainfall amount and soil water content information in order to adjust irrigation level.

Dicamba Technology—Current Status

Larry Steckel
Professor
UT Department of Plant Sciences

In trying to manage Palmer amaranth, cotton and soybean growers in Arkansas, the Bootheel of Missouri, Mississippi, and Tennessee embraced the Xtend weed management system in 2017. Roughly 85 percent of cotton and over 50 percent of soybean varieties planted were Xtend varieties. The weed control, particularly Palmer amaranth, was very good. Unfortunately, most growers in those states struggled to keep dicamba in the field.

The Departments of Agriculture in each of these respective states were swamped with nearly 1,500 dicamba drift complaints to investigate. Weed scientists from those states estimated 1.9 million acres of non-Xtend soybeans alone were damaged by off-target dicamba. This does not count service calls Extension personnel ran on trees, vineyards, truck patches, gardens and homeowner landscaping exhibiting dicamba injury symptoms.

A survey of Tennessee Extension agents concerning the causes of the drift can be categorized into five basic reasons. In listing from least frequent to most frequent cause of dicamba drift in their investigations, tank contamination was the least found cause followed by use of illegal dicamba formulation, dicamba misapplication, spraying into a temperature inversion, and finally XtendiMax or Engenia volatilization.

Soybeans that were injured by off-target dicamba were at all different growth stages. The ones that were still in the vegetative growth stages seemed to recover in a few weeks. Soybean fields that were into flowering stages showed visual symptoms longer. In some cases, less fortunate fields that were drifted on multiple times never did completely recover.

The ramifications of this off-target dicamba are still being assessed and probably will be ongoing for years to come. Many sensitive soybean fields that were damaged and showed significant visual symptoms recovered by harvest time and farmers reported little or no yield loss. Still other fields, particularly those drifted on multiple times, were reported by growers to have lost 10 percent to 20 percent of their expected yield.

Extensive dicamba stewardship training took place in all four states prior to the 2017 growing season. For example in Tennessee alone there were 4,600 applicators who took a 30-minute dicamba stewardship training online module, there were 16 dicamba classroom training sessions that 2,300 applicators attended, over 20 blog posts on UTCrops.com that were accessed over 25,000 times, and 16 in-season YouTube training videos that were viewed over 13,500 times. This plus all the education provided by Monsanto and BASF personnel would suggest that increased education alone cannot solve this issue.

Xtend cotton was also used extensively in Alabama, Georgia, North Carolina, South Carolina, and Texas. Applicators in those states had much fewer issues with dicamba trespassing across the landscape. A reason given for fewer problems was the extensive applicator training conducted in Alabama, Georgia, and North Carolina. Perhaps, but applicator training in South Carolina and Texas was similar to what occurred in Tennessee. Other reasons mentioned are the dramatically fewer soybean acres in most of those states. Non-Xtend soybean are in harm's way for drift for 3 months while most of the vegetable crops grown in Georgia have much shorter growing season and therefore are less exposed temporally to drift. Other opinions such as differences in topography and environment may be causes. The bottom line is that no one knows for sure.

The US Environmental Protection Agency imposed new regulations for the use of dicamba in Xtend crops for the 2018 growing season in an effort to mitigate off-target dicamba. These rules include that applicators must maintain specific records of product use, dicamba products can only be applied at wind speeds less than 10 mph, new tank cleanout procedures are mandated, and now Engenia and XtendiMax are restricted use herbicides.

The new EPA rules went into place in early July 2017. As of mid-June 2018 there have been very few dicamba drift issues in Tennessee. However, dicamba drift reports to sensitive vegetation in Alabama, Arkansas, Mississippi, and Missouri have been very abundant. Based on the fact that about 70 percent of the soybeans in Tennessee were planted the first half of June the jury is still out on whether Tennessee applicators on any given day can keep dicamba in the target field better than their colleagues in neighboring states.

Soybean Prevent Planting

Aaron Smith
Assistant Professor
UT Department of Agricultural and Resource Economics

Kevin Adkins
MS Candidate
UT Department of Agricultural and Resource Economics

Prevented planting coverage provides producers with valuable protection in the event they are unable to plant an insured crop by the final planting date or during the late planting period due to an insured cause of loss (usually excess moisture in Tennessee). The provision is designed to help cover part of the pre-plant cost of production. As such, different crops receive different prevented planting "factors." The factors are applied to the total coverage purchased to determine the prevented planting indemnity payment should a prevented planting loss occur. Recently the USDA Risk Management Agency (RMA) has changed several prevented planting factors and could make additional modifications in 2019, due in part to the higher potential for moral hazard linked to prevented planting provisions—allowing for the indemnity payment to exceed the costs-to-date invested in the crop, encouraging producers to accept the prevented planting payment instead of producing a harvested crop. Our analysis examined the impact of the prevented planting coverage factors and crop insurance coverage buy-up levels on potential indemnity payments versus bring a crop to harvest under different planting dates and scenarios.

Our analysis evaluated a producer's decision to plant an insured crop during the late planting period or take the prevented planting payment, leaving the land fallow or planting a cover crop. A producer could plant an alternative crop, however, this option was not considered in this analysis as in Tennessee typically soybeans are the last major row crop planted. We assumed the producer's decision to plant during the late planting period or take the prevented planting payment is based on the objective of maximizing profit. If the producer purchases revenue protection crop insurance, which includes the prevented planting provision (60 percent for soybeans), and is prevented from planting the crop, the crop insurance policy guarantees the producer will receive an indemnity payment based on their revenue guarantee. The revenue guarantee is determined by APH yield, the projected crop insurance price, and a buy-up coverage level (50 percent to 85 percent). The premium increases as the coverage buy-up level increases. Additionally, the decision to take the prevented planting payment will depend on the projected spot price received by the producer at harvest, the projected cost of production both prior to planting (i.e., chemical, land rent, and machinery) and after planting, and projected harvested yield.

Soybean yield data used in the analysis came from a nonirrigated planting date experiment conducted at the University of Tennessee AgResearch and Education Center at Milan, Tennessee, from 2008 to 2010. The experiment included soybeans of maturity groups (MG) II, III, IV, and V. The main plot treatments were four MGs (II, III, IV, and V), the subplots were two seeding rates, and sub-subplots were seven planting dates. There were no differences in yield across MGs, thus, we estimated soybean yield response to planting date combining the MGs. In each year, soybeans were planted from late-April to late-July. The final planting date (for crop insurance purposes) for soybeans in Gibson County, Tennessee, is June 15 and the late planting period is 20 days (July 5). Data from this experiment fall within the planting window of interest in this study. The quadratic yield response function to planting date for soybeans indicated that yields were increasing at a decreasing rate as planting date was lengthened. The yield maximizing planting date was May 19 for soybeans. The optimal planting date falls within the planting window for the revenue protection policy and aligns with UT recommendations.

Average production costs from 2011 to 2016 were estimated using the University of Tennessee Crop Budgets for nonirrigated, no-till soybeans. Pre-planting costs included land rent, chemical costs for burndown, fertilizer applied pre-planting, and machinery. We assumed a producer could return or store other inputs such as seed, chemical, and fertilizer if they were unable to plant; thus, these costs were not included as a pre-planting cost. The pre-planting costs were subtracted from the total production costs to determine the post-planting production costs. The cost of the summer cover crop was developed following the USDA NRCS recommendations. Producers have several options when selecting a cover crop for indemnified prevented planting acres. We assumed the total cost of the cover crop was estimated to be $51.20/acre with seed costing $30/acre and machinery cost was $21.20/acre.

The results of our analysis, for soybeans, indicated at the current prevented planting coverage factor of 60 percent, profit-maximizing producers would choose to plant in the late planting period over abandoning production and taking the indemnity payment. This results holds true regardless of the revenue protection coverage level. Thus, reducing the prevented planting coverage factor or requiring producers to plant a cover crop on indemnified acres would not be necessary to avoid payments in excess of the costs incurred prior to planting.

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Tour D: Resistance Management

Herbicide Resistance

Charlie Cahoon
Assistant Professor
and Extension Weed Specialist: Corn and Cotton
Department of Crop and Soil Sciences
North Carolina State University

It is a common misconception that herbicides cause the genetic mutations responsible for herbicide resistance. However, development of herbicide-resistant weeds is an evolutionary response to intense selection pressure caused by repeated use of herbicides with the same mode of action. Mode of action (MOA) is defined as the biochemical or physiological process in a plant that is disrupted by an herbicide and ultimately leads to plant death. The genetic mutations that confer herbicide resistance naturally occur in our weed populations. It is our job, through herbicide resistance management, to ensure these naturally occurring mutations are not exposed to intense selection pressure that allow these biotypes to flourish within a weed population.

Reduced target site sensitivity due to target site mutation, target site amplification, increased metabolism of the herbicide, decreased herbicide activation, and herbicide sequestration away from the target site are mechanisms by which weeds can evolve herbicide resistance. Globally, 494 unique cases of herbicide resistance have been confirmed, 254 species of weeds have developed herbicide resistance, and resistance has evolved to 23 of the 26 known herbicide sites of action. Currently, we are on what has been termed an "herbicide treadmill," meaning that we overuse a single MOA until it fails and then switch exclusively to another MOA until it fails. Breaking this trend is paramount to preserving the sustainability of our no-till cropping systems.

Best management practices for reducing herbicide selection pressure outlined by Norsworthy and others (2012) include: 1) understanding the biology of weeds present; 2) use an integrated approach to weed management; 3) plant into weed-free fields and keep fields weed free (start clean, stay clean); 4) plant weed-free crop seed; 5) routinely scout fields; 6) use multiple, effective MOAs against problem weeds and weeds prone to herbicide resistance; 7) use the full labeled rate and apply herbicides at recommended weed sizes; 8) incorporate cultural weed management tactics that favor crop growth over weeds; 9) use mechanical and biological tactics where appropriate; 10) prevent spread of weeds within fields and field to field; 11) manage weed seed at harvest and postharvest to ensure the weed seedbank is not replenished; and 12) manage field borders to avoid encroachment of weed species into crop fields.

The herbicide resistance portion of this tour stop aims to help attendees better understand how herbicide resistance develops and how implementing the aforementioned tactics can reduce herbicide selection pressure and lessen the odds of herbicide resistance.

Fungicide Resistance

Kiersten Wise
Extension Associate Professor
Department of Plant Pathology
University of Kentucky, Princeton

PEST RESISTANCE MANAGEMENT

Fungicide Resistance in Field Crops FAQs

CROP PROTECTION NETWORK
A Product of Land Grant Universities
cropprotectionnetwork.org
CPN-4001 December 2016

Can the fungi that cause common field crop diseases develop fungicide resistance?

Yes. In fact, researchers in several North Central states have confirmed that the fungus that causes frogeye leaf spot in soybean has developed resistance to the quinone-outside inhibiting (QoI/strobilurin) fungicide group (Figure 1).

Figure 1. Populations of the fungus that causes frogeye leaf spot in soybean have developed resistance to QoI/strobilurin fungicides.

How do fungi become resistant to specific fungicides?

Fungicide applications do not cause resistance. Resistant fungal strains are already present in the fungal population. Such resistance is caused by naturally-occurring genetic mutations.

Fungicide applications select for these resistant fungal mutants — the fungicides kill the fungicide-sensitive population and only the resistant mutants survive. Eventually, the population of the resistant fungal strains increases and replaces the sensitive fungal population (Figure 2).

Figure 2. This figure demonstrates the selection for resistant (red spots) fungal strains among fungicide sensitive strains (blue spots) with repeated applications of the same fungicide active ingredient.

Once the population of the fungicide-resistant mutants is predominant, efficacy of a specific, fungicide active ingredient may be reduced or lost.

Why should I worry about fungicide resistance?

When fungicide resistance occurs in a fungus, fungicide applications of a specific active ingredient may no longer effectively control the particular disease the fungus causes. Several fungicide active ingredients are at high risk for developing fungicide resistance, especially in the QoI/strobilurin group.

How many fungicide groups are currently available?

There are multiple fungicide groups available for use on field crops, but the majority of available fungicide products fall into two groups: the QoI group and the demethylation inhibitor (DMI) group (Table 1).

Fungicide group names represent different target sites within specific modes of action. A mode of action is how the fungicide's active ingredient inhibits fungal development. For example, a fungicide may work by inhibiting respiration in the fungus. A target site is the specific location at which the fungicide works in the fungus.

The Fungicide Resistance Action Committee (FRAC) developed a numerical code for classifying fungicides. Each number represents a specific target site or group name (Table 1). Fungicide labels include these "FRAC Codes." If a fungus is resistant to a specific fungicide active ingredient, then it may be resistant to all of the fungicide active ingredients that have the same FRAC Code.

Table 1. Example of Fungicide Resistance Action Committee (FRAC) fungicide classification for azoxystrobin and propiconazole.

Active Ingredient	FRAC Code	Group Name	Chemical Group	Mode of Action
azoxystrobin	11	quinone-outside inhibitor (QoI)	methoxy-acrylates (strobilurin)[1]	Fungal respiration inhibitor
propiconazole	3	demethylation inhibitor (DMI)	triazole	Inhibits sterol biosynthesis in membranes of fungal cells

[1]Fungicides in this group are commonly referred to as strobilurins, however, the FRAC no longer specifies these active ingredients as strobilurins.

How can I delay fungicide resistance?

Take the following steps to delay fungicide resistance:

- Apply a fungicide only when necessary and in response to increased disease risk.
- Avoid applying fungicides that contain only one FRAC code.
- Tank-mix or use pre-mixed fungicides that have different FRAC codes.
- Only apply labeled rates. Applying a sub-lethal dose of a fungicide increases the risk of fungicide resistance.
- Scout fields within two weeks after any foliar fungicide application. Determine if the fungicide is adequately managing the disease. Contact your local extension specialist if you believe fungicide resistance may be an issue in your field.

Find out more

The Crop Protection Network (CPN) is a multi-state and international collaboration of university and provincial extension specialists, and public and private professionals who provide unbiased, research-based information to farmers and agricultural personnel. Our goal is to communicate relevant information that will help professionals identify and manage field crop pests.

Find crop management resources at CropProtectionNetwork.org.

Find information about identifying soybean diseases and fungicide efficacy from the Soybean Research and Information Initiative at soybeanresearchinfo.com/resourcelibrary.html.

Authors
Carl Bradley, University of Kentucky; Martin Chilvers, Michigan State University; Loren Giesler, University of Nebraska-Lincoln; Daren Mueller, Iowa State University; Adam Sisson, Iowa State University; Damon Smith, University of Wisconsin-Madison; Albert Tenuta, Ontario Ministry of Agriculture, Food and Rural Affairs; Kiersten Wise, Purdue University.

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Reviewers
Emmanuel Byamukama, South Dakota State University; Anna Freije, Purdue University; Dean Malvick, University of Minnesota; Sam Markell, North Dakota State University.

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Insecticide Resistance

Gus Lorenz
Professor, Extension Entomologist
University of Arkansas

This presentation will address the challenges and potential solutions related to insecticide resistance management in common pests of field crops. Many insects have developed resistance to commonly used insecticides. Methods to prevent and delay resistance will be discussed. The best approach is to prevent or delay resistance from occurring, rather than responding to resistance after it develops.

For traditional insecticide applications, using the least amount of insecticide needed to effectively control the pest(s) will reduce the selection pressure for resistance. This can be accomplished by regular scouting of crops and the use of established treatment thresholds. Following recommended planting dates, fertility practices, and other crop management practices can also help reduce the need for insecticides, and thus selection pressure for resistance. An important method of delaying or preventing resistance is the rotation or mixing of insecticides having different modes of actions, thus forcing insects to develop resistance to two or more modes of actions nearly simultaneously. Once resistance has developed, methods to mitigate resistance are similar, such as rotating or mixing alternative insecticides and/or the use of new insecticides with novel modes of action.

Resistance management for Bt toxins present in genetically modified (GM) corn and cotton is somewhat unique. In this case, the objective is for plants to continually express a highly toxic dose of Bt toxins so that only a small number of highly resistant insects are expected to survive. In this scenario, any resistant survivors would likely mate with unselected individuals from other non-Bt hosts. Presumably, any offspring would be susceptible to the Bt toxins in GM plants. This "high-dose" approach is in contrast to a "low-dose" approach as recommended above for traditional insecticide applications. As with foliar applied insecticide applications, including multiple Bt traits with different modes of action is a method to prevent or delay resistance.

Unfortunately, there are obstacles to resistance management, which include a lack of alternative modes of action, higher costs of applying alternative insecticides, high pest pressure resulting in the need for multiple insecticide applications, and an insect's innate ability to develop insecticide resistance. Examples of current insecticide resistance problems will be discussed including thrips, tarnished plant bug, bollworm, and others. Suggestions for maintaining adequate plant protection and profitability in the presence of resistance insect populations will be made.

Tour E: No-Till Cotton Production in Tennessee

Cotton Planter Attachments for High-Biomass Covers

Tyson Raper
Assistant Professor
UT Department of Plant Sciences

William E. Hart, Michael J. Buschermohle, Shawn A. Butler, Blake A. Brown

Summary

The biggest hurdle in the integration of cover crops into the cotton production system is establishment of the cotton crop. The purpose of this presentation is to highlight preliminary results of a row cleaner, press wheel, and double disk opener trials to increase the consistency of seed placement, decrease kickouts, decrease hair-pinning, and close the furrow in high biomass, cover cropped systems. This producer-identified information void must be filled if cover crops are to be successfully integrated into cotton production.

Problem

Planting cotton into soil health cover crop mixtures during the spring of 2016 and 2017 resulted in several inadequate stands. Failures have stemmed from inconsistent seed depth, seed kickouts, hair-pinning of residue within the furrow, and failure to close the furrow (Fig. 1). Issues have been noted when planting into terminated and living (green) cover crops. It is hypothesized that alternative row cleaner equipment and/or slight modifications to settings would increase the consistency of seed placement, reduce kickouts, eliminate hair-pinning and properly close the furrow; proper system selection and setup has resulted in successful stand establishment in several fields within Tennessee (Fig. 2). Unfortunately, the expense of outfitting a planter prevents a producer from quickly switching from system to system; after selecting one system, most are committed. Trials designed to assist producers in attachment selection and settings would directly smooth cover crop integration and increase the sustainability of cotton production.

Methods

Row Cleaner Trial: Twelve different row cleaner systems plus a control (no row cleaner) were selected and installed across the width of the planter. Each plot consisted of one row. After each row cleaner was installed, the planter was set. Setup attempted to maximize placement of seed within the recommended 0.25- to 0.75-inch range while causing minimal disruption of the soil surface. The same double disk openers and closing wheel systems were used for each treatment. Treatments were repeated three times.

Press Wheel Study: Six press wheel systems were selected and installed. One press wheel setup was installed on one row unit; therefore, each plot consisted of one row. Each unit was set up to properly close the furrow while minimally disrupting the soil surface. The same row cleaners and double disk openers were used for each treatment. Treatments were repeated three times.

Double Disk Opener Trial: Notched, smooth, smooth with v-slice, and serrated double disk openers were installed across the width of the planter. Each plot consisted of one row. After installed, planter was set to maximize placement within the recommended .25-.75” range. The same row cleaner system and press wheel system was used for each treatment. Treatments were repeated three times.

Preliminary Results

Since each trial is designed to evaluate the ability of specific planter attachments to establish profitable stands, measurements will include stand counts, visual vigor ratings and destructive sampling of 5 row feet to further evaluate seedling vigor. End of season data to be collected will include measurements of maturity (percent open, node above cracked boll) and seedcotton yield. These measurements and ratings have not yet been collected and analyzed, but preliminary results will be discussed during the presentation.

Making the Replant Decision

Shawn Butler
Research Associate/PhD Candidate
UT Department of Plant Sciences

Tyson Raper, Michael Buschermohle, and Cheyenne Williams

Introduction

Problem 1: Determining stand density

Emerged plant counts, commonly referred to as stand counts, are the most utilized method to determine plant population across a given area. Although this method is fast, the approach is reliant upon a highly uniform plant population across the entire field and quality of the data is highly correlated with the number of measurements collected across the area of interest. Human bias in selecting areas of the field also can influence the estimated plant population, naturally skewing the estimation to favor either replanting or accepting a given stand. One proposed use of unmanned aerial systems (UAS) is to produce quantitative data to support replant decisions by spatially assessing plant stands and uniformity. Theoretically, an aerial approach could provide spatially dense information on these parameters across large areas quickly and remove human bias. Currently, no known aerial assessment tools have been developed to estimate cotton plant population and uniformity.

Problem 2: Determining yield potential of current stand compared to replant

Growers occasionally face poor environmental conditions prior to or after planting which stress emerging seedlings. If these stresses are severe enough to kill a substantial number of the emerging seedlings, a decision of whether to accept or replant the crop must be made. It has been demonstrated that accepting a uniform, lower plant population may provide adequate yield potential, especially if seeded earlier in the recommended planting window and environmental conditions are favorable. However, lower populations and later planting dates may delay maturity, increase risk of poor fiber quality, and must be managed for earliness. A model considering cotton plant population and planting date to predict lint yield potential may greatly assist in the replant decision-making process and provide guidance towards management requirements throughout the season. The objectives of this research were to: 1) investigate the ability of unmanned aerial systems to accurately and precisely determine varying populations of cotton, and 2) determine the influence of planting date and plant population on lint yield potential.

Methods

During the 2016, 2017, and 2018 season, trials have been established across Tennessee, in Mississippi, and in Missouri. Trial design is a randomized complete block with four replications. In each trial, seeding rate and planting date are evaluated. Seeding rates evaluated at each planting date range from 3,500 sd/ac to 48,000 sd/ac. Planting dates within each trial begin during the target planting window (April 20–May 10) and terminate approximately 21 days after the first planting date. After emergence, cotton plant stands were manually counted and images were obtained from a MicaSense Red Edge (MicaSense, Seattle, Washington) multi-spectral sensor mounted beneath a custom quad-copter flying at an altitude of 30 meters. Red and NIR spectral band images were collected and stitched using Atlas. A Python coded program was constructed to calculate NDVI and count plants within each plot using the ArcPy plugin of ArcMap 10.5 (ESRI Redland, California). Simple linear regression was run in JMP Pro 13 (SAS Institute, Cary, North Carolina), correlating estimated number of plants to ground-truthed counts.

Preliminary Results

Based on initial results, the utilization of aerial imagery may be a sufficient tool to improve accuracy and efficiency of plant stand assessment; stands collected from the automated program have resulted in very strong correlations with ground-truthed data ($r2>0.90$). Relationships degrade at higher plant populations, likely due to overlapped cotyledons at sufficient stands, but it is unlikely this will negatively impact data quality since the relationship erodes at populations typically deemed to be “acceptable” for cotton.

Agronomic data collected from trials to date have been embedded within a surface model consisting of yield, planting date and population. Currently, data supports the previously developed extension recommendations; target planting date should fall between April 20 and May 10. Additionally, seeding rate should target 38,000 to 45,000 sd/ac during a typical year.

Integration of the remote assessment of cotton stand with the yield potential of the current stand versus a replant has the potential to remove human error from the replant decision and provide tremendous value to the growers along the northern edge of the cotton belt.

Weed Control in No-Till Cotton

Drake Copeland
PhD Candidate
UT Department of Plant Sciences

No-till weed control in cotton has become more challenging in recent years with the spread of glyphosate-resistant weeds. Glyphosate-resistant (GR) Palmer amaranth, in particular, has become a major control issue in cotton. Starting clean with a good PRE is especially important in cotton because timely applications of POST applied herbicides can be challenging. Caparol, Cotoran, and Brake have been the best choices for PRE applied residual control of pigweed in Tennessee. In 2018, the residual control these herbicides provided was mostly good. However, there was some inconsistent performance do to either soil type differences or lack of activation. For residual control in crop after the PRE has worn off, Dual Magnum or Outlook can extend residual control of GR Palmer pigweed.

Due to GR Palmer pigweed, many growers have moved from a glyphosate-based system to an Xtend or Enlist based system. However, due to labeled directions, there are many times that the auxin herbicides those crops are tolerant to cannot or should not be used.

As such, Liberty will often be the first choice for POST applications. Liberty is a nonselective herbicide, like glyphosate, but there are several differences. First of all, Liberty will not control large pigweed like glyphosate once did. The label states pigweed should be 4 inches or less for consistent control, but may control 6- to 8-inch pigweed when the conditions are right. Another major difference is that glyphosate is a systemic herbicide while glufosinate is a contact herbicide. This means you need COVERAGE with glufosinate. At least 15 GPA is required, but 20 GPA or higher may be required with higher pigweed pressure. Today, we have several different nozzle types available on the market and when drift is a concern, air induction or turbo teejet nozzles are good options for reducing the risk of drift. For Liberty to be effective though, these nozzles are not good options because it reduces coverage. Flatfan or XR nozzles are recommended with herbicide applications that include Liberty. In addition, time of day of application may be a factor for pigweed control with Liberty. For glufosinate to work in the plant, it must be actively photosynthesizing. Therefore, growers should avoid applying glufosinate early in the morning. Our research indicates that growers should wait at least 2 hours after sunrise before applying Liberty.

Technological Advances in Insect Pest Management

Scott Graham
PhD Candidate
UT Department of Entomology and Plant Pathology

Sandy Steckel
Extension Assistant
UT Department of Entomology and Plant Pathology

Insect pests usually cost Tennessee cotton producers from $40 million to $70 million annually. Over one-half of Tennessee's typical insect control budget is accounted for by costs of Bt cotton, preventative insecticides used for thrips control, consulting fees, and maintenance of boll weevil eradication.

Thrips are small, slender insects that belong to the order Thysanoptera. Several kinds of thrips may be observed feeding on cotton in Tennessee, but tobacco thrips are predominant. Thrips are consistently among the top three to four economically most important pests of cotton grown in Tennessee, and they inflict economic damage to some fields on an annual basis. Damage to cotton is most common during the seedling stage because small plants are more susceptible to injury. Environmental conditions that result in poor seedling growth and vigor increase the chance of economic damage. Seedlings may be killed if heavy infestations persist unchecked. Foliar applications of insecticide may be justified to prevent economic damage in cold, wet years even when at-planting insecticides were used. Tobacco thrips have developed resistance to thiamethoxam and imidacloprid, neonicotinoid insecticide seed treatments, and although seed treatments remain an important component of thrips control, alternative treatments are needed.

Plant bugs are now the most destructive pest of cotton in the state, feeding in squares, flowers, and on bolls. The most common plant bug found is the tarnished plant bug, but clouded plant bugs may also occur. Multiple, overlapping generations of plant bugs occur each year. The tarnished plant bug is the most important pest of Tennessee cotton from the time of first squaring and through the first several weeks of bloom. Over the last five years, an average of 3.6 insecticide applications per year (3.6) at a total cost of over $30 per acre have been made annually to each acre of cotton for the control of plant bugs. Further, yield losses typically exceed 20,000 bales of cotton annually.

Bt cotton has been genetically modified by the insertion of one or more genes from a common soil bacterium, Bacillus thuringiensis. These genes encode for the production of insecticidal proteins, and thus, genetically transformed plants produce two or more toxins as they grow. The Bt traits currently on the market have activity which is limited almost exclusively to caterpillar pests (Lepidoptera). Bt cotton has eliminated the need to treat for infestations of tobacco budworm. Prior to bloom, the need to treat for bollworm is greatly reduced. However, the level of bollworm control provided by some Bt cottons may not be sufficient once cotton has begun to bloom. Supplemental insecticide sprays for bollworm, loopers, and armyworms are less likely to be needed on cotton that has multiple Bt toxins. However, recent data suggest that bollworms (a.k.a., corn earworm) are developing resistance to some Bt toxins in cotton and corn. New Bt technologies are now being studied that have activity on infestations of thrips and tarnished plant bug.

This presentation will provide information about best management practices and technologies, including new insecticides and new Bt traits, being evaluated for the control of the top three insect pests of cotton in Tennessee, namely thrips, tarnished plant bug, and bollworm.

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Tour F: Beef Cattle—Managing Calving Difficulties and Ensuring Successful Rebreeding

Calving Difficulty Leads to Slow Breed-Back, Takes Money Out of Your Pocket

Justin Rhinehart
Associate Professor
UT Department of Animal Science

To achieve the economically driven objective of having cows produce a calf at about the same time each calendar year, cows need to rebreed within 80 to 85 days following the time of calving. There is a period of time after calving that a cow does not cycle (postpartum anestrous). That period of time from calving until the cow is fertile again is commonly referred to as the postpartum interval. Also, consider that just breeding back within that 80- to 85-day timeframe is not the only driver of profitability. Cows that breed early in the season are generally more profitable.

The postpartum interval is not a set period of time for every cow, and it can be different for the same cow every year. The issue that makes it a major point of focus is that its length can be influenced by several different factors; some that we have a good grip on managing and some we likely do not even know about yet. As with anything we manage in cattle, the end result is a combination of genetics and environment. The length of an individual cow's postpartum interval is a result of how its genetics allow it to respond to the environment it is managed under. The major environmental factors are the presence (or absence) of a calf, nutritional status, health status, age, and calving difficulty. Having a plan in place to manage these factors at the optimum level for your business model should give your cows the opportunity to breed back as quickly as you need them to.

Research conducted by a number of research groups throughout the 1970s and early 1980s indicated that calving difficulty led to fewer cows being fertile at the beginning of the next breeding season. The research conducted since those early findings has not been completely conclusive as to the specific link between dystocia and longer postpartum intervals. However, taken as an entire body of work, those studies have lead cow/calf producers to adopt the best management practices of selecting low birthweight sires, providing adequate nutrition prior to calving, and providing early assistance for heifers and cows that experience calving difficulties.

Trauma to the reproductive tract leads to a longer recovery (prolonged uterine involution); the first event that needs to take place before normal estrous cycles can be reestablished. Moreover, severe trauma can cause infection that delays recovery even longer. More physical exertion during the calving process depletes energy reserves and can lead to decreased body condition scores that do not recover as quickly as if the calving process had been easier.

This tour will focus on how calving difficulty, also called "dystocia," affects how long it takes a cow to become fertile again after calving. The presentations will also address how you can manage your cattle to avoid calving difficulties and shorten the postpartum interval. All this will be discussed with the goal of giving you tools to take back to your operation to increase the profitability of your cow herd. More specifically, this presentation will set the stage for following speakers by explaining how and why calving difficulty leads to a longer postpartum interval.

Genetic Selection to Avoid Calving Difficulties

David Kirkpatrick
Professor
UT Department of Animal Science

Calving difficulty (dystocia) can increase calf losses, cow mortality and veterinary and labor costs as well as reduce weaning weights and result in delay in return to estrus and lower conception rates. There are many factors that affect calving difficulty in beef cattle. Some of them are affected by genetics and others are affected by management, nutrition, and other factors and the interrelationship among them. Among those factors may be: age of dam, calf birth weight, sex of calf, dam pelvic area, dam body size, gestation length, breed of sire, breed of dam, sire genotype, dam genotype, nutrition of dam, condition of dam, shape of calf, presentation of fetus, geographic region, season of year, and other unknown factors.

Dystocia is a result of the disproportion of the calf size at birth and the dam's birth canal. Managing calving difficulty can start way before the calving season. In fact about 283 days earlier than the calving season. Selection decisions can have a major impact on calving difficulty, particularly for birth weight as it is a highly heritable trait. From a genetic standpoint, there are selection tools available to manage the incidence of dystocia in a beef herd. Expected progeny differences (EPDs) provide effective tools to manage calving difficulty. EPDs are estimates of an animal's genetic merit as a parent for a particular trait and are used to predict the difference in the performance of offspring between two prospective parents for a particular trait. It is important to note that they predict differences and rather than actual performance. Traits useful for reducing dystocia are birth weight, calving ease direct, and maternal calving ease EPDs.

Birth weight EPDs are expressed in pounds and are used to predict differences in pounds of birth weight of progeny between prospective sires. Larger differences indicate greater birth weights in a sire's progeny which can be a contributor to dystocia.

Calving ease direct (CED) EPDs are expressed as a difference in percentage of unassisted births and predicts the difference in ease with which a sire's calves will be born when he is mated to first-calf heifers. Larger values indicate greater calving ease or a larger percentage of unassisted births in first-calf heifers. It represents genetic differences for many of the factors to include birth weight that contribute to calving difficulty and is the most important EPD to use on selection for calving ease in first-calf heifers.

Calving ease maternal (CEM) EPDs predict the average ease with which a sire's daughters will calve as first calf heifers compared to daughters of other sires. It is expressed as a difference in percentage of unassisted births with a higher value indicating greater calving ease in first-calf daughters. CEM represents genetic differences in sire's daughters for calving ease and reflects a bull's ability to sire daughters that calve unassisted. In operations that retain replacement heifers, CEM can become important in bull selection.

Example: Using EPDs to Compare Bulls for Calving Ease

BULL	BW EPD	CED EPD	CEM EPD
A	2.5	4	7
B	-1.5	11	10
DIFFERENCE	4.0	7	3

From this example you would expect that Bull A would sire calves that averaged 4 pounds heavier than calves sired by Bull B (2.5 – minus 1.5 = 4). You would also predict that first-calf heifers bred to Bull B would have 7 percent fewer assisted births than those of first-calf heifers bred to Bull A. One also would predict that 3 percent more of Bull B daughters would calve unassisted as first calf heifers than first-calf heifers sired by Bull A.

Managing Nutrition to Ensure Calf Vigor and Subsequent Cow Fertility

Jason Smith
Assistant Professor
UT Department of Animal Science

Often, we focus on genetics as a means of improving cow herd productivity and profitability. It is without question that genetics are a crucial component of herd improvement. However, it is important to recognize that genetics are only as valuable as the environment will allow them to be. This is due to the fact that an animal's phenotype, or what we actually observe in the animal, is the result of an interaction between its genetics and the environment. Nutrition often makes up the majority of the environmental component, and thus has the ability to substantially limit any phenotypic trait, including reproduction.

While there are a number of nutritional factors that influence reproduction, protein and energy nutrition are at the forefront. Cattle partition, or prioritize, the use of these nutrients for their own survival and the survival of the calf at their side before diverting them toward other uses. And while the list of those specific uses is fairly long and complex, reproduction always finds itself at the bottom, meaning that reproduction is generally the first trait to be sacrificed when nutrition is a limiting factor. In order to preserve reproduction, a cow needs to be in a nutritional state that tells her body that she can not only support herself and the calf at her side, but that she's ready to support another. In order for that to happen, she needs to either be consuming enough energy and protein to meet her demands, or have enough excess condition to fill the void.

Body condition score (BCS) is our greatest indicator of a cow's current nutritional state, and it acts as a form of insurance for reproductive efficiency. Excess body condition helps to fill the void when we aren't able to meet her needs. If she doesn't have any to spare, she has no reserve to pull from, and reproduction suffers. Evaluating BCS at set points throughout the year provides the opportunity to adjust feeding or supplementation programs with ample time to actually make a difference. Weaning, at the beginning of the calving season, and at the beginning of the breeding season are three ideal times to do so. A cow that calves at a BCS of less than 5 is far less likely to breed back within the amount of time required to calve annually when compared to a cow that calves at a BCS of 5 or greater.

Plane of nutrition also affects reproductive efficiency, even when BCS is less than ideal. As the magnitude of body condition loss following calving decreases, or plane of nutrition increases, reproduction generally improves. Ionophores, as well as nutrient-dense supplemental feedstuffs fed or consumed at a level that provides a substantial amount of energy and protein, can be quite valuable in this regard. Just keep in mind that this strategy isn't a silver bullet for ensuring reproductive success, as there is no equally effective substitute for sending a cow into the breeding season in ideal condition.

Aside from energy and protein nutrition, mineral nutrition also plays an important role in reproduction. While some minerals may be more influential than others, almost all required mineral elements play some role in reproduction. In almost all situations, and especially in Tennessee, forages alone or forages supplemented with only white or trace-mineralized salt will not meet the mineral requirements of cattle. Luckily there are a plethora of different mineral supplement formulations that come in a variety of physical forms that can be employed to ensure that mineral status doesn't limit reproduction. Work with your Extension personnel or nutritionist to determine which option or options are the most appropriate for your operation.

Even in situations where fertility during the breeding season is not a limiting factor, not meeting the nutrient requirements of pregnant cows during gestation can have major implications to calf health and performance. Calves that are deprived of nutrients during fetal development generally lack the ability to adequately regulate their body temperature, and often have impaired immune systems, along with decreased growth performance, feed efficiency and fertility. These responses to a nutritional insult are commonly referred to as fetal programming, and continue to be issues not only in Tennessee, but across the country. Unfortunately, many of these issues are caused by the fear of feeding pregnant cows during late gestation, and its effect on birth weight and calving difficulty. The notion that pregnant cows shouldn't be supplemented to meet their requirements and store body condition during late gestation because it increases birth weight and causes calving difficulty is nothing more than a common myth. Focus on feeding pregnant cows to meet their requirements, just not in excess to where they become obese (BCS greater than or equal to 8). Feeding pregnant cows to a BCS of 8 or greater can increase the incidence of calving difficulty; however it isn't due to a change in birth weight, but rather due to deposition of internal fat that may cause some constriction in the birth canal. Nonetheless, feeding at the level necessary to achieve this level of condition is impractical for almost all producers.

To help ensure that your efforts toward genetic improvement are an investment rather than an expense, focus on your nutritional management program. Use it to equip your cattle with the tools that they need to have successful breeding and calving seasons, that your calves are not born at a disadvantage, and to ensure that your efforts from a genetic improvement standpoint are an investment rather than an expense. All the while, keep in mind that there is no replacement for meeting the energy, protein, and mineral nutrition needs of the cowherd, and that doing so generally costs much less than not.

Dystocia Management (Pulling Calves)

Lew Strickland
Assistant Professor
UT Department of Animal Science
UT College of Veterinary Medicine

Successful calving seasons are the result of good planning and hard work. Observation of cows and heifers before and during the calving season is necessary to ensure a good calf crop. Cows should be checked at least once daily during the calving season, and heifers should be checked more frequently, perhaps several times a day. Having the cows and heifers in an easily accessible pasture will make this task more manageable. Also, allowing animals to calve in clean pastures is better for the health of the calf and the cow or heifer.

One of the complications encountered during the calving season is dystocia (a difficult delivery), and sometimes calving assistance is required. Therefore, producers need to be familiar with the signs of impending parturition as well as the sequence of events associated with normal labor and delivery to determine when assistance is necessary.

Signs of impending parturition (calving):

- The udder and vulva will often enlarge 1-3 weeks prior to parturition.
- Cows and heifers often become more nervous (restless) and, if possible, may isolate themselves from the rest of the herd just prior to parturition.
- Cows and heifers may show signs of abdominal discomfort by kicking at their belly; they may also glance to the rear nervously.
- The tail-head appears raised as ligaments around the rump of the cow or heifer relax.

Normal parturition is divided into three sequential stages:

Stage I—Preparatory

- Duration: cows (4-8 hours); heifers (6-12 hours).
- The cow or heifer may become nervous and isolate herself from the rest of the herd.
- Uterine contractions begin.
- “Dropping” of colostrum/milk into the teats.
- “Water bag” appears towards the end of this stage. Stage II begins when the water bag breaks.

Stage II—Delivery of the calf

- Duration: cows (less than 1 hour); heifers (1-4 hours).
- The cow or heifer is now actively straining.
- In normal parturition, the calf's forelegs and head protrude first about 70 percent of the time, and the hind legs and tail come first about 30 percent of the time.
- The calf is delivered.

Stage III—Expulsion of the placenta (afterbirth)

- Duration: cows and heifers (1-12 hours; usually occurs within the first few hours).
- Cow or heifer straining decreases.
- Uterine contractions continue and the placenta is expelled.
- If the placenta is not expelled soon after birth, do NOT manually remove the placenta by pulling it out. Manual removal can leave portions of the placenta in the uterus and serve as a source of infection.

Assistance may be necessary when parturition does not proceed as described, and early intervention is the key to a successful outcome. Waiting too long to provide assistance unnecessarily risks the life of the cow or heifer and her calf. Seek the help of a veterinarian or experienced producer when needed.

Supplies used to assist with calf delivery:

- Obstetrical (OB) chains or ropes, and chains are preferred because they can be easily disinfected after use. OB chains and ropes are used for pulling on the legs. NEVER attach OB chains or ropes to the jaw and pull on a calf, as the jaw will almost always fracture.
- OB handles for pulling on the chains or ropes.
- Mechanical calf puller ('calf-jack')—USE WITH CAUTION AND DO NOT APPLY EXCESSIVE FORCE. A calf-jack can exert substantial force on the cow or heifer and the calf. When used improperly the cow, heifer, and/or calf can be injured or killed. NEVER ATTEMPT TO DELIVER A CALF BY PULLING WITH ANY TYPE OF VEHICLE.
- OB lubricants.
- Plastic gloves.
- Buckets.
- Towels and paper towels.
- Iodine for disinfecting the calf's navel.

Some things to keep in mind when trying to decide when to call your veterinarian:

- Calving takes time, and it often takes longer for heifers than cows, so be patient. However, progress should be steady and generally fit within the timeframes previously mentioned. Once Stage II begins (delivery of the calf), the cow or heifer should make visible progress about every 15 to 20 minutes.
- Use the “2+1 rule” to help determine when to call. Upon examination, 2 feet and 1 head (or 2 feet and 1 tail) should be felt or seen for a normal delivery to proceed.
- If the cow or heifer becomes exhausted and quits trying to calve, then assistance is necessary.
- When in doubt, call your veterinarian. The outcome is always more favorable if assistance is provided sooner rather than later.

If possible, and if safe for you and the animal, capture the cow or heifer needing assistance before your veterinarian arrives. This will make his or her job easier, and minimize your expenses.

If you have any further questions, please contact your local Extension agent, or lstrick5@utk.edu 865-974-3538.

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Tour G: Nutrient Management

Verification of University of Tennessee's P and K Fertilizer Recommendation for Row Crops

Surendra Singh
PhD Candidate
UT Department of Biosystems Engineering and Soil Science

Hugh Savoy and Sindhu Jagadamma, UT Department of Biosystems Engineering and Soil Science

Xinhua Yin, UT Department of Plant Sciences

Soil test-based fertilizer application is crucial for producing sufficient food without adversely affecting the environment and producers' benefits. Soil testing laboratories follow several philosophies when making fertilizer recommendations including maintenance, building and sufficiency philosophies. The University of Tennessee follows a combination of building and sufficiency philosophies, which has proven to be the most profitable approach. Accordingly, UT had stopped recommending phosphorus (P) and potassium (K) fertilizer applications since 2008 on soils testing high for P and K because of the lack of profitable returns. However, commercial laboratories tend to recommend higher fertilizer rates than UT, despite equivalent soil testing results.

To address the producers' concerns regarding the discrepancy in fertilizer recommendations between UT and the commercial labs, two field trials were initiated in 2009 for a corn-soybean-wheat rotation system on low- to medium-testing soils at UT's AgResearch and Education Center in Milan, Tennessee, and Highland Rim AgResearch and Education Center in Springfield, Tennessee. The objectives of this study were (i) to assess the grain yield response of row crops to P and K fertilizers on soils testing low to medium on soil P and K levels, and (ii) to determine the change in soil P and K levels to different rates of P and K fertilizer application over time on low- to medium-testing soils. We evaluated five rates of P (0, 60, 120, 180, and 240 lb P2O5 acre-1), and K (0, 50, 100, 150, and 200 lb K2O acre-1) fertilizers. Crop yields did not change with fertilizer application during the initial few years of study, even from the plots we had low P and K contents prior to the experiment. We also found that application of 120 to 240 lb of P2O5 acre-1 brought soil P level from low to high at both locations and application of 150 to 200 lb of K2O acre-1 brought soils from low to medium K range. Our results indicate that region-specific optimization of fertilizer recommendation based on soil-test levels is needed to maximize economic yield.

Profitability of Enhanced Efficiency Urea Fertilizer in No-Till Corn Production

Chris Boyer
Associate Professor
UT Department of Agricultural and Resource Economics

Xinhua (Frank) Yin
Associate Professor
UT Department of Plant Sciences

Xia (Vivian) Zhou
Research Associate
UT Department of Agricultural and Resource Economics

James A. Larson
Professor
UT Department of Agricultural and Resource Economics

Abstract

Nitrogen (N) is an expensive input in corn production that is difficult to manage in farm fields. Applied N can be lost to nitrification and to the air through ammonia volatilization. Efficient management of N in corn is important to reduce nutrient and sediment loading to local and regional water bodies in the Mississippi River Basin and it is also an important priority for the USDA Natural Resources Conservation Service.

For no-till (NT) corn production in Southeast and Tennessee, ammonium nitrate (AN) was the primary N source, which is a much more stable source of N and has minimal ammonia volatilization. However, due to security reasons, AN has become difficult to purchase and most producers broadcast urea on soil surface. Urea has a considerably higher amount of N loss due to ammonia volatilization and nitrification.

Enhanced efficiency (EE) N fertilizers have been developed to reduce N losses from fertilizer such as urea and to improve N use efficiency in crop production. These products contain additives that work either as nitrification inhibitors or urease inhibitors or to coat the fertilizer with a polymer to slow the release (controlled release) of N to the soil, which are marketed as environmentally smart N (ESN). For producers to adopt EE N fertilizers, the revenue gained from yield increases must be greater than the cost of the product. Many studies have examined the effects of these products on yield, but little research exists on the profitability of these EE N fertilizers.

This study determined the effects of EE urea fertilizers on NT corn (Zea mays L.) yields and net returns (NRs) in Tennessee.

Corn yields were from experiments conducted from 2013 through 2015 at three locations in Middle and West Tennessee (Springfield, Tennessee; Milan, Tennessee; and Jackson, Tennessee). Corn was grown using University of Tennessee Extension recommended NT corn production practices. The plots at each experiment site were fertilized for P and K as needed according to University of Tennessee soil test recommendations by Mehlich I soil test prior to planting. The experimental plots for each N treatment were replicated four times in a split-plot design. Two N fertilization

rates of 110 and 150 lb/acre were assigned as the main plot treatments. Each fertilizer main plot was split by randomly assigning seven sub-treatments including no N fertilizer, AN, untreated urea, urea + 30-40 percent MICP (Nutrisphere-N, Specialty Fertilizer Products, LLC, Leawood, KS), urea + 20 percent NBPT (Agrotain, Koch Agronomic Services, LLC, Wichita, KS), urea + 26.7 percent NBPT (Agrotain Ultra, Koch Agronomic Services, LLC, Wichita, KS), and PCU (Environmentally Smart Nitrogen, Agrium U.S., Inc., Loveland, CO). The no fertilizer control was used to determine yield differences for corn treated with N fertilizer. The AN control was used to compare yields with corn fertilized with untreated urea or EE urea fertilizers. Net returns (NR) by N fertilizer rate and EE urea treatment were compared to no N fertilizer and AN controls. Breakeven and sensitivity analysis was used to compare yields and identify the threshold of positive NRs for using EE urea fertilizer relative to AN (little to no N loss).

For the EE urea fertilizer treatments, yields and NRs for urea + MICP were not significantly different from untreated urea. However, three EE urea fertilizer treatments did provide significantly higher yields and NRs (urea + 20 percent NBPT, urea + 26.7 percent NBPT, and PCU) than untreated urea, but yields and NRs for these EE fertilizers were significantly below those of AN. Results also indicated that the lower NRs for urea + NBPT and PCU held for AN fertilizer price premiums relative to urea of $0/lb N and $0.17/lb N that were observed in Tennessee between 2000 and 2015. With the growing reliance on urea fertilizer in NT corn production in Tennessee because AN fertilizer has become increasingly unavailable, however, urea + NBPT and PCU offers the greatest potential to improve expected NRs relative to untreated urea. Whereas, urea + MICP was not effective at providing higher yields or NRs than untreated urea under NT growing conditions in Tennessee.

Managing Sulfur for Higher Row Crop Yields

Frank Yin
Associate Professor
UT Department of Plant Sciences

Sangeeta Bansal
Graduate Research Assistant
UT Department of Plant Sciences

Sulfur (S) is an essential macronutrient in plant growth and development. Sulfur deficiencies in crops have increasingly occurred due to less to no addition of S to soil because of increased use of S free fertilizers, greater S removal from soil by crops with enhanced yields and under more intensified cropping systems, less S deposition to soil from the atmosphere because of tightened environmental regulations, and declined use of S containing pesticides.

Field cotton trials were conducted on various soils across Tennessee with a total of 16 site-years during 2014-2016. Five S application rates of 0, 10, 20, 30, and 40 pounds of sulfur per acre (lb S/a) broadcast on soil surface around planting were tested at each site-year in a randomized complete block design with four replicates. Soil available S level prior to treatment initiation and after cotton harvest, leaf S concentration at early bloom and late bloom, lint yield, and fiber quality were determined on a plot basis. The fields used for this study had initial soil S fertility level ranging from very low to medium during February to March according to the soil S test interpretations from the Waypoint Analytical Laboratories at Memphis with Mehlich 3 as the extractant. The responses of leaf S concentration to S applications were often greater at early bloom than late bloom. Leaf S at early bloom responded significantly to S applications at 14 out of the 16 site-years. Leaf S concentration increased as S rate went up from 0 to 30 or 40 lb S/a. Lint yield responses to S applications varied with sites and years. Lint yield responded significantly to S applications at seven out of the 16 site-years. Application of 10 lb S/a significantly increased lint yield by 7.6 to 25.1 percent from the seven responsive site-years. These results suggest application of 10 lb S/a is generally adequate for cotton in Tennessee. Fiber quality and soil residual S level after cotton harvest rarely responded to S applications. When data were combined across the seven site-years where lint yield responded significantly to S treatments, application of 10 lb S/a increased lint yield significantly by 10.4 percent, and 10 lb S/a was adequate for cotton to reach optimal lint yield. Averaged over all the 16 site-years, leaf S concentration increased significantly with each increment in S application rate. Lint yield was significantly increased by 6.1 percent with application of 10 lb/a relative to zero S. Average results over the 16 site-years also suggest application of 10 lb S/a is enough for optimal cotton yield in Tennessee. There was a highly significant and strong regression between ammonium acetate extracted soil S and Mehlich 3 extracted soil S under a linear model when the data were combined across all 16 site-years. The quantitative relationship between these two soil S extracting methods could be described as follows: Ammonium acetate extracted soil S (lb/a) = $-7.0875 + 2.8078 \times$Mehlich 3 extracted soil S (lb/a). Although ammonium acetate extracted much more available S from the soil than Mehlich 3, they had a good relationship according to the regression equation. This regression equation might be used to convert ammonium acetate extracted soil S to Mehlich 3 extracted soil S, and vice versa.

Responses of corn, soybean, and cotton to S applications were compared on the same S deficient field at the University of Tennessee AgResearch and Education Center at Milan during 2013-2015. Treatments of 0, 10, 20, and 30 lb S/a were broadcast applied as ammonium sulfate each year around planting to replicated plots. Significant yield responses to S applications were obtained from corn and cotton but not from soybean. Corn and cotton yields were increased by 19.3 percent and 11.7 percent, respectively, at maximum with S applications. These results suggest corn and cotton are more responsive to S application than soybean on low S soils.

In addition to the soil S test result, other field information should also be used to determine if S application is needed. From research in Tennessee and other states, Soils with coarse texture, low organic matter, and good drainage are most likely to respond favorably to S applications. Sulfur deficiency symptoms are more commonly observed on fields under conservation-tillage, particularly no-tillage, due to the lower soil temperatures, especially in the early growing season. Cool and/or wet springs may also slow down the release of S from soil organic matter and thus increase S deficiencies.

In conclusion, more attention on S management is warranted for optimal yields of row crops under Tennessee production environments. On low S soils, applying 10 lb S/a as a part of the fertilizer program may benefit crop yields, especially where plant tissue tests have suggested S deficiency or crop S deficiency symptoms have been seen in the past.

Soil and Plant Testing Services from the UT Soil, Plant and Pest Center

Robert Florence
Lab Director
UT Soil, Plant and Pest Center

The Soil, Plant and Pest Center provides testing for soil fertility, plant tissue nutrients, plant disease, forage quality, and insect ID. Sample results and interpretations are highly dependent upon sampling.

Soil sampling: A 0 to 6-inch sample, collected from at least 10 spots within the area of interest, is suggested. It is suggested to not let one sample represent more than 10 acres. Consistency in sampling depth is critical for long-term undisturbed soils as surface stratification or phosphorus or potassium may occur. Too shallow of a sample may cause results to be higher than if a proper 0 to 6-inch depth sample was collected. Taking at least 10 cores per sample is advised in order to get a better representative sample of the area of interest and to have the results as close to the true average of the field as possible. This will also help in truly identifying soil testing trends over time, as opposed to year to year difference possibly be due to inherent field variability.

Plant Tissue: Interpretations for plant tissue nutrients are dependent upon plant stage and plant part sampled. Proper stages and plant parts vary with crop, please visit our website for a link to proper sampling and interpretations for Southeastern crops.

Plant Disease: Samples for crop disease may be submitted to the lab. Please send ample amount of samples that are showing the disease. Dead samples are not useful in identification. We do not confirm herbicide damage.

Forage quality: We have updated our packages this year. We offer a full suite of NIR analysis, wet chemistry mineral analysis, and nitrate analysis. Please take a representative sample of the forage for testing and send in at least one-half gallon of material to the laboratory.

Insects: It is advantageous to send in insects at multiple stages of growth if possible. Insect sample vials are available at your county Extension office. These vials are filled with propylene glycol that both preserve the insect for ease of identification and allow for shipment in the US mail.

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Tour H: Precision Agriculture

Panel Discussion: My Experiences with Precision Ag

This tour will feature an open dialogue panel discussion with four growers and consultants who have varying levels of experience with precision ag. We hope you will join us and discover the advantages, as well as challenges, in adopting precision ag technologies.

Lori Duncan, Moderator
Row Crop Sustainability Specialist
UT Extension

Joe Jenkins
Jenkins Precision Ag Service

Jeff Hill
Producer, Lauderdale County

Jason Head
Farm Manager, Long Vue Farms

Bob Walker
Producer, Fayette County

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Tour I: Reducing Nutrient Losses

We Are All Connected: The Gulf of Mexico and the Mississippi River Basin

Doug Daigle
Louisiana Hypoxia Working Group
Louisiana State University

Tennessee is among the states participating in the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (or Gulf Hypoxia Task Force). This federal-state body was created in 1998 to address the problem of the large annual area of low-oxygen, or hypoxia, in the nearshore waters of the northern Gulf of Mexico. This zone of low-oxygen poses a threat to the Gulf ecosystem and the productive coastal fishery it supports.

The Task Force has developed and is implementing the Action Plan for Reducing Hypoxia in the Gulf of Mexico (2001, 2008, 2015), a cooperative effort between the states, federal partner agencies, research institutions, and stakeholders in the Mississippi River Basin. The action plan is based on voluntary, cost-effective actions aimed at reducing nutrient loading to the Basin and the Gulf.

Tennessee is contributing to this effort in a number of ways—agricultural conservation and management, ecosystem restoration, and reduction of point source nutrient loading—and like the other task force states, has developed its own nutrient reduction strategy. We'll look at how these efforts are contributing to the effort to reduce Gulf hypoxia by improving water quality in Tennessee streams and tributaries that drain into the Mississippi River.

Doug Daigle is the Coordinator of the Lower Mississippi River Sub-basin Committee on the Gulf Hypoxia Task Force, which includes the states of Arkansas, Louisiana, Mississippi, Missouri, and Tennessee.

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force

epa.gov/ms-htf/hypoxia-task-force-members

Action Plan for Reducing Hypoxia in the Northern Gulf of Mexico
epa.gov/ms-htf/hypoxia-task-force-2008-action-plan-and-related-documents

Tennessee Nutrient Reduction Framework
tn.gov/environment/program-areas/wr-water-resources/watershed-stewardship/watershed-management-approach/tennessee-nutrient-reduction-framework.html

Development of the Tennessee Nutrient Loss Reduction Strategy

John McClurkan
Tennessee Department of Agriculture

Since 1997 the Tennessee Department of Agriculture has been involved with the Gulf of Mexico Hypoxia Task Force, which is a group of state and federal agencies formed to find solutions to the "Dead Zone" or Hypoxic Zone in the Gulf of Mexico. This area of low dissolved oxygen in the Gulf forms each year and is triggered by nitrogen and phosphorus loadings from the Mississippi River Watershed.

In 2011, the federal government requested each of the 12 Mississippi River Basin states develop a framework from which to address nutrient concentrations to the Mississippi River. Tennessee, being one of these 12 states, developed a draft framework that has two main components, one for point sources and one for nonpoint sources.

Point sources of nutrients would consist primarily of discharges from industrial and municipal wastewater treatment plants and other permitted discharges. Since Tennessee law gives the Department of Environment and Conservation (TDEC) the authority to permit these discharges, TDEC has the lead on the point source portion of the nutrient framework.

Stormwater runoff from the farm landscape is an example of nonpoint source discharges to our state waters. This is the part of the framework where voluntary, incentive-based soil and water conservation programs tie in.

According to TDEC data from 2014, approximately 3,375 miles of streams and 15,693 acres of lakes in Tennessee are impaired due to nutrients. The US Geological Survey has estimated that 5.5 percent of the total nitrogen and 5.3 percent of the total phosphorus delivered to the Gulf of Mexico is contributed by sources in Tennessee.

The core of the framework for nonpoint source runoff is to continue to incentivize the installation of conservation practices, and advocating for landowners to continue to apply nutrients as recommended by soil testing, and continue to advance conservation tillage, precision agriculture technologies and practices like cover crops.

The perspective of the framework for nutrients is to focus our attention on making improvements to Tennessee waters. Since we are upstream of the Gulf of Mexico, we will simultaneously be helping shrink the size of the hypoxic zone there.

Best Management Practices (BMPs) to Improve Water Quality in Agricultural Production Systems and USDA Programs Available for the Mississippi River Basin Initiative

Pat Turman
State Agronomist
USDA Natural Resources Conservation Service

The USDA Natural Resources Conservation Service (NRCS) has several conservation practices to help improve water quality in different agricultural production systems. NRCS provides technical and financial assistance to help producers incorporate water quality improvement practices on their operation.

NRCS conducts assessments on operations to determine site-specific conservation practices that would be the best fit for each operation and improve water quality based on the objectives of the agriculture producer. One key assessment NRCS provides is to estimate the amount of soil loss per field in tons/acre/year. Adopting a conservation tillage practice such as no-till can improve both water quality and productivity over time. Tillage destroys soil aggregates and crop residues, which impact how much soil will move offsite during precipitation events. Vertical tillage implements are one type of equipment that destroys the soil structure in the top 2 to 4 inches, resulting in increased soil loss. No-till system establishment is a key fundamental practice for water quality improvement.

Cover crops are another key conservation practice for water quality and productivity improvement. Cover crops improve the organic matter percentage in the soil, water infiltration, aggregate stability, and weed suppression. They also improve the soil biota population over time thereby improving nutrient cycling. Another key water quality benefit when using cover crops is the uptake of potential excess nutrients from the proceeding growing season. This prevents nutrients from moving off-site into either ground or surface water. As cover crops break down following termination, their nutrients are slowly released and can be utilized by the following crop. Other conservation practices used for water quality improvements include nutrient management, pest management, irrigation water management, field borders, vegetative filter strips, riparian herbaceous cover and riparian forest buffers.

The nutrient management conservation practice promotes the 4 R’s of right time, right source, right amount, and right method of application. Nutrient management planning can be implemented on cropland and pasture when dealing with 10-acre grid budgeting, as well as grid or zone soil sampling for variable rate application of nutrients. Nitrogen is a key nutrient that can impact water quality and is considered a contributing factor to the hypoxia zone in the Gulf of Mexico. The management of nitrogen based on the source, timing, and application method is another aspect that is addressed through the nutrient management conservation practice. Phosphorus is the other major nutrient that impacts water quality and is assessed for proper management in the nutrient budget. The tools used by NRCS to assess the loss potential of these nutrients from a specific site are the Nitrogen Leaching Index and the Phosphorus Index.

NRCS may provide financial assistance to help the producer implement the chosen conservation practices. NRCS has recognized the Mississippi River Basin as a conservation initiative for nearly 10 years. Programs in the MRBI include the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). Both programs address water quality on cropland, pasture, associated agricultural land and farmstead land uses.

Producers can work with their local NRCS field office to receive technical assistance and apply for financial assistance. To find your local NRCS office, visit nrcs.usda.gov/wps/portal/nrcs/main/tn/contact/local.

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Tour J: Crop Rotations and Cover Crops with No-Till

Dual Use Cover Crops in No-Till Soybean/Corn Rotations

Alison Willette
MS Candidate
UT Department of Plant Sciences

Cover crop species offer varying ecological returns to a production system; however, the magnitude of these returns is highly dependent on species suitability to a geographical region. An additional concern in introducing cover cropping to an established row crop system is achieving balance of ecological benefits with economic returns. One way in which cover crops may provide additional, and more immediate, economic returns is through dual use as both a cover and a forage. The objectives of this study are to determine cover crop species suitability to different regions of Tennessee and to assess differences in economic and ecological returns in single use cover crop management compared with dual use cover crop/forage management in no-till soybean/corn rotation systems.

To address these objectives, 18 cover crop treatments were examined under two management practices 1) cover crop terminated prior to cash crop establishment, and 2) cover crop harvested as a forage and terminated prior to cash crop establishment. To assess suitability in both a corn/soybean and soybean/corn rotations, these treatments were duplicated in a crossover design under two planting/harvest timings: 1) a long-season cover crop (following corn/preceding soybeans) and 2) a short-season cover crop (following soybean/preceding corn).

Treatments were arranged in crossover randomized complete block design with three replications and drilled in small plots (10 x 25 feet – 12 x 30 feet) at three locations in fall 2017: East Tennessee AgResearch and Education Center (Knoxville), Middle Tennessee AgResearch and Education Center (Spring Hill), and the AgResearch and Education Center at Milan (Milan). The forage treatment was not included at the Milan location due to limited forage production in that area. Long season plots were planted in mid-September and short season in mid-October.

Monthly collection of plant height and percent cover data on all plots and biomass samples from a randomly selected 1 square foot area on forage plots began 1 month after establishment. Biomass sampling was also done on all plots on the forage harvest date. Harvest of short-season forage plots began in early April, while harvest of the long-season forage plots began in mid to late April. Biomass was harvested at a height of 2 inches from the center 3 feet of each plot and weighed using a scale attached to a tarp suspended from a tripod. Grab samples were collected and dried to calculate percent moisture, which was used to convert yield into dry matter yield per acre. Plots were terminated approximately 1 week after forage harvest using a nonselective herbicide. Cash crops were planted approximately 1 week after termination. A nonselective herbicide and a pre-emergent herbicide were applied at planting. Weed notes were taken at 1 week after herbicide application and 2, 4, and 6 weeks post planting.

In year one, differences in forage yield differed significantly by species, location, and season. Nine of the 17 species showed no significant difference in forage yield by season or location. Of the remaining species, forage yields tended to be higher in the long season plots, although this difference sometimes differed by location. For oat, wheat, and canola, the long-season forage yield was higher than the short-season forage yield at the Middle Tennessee AgResearch and Education Center, but did not differ at the East Tennessee AgResearch and Education Center. For crimson clover, red clover, hairy vetch, woolypod vetch and Austrian winter pea, the East Tennessee long-season plots had significantly higher forage yield compared with Middle Tennessee Center's long season plots, and both had significantly higher yield than the short season plots at either location.

The ratio of cover crop biomass to total biomass at harvest for all plots also differed by species, location, and season. No differences were observed between short- and long-season plots by species at the East Tennessee AgResearch and Education Center or the Middle Tennessee AgResearch and Education Center. At the AgResearch and Education Center at Milan, however, canola, red clover, forage radish, turnip, and common vetch had greater than 73 percent cover crop biomass in long-season plots but nearly 0 percent cover crop biomass in short-season plots. At all locations, sunn hemp and berseem clover were not competitive in both short and long seasons, and common vetch, arrowleaf clover, and forage radish did poorly in short-season plots. Other species that exhibited low percentages of cover crop biomass only at some locations include short season canola at the AgResearch and Education Center at Milan, short-season red clover at Milan and the East Tennessee AgResearch and Education Center, and long-season forage radish at Middle Tennessee AgResearch and Education Center. The remaining species by location by season did not show significant differences from the highest ratio of 100 percent cover crop biomass.

In summary, most of the legume species benefited from a longer growing season while the cereals, in general, showed less of a response. Of the species evaluated, the long-season crimson clover produced the highest amount of biomass, averaging 3,771 DM lbs/a, followed by long-season hairy vetch (2,826), Austrian winter pea (2,620), and woolypod vetch (2,572). Under short-season conditions, wheat (1,163), triticale (996), and oat (814) had the highest DM lbs/ac across locations. These data suggest that following soybeans, which require a later harvest, cereals may be a better cover crop option. However, if earlier cover establishment is possible, legumes may provide significantly higher biomass. These data are based on only a single year of data. Because of the colder than usual temperatures observed over the 2017–2018 cover crop season, these trends might not remain true under more typical Tennessee winter temperatures.

Slug Management in Cover Crops

Scott Stewart
Professor
UT Department of Entomology and Plant Pathology

Clay Perkins
MS Candidate
UT Department of Entomology and Plant Pathology

Although there is a renewed interest, the use of cover crops in agriculture is not new. There are obvious and well documented benefits to using cover crops, at least in some circumstances, in improving soil heath, reducing nutrient and pesticide runoff, and the suppression of weeds. Cover crops can also provide resources for pollinators and other wildlife. Similarly, there are examples where cover crops have created problems in stand establishment, the introduction of weedy plants, or increased problems associated with plant pathogens or insect pests. As with any change in production systems, there are gaps in our knowledge of how cover crops affect the management of the following cash crop. How does the timing of cover crop planting, the timing of its termination, or the selection of cover crop species itself influence the subsequent crop and what steps should be taken to mitigate any potential problems related to the use of cover crops?

This presentation will review some of the findings from research done in 2018 and previous years. This research is evaluating how selected cover crop mixes affect the management of insect pests. In collaboration with other UT researchers, we have been evaluating how the use of cover crops, the timing of herbicide application to cover crops, and the use of insecticide seed treatments impact pest infestations. Preliminary observations show an increased incidence of insect injury related to the use of some cover crops in cotton, corn, and soybean. In contrast, positive impacts of the cover crops by reducing thrips injury in cotton have been observed.

In corn, infestations of southern corn rootworm caused stand losses behind a wheat/vetch cover crop, but these losses were largely prevented by the use of insecticide seed treatments. Similarly, southern corn rootworm and pea leaf weevil caused substantial injury in soybean when a wheat/vetch cover crop was used, but again, the use of an insecticide seed treatment greatly reduced the injury caused by both pests. Applying herbicide to terminate the cover crop several weeks in advance of planting also reduced insect injury. In cotton, significant injury cause by threecornered alfalfa hopper caused serious stand losses in cotton tests done in grower fields where cover crops were planted. All seed were treated with insecticide, but this did not provide adequate protection. However, termination of the cover crops several weeks in advance of planting substantially reduced injury. However, in these same tests, thrips injury was worsened when the cover crop was terminated early.

Slugs remain a threat and a challenge to control in reduced-tillage fields, and cover crops appear to increase the risk of slug injury. In 2018, some of the cotton tests mentioned above suffered stand loss related to slug feeding. Data will also be presented on methods to help predict and manage infestations of slugs and other pests that might occur in field crops.

Long-Term Crop Rotations and Cover Crops

Virginia Sykes
Assistant Professor
UT Department of Plant Sciences

Cover crops and crop rotations are activities that show positive improvements to production systems, but often those improvements exhibit slowly over a long period of time. Most research studies include only 2 to 3 years of data collection, making it difficult to accurately assess long-term treatment impacts. The University of Tennessee "systems study" was initiated in 2001 in two locations, Milan and Spring Hill, Tennessee, with the goal of examining long-term effects on soil organic carbon, overall soil health, crop yields, and economic viability under varying cover crop and crop sequence treatments in no-till production systems.

The systems study design includes several permutations of corn (C), soybean (S), and cotton (T) sequences within 4-year cycles under varying biocover treatments, including Austrian winter pea, hairy vetch, wheat, poultry litter, and fallow. Treatments are arranged in a split-plot randomized complete block design with three replications. The Milan location includes all three cash crops arranged into 13 different 4-year sequences: TTTT, CCCC, SSSS, TSTC, TSCT, TCTS, TCTC, CTSC, CCST, CSCS, SSCT, STCS, STST. The Spring Hill location includes only two cash crops (corn and soybean) arranged into eight different 4-year sequences: CCCC, SSSS, CSCS, CCSC, CSSC, SCSC, SCCS, SSCS. Cash crop yields have been monitored annually since 2002 and soil tests (Mehlich 1, %N, %C, and %OM) have been performed at the end of every 4-year cycle. Additional data have been collected at various stages of the study on select treatments, including soybean cyst nematode populations (2001, 2002, 2003, 2004), earthworm populations and diversity (2013, 2015), microbial diversity (2013, 2014), soil physical properties (2015, 2016), heavy metal content (2017), water availability (2015, 2016, 2018, 2019), soil chemical properties (2015, 2016, 2018, 2019), nutrient cycling (2018, 2019), and soil respiration (2018, 2019). This discussion will summarize some of the key findings resulting from this research study over the past 17 years.

Cash crop yields are a primary concern for many when implementing new production system practices. Crop rotation has a long history of implementation in agricultural systems with the expectation that continuous cropping systems will exhibit reduced yields over time due to crop specific nutrient depletion and pest population build-up. Yield data analyzed from this study included a 12-year period, 2002 to 2013. Contrast statements were used to compare continuous cropping systems to systems that include one or two iterations of an alternate crop within a 4-year cycle. Combinations that resulted in greater yield compared with continuous cropping systems included corn yield when rotated with 2 years of soybean (+6 percent) or 2 years of cotton (+6 percent) and soybean yield when rotated with 1 year of corn (+8 percent). The remaining rotations of corn and soybean were not significantly different from continuous cropping. In contrast, cotton yields when rotated with corn or soybean exhibited yields that either did not differ or were significantly lower (-13 to -16 percent) than continuous cotton.

Not surprisingly, in corn systems, implementing a leguminous cover crop (Austrian winter pea or hairy vetch) resulted in a yield advantage (+5 percent) compared with fallow, while poultry litter had no effect and wheat resulted in reduced yields (- 4 percent). In soybean systems, only poultry litter resulted in a yield advantage (+8 percent) compared with fallow. In cotton, none of the biocovers differed from the fallow treatment.

In addition to examining impacts on yield, this study has looked at several measures of soil health. Across these studies, poultry litter has exhibited the greatest impact on soil health parameters compared with the remaining biocovers. From 2002 to 2013, the poultry litter treatment exhibited higher pH, P, K, Ca, Mg, N, and C in the top 0-15 centimeters of the soil compared with fallow at both locations. Earthworm populations at the Milan locations were also significantly higher under the poultry litter treatment, microbial communities were distinctly different, and surface soil organic carbon accumulation was greater compared with the remaining treatments. None of the treatments showed significant accumulation of soil organic carbon over the baseline until year 8, confirming the importance of studies looking at long-term impacts.

Crop rotations have also shown a significant impact on soil health. At the Milan location, earthworm populations were significantly lower in continuous cotton and cotton corn sequences. Continuous cotton also resulted in less diverse microbial populations compared with continuous corn, continuous soybean, and soybean corn rotations. However, continuous cotton and cotton rotations did show higher rates of long-term surface levels of soil organic carbon accumulation compared with continuous corn and continuous soybean. The highest rates of surface soil organic carbon accumulation were generally observed in rotations containing at least two soybean crops within the 4-year sequence. At the Spring Hill location, which did not include cotton rotations, continuous soybean and SSCS sequences accumulated the most soil organic carbon compared with initial levels. Data on additional soil health attributes are being compiled, including soil respiration and heavy metal composition. Data on soil water holding capacity and soil physical properties will be presented by Amin Nouri on Tour K.

Use of Poultry Litter on Row-Crops in Tennessee: How Much Do I Need to Use?

Shawn Hawkins
Associate Professor
UT Department of Biosystems Engineering and Soil Science

Row crop producers in Gibson and surrounding counties will soon have greatly improved access to an alternative crop nutrient source (see the *Tennessean* news release on March 23, 2018, “Tyson chicken plant: Rejected in Kansas, welcomed in Tennessee.” This new poultry production complex will include 12 pullet houses, 39 hen houses, and 330 broiler houses and will process 1.25 million broilers per week at a plant being built in Humboldt, Tennessee. The complex will be at full production capacity by 2020.

A byproduct of this production complex will be approximately 80,000 tons of broiler litter, which is roughly equivalent to a 3:3:3 fertilizer (60 lbs-N, 60 lbs-P2O5, and 60 lbs K2O per ton of litter “as is”). Much lower total quantities of nutrients will be available from the small number pullet and layer farms. Row crop producers seeking to maximize nutrient use efficiency using poultry litter/manure should ask for a litter/manure analysis when purchasing the product.

Efficient use of litter nutrients begins, in addition to the litter nutrient analysis, with a soil test to determine crop phosphorus and potassium needs. Soil test results available from the University of Tennessee Soil, Plant and Pest Center are backed by replicated and controlled research and include nitrogen application rate recommendations that target the most profitable fertilizer application rates.

Once litter and soil test results are available, the method of setting litter application rates depends on which nutrient needs are targeted. For soils with low or medium soil test phosphorus concentrations, an application based on crop nitrogen needs will almost certainly meet crop phosphorus needs. This is because the phosphorus and potassium in litter can safely be assumed to be 100 percent crop available, whereas research by University of Tennessee Extension has demonstrated that broiler litter nitrogen is only approximately 45 percent crop available. Setting the manure application rate based on crop phosphorus needs can be accomplished by simply dividing the crop phosphorus recommendations by the litter phosphorus concentration. A credit can then be taken for the litter nitrogen that is applied by multiplying the application rate by the litter nitrogen content and by 0.45 (45 percent).

One good strategy that should be considered by corn grain producers is to utilize broiler litter as a starter fertilizer when performing split applications of nitrogen at planting (approximately 1/3 of total recommended nitrogen) and V6 (approximately 2/3 of total recommended nitrogen). For example, when recommended application rate of 180 lbs-N per acre is targeted for production, approximately 60-80 lbs of available nitrogen can be made at planting by applying 2.5 tons of broiler litter per acre. The litter will efficiently replace both corn grain phosphorus and potassium crop removal, and provide nitrogen at planting when the availability of the nitrogen is less critical to maximum crop yield. The split application of nitrogen can then be more safely made using commercial fertilizer. This and other efficient broiler litter application rate strategies will be presented at the field day, as well as the precautions necessary to protect surface water quality when land applying litter.

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Tour K: Cover Crops: What Do They Do for Crop Yield and Soil Properties?

Planting Methods, Timing of Planting, and Impact of Cover Crops on Crop Yields

Forbes Walker
Associate Professor
UT Department of Biosystems Engineering and Soil Science

Brian Kozlowski
Research Associate
UT Department of Biosystems Engineering and Soil Science

In recent years cover crops have become an important component of many cropping systems in West Tennessee, especially in corn-soybean rotations. The addition of winter cover crops can have many benefits to a cropping system including reducing soil erosion over the winter months, weed suppression, increasing soil organic matter, increasing water infiltration and improving overall soil health. If legumes are used as a cover crop, nitrogen fertilizer costs can be reduced. Additionally they can also help scavenge residual nutrients from the main crop and thus improve water quality.

In 2013, two cover crop research and demonstration sites were established at the AgResearch and Education Center at Milan, West Tennessee. Following the termination of the cover crops, corn or soybean was established as the main crop. The main crops alternate each year in a corn-soybean rotation common in West Tennessee. One study is assessing the effect of planting date and the other study the effect of seeding method (broadcast vs. drill). Biomass production, weed suppression, and corn and/or soybean yield following the different cover crops are measured in each study. In the planting date study we are comparing the effectiveness of three of the cover crop mixes and an unseeded control. In the seeding method study we are comparing six cover crop treatments (wheat; cereal rye; cereal rye and crimson clover; cereal rye and hairy vetch; a multispecies mix of cereal rye, oats, crimson clover, turnips, and radish; and an unseeded control). This presentation will summarize the biomass production, weed suppression, and corn and/or soybean yields from 2013 to 2017.

Cover crop establishment after broadcasting the seed compared to drilling the seed gave similar results in years when there is adequate soil moisture before and after seeding. In dry or wet years, cover crop establishment was poor if the seed was broadcast, so drilling is recommended. Our results show that earlier planted cover crops tend to produce more aboveground biomass, and thus suppress more weeds. In years with good rainfall, there was no difference in yields of corn or soy following single species, two species, or multispecies cover crop mixes. In drier years, when summer rainfall distribution was poor, yields of soybean following multispecies cover crops were significantly increased compared to no cover crops. We hypothesize that this is due to the improved soil physical properties and increased water infiltration rates that results in a positive and significant crop yield response.

Impact of Cover Crops on Soil Physical and Chemical Properties

Sindhu Jagadamma
Assistant Professor
UT Department of Biosystems Engineering and Soil Science

Manny Sabbagh
MS Candidate
UT Department of Biosystems Engineering and Soil Science

Cover cropping is a widely accepted practice to tackle the challenge of producing sufficient food for the growing population without compromising our soil and environment. Producers are very enthusiastic about the multiple benefits of cover cropping such as controlling soil erosion, suppressing weed growth, reducing nutrient leaching, and increasing soil organic matter content. In reality, each cover crop species performs specific function in soil. For example, leguminous cover crops improve nutrient availability to crops through nitrogen fixation. Being high biomass producers and nutrient scavengers, grass species control soil erosion, suppress weeds, and improve soil organic matter content. Tap-rooted cover crops such as brassicas are an excellent choice for reducing soil compaction. Because no single species can deliver all the benefits, mixtures of diverse species of cover crops can be more beneficial than a single species. Consequently, farmers started adopting mixtures of legumes, grasses, and brassicas.

Considering the strong interest among farmers on diverse cover crop species, a field trial was initiated in 2013 at the University of Tennessee's AgResearch and Education Center in Milan, Tennessee, to study the effect of different cover crop species on row crop production and soil health. This field trial includes six cover crop treatments such as (i) wheat, (ii) cereal rye, (iii) cereal rye+hairy vetch, (iv) cereal rye+crimson clover, (v) soil health mix (six-crop mixture of cereal rye, crimson clover, hairy vetch, daikon radish, turnips, and whole oats), and (vi) a cover crop free control. Since October 2016, soil samples have been collected in different seasons from 0-5, 5-10, and 10-20 centimeter depths and analyzed for soil moisture content, soil organic matter, and inorganic nitrogen content.

Results indicate that soil moisture and soil inorganic nitrogen contents were higher from plots planted with double- and multispecies cover crops. Soil organic matter did not change across the cover crop treatments. Overall, planting a combination of species shows promising results for a healthy soil by improving nitrogen availability and water retention. A field study is currently underway to understand the decomposition pattern of these cover crops during the main crop season. Within 2 weeks of incorporation, a considerable proportion of the cover crop residues were decomposed. This research provides valuable information for farmers on the best cover crop species or combination of species to broadly improve soil nutrient availability and soil health.

Impact of Cover Crops and Crop Rotation on Soil Physical Properties

Amin Nouri
Postdoctoral Research Associate
UT Department of Biosystems Engineering and Soil Science

No-tillage under low residue cropping systems may not protect soil surface and improve soil quality better than conventional tillage. Cover crops and crop rotation are major companion practices that are combined with no-tillage to improve the soil quality by increasing and diversifying the biomass production. Cover crops provide additional surface cover to reduce soil erosion, increase water infiltration, increase water retention capacity by increasing the soil organic matter, decrease evaporative moisture losses, decrease soil compactness, and increase yield. No-tillage generally accumulates the organic matter and nutrients near the soil surface. Crop rotations including deep-rooted species can increase nutrient recycling and carbon storage at subsoil and consequently improve biodiversity, soil porosity, water flow, and water holding capacity.

The impact of cover crops and crop rotation on soil physical properties and corn, cotton, and soybean yield was assessed in two long-term experiments located at the West Tennessee AgResearch and Education Center in Jackson, Tennessee, and the AgResearch and Education Center at Milan, Tennessee. The first experiment was a continuous cotton initiated in 1981 with three levels of cover crops (hairy vetch, winter wheat, and no cover control) applied on no-tillage and conventional tillage. The second experiment was established in 2002 as a summer cropping system study. Cropping managements were six monocropping systems and double species rotations of corn, cotton, and soybean (corn-corn, soybean-soybean, cotton-cotton, cotton-corn, corn-soybean, soybean-cotton) seeded on no-tillage system with winter fallow. This presentation will summarize the water infiltration and transmission, water holding capacity, soil compactness, and crop yield under different tillage and cropping systems.

In cover crop study, soil compactness (bulk density) measured before the annual tillage did not differ significantly among cover crops and between tillage systems. Differences in field soil moisture content were more evident in drier periods of growing seasons, resulting in 28.6 percent and 36.4 percent greater moisture content in vetch cover crop and no-tillage than no cover crop and conventional tillage, respectively. Our result showed that long-term incorporation of cover crops—in particular, vetch with no-tillage—significantly improved the initial infiltration, cumulative infiltration, and water transmission. Among cover crops, the greatest cotton lint yield was measured in hairy vetch (1672 kg ha-1), and no-tillage (1728 kg ha-1) produced significantly higher yield than conventional tillage (1541 kg ha-1).

In the crop rotation study, cropping in rotation did not show any advantage over monocropping systems. However, corn either as continuous cropping or when rotated with cotton and soybean improved soil physical properties and/or increased yield. In contrast, incorporation of cotton in cropping system decreased near-surface root penetrability by 17 percent compared to corn and soybean cropping systems. Soil moisture content during dry periods was 18 percent greater in corn-soybean and continuous corn than other managements. Water infiltration and transmission were greater under corn-soybean and continuous soybean while the highest plant-available water content was found in corn-soybean and continuous corn. Corn-soybean rotation resulted in highest corn and soybean yield and cotton-corn rotation produced the highest cotton yield.

Impact of Cover Crops and Crop Rotation on Infiltration, Runoff, and Erosion: Rainfall Simulator Demonstration

Mike Hubbs and Greg Brann
Soil Health Specialists
Tennessee Association of Conservation Districts

Abstract

Rainfall simulator is a tool to show the impacts of increasing soil carbon on soil function such as soil structure, runoff, and erosion. Growing cover crops, crop rotations, and no-till affect the soil's ability to function. There are four principles that affect soil health, which is the capacity of soil to function:

1. **Reduce disturbances.** Tillage breaks down soil aggregates, which affects pore spaces in soils.

2. **Keep soils covered.** Crop residue provides food, shelter, and insulation for soil biology.

3. **Keep roots growing as continuously as possible.** Plants produces sugars (carbon) through photosynthesis. Roots exude a portion of that carbon to feed soil biology. Soil biology aggregates soils and cycles nutrients.

4. **Increase diversity.** Diversity above ground increases soil biology diversity. Continuous carbon production through growing cover crops and crop rotations and protecting the benefits with no-till improves soil health.

Summary

Agricultural soils do not function very well due to long-term tillage and monoculture. Soil health is defined as the capacity of soil to function. Literature shows that functions of soil include productivity and biodiversity, the ability to infiltrate water, filtering and buffering, storage and cycling of nutrients, and structural support for plant growth. Tennessee NRCS and conservation partners have been focusing on conservation practices to improve soil health since 2013.

The key to improving soil health is to increase soil carbon. Carbon (sugar) is increased by intercepting energy from the sun and having a green plant growing nearly continuously. As we have green plants growing through grazing management for pastures, and adding a cover crop to crop rotation system, we can produce continuous carbon in the plants through photosynthesis. As carbon is increased in plants, soil biology will decompose plant material into soil organic matter or soil carbon.

By growing diverse mixtures in our cover crops, we can achieve soil biology diversity. Diversity and continuous cover provides the carbon from leaking roots to feed the soil biology. The consumption of organic material aggregates the soil and cycles nutrients. The covers on the surface breaks the impact of raindrops and reduces erosion, but the aggregated soil provides the pore space that improves infiltration.

The rainfall simulator will demonstrate five different management treatments and the effects of management on erosion, infiltration, and runoff. As farmers improve their soil health, water infiltration will improve fairly rapidly. Other benefits such as weed suppression and more nutrient cycling will show years 3-5. All of this depends on where the baseline of soil health is when one begins using no-till and cover crops.

Farmers can improve their soils by not tilling, keeping an active root growing, keep the soil cover, and adding diversity.

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Tour L: Are You Having a Hard Time with Fragipans?

Fragipans and Hard Pans? How Do They Form? Where Are They Found?

David McMillen
State Soil Scientist
USDA-NRCS

Managing Fragipans: What Can I Do if I Have Them?

Neal Eash
Professor
UT Department of Biosystems Engineering and Soil Science

Do I Need to Rip? Managing Hard Pans and Fragipans

Matthew Denton
USDA-NRCS

Fragipans are prevalent in the loess soils of West Tennessee as well as across the Lower Mississippi Valley and Southern Appalachian regions. They are dense soil layers that occur during soil formation. Even though their exact formation process is not understood, they are thought to be weakly cemented with silica and iron oxides. Usually, they are found at the interface of two parent materials. Fragipans impair root growth and downward water movement. Therefore, water holding capacity of the soil is severely limited. Other than being more dense than other soil layers, fragipans will rupture under pressure when squeezed or pinched; they will slake in water; have reduced porosity; and coarse prismatic, columnar, or blocky structure. In West Tennessee, fragipans range in depth from near the soil surface to 30 inches deep.

A soil pit will be available onsite to view properties of a fragipan as they occur in the soil.

Other dense layers occur in the soil and are common in high agricultural areas. These layers go by names such as "traffic pan," "tillage pan," or simply "hard pan." These occur at or near the surface and are human induced through management of the soil such as field traffic when soil is saturated. Like fragipans, these layers are denser than natural soil, have decreased porosity, rupture under pressure, and slake in water. However, these dense layers are characterized by horizontal platy structure that can be as deep as 6 to 8 inches into the soil. These dense plates impede water infiltration and many times channel roots along the planes between the plates, thus impairing root development by limiting soil moisture and nutrients.

The effectiveness of tillage to alter fragipans is directly proportional to the depth of the dense layer. Deep tillage may increase rooting depth in some situations. However, tillage will decrease porosity, infiltration, and soil organic matter, all reducing capacity of the soil to hold plant available water. Also, tillage will greatly increase the water erosion potential.

Dense layers occurring at the surface can effectively be alleviated by tillage. Again, tillage benefits can be offset by the drawbacks and is not sustainable. When producers are confronted with compaction caused by their equipment, their first response is often to attempt to fix the problem with another implement. However, a preferred way to reduce the soil's proneness to compaction is to increase soil organic matter so that it can replenish itself through the activity of macro and microorganisms and deep-rooted plants. Prevention is key and possibly requires some alternative management strategies to ensure that the potential for compacted soils are reduced.

Multispecies cover crops offer a sustainable alternative to tillage to reduce the effects of dense surface layers. Cover crop mixtures can be tailored to soil properties such as drainage and texture. Other benefits of cover crops are increased infiltration, weed suppression, and nutrient cycling. Soil compaction can be improved by utilizing both taproot and fibrous rooted species of cover crops concurrently. Although, tap-rooted species may penetrate compacted soils better than fibrous-rooted species, it is vital to have a diverse mixture present in crop fields to ensure that all resource concerns are effectively maintained and desirably improved.

It may take several crop cycles to fully see the benefits from reduced soils disturbance and cover crops, but to help offset some of the costs the US Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) offers up to 5 years of assistance to reduce the burden of implementing conservation systems on lands across the nation. USDA-NRCS has numerous opportunities for technical and financial assistance through our various programs and initiatives. Multispecies cover crops, intensive no-till systems, crop residue management, and controlled traffic activities are just some of the options available with USDA-NRCS.

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Tour M: Crop Variety Demo

The No-Till Crop Variety Demonstrations will have varieties of corn, cotton, and soybean technology on display. Participants may interact with representatives from the various companies represented. This tour will be located immediately behind the bus loading area.

UniSouth Genetics, Inc.

Monsanto Company

Credenz

Stoneville

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Tour N: Forestry Log Grading and Sawing

Demonstration of Band Milling and Fundamentals of Log Grading

Adam Taylor
Professor
UT Department of Forestry, Wildlife and Fisheries

Hardwood log grading is the process of estimating the quality of the lumber that can be sawn from that log. Log scaling rules estimate the quantity of lumber. The grade, scale and species of hardwood logs all contribute to determine their value when sold at a sawmill. A log price sheet summarizes this information and is used to determine the price paid for each log. In hardwood lumber, quality generally is more important than quantity, and quality can be affected by many factors, including species, board size, and defects such as knots.

Log scaling rules use the log's diameter (at the small end, inside the bark) and length to calculate the lumber yield, expressed in board feet. Calibrated rulers are used to speed the log scale calculation. There are many different log scaling rules, but the two most commonly applied in Tennessee are the Doyle and International rules. The rules are easy to apply, but it is important to understand the differences between the various rules. In particular, the Doyle rule underestimates the actual lumber yield in small logs; the resulting "overrun" is well-known, is accounted for in pricing, and is one way that a sawmill can monitor its efficiency.

Log grading varies according to the buyer and market demands; however, the principles of log grading consistently reflect the premium paid for high-quality hardwood lumber. The principles are that large, straight logs, with few visible knots, scars, or other defects are preferred. Because log size is considered in both grading and scaling, there can sometimes be confusion as to whether "bigger is better."

Log grading depends on using clues visible on the surface of the log to make an educated guess as to the quality of the wood hidden inside the log. Thus, experienced log buyers and sawmill operators may be able to "see" potential defects in logs that the untrained eye would miss. One of the best ways to learn about the log grading process is to observe a log being sawn, so that the relationship between surface features and the inner wood quality is revealed. At this tour stop, a portable sawmill will be in operation, so that the inside and outside of logs can be compared.

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Tour O: Forestry

Overview of the UT Forest Resources AgResearch and Education Center

Kevin P. Hoyt
Center Director
UT Forest Resources AgResearch and Education Center

The UT Forest Resources AgResearch and Education Center is a field-based laboratory that provides the land, personnel, and supporting resources necessary for implementing and assisting with science-based forestry, wildlife, and associated natural resources research. Social, biological, and ecological research projects have also been studied on the property. The UT Forest Resources AgResearch and Education Center supports UT faculty, students, and cooperating partners who are discovering better, more sustainable ways to manage forests and natural resources to benefit humans and the environment. Ongoing efforts are leading to advancements in forest productivity/health, tree improvement and sustainable practices that benefit landowners, the industrial forest products sector and the citizens of Tennessee.

The UT Forest Resources AgResearch and Education Center mission is to: (1) provide the land and supporting resources necessary for conducting modern and effective forestry; wildlife; and associated social, biological, and ecological research programs, (2) demonstrate the application of optimal forest and wildlife management technologies, and (3) assist with transfer of new technology to forest landowners and industries. The vision of the UT Forest Resources AgResearch and Education Center is to be the leader in promoting continuous improvement for safe operations, innovative natural resources research, and educational outreach.

The 11,368-acre Forest Resources AgResearch and Education Center is among the largest of the 10 field laboratories in the UT AgResearch system. It includes three forests located in East and Middle Tennessee and an arboretum at its headquarters in Oak Ridge.

- The Oak Ridge Forest located in Anderson County was established in 1964 and is conveniently situated for researchers from the UT Institute of Agriculture, UT Knoxville, and the Oak Ridge National Laboratory. This 2,204-acre facility hosts studies that examine forest management practices including natural regeneration, timber harvests, road construction and tree growth. Ongoing research is focused on dogwood breeding, silviculture, tree improvement, and integrated pest management. Other research and demonstration projects are being focused on unmanned aerial systems and diameter limit cutting VS sustainable forestry harvesting practices. Recent field-based training programs have been offered for the Tennessee Forestry Association—Master Logger Program and the UT Law Enforcement Innovation Center—National Forensic Academy.
- The UT Arboretum is situated within the Oak Ridge Forest and is designated for public education and service. The 250-acre arboretum serves as the Forest Resources AgResearch and Education Center's administrative offices and has an extensive trail system connected to a new auditorium. It features more than 2,500 woody plant specimens and enjoys strong volunteer support from the UT Arboretum Society. It serves as the educational and community outreach arm of the center and provides visitors with

opportunities to see the value of forests as ecosystems essential for a variety of plants and wildlife as well as a source of timber for wood-based industries. An arboretum educational program coordinator was hired in May 2017 to initiate/expand environmental educational programming, community outreach, and summer camp programs for children.

- The Cumberland Forest established in 1937 measures over 8,000 acres in Morgan and Scott Counties and facilitates several large- and small-scale forest and wildlife management research projects as well as ecological demonstration projects. The Cumberland Forest hosted some of the earliest strip mine reclamation research in Tennessee. The unit is the site of the Horney Head Creek Restoration Project and several other recently established Shortleaf Pine demonstration plantings. The UT Department of Forestry, Wildlife and Fisheries hosts annual prescribed fire training courses and the UT Law Enforcement Innovation Center—National Forensic Academy hosts ongoing field training at the site. Other recent field training topics have included forest road construction and timber inventory methods.
- The Highland Rim Forest established in 1962 is located in Franklin County in an area known as "The Barrens." This 864-acre site is used to research optimum species and production systems to increase forest productivity. Past legacy research has been focused on oak Barrens/prescribed fire, forest soil mapping, silviculture, forest management, tree improvement, and a multi-conifer species Pinetum collection. Recently established field demonstration projects are focused on shortleaf pine restoration and diameter limit cutting vs. sustainable forestry harvesting practices. The unit has hosted several Tennessee Healthy Hardwoods field days and has served as field training site for the UT Forestry, Wildlife and Fisheries prescribed fire course.

The research, education, and outreach performed at the UT Forest Resources AgResearch and Education Center helps private forest landowners and forest-based industry operate successful, environmentally sustainable operations that benefit businesses and consumers. These ongoing efforts improve the quality of life for all Tennesseans by providing wood and fiber products as well as conserving soil, water, air and wildlife for the benefit of our society.

Invasive Pests in Forest Settings

Larry Tankersley
Extension Forestry Specialist
UT Department of Forestry, Wildlife and Fisheries

Discussion of several common nonnative plants that are commonly invading areas where they are not wanted.

Species include tree of heaven, paulownia, mimosa, privet, bush honeysuckle, Japanese honeysuckle , kudzu , sericea and other lespedeza, Japanese stiltgrass.

Intro to lingo:

Native vegetation is historically found in local areas and is well-suited to the environment.

Exotic plants are found locally but originated in another country or continent. These are also **nonnative**, but a plant from a different region of this country or continent, are likewise nonnative.

Invasive plants can be either native or nonnative and cause economic and ecological damage by crowding out more desirable plants. Invasive plants spread at a rampant rate, often assisted by humans. The seeding and sprouting character of these plants contributes to their spread in addition of people moving them around.

Controlling nonnative invasive plants is often difficult. Cutting and mowing remove the plant from sight, but the root system is only temporarily affected and the plant is often back soon. Most professionals recommend herbicide applications as the most effective way to control invasive plants. When used properly herbicides have a number of benefits. Primarily, herbicides can kill the entire plant, roots included, thus preventing/reducing sprouting. Established patches of invasive weeds typically require repeated treatments for eradication. Determination is often required to maintain control of many of these plants.

The recommendations provided are intended as treatment for one or a few individual plants not for broadcast treatments of sizable area. Every situation should be carefully evaluated before any herbicide is used. Regardless of the herbicide used, carefully read the label and follow the directions.

Control Recommendations			
Species	**Large Trees**	**Saplings**	**Seedlings**
Tree-of-Heaven	Stem injections with Garlon 3A, Pathway*, Pathfinder II or Arsenal AC*. Midsummer application is best. Apply herbicide to stumps of felled trees to prevent resprouting.	Apply Garlon 4 as a solution in a basal oil to the bark of saplings. Basal oil will help keep the herbicide on the tree. A penetrant would help the herbicide get through the bark.	Wet leaves in late summer with a water-herbicide mixture with surfactant (helps herbicide adhere to the leaf and be more effective). Herbicides include Arsenal AC*, Krenite S or Garlon 4.
Royal Paulownia	Stem injections with Arsenal AC* or a glyphosate herbicide. Apply any time besides March and April. Apply herbicide to stumps of felled trees to prevent sprouting.	Apply Garlon 4 in a basal oil to the bark of saplings. Use a bark penetrant.	In late summer and early fall, apply Arsenal AC*, a glyphosate herbicide, Garlon 3A or Garlon 4 with surfactant to leaves.
Mimosa	Stem injections with Garlon 3A or Arsenal AC*, both applied by the label at any time but late spring. Apply herbicide to stumps of felled trees.	Apply Garlon 4 in a basal oil to the bark of saplings. Use a bark penetrant.	In late summer and early fall, apply Garlon 3A, Garlon 4 or glyphosate herbicide with surfactant to leaves.
Privet	Apply Garlon 4 in a basal oil to the bark of larger plants. Use a bark penetrant. Can also cut stems and treat stumps with Arsenal AC*, Velpar L*, a glyphosate herbicide or Garlon 3A.	Apply a glyphosate herbicide or Arsenal AC* with surfactant in August though December. Wet all leaves.	
Amur Honeysuckle	Cut stems and treat stumps with Arsenal AC* or a glyphosate herbicide.	Apply a glyphosate herbicide with surfactant to leaves in August – October. Garlon 4 in basal oil can be used on stems.	
Japanese Honeysuckle	Cut large vines and treat stumps with a glyphosate herbicide or Garlon 3A in late summer and early fall. Prescribed fire in spring also can control vines.	Spray leves with Escort* and a surfactant in late summer. Treat foliage with a surfactant and glyphosate herbicide or Garlon 3A or 4 in July through October.	
Kudzu	Apply a glyphosate herbicide or Garlon 4 with surfactant to leaves and stumps. Can apply Garlon 4 with penetrant and basal oil to bark of large vines in January – April.	Wet all leaves with the following herbicides in a surfactant-water mix: Tordon 101*♦ or Tordon K*♦ in July – October, Escort* in July – September, or Transline+.	
Sericea or Chinese Lespedeza	Wet all leaves with the following herbicides in water with a surfactant in July through September: Garlon 4, Escort*, Transline+, glyphosate herbicide or Velpar L*. Mowing the vegetation at least a month before treatment makes the herbicide more effective.		
Japanese Grass	Apply a glyphosate herbicide in a water-and-surfactant mix in late summer. Vantage can be used according to its label for more protection of surrounding plants. Repeat treatments will be necessary over several years.		

* Use may kill or injure non-target surrounding vegetation by root uptake of this herbicide.

+ Transline controls the leguminous group of plant species.

♦ For Tordon herbicides to be effective, rainfall must occur within six days following application for soil activation. Tordon herbicides are Restricted Use Pesticides.

Precautionary Statement:

To protect people and the environment, herbicides should be used safely. This is everyone's responsibility, especially the user. Read and follow label directions carefully before you buy, mix, apply, store or dispose of an herbicide. *According to laws regulating herbicides, they must be used only as directed by the label.*

Disclaimer:

Herbicides recommended in this publication were registered for the prescribed uses when printed. Herbicide registrations are continuously being reviewed. Should registration of a recommended herbicide be cancelled, it would no longer be recommended by the University of Tennessee. Use of trade or brand names in this publication is for clarity and information; it does not imply approval of the product to the exclusion of others, which may be of similar, suitable composition, nor does it guarantee or warrant the standard of the product.

Ticks and Tick-Borne Diseases: An Overview

Allan Houston
Research Professor
UT Department of Forestry, Wildlife and Fisheries/Ames Plantation

Anyone who has spent time in the out-of-doors recognizes being bitten by a tick is a real possibility.

Generally speaking, 30 years ago finding a tick embedded would have been cause for discussion all summer long. Nowadays, finding a tick is not only common, but, unfortunately, for those who regularly venture outside and into tick habitat, relatively routine.

There are four tick species in West Tennessee that will accept humans as a host and all four occur in three life stages: larval or what are often referred to as "seed ticks," nymph, and adult. All three stages bite.

Ticks carry a number of diseases and some are quite serious, both in terms of immediate illness and in terms of maladies than can affect a person for life. They range from the more familiar diseases such as Lyme and Southern Tick-Associated Rash Illnesses (STARI) that include moderately uncomfortable, short-lived symptoms or very severe and potentially life-threatening diseases like Rocky Mountain spotted fever to lesser known but increasingly more common illness such as meat allergy, which can result in the victim no longer able to consume red meat. Ticks carry bacteria, viruses, and even neurotoxins that can cause human illness.

The presentation will describe these tick species and their life stages. It will explain how ticks live, how they acquire a host, what those hosts might be, and how disease transmission occurs. It will describe typical habitat for ticks as well as habitats that are relatively unsuitable for ticks. The range of tick diseases will be described and the presentation will give some idea of when during the year certain diseases are most highly reported. It will describe research accomplished on the UT AgResearch and Education Center at Ames Plantation where several thousand ticks were caught and examined for certain disease loads.

The presentation will also describe things a person might do to help avoid being bitten and what to do if a tick is discovered embedded.

Ticks are here to stay. Disease loads may increase as new maladies are discovered or as they are transported from other places, including disease agents perhaps currently off our shores. Heightened awareness can lead to a decreased possibility for exposure to tick-borne disease. This talk will not only give the audience a tendency to itch and scratch during the presentation, it will also provide insight and tools to help avoid exposure to ticks, their bite and the serious diseases they can carry.

Sustainable Forestry versus Diameter Limit Cutting

David Mercker
Extension Specialist
UT Department of Forestry, Wildlife and Fisheries

Sustainable Forestry

Forest ownership carries an opportunity to practice sustainable forestry. In this sense, sustainable means managing the forest in such a way that it provides a continuous output of products and services, without causing lasting harm or affecting forest productivity (Schuler and McGill 2006). Sustainable forestry embraces "monitoring forest heath . . ., maintaining appropriate levels of stocking and structure, enhancing the growth and vigor of desirable species, and regenerating new trees and forests when the current ones reach maturity or no longer serve the landowners' needs" (Kenefic and Nyland 2005). Diameter limit cutting, as described in this presentation, generally is counter to sustainable forestry.

Diameter Limit Cutting Defined

Diameter limit cutting (DLC) is the practice of harvesting all merchantable trees above a specified diameter (for instance 16 inches and larger in diameter). Diameter limit cutting is a form of high-grading. In forestry, "high-grading is the removal of the most commercially valuable trees (high-grade trees), often leaving a residual stand composed of trees of poor condition or species composition" (Helms 1998).

With DLC, timber diameter is measured either at 4.5 feet above the ground level (referred to as diameter at breast height or DBH), or at stump height. In most cases, however, DLC does not remove undesirable species, culls, or poor-grade trees that fall within the specified diameter limit. Nor does DLC harvest the smaller unacceptable trees with diameters below the specified diameter limit. Such trees have little investment value and should be removed to promote stand improvement. What DLC does do is sacrifice immature, desirable crop trees before they reach financial maturity—trees, which if left to grow, could develop into high-quality, top-value timber, desirable to the hardwood industry. It is these shortcomings of DLC that challenges sustainable forestry.

Forest Options Following DLC Harvests

Landowners and foresters are regularly faced with decisions on how to manage timber stands once "the damage has been done," i.e., forest stands have undergone DLC (or many occurrences of DLC). Proper forest management is highly dependent upon the availability of acceptable growing stock (AGS) within the stand. Here AGS refers to trees meeting specified objectives of species, quality, vigor, and value. As outlined in UT Extension PB 680 "Treatments for Improving Degraded Hardwood Stands" (Clatterbuck 2006), two options exist for degraded stands: rehabilitation or regeneration.

Where sufficient acceptable growing stock exists, stands can be rehabilitated (improved) via sanitation harvesting, crop tree release, or pre-commercial timber stand improvement. With these practices, undesirable trees are either harvested or deadened in an effort to create adequate growing space for the desirable (AGS) trees. If a market cannot be located for the undesirable trees, they can be deadened by girdling and/or with herbicide treatment. Cost-share assistance is sometimes available from both the state and federal governments to offset investments in deadening undesirable trees.

Alternatively, when the growing stock is so poor that stand continuation is not economically viable (a decision that should involve assessment by a professional forester), stand regeneration is the preferred option. Regeneration is the act of starting (or reproducing) a new forest, and it can occur in a variety of ways, including clearcutting, patch openings (small clearcuts), shelterwood, or planting. With these techniques, new seedlings are released, invade or are planted to occupy growing space, eventually becoming a viable stand.

Southern hardwood forests are difficult to sustain with continuous partial harvesting. Doing so favors the reproduction of shade tolerant species, generally viewed as less desirable. Regeneration of many of the more desired species (oaks, tulip poplar) requires that at some point, a heavier, stand initiating harvest is needed—thereby allowing adequate sunlight to reach the forest floor and encourage seedling development.

Conclusion

Diameter limit cutting has been practiced for generations, is simple to implement, and can provide favorable short-term financial returns. However, DLC usually leaves a degraded forest. This runs counter to sustainable forestry. With DLC, trees with highest current value are harvested, leaving slow-growing, undesirable and/or poor-quality trees behind. Stand growth, yield, and future timber sale incomes are compromised.

This presentation creates awareness of the problems of DLC with intent to reduce the implementation of this practice. Before a commercial timber harvest is conducted, landowners are advised to first seek assistance from a professional forester. With the forester’s knowledge, a plan can be developed that will not only avoid DLC, but reverse the deleterious effects.

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Tour P: Farmers vs. Hunger

Sponsored by:

Hunters Sharing the Harvest

Tennessee Soybean Promotion Council

Taco Bell of Milan

Farm Credit Mid-America

Outreach Inc.

Other sponsors will be listed at the Field Day.

On-site Coordinator: Chuck Danehower

UT Extension Area Specialist—Farm Management

This stop features a hands-on activity where participants will assemble a soy meal protein and vitamin-enhanced macaroni and cheese product that is a substantial meal for children and adults. The soybean ingredient is a vital component of this nutritious and affordable meal. Soybeans are grown on 1.6 million acres in Tennessee and are the largest row crop in the state.

In Tennessee, 15.4 percent of the state's population, including 21.1 percent of the children, are food insecure and can't afford enough food to consistently meet their basic needs. In Gibson County, home of the Milan No-Till Field Day, 19.8 percent of the population and 27.2 percent of the children are considered food insecure. The meals packaged at this tour will be distributed to food banks and food pantries throughout the local area.

Stop in and help stamp out hunger while attending the Milan No-Till Field Day. Activities will begin at 9:00 a.m. and will continue throughout the day.

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