Progress Report 402

1998 Agronomy Research Report

University of Kentucky

College of Agriculture

Agricultural Experiment Station

Department of Agronomy

Lexington

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edited by M. Scott Smith

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Following an intensive review of all research and graduate education units at the University of Kentucky, the Department of Agronomy was recently designated as a "distinguished, nationally competitive" research program. This distinction will place agronomic research among a small number (only 20 at the University of Kentucky) of "targets of opportunity." These departments are eligible to compete for Kentucky's new Research Challenge Grants. They will be expected to lead the way as the University strives towards its legislatively mandated goal of becoming a nationally distinguished public research institution.

The Department of Agronomy received this distinction in part because it conducts both basic and applied research of the highest quality. Several of our faculty are engaged in cutting-edge, fundamental studies of plant biochemistry and genetics, and the chemistry and biology of environmental processes. Such investigations will have long-term payoffs in the form of greatly improved productivity and quality of crop plants, and enhanced conservation and utilization of soil and water resources.

However, this report emphasizes applied and field experiments of current importance to Kentucky agriculture. Our faculty provide brief updates of continuing projects and initial reports on recently completed studies. *Agronomy Research* is published every other year to inform professional agronomists, crop producers, and crop consultants about recent developments in the University of Kentucky Department of Agronomy.

Research Highlights

Examples of interesting and potentially important research accomplishments during the last year include:

- No-till wheat studies at the University of Kentucky and on experienced, no-till wheat farmers' fields indicate that this practice is beneficial and economically feasible for many growers in the state. Through research and education, the newly formed Wheat Science Group at the University is leading a Kentucky Small Grain Grower's initiative to have 75 percent of the wheat no-till planted by the year 2005. The Wheat Science Group is a coordinated group of specialists from all disciplines with a structure that will allow a more effective and practical approach for solving problems and creating new opportunities to serve the small grain growers of Kentucky.
- A continuing goal of our burley tobacco breeding program has been the development and release of cultivars with increased resistance to *Phytophthora parasitica* var. *nicotianae*, the causal agent of black shank. Towards this goal, KY 910 (KX94148) will be released to seedsmen in 1998. KY 910 has been evaluated in Kentucky under disease pressure at our black shank nursery in Franklin County, and in field performance trials for three years. This new cultivar was released for its high resistance to Race 0 of black shank, medium resistance to Race 1, early maturity, and virus resistance.
- A large portion of maintenance budgets for golf courses can be attributed to fungicide applications. Research was conducted investigating cultural control of fungal diseases while reducing fungicide inputs. Results showed even without fungicides, dollar spot disease may be consistently reduced by as much as 50 percent on golf greens, and up to 80 percent on creeping bentgrass fairways through cultural practices alone.
- An enzyme capable of detoxifying multiple types of pesticides has been cloned from corn and expressed in yeast. This gene has the potential for developing new crops with multiple pesticide resistance, being used by industry for studies of pesticide degradation, and aiding in the development of integrated pest management through better understanding of how pesticides interact to cause corn injury.
- Research data from the Weed Science field program supported the registration of Spartan herbicide for morning glory control in tobacco.
- Due to its superior yielding ability in the Kentucky Soybean Performance Tests, Soybean line KY 91-1214 was released as a new maturity group IV soybean variety by the Kentucky Agricultural Experiment Station.
- A new tobacco sucker control option was promoted through field days, demonstrations, and winter meetings. Utilization by producers increased from an estimated 1 percent in 1996 to 35 percent in 1997. Improved sucker control and increased yields are expected, while MH residue levels should decline. Lower residues could improve the standing of Kentucky burley tobacco in the world market.
- Predicting corn seed deterioration would provide a valuable management tool for the seed industry. A four-year study investigated the effect of constant storage temperature and seed moisture on seed deterioration across six corn hybrids of various initial seed vigor levels. Both the hybrid and initial seed vigor affected the rate of deterioration with low vigor seed lots deteriorating faster. A model was developed that accurately predicted the time to loss of corn seed germination (±10 percent) across 17 storage environments.
- We are developing new ways to express multiple genes in plants. We tested a strategy for simultaneously expressing several enzymes in different subcellular compartments of plants. Our studies provide a means by which complicated metabolic pathways may be introduced in plants, with a minimum of transgenic and genetic manipulation.
- Our research on the fertilization of tobacco transplants in the float system identified nitrite toxicity as the primary cause of poor growth of transplants fertilized with urea. In 1994 and 1995, urea-based fertilizers caused an estimated $2 million in damage to burley tobacco transplants. As a result of our float

system fertility studies, tobacco growers have learned to avoid fertilizers containing urea.

- Bioassays detected the first evidence of an interaction between alkaloids of endophyte-infected tall fescue. Toxicity of ergotamine and N-formyl loline appears to be mediated by the same membrane-bound receptor. This discovery could lead to a better understanding of fescue toxicosis and the development of new methods of managing this perennial problem, which costs the Kentucky livestock industry $100 million annually.
- Genetic engineering methods have been used to introduce coat protein (CP) genes from both tobacco and soybean viruses into the respective host crops. We have demonstrated in laboratory, greenhouse, and field experiments that transgenic lines carrying non-pathogenic CP genes are stably inherited and provide useable field levels of resistance to virus attack. Two burley tobacco transgenic lines carrying a viral CP gene were promising enough in a variety evaluation test in 1997 that the two lines will be entered in the preliminary regional variety test in 1998.
- Research on no-till production of corn, soybeans, wheat, and tobacco continues. Kentucky continues to lead the nation in percentage of no-till crops (44 percent in 1994; 48 percent in 1997), with 94 percent of double-crop and 49 percent of full season soybeans, and 52 percent of the full season corn no-tilled. Hickman and Trigg Counties led the state, and produced 85 percent of their corn, soybean, and wheat acreage by no-till in 1997. The erosion control this provides is very notable.
- Our research has demonstrated that fecal bacteria from poultry litter can rapidly infiltrate soil during rainfall. The infiltration has considerable spatial variability and is associated with macropore flow. Tillage, which disrupts macropore continuity, will impede but not prevent microbial infiltration to shallow ground water. This on-going research will be used to devise appropriate management practices for animal waste disposal on land.
- A major goal of the Kentucky Forage Variety Testing Program has been to encourage use of improved, proprietary forage varieties. Since 1994, farmers have bought significantly more proprietary alfalfa and red clover varieties compared to public lines. Based on surveys, purchase of proprietary alfalfa varieties is up 42 percent since 1994. If 25 percent of Kentucky's 300,000 acres of alfalfa are reseeded annually, and 42 percent of farmers choose to upgrade to a better variety of alfalfa, this would total $9.45 million additional revenue in farm receipts. Sales of improved, proprietary varieties of red clover have increased by at least 90,000 pounds of seed compared to 1994 levels. This quantity would seed 9,000 acres of red clover and this improved forage would be worth an additional $2.3 million in farm receipts compared to what unimproved red clover varieties would produce.

M. Scott Smith
Department Chair and Editor

Review: Turfgrass Management and Science in Kentucky

D.W. Williams and A.J. Powell, Jr.

The turfgrass industry is growing in Kentucky, as well as across the nation. There are nearly one million acres of managed turf in the Commonwealth with approximately $400 million spent annually on turf maintenance. The majority of this acreage is in home and commercial lawns as well as highway rights-of-way and medians.

Golf course acreage is small compared to other categories. However, turf managed as golf courses usually receives much more management input than general turf areas and lawns. Consequently, the cost of managing an acre of golf turf is much higher, with annual golf course maintenance budgets in Kentucky ranging from less than $100,000 to nearly $1 million per course.

There are approximately 280 golf courses in Kentucky with more under construction daily. The game of golf still enjoys significant popularity and growth, and as more and more courses are constructed, the competition for golfers increases. This competition creates pressure on golf course superintendents to produce excellent playing conditions while keeping costs at a minimum and protecting the environment.

There are more than 3,000 athletic fields in Kentucky, and scores of new fields are being built annually. With increased emphasis on sports, such as soccer, the need for more traffic-tolerant grasses and overall safer fields is imminent.

Homeowners and lawn care operators (LCOs) are also very interested in improving turf in a cost-effective manner. Although the chemical lawn care industry has declined somewhat in recent years, it is still a very active enterprise; however, there appears to be a large increase in lawn maintenance (mowing and cleaning) businesses, both in Kentucky and elsewhere. Many homeowners have become do-it-yourself turf managers and rely on the Cooperative Extension Service for technical support.

The desire for improved turf while reducing costs and inputs for lawns and general turf has resulted in significant improvements via research activities. For example, Kentucky bluegrass is rarely recommended for use in home lawns and general turf as it was in the past. Breeding efforts and cultivar evaluations have provided improved tall fescues that provide beautiful lawns with much less input. New tall fescue cultivars have much improved color and texture, yet perform well in the transitional climatic zone of Kentucky.

There are also significant changes occurring in golf turf management. Historically in Kentucky, golf fairways on public courses were composed mostly of Kentucky bluegrass and/or perennial ryegrass. High dollar private clubs provided superior playing conditions with creeping bentgrass, bermudagrass, or zoysiagrass fairways. There is now a strong inclination for new public and semi-private courses to establish bentgrass, bermudagrass, or zoysiagrass fairways. This change is mostly a reaction to increased competition and may increase maintenance budgets, but is also due in part to improved cultivars and management techniques.

These trends in lawn and golf turf management provide many research challenges. The turfgrass research effort at the University of Kentucky expanded in 1997 with the establishment of one additional research and teaching faculty position. This will allow for increased efforts in both applied and basic research activities.

Our current and projected research efforts strive to support and shape trends in turf management. This is accomplished by investigating questions that apply to both Kentucky and the turf industry at large. The majority of the current effort is focused on applied research.

UK participates in the National Turfgrass Evaluation Program (NTEP). NTEP trials are cultivar evaluations and are conducted at locations across the U.S. We are currently managing tests of creeping bentgrass (*Agrostis palustris*) for golf greens and fairways, seeded and vegetative bermudagrass *(Cynodon dactylon*), seeded and vegetative zoysiagrass (*Zoysia japonica*), high and low maintenance Kentucky bluegrass (*Poa pratensis*), perennial ryegrass (*Lolium perenne*), tall fescue (*Festuca arundinacae*), and fine fescues (*Festuca spp.*). Data from these tests become part of a national database and are also heavily used in regional Extension activities.

Pesticide efficacy trials are also conducted annually. Herbicide trials consist of pre- and postemergent products for both grassy and broadleaf weeds. In addition to these industry sponsored trials, several experiments seek to improve the efficacy of currently available products. Examples include investigating the timing of non-selective herbicides applied to dormant bermudagrass to control winter annual weeds, fall applications of preemergent herbicides on bermudagrass to control winter annuals, control of *Poa annua* on golf courses, and herbicides to control nimblewill and Star of Bethlehem in Kentucky bluegrass. Fungicide and insecticide efficacy trials in turf are conducted annually in cooperation with the Departments of Plant Pathology and Entomology.

A significant effort in the recent past investigated cultural disease control on creeping bentgrass managed as golf fairways and greens. This project investigated reducing fungicide inputs while maintaining acceptable turf quality. The project has been quite successful and will continue into the future.

Management of fine turf in Kentucky can be quite a challenge. Our climate may provide conditions similar to those in Atlanta, Georgia, in any given summer while being comparable to a northern winter the same year. For that reason, neither cool season (C3) nor warm season (C4) grasses are perfectly adapted to Kentucky. This leads to numerous research challenges.

Most new or recently built golf greens are constructed of 80 to 90 percent sand. This can create many problems for creeping bentgrass during an Atlanta-like summer. As part of our expanded research effort, we have constructed a one-half acre sand research putting green at the Spindletop Research Station. The new green will be used to study topics ranging from IPM to fertility. Additionally, 25 lysimeters were constructed along one edge of the green to allow for studies of pesticide and nutrient movement through the root zone. The new green more than doubles the available area for future sand-based bentgrass research.

Other projects with cool season grasses are also in progress. A study of brown patch disease (*Rhizoctonia solani*) on tall fescue is in its fourth year. This study investigates the effects of nitrogen fertility, tiller density, and mowing height on disease incidence and severity. Gray leaf spot (*Pyricularia grisea*) on perennial ryegrass has become a problem in Kentucky. We are also conducting a study on the effects of mowing height and nitrogen fertility on this disease, as well as concurrent laboratory studies to facilitate field inoculation techniques.

Warm season grasses may also experience serious problems in Kentucky. It was estimated that during the winter of 1996-97, as much as 40 percent of all bermudagrass in the Commonwealth was lost to cold weather stress. Losses of this magnitude certainly indicate the need for research on improving warm season grass management.

One major improvement was our release of Quickstand bermudagrass, a more winter hardy variety with less disease problems. It is currently being used on many athletic fields and golf courses in Kentucky and surrounding states.

Several management experiments with warm season grasses are underway. One way to avoid or reduce cold weather damage to warm season grasses is to use synthetic covers. This is not practical for large areas like golf fairways, but it is a very viable option for athletic fields and golf tees. We have completed the first year of testing 12 covers.

One exciting and expanding area of warm season grass research is the introduction of seeded cultivars. Until recently, almost all warm season grasses have been established vegetatively by sprigging or sodding. Plant breeding efforts have given rise to many new cultivars propagated by seed. Seeding provides obvious advantages to vegetative methods of establishment as long as acceptable turf quality is maintained.

In addition to NTEP trials of seeded and vegetative cultivars, three new experiments are underway. A study of the timing of establishment as related to winter survival is entering its second growing season. This trial will contrast seeded and vegetative cultivars, and aid in establishing a limit on late-season establishment of bermudagrass.

Two extramurally funded bermudagrass projects will begin in the 1998 growing season. The first will screen new bermudagrass germ plasms for winter hardiness in Kentucky. This will hopefully lead to the release of cultivars with improved tolerance to our northern-like winters. The second project will investigate the effects of seeding rate and N fertility on the rate of establishment and winter survivability of seeded bermudagrass.

As the expansion of the turf research effort continues, so will basic research activities. Currently, two projects are in the planning stages. One will investigate the relationship between *Sclerotinia homoeocarpa* (the causal agent of dollar spot disease) and creeping bentgrass. Some cultivars of creeping bentgrass exhibit desirable levels of resistance to dollar spot, and a better understanding of the host/pathogen relationship may help explain and exploit the resistance mechanisms. Secondly, previous studies of dew formation on creeping bentgrass have raised new questions regarding the structure and nature of hydathodes (leaf structures which exude fluids). Experiments are being considered which would expand our knowledge in that area.

The UK Turfgrass Science Program is experiencing significant growth. We welcome the challenges presented by this growth, and by new problems in turfgrass management. Our research program is designed to meet the needs of the industry in the Commonwealth, as well as to answer broader questions applicable to other areas of plant science. A summary of all turfgrass science research activities is published annually. Copies of the report may be obtained through the UK Department of Agronomy or through local county Extension offices.

Review: Precision Agriculture Research in Agronomy

R. I. Barnhisel

Precision agriculture is becoming a popular topic in many trade magazines and especially among the larger progressive farmers of Kentucky. Precision agriculture (PA) has been known by several different terms: site specific management, farming by wire, and prescription farming, to name but a few. Up to the present time, this technology tends to be driven by industry and few universities have conducted experiments in this area. Research that would now be classified as PA began in Kentucky in 1989. This was associated with surface mine reclamation of prime farmland, but did not involve the degree of technology available today. Yield and soil maps were constructed to exhibit differences in mine soil properties such as density and the effect of various treatments to remove compaction.

Later, in 1993, one of the early projects on more typical agricultural land was started, specifically studies of varying corn populations according to topsoil thickness or landscape position. This work was started after a farmer, Kevin Clark, asked Morris Bitzer to help him determine if varying the seeding rate, by decreasing it on thinner soils and increasing it on thicker soils, produced greater yields than simply planting the same rate for the entire field. The answer was yes and the first phase of this work was published in 1997.

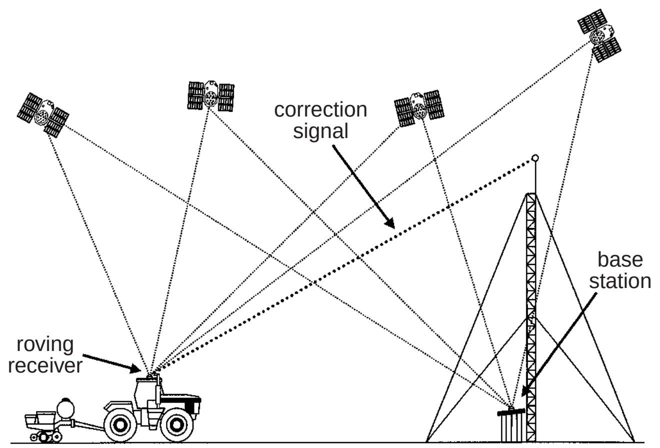
What does precision agriculture involve? Basically there are several components. One is a data logger to record yields from a yield monitor that are geo-referenced. This employs the Geographic Positioning System (GPS). The equipment includes a receiver to obtain radio signals from at least four satellites and a processor to interpolate these data. A second signal is also used to increase the accuracy of the GPS signals. They may come from a private source or from Coast Guard stations. Such signals are then called DGPS; these differential calculators reduce the error inherent in the satellite signals from 10 to 20 meters to 1 to 2 meters. With more expensive instrumentation, accuracy of positions can be reduced to a couple of centimeters.

Yield monitors calculate the flow of grain through a harvester such as a combine. These data are converted to bushels per acre and when linked to GPS data, yields can be displayed for entire fields or farms. When these data are entered into a Geographic Information System (GIS), yields can be correlated with other properties such as soil fertility, soil type, zones of soil composition, weed populations, etc. When meaningful relationships are developed, farmers may vary inputs to further increase yields, but more importantly, manage inputs or variable costs so that profits can be increased. Until the advent of GPS/GIS, farmers managed their farms on a field by field basis. Now it is theoretically possible to manage their farms on an acre by acre basis.

The precision agriculture approach has perhaps raised more questions in both the minds of the farmer and researcher than it has answered. Some early questions centered on soil fertility which led to grid soil sampling. Several thousand acres have been grid sampled in Kentucky. The grid size varies widely from as small as 50 foot X 50 foot spacing, as we have done associated with research projects, to as large as 450 foot X 450 foot. The most commonly used spacing is perhaps 330 foot X 330 foot, or an area that represents 2.5 acres. Once these soil data are collected, another set of maps is prepared which are also geo-referenced. Variable fertilizer or lime rates may be assigned to the various polygons.

The validity of this approach is still under debate. What causes soil fertility in a field to vary? Was it because this field originally was two or more smaller fields that were managed differently in the past? Do fields vary due to inherent soil differences in drainage or parent materials? Were these differences due to past management such as different degrees of erosion? Or were nutrients applied in such a way to create these variations due to poor equipment design or operation? Perhaps simply spreading fertilizers or animal manures in the same pattern year after year created variations.

Local area differential correction—correction signal generated and broadcast from earth station (USCG Radio Beacon).



In any case, precision agriculture uses site-specific prescription maps to manage these variations. Assuming yield-limiting variations can be reduced by using different equipment or using existing equipment differently, yields should increase as well as profit. These maps are linked to fertilizer spreading equipment and rates are varied according to the need of individual polygons. If this approach is successful, potential adverse environmental impacts may also be reduced, if not eliminated. Only enough nutrients or chemicals needed to produce the greatest economic return would be needed. Similar approaches such as applying nitrogen based on yield potential of the soils that occur on the landscape in conjunction with corn seeding rate experiments are in progress across the state. It is the expectation of this research that economic benefits gained will pay for the added equipment needed for precision agriculture within a couple of years, and have a significant improvement in water quality. This technology is also being extended to manage application of animal wastes.

This work is a fully cooperative effort between the Agronomy Department, the Department of Biosystems and Agricultural Engineering, several county agricultural agents, and farmers. Eventually inputs from other departments will be an important component of this research, including Agricultural Economics, Animal Sciences, and Entomology. Currently numerous experimental field plots have been established on the Woodford County Research Farm and on cooperating farms in Shelby, Nelson, Marion, Hardin, Hopkins, Daviess, Fulton, and Henderson Counties.

Potential Agronomic Benefits of Wood Ash Application on Reclaimed Surface Mined Lands

D.C. Ditsch, W. Turner, M. Collins, and J.H. Grove

Wood ash is a by-product generated by paper companies, lumber manufacturing plants, and utilities that burn wood products, bark, and papermill sludge as a means of disposal and/or energy production. The chemical characteristics of industry-generated wood ash can be highly variable and are a function of tree species and the part of the tree burned. In general, wood ash has a Calcium Carbonate Equivalent (CCE) ranging from 35 to 85 percent making it useful as a liming amendment. Wood ash also contains variable amounts of many essential plant nutrients such as phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), and boron (B).

The land application of any industrial by-product is often regulated by its heavy metal content and potential environmental impact. In general, wood ash is lower in heavy metals than coal fly ash.

In the Appalachian coal fields of eastern Kentucky, Trus Joist MacMillan has recently constructed the largest single-product engineered lumber plant in the world. At this plant, small diameter yellow poplar, black gum, and sycamore (less than12-inch diameter) will be processed into structural building materials using newly emerging technologies. Logs entering the plant are prepared for processing by first being debarked. Tree bark is burned in a furnace as an energy source for numerous plant operations, resulting in 6,000 tons of wood ash generated each year.

The Trus Joist MacMillan plant was constructed on a reclaimed surface mine site in Perry County, near many active coal surface mines. Reclaiming these mine sites typically requires the application of agricultural limestone and fertilizers to obtain vegetative cover and achieve the level of plant productivity required by state regulatory agencies. Unfortunately, the geology and remoteness of this coal mining region results in high quality liming materials being expensive because they must be transported from outside the area. Thus the availability of wood ash as a liming agent is of considerable interest to the mining industry and to Trus Joist MacMillan as an economical and environmentally safe alternative to landfill disposal.

In 1996, a field study was initiated on a mine site in Perry County, Kentucky, to compare the use of wood ash generated from the Trus Joist MacMillan plant with agricultural limestone to adjust soil pH for the establishment of orchardgrass and red clover on acid mine spoil. Response to liming source and rate was measured by clipping the vegetative growth from each plot and measuring the dry matter production during the growing season. Soil pH was also measured for each plot at the end of each growing season. Results following two growing seasons (1996 and 1997) indicate that wood ash is an excellent liming amendment that benefits the establishment and production of orchardgrass and red clover. During this study period, the application of wood ash increased soil pH from 3.9 to 7.1 at the 26 ton/acre rate. Agricultural limestone increased soil pH to 6.8 during this same period with an application rate of 8.8 tons/acre. The higher rate of application for wood ash to achieve the same relative pH is due to its lower CCE compared to agricultural limestone (33 percent and 67 percent, respectively). Plant tissue data has not been summarized at this time but visual ratings for percent of ground cover suggest that wood ash, applied as a liming amendment, increased dry matter accumulation.

As a result of this study, the Kentucky Department of Waste has approved the application of wood ash on property currently being mined by the Cyprus Coal Company in Perry County. We are working with Cyprus Coal and Trus Joist MacMillan to determine the liming quality variability of wood ash being produced in order to establish recommended application rates for future use on other mine sites. This study will continue through the 1998 growing season.

Kenaf Production Studies

M. J. Bitzer, W. P. Bruening, W. W. Witt, and D. Ditsch

Introduction

Kenaf (*Hibiscus cannibinus L.*) is a promising new United States crop source of raw material for pulp. It is a fast-growing, productive plant with fairly wide adaptation. Kenaf has now been tested in Kentucky for the past four years and has shown much promise as an alternative crop for Kentucky farmers.

Data has shown that top yields can only be achieved by growing the kenaf in rows of 15 inches or narrower (Bitzer and Bruening, 1997). If kenaf is ever produced commercially in central Kentucky, much of the crop should be planted using no-tillage farming methods to decrease erosion problems associated with the rolling and highly erodible topography of the area. A limited amount of no-tillage research has been done which has shown that kenaf can be successfully grown by no-tillage (Hovermale, 1994). The limiting factor is the registration of the proper herbicides to control the vegetation and weeds. Another possible land area that is available for growing kenaf is on reclaimed mine spoils. There has been no previous research on growing kenaf on mine spoils.

The objective of this study was: (1) to evaluate several herbicide combinations for producing no-tillage kenaf in wheat mulch and sod, and (2) to evaluate the potential for using mine spoils in eastern Kentucky to produce kenaf.

Materials And Methods

No-tillage Kenaf Test: Six herbicide treatments were compared for planting kenaf no-till into fescue sod and a wheat cover crop. A conventional plot of kenaf was grown adjacent to these plots. The six treatments were: (1) Roundup ultra, at planting (AP), (2) Roundup ultra, early preplant (EP), (3) Roundup ultra, EP plus Roundup ultra AP, (4) Roundup ultra EP plus Prowl EP, (5) Roundup ultra EP plus Gramoxone extra AP, and (6) Gramoxone extra EP plus Gramoxone extra AP. The rate of application for the herbicides was: Roundup ultra at 3 lbs active ingredient per acre (ai/A), Prowl at 1.5 lbs ai/A, and Gramoxone at 0.93 lb ai/A with a surfactant. The kenaf variety, Everglades 41, was drilled in 14-inch rows into the fescue sod and wheat cover crop on May 19. The early preplant treatments were applied on April 29. Nitrogen was applied at the rate of 100 lbs/A. The herbicides Poast and Staple were applied postemergence when the kenaf was about 15 inches tall.

Kenaf Seeded On Mine Spoils: Seed of the cultivar, Everglades 41, was planted with a Tye seeder in ten-inch rows on a mine spoil site in Breathitt County in eastern Kentucky. The soil was disked three times only two to three inches deep due to a severely compacted area beneath the disked spoil. Four drill strips were seeded that were approximately 100 feet long. Nitrogen was applied to the soil at the rate of 100 lbs/A. Two of the strips were irrigated as needed during the growing season. A total of four irrigations were required with about one inch of water applied each time.

Results And Discussion

No-Tillage Kenaf Test: The herbicide treatment, Roundup ultra EP plus Roundup ultra AP, gave the best early weed control in both the sod and wheat cover crop. Excellent weed control was obtained in all plots following the postemergence applications of Poast and Staple. These two herbicides did an excellent job of controlling the broadleaf and grasses that had regrown following the contact herbicides. The kenaf only grew to a height of 5 1/2 feet in the no-till planted areas and only 6.0 feet tall in the conventionally planted area. The yields obtained in the no-till and conventional area are presented in Table 1. The yield was slightly higher under the best herbicide treatment but was highest in the conventional area. The growth of the kenaf was severely reduced during the summer due to the colder than normal temperatures which resulted in below normal accumulation of growing degree days. The number of growing degree days for kenaf were over 281 degree days short by October 1. The last day that temperatures were warm enough to produce any growing degree days in 1997 was October 13 whereas the last day for 1994-96 was November 3. The rainfall was over 5 inches short from July through October. However, since kenaf is a subtropical plant, the lack of height is more attributable to the colder weather during the summer of 1997. Even with the poor growth, yields of 4.0 tons per acre of dry matter were obtained.

Table 1. Yields of no-till and conventional kenaf, 1997, Lexington, Kentucky.

Treatment	Yields (T/A)
No-Till	
Roundup EP plus AP	4.0
Roundup plus Prowl EP	3.4
Conventional	
Prowl AP	4.5

Kenaf Seeded On Mine Spoil: An excellent stand was obtained on this mine spoil site. However, due to the severe compaction of this mine spoil, the roots of the kenaf were unable to penetrate any deeper than the top two to three inches. The root mass was very small and was only in the area of the soil which had been disked prior to seeding. The height of the kenaf on the non-irrigated strips was only 18 inches and the height of the kenaf on the irrigated strips was about four inches taller. A few stalks of kenaf were nearly four feet tall. When the root systems of these plants were examined, a small root had grown up to six inches long into a small crack in the subsoil area. In 1998, a ripper will be used to try and open up the compacted subsoil to facilitate root growth. However, it does not appear that kenaf will grow very well on a mine spoil site.

Denitrifying Bacteria Stratify Above Fragipans

M.A. Fairchild, M.S. Coyne, J.H. Grove, and W.O. Thom

Physical boundaries caused by discontinuities within soil may create environments favorable to microbial activity. Such boundaries can restrict flow, increase the concentration of dissolved organic C and N compounds, trap organic materials, and decrease aeration. Fragipans represent one type of boundary layer common in soils. These layers consist of cemented materials that frequently create perched water tables. In Kentucky, more than 900,000 hectares contain fragipan soils, some of them overlying the ecologically sensitive cave systems in the Mammoth Cave region.

Denitrification may be enhanced in these boundary layers since the potential for denitrification is regulated, in part, by available C, N inputs, and aeration. Little work has been done on denitrification in fragipans, but the denitrification potential in these layers could be significant.

The role of production agriculture in NO_3- contamination of ground water has come under much scrutiny. Once NO_3- moves below the plant root zone, it is commonly assumed to be transported to ground water without further changes. This is an acute problem in the karstic Mammoth Cave region of south-central Kentucky where open channels may provide rapid avenues for NO_3- movement. Since fragipans are close to the soil surface, they may create a favorable environment to effectively remove NO_3- by denitrification. This study investigated evidence that denitrification in a fragipan soil subjected to conventional agricultural practices reduced NO_3- leached below the rooting zone of corn (Zea mays L.).

If denitrification were a mechanism of NO_3- removal in the fragipan soil, it should have been associated with lower NO_3- contents (although there are other mechanisms for NO_3- removal besides denitrification), the presence of denitrifiers, and higher N_2O production. Our preliminary studies suggested that denitrification was enhanced in these fragipan soils. Denitrifiers were present in perched water at concentrations approaching 5.0×10^4 mL^{-1} (as estimated by the MPN technique). Nitrous oxide, one gaseous product of denitrification, was present in concentrations up to 25 times greater than the normal atmosphere (0.33 ppm).

It seemed likely that if the fragipan created an environment conducive to denitrification (as evident by water perching, NO_3- removal, denitrifier numbers, and N_2O production), then the population of denitrifiers capable of carrying out these processes should be stimulated in these environments. The average MPN of denitrifiers in soil immediately above the fragipan were 3.9×10^2 g^{-1} soil where no manure was used and 4.9×10^3 g^{-1} when 10 Mg ha^{-1} manure was applied (Table 1). In soil below the fragipans, denitrifiers were either nondetectable or fewer than 4.6×10^2 g^{-1} (Table 1). Management practices, such as cover crop use, did not appear to affect the denitrifiers counted in soil.

A second series of soil cores was extracted from the site to confirm whether stratification of denitrifiers existed in the soil profile immediately above the fragipan. Regardless of manure addition, stratification of denitrifier numbers occurred. Manure addition to the soil surface enhanced this stratification, and denitrifier numbers remained significantly higher into the fragipan.

Table 1. Effect of manure and a cover crop on the stratification of denitrifiers in a fragipan soil.

	0 Mg ha^{-1} Manure		10 Mg ha^{-1} manure	
Soil Depth (cm)	Cover absent	Cover present	Cover absent	Cover present
	Average MPN count of denitrifiers g-1 soil†			
0 - 15	3.9×10^4	7.8×10^4	1.3×10^5	7.8×10^4
15 - 30	9.0×10^3	2.5×10^4	2.2×10^4	1.4×10^5
30 - 45	6.8×10^3	1.8×10^3	1.0×10^4	5.1×10^3
45 - 60	1.8×10^3	1.5×10^2	8.5×10^2	7.1×10^3
60 - 75	3.0×10^2	4.7×10^2	1.2×10^3	8.6×10^3
> 75	1.7×10^2	ND	ND	4.6×10^2

†Mean of 4 plots. ND = not detectable. The fragipan is at a depth of approximately 75 cm.

The fragipan may simply have been making the environment favorable for all organisms. If so, denitrifiers would be no more likely to be selected than would any other bacteria. However, when denitrifier count was compared to total bacterial plate count by depth, we observed a pronounced trend for denitrifiers to form a larger fraction of the overall microbial community, immediately above the fragipan. These data demonstrate that the fragipan created an environment selective for denitrifiers.

This research provided evidence that fragipans, as boundary layers, can create environmental conditions favoring a specific microbial group—the denitrifiers. Denitrifiers can indirectly be credited with helping to reduce NO_3- leaching in the fragipan soils. Furthermore, we showed that denitrifiers were influenced by the surface management imposed. Affecting denitrifier activity at depth through surface management of fragipan soils appears feasible and indicates a role for denitrifiers in reducing ground water contamination of the Mammoth Cave ecosystem. We conclude that this fragipan soil selected for elevated denitrifier populations, that the denitrifiers were affected by the management techniques applied at the soil surface, such as cover crop use and manure application, and that this environment has the potential to reduce NO_3- leaching to ground water below fragipan soils.

Infiltration Of Fecal Bacteria Through Soils: Timing And Tillage Effects

C.S. Stoddard, M.S. Coyne, J. H. Grove, and W.O. Thom

Land-applying animal wastes potentially exposes humans and animals to fecal pathogens, either by direct contact with soil and produce, or via ground water contamination. Some of these organisms are Salmonella, certain pathogenic *Escherichia coli* strains, protozoa such as *Cryptosporidium* and *Giardia*, and enteric viruses. Whether soil adequately filters these pathogens before they reach ground water depends on the interaction of porosity, texture, depth, water content, rainfall intensity and duration, and soil management.

Some generalizations can be made about filtration: 1) it is the major limitation to pathogen movement through soil; 2) pathogens move only a few inches into unsaturated soil but much greater distances into saturated soil; 3) the smaller the soil particle size (the finer the texture), the better the filtering of pathogens; 4) pathogen adsorption to soil restricts movement and is affected by clay content, pH, and cation concentration in soil water.

Macropore flow (flow through those pores that drain water freely) is often used to explain how microbes can move rapidly through unsaturated soil. If you imagine the soil as being full of macropores, then you do not think of it as a filter (where everything moves at about the same rate and is affected uniformly). Instead, you think of it as a sieve with many different sized holes ranging from the very small to the very large. Water dribbles through the smallest holes and pours through the largest holes. This means that when macropore flow occurs, a lot of water (and some pathogens) move through soil without being filtered.

Agronomic practices and crop management techniques, such as manure application and no-tillage, influence soil structure and affect water movement. Soils that are well-structured have more macropore flow and more movement of both water and microbes than soils that are not well-structured. Unfortunately, too few studies have looked at how tillage (or the lack of it) affects microbial movement. The possibility that pathogenic microbes will leach to ground water is a big concern where ground water occurs at shallow depths. Work at the University of Kentucky suggests that no-tillage, which results in more macropores, could enhance microbial movement. We designed a field experiment, using typical agronomic practices, to examine fecal bacteria transport through shallow no-tillage and chisel/disk soils to which dairy manure was applied at different times of the year, and to assess the survival of the fecal bacteria in manure treated soil.

This experiment was conducted at the Kentucky Agricultural Experiment Station in Lexington between April 1993 and April 1995. The site was on a well drained Maury silt loam that had six treatments: 1) no-tillage, no manure; 2) no-tillage, fall manure; 3) no-tillage, spring manure; 4) no-tillage, fall and spring manure; 5) chisel disk, no manure; and 6) chisel disk, spring manure.

Fresh dairy manure was surface applied with a commercial spreader before planting in late April to early May for the spring manure treatments, and after harvest in early to mid-November for the fall manure treatments. The fresh manure was 20 to 35 percent solids. Manure spreaders were calibrated to deliver approximately 4.5 tons/acre (dry weight). The actual delivery rates (all in terms of dry weight) were 4.6 tons/acre in spring 1993, 3.8 tons/acre in fall 1993, 5.2 tons/acre in spring 1994, and 7.1 tons/acre in fall 1994.

Tilled treatments were chiseled 8 to 10 inches deep and disked twice immediately following spring manure application. Chiseling was performed using twisted shanks on 12-inch centers. Pioneer 3279 corn was planted on May 21, 1993 and May 10, 1994 at 23,000 seeds/acre. After harvest but before fall manure application, winter rye (Secale cereale L.) was drilled in 7-inch rows on all plots (about mid-November).

We collected water samples 35 inches below the soil surface and measured volume after every rain that caused leaching. We took our first samples on June 14, 1993 and continued through March 15, 1995. Within 24 hours of collecting either a soil or water sample we analyzed it for fecal coliforms. These are bacteria that indicate whether a sample has potentially been contaminated by fecal waste and are used to assess the microbiological quality of surface and ground water.

The unmanured soil had low fecal coliform counts (background level). Adding dairy manure increased their numbers enormously (Table 1). After manure application, fecal coliforms decreased to background levels in about six months. The fecal coliforms in manure added to soil usually began to die off immediately, but in some seasons, death was delayed by up to two weeks. Fecal indicator bacteria die off quickest in hot, dry, sunny conditions. In this study, fecal coliforms died significantly faster in fall than in spring-applied manure treatments. This was most likely due to freezing conditions, which are usually lethal for indicator bacteria. Table 2 shows the number of days it took for the fecal coliform numbers to decline by 50 percent in each season (the half life).

There was not any difference in the die-off rates due to tillage treatments after the 1994 spring manure application. Greater soil-manure contact often results in increased microbial die-off rates, but we saw almost no difference between incorporated and unincorporated manure. We suspect that die-off promoted by greater soil-manure contact in chisel/disk treatments was counterbalanced by greater ultraviolet radiation kill in no-tillage treatments. However, tillage did result in fewer fecal coliforms over time. This is partly because tilling the manure into soil helps to dilute the bacterial numbers.

Fecal coliform movement to at least 35 inches occurred with the first leaching rain after manure application. Fecal coliform concentrations were greater than 8000 CFU/100 mL (100 mL is about 3.4 fluid ounces) just after the spring 1994 manure application. For comparison, the primary water contact standard in Kentucky (bathing and swimming water) is only 200 fecal coliform Colony Forming Units (CFU)/100 mL and the potable water standard is <1 fecal coliform CFU/100 mL. Fecal coliform concentrations in leachate from manured treatments declined to nondetectable levels within 60 days, and were not significantly different from unmanured treatments until the next manure application. Bacterial concentrations fluctuated frequently, however, often increasing again after the initial drop in concentration. Bacteria adsorbed to soil can become resuspended and travel

Table 1. Concentration of fecal coliforms (Colony Forming Units per gram of soil) in manured and unmanured soils.

Manure application date	Unmanured	Manured
10 May 1993	72	510,000
24 November 1993	10	660,000
20 April 1994	31	690,000

Table 2. Half lives of fecal coliforms after manure application.

Year	Period	Tillage	Half life (days)
1993	Spring	No-Tillage	7.7
	Fall	No-Tillage	5.8
1994	Spring	No-Tillage	6.9
	Spring	Chisel/Disk	6.9

The half-life is the time (in days) needed to reduce fecal coliform populations by 50 percent.

Table 3. The average fecal coliform concentrations in lysimeter pans installed at a depth of 36 inches as affected by manure and tillage for the eight periods of the study (April 1993 - April 1995).

Comparisons		Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Manure	Tillage[a]	1993	1993	1993	1994	1994	1994	1994	1995
		Average Colony Forming Units per 100 mL							
Manure x tillage									
None	CD	2	4	3	<1	54	7	2	<1
None	NT	12	3	3	1	30	4	2	1
Spring	CD	18	7	15	1	221	2	2	1
Spring	NT	16	4	2	<1	148	5	2	1
Manure timing									
None	NT	22	7	3	1	110	9	2	1
Spring	NT	7	7	<1	<1	200	3	<1	2
Fall	NT	16	15	99	2	164	4	245	2
Fall + Spring	NT	55	25	45	1	2208	2	665	4

[a]CD = chisel/disk, NT = no tillage

significant distances under saturated conditions. In winter, ample precipitation created near-saturated soil conditions and increased water flow. This may have caused fecal coliforms that were previously adsorbed to soil particles to move into the lysimeters.

The average fecal coliform concentrations in leachate from the various tillage systems are presented in Table 3. Chisel disk treatments had consistently greater water flow overall, so they had the potential to carry more fecal coliforms through the soil profile. Overall, chisel/disk treatments tended to have higher average fecal coliform concentrations in leachate than no-tillage treatments, but these differences were small and not statistically different. Fecal coliform concentrations were greatest in the spring and fall (particularly in 1994 when manure application rates were higher), but declined to low levels in other periods.

The appearance of elevated fecal coliform concentrations with the first rain after manure application to cause leachate collection was consistent with other studies. Our results suggest that macropore flow rapidly transmitted fecal organisms from the surface past the soil matrix. The immediate potential contamination of shallow ground water from surface-applied manure was similar regardless of when manure was applied.

Regardless of when manure was applied, fecal bacteria moved downward to a depth of at least 35 inches in this study. This suggests that fecal bacteria could contaminate ground water in a well-structured, shallow soil. Fecal bacteria moved past the root zone as soon as rain of sufficient duration or intensity caused leaching. Macropore flow was probably the main factor contributing to the rapid fecal bacteria movement through soil. Within 60 days, water quality was back to normal because bacteria died off. In Kentucky, abundant winter precipitation facilitates percolation of bacteria toward ground water after fall manure application. This risk is less with spring manure application because of reduced water flow at this time.

No-tillage practices appear to be compatible with manure use on shallow, well-drained soils. While spring applied manure was usually a statistically significant factor in many responses, the manure by tillage interaction was not. Therefore, the benefits (increased yields) and problems (increased fecal contamination of leachate) of manure application seem to be similar in both tillage systems used in this experiment. Fecal contamination did not persist in soil. Dairy manure can be used on a long-term basis without degrading the bacteriological quality of shallow water below the rooting depth, but it has potentially serious short-term effects, particularly where ground water levels are near the soil surface.

Factors Affecting Fecal Coliform Reduction By A Vegetative Filter Strip

M.A. Cooprider and M.S. Coyne

Agricultural pollution such as runoff from feedlots, pastures, or fields where animal waste has been applied is a continuing problem. The main pollutants associated with animal wastes are organic wastes (BOD), nutrients, and pathogens. Pathogen indicators such as fecal coliforms (*Escherichia coli*) often exceed stream water quality standards and are the major cause of substandard surface water quality in Kentucky.

One of the major animal waste concerns in Kentucky is poultry litter disposal. Most poultry wastes are land applied. Consequently, effective Best Management Practices are needed to alleviate or prevent bacterial contamination of runoff from manure-amended fields.

Vegetative filter strips (VFS) are a relatively low cost, low maintenance solution to many runoff water quality problems. They reduce erosion, slow runoff, and are very effective in removing sediment and sediment-bound nutrients. Their ability to sufficiently reduce fecal coliforms to meet water quality standards (200 to 2000 colony forming units per 100 mL for primary or recreational water) is still being documented. To extend the use of VFS pollutant removal to bacteria, several parameters have been manipulated in previous studies and may require further investigation. Some of these parameters include VFS length, height and plant species, and type of flow in the VFS (overland versus channelized flow). One factor that has rarely been studied in bacterial runoff investigations with grass filter strips is field vegetative cover. The objective of this study was to determine the relationship between vegetative cover on waste-amended plots and bacterial trapping efficiency of a vegetative filter strip.

Runoff from a no-till Maury silt loam soil located on a 9 percent slope and its trapping by tall fescue/Kentucky bluegrass filter strips was examined. Poultry litter amended plots were 17.6 meters (m) long by 4.6 meters (m) wide and grass filter strips (4.5 m long by 4.6 m wide) were located downslope. Sampling gutters were located downslope of each strip and runoff was collected periodically during rain simulation studies. Plots had a weedy cover in 1996 and an annual ryegrass cover in 1997. Plots chosen for vegetative cover removal (minimum cover treatment) were mowed to a height of 5 cm. Broiler litter was applied at a rate of 10 Mg/ha and not incorporated. Two rain simulations, each with an intensity of 6.4 cm/hour (approximating a 1 in 50 year storm in central Kentucky) were used to induce runoff from the waste amended strip.

During the first rain, cumulative fecal coliform runoff from the waste amended strip did not vary significantly for the treatments (fecal coliform numbers averaged 1.5 X 10^8 CFU in 1996 and 2.6 X 10^9 CFU in 1997). Higher numbers were expected in 1997 because the litter applied contained about 10 times as many fecal coliforms. The only significant difference in fecal coliform runoff from the waste amended strip occurred in the second rain (in 1996). There was significantly lower cumulative fecal coliform runoff with the minimum cover treatment (2.8 X 10^6 CFU versus 1.1 X 10^8 CFU for the cover intact treatment). This could possibly be due to bacterial die-off because of exposure to ultraviolet light (with less vegetative cover protection). Average cumulative fecal coliform outflows from the grass filter strip ranged from 10^7 to 10^9 CFU.

During both years, vegetative cover had no effect on flow rate in the waste amended strip in either rain event. In 1996, vegetative cover on waste amended strips did not affect grass filter strip flow rates either. However, in 1997, litter amended plots with the minimum cover treatment had lower flow rates in their grass filter strips compared to those plots with cover intact (22 versus 50 L/min in the first rain and 19 versus 47 L/min in the second rain) even though there was no treatment effect on flow rate in the litter amended strip. These lower VFS flow rates with minimum cover plots corresponded to higher fecal coliform, water, and sediment trapping efficiencies.

Despite the flow rate effects (and correlation with minimum cover) on trapping efficiency in 1997, the 2-year average for fecal coliform trapping efficiency indicated no significant difference between the cover treatments. Fecal coliform trapping was 48 percent versus 47 percent in the first rain and 45 percent versus 35 percent in the second rain (for cover intact and cover removed, respectively). Previous work with these plots indicated a higher fecal coliform trapping efficiency (74 percent) when litter was incorporated (by chisel plow and disk). To summarize, incorporation of wastes and low flow rates may increase grass filter efficiency. Our results indicate that vegetative cover had no effect on filter strip reduction of fecal coliforms. However, vegetative cover density and uniformity may also affect flow rate, and cover was sparse (weedy) and nonuniform in 1996. Therefore, although there was no noticeable effect of vegetative cover on flow rate in the waste amended strip, improved cover uniformity and density may decrease flow rates in the waste amended and filter strips and increase trapping efficiency.

Table 1. Effect of vegetative cover on vegetative filter strip efficiency–rain 1.

Treatment		Fecal coliform trapping efficiency	Water trapping efficiency	Sediment trapping efficiency
			%	
cover intact	1996	64	62	79
	1997	33	23	50
	average	48	43	64
minimum cover	1996	26	73	75
	1997	68	84	55
	average	48	43	64

Table 2. Effect of vegetative cover on vegetative filter strip efficiency–rain 2.

Treatment		Fecal coliform trapping efficiency	Water trapping efficiency	Sediment trapping efficiency
			%	
cover intact	1996	43	36	44
	1997	46	26	66
	average	45	31	55
minimum cover	1996	0	37	92
	1997	70	59	89
	average	35	48	90

Yield and Forage Quality of Silage Corn Cultivars

M. Collins, J. Grimes, T. Putnam, and J. Henning

Corn is among the most productive forage species available to Kentucky livestock producers. Corn silage provides an excellent source of energy but crude protein must frequently be supplemented. Significant cultivar differences in silage corn quality have been recognized in recent years. Recent plant breeding efforts have had the goal of increasing forage corn crude protein concentration. A two-year field study was conducted in cooperation with personnel from Ohio State University to compare dry matter yield and forage quality characteristics of a number of forage corn cultivars, including some selected for increased crude protein concentration or for improved suitability for grazing.

Dry matter yields were higher in 1996 than in 1997 with top yields of 8.6 and 6.0 tons/acre for the highest yielding cultivar, respectively. Cultivar differences in yield were found in both years, however, cultivar yields between the two years were not well correlated (r=0.12). Baldridge cultivars, selected for increased crude protein concentration, yielded significantly less than three or more of the other cultivars each year (Table 1). On average, these varieties yielded 68 and 71 percent as much as the highest yielding cultivar in 1996 and 1997, respectively.

There was no difference among cultivars in crude protein concentration in 1996 but there was in 1997 (Table 2). Crude protein concentration ranged from 6.2 to 8.4 percent on a dry matter basis. In 1997, we found a significant negative relationship between dry matter yield and CP concentration. The concentration of crude protein declined by 0.3 percentage units for each 1 ton/acre increase in DM yield. The regression relationship between CP and yield in 1997 was CP (%) = 8.7 - 0.26 x Yield (tons/acre). In the same year, the concentration of fiber (NDF) declined as yield increased, suggesting that the higher yielding cultivars were those with the greatest levels of grain production, and thus a smaller proportion of stalk and leaves.

The primary value of corn silage is in supplying high yields and high energy value for ruminants, thus it would not appear to be advisable to sacrifice significantly in either of these two parameters to achieve small or moderate increase in crude protein concentration. Our results indicate that silage corn cultivars do differ in forage quality, but also show that environment significantly impacts these quality differences.

Table 1. Dry matter yield of silage corn cultivars.

Cultivar	1996	1997
	tons/acre	
Baldridge BH511	5.5 h*	4.2 cd
Baldridge BH611	5.9 gh	4.7 b-d
Baldridge Grazing	6.1 f-h	4.1 d
Bird B83CV	7.9 a-c	5.0 a-d
Bird P52	8.0 ab	6.0 a
Countrymark 715	8.6 a	4.7 b-d
Countrymark 790	7.4 b-e	5.3 a-c
Countrymark 812	7.7 a-d	4.8 b-d
Dekalb DK642	7.1 c-e	5.7 ab
Dekalb DK646	7.2 b-e	5.7 ab
Dekalb DK683	6.6 e-g	5.7 ab
Mycogen 6759	7.0 de	5.5 ab
Northrup King NK8655	6.8 ef	6.1 a
Northrup King NK8811	7.3 b-e	6.0 a
Pioneer 3217	7.0 de	4.8 b-d
Pioneer 3223	7.3 b-e	5.5 ab

*Values followed by the same letter within a column are not significantly different (P=0.05) according to the LSD test.

Table 2. Crude protein concentration of silage corn cultivars.

Cultivar	1996	1997
	%	
Baldridge BH511	7.9 a*	8.2 ab
Baldridge BH611	9.0 a	7.8 bc
Baldridge Grazing	8.5 a	8.4 a
Bird B83CV	8.9 a	7.3 cd
Bird P52	8.8 a	6.9 d
Countrymark 715	8.8 a	7.2 d
Countrymark 790	8.1 a	7.0 d
Countrymark 812	8.5 a	7.0 d
Dekalb DK642	9.1 a	7.9 a-c
Dekalb DK646	9.0 a	7.9 a-c
Dekalb DK683	7.9 a	8.1 ab
Mycogen 6759	9.4 a	6.2 e
Northrup King NK8655	7.9 a	7.0 d
Northrup King NK8811	8.1 a	6.8 d
Pioneer 3217	8.3 a	6.8 d
Pioneer 3223	8.5 a	6.9 d

*Values followed by the same letter within a column are not significantly different (P=0.05) according to the LSD test.

Switchgrass Biofuels Production in West Kentucky

M. Rasnake

Six cultivars of switchgrass (Panicum virgatum) were established in 1993 at Princeton on a Tilsit soil (fine-silty, mixed mesic Typic Fragiudult). The plots were no-till seeded into a wheat cover crop that had been mowed, allowed to regrow, then sprayed with glyphosate. Two upland type cultivars (shelter and cave-in-rock), two lowland type cultivars (Alamo and Kanlo), and two lowland type experimentals (NC-1 and NC-2) were used. Two cutting management treatments—cut once in November and cut twice in late June and November—were used on all cultivars. Treatments were replicated four times in a randomized complete block-split plot design.

Yields for four years of harvest are shown in Table 1. In general, the lowland types produced greater yields than the upland types. Even though the experimentals started with poor stands, after the first harvest year their yields compared favorably with the lowland type cultivars. Individual plants expanded and filled in much of the vacant space. They also grew taller and had larger stems.

In the first harvest year, the two cut system had higher yields than the one cut. This was reversed with the second and third harvest years. The one cut plots appeared to have greater vigor and started growth earlier in the spring. This may have been a disadvantage in 1997 since some of the one cut plots had six to ten inches of new growth before a late freeze killed it back to the soil line. Three of the four lowland types had lower yields on the one cut plots that year.

These studies have shown that switchgrass has the potential to produce high yields in West Kentucky. It can be used as a biofuels feedstock or forage for livestock. It is also beneficial as wildlife cover and soil and water protection.

Table 1. Switchgrass yields at Princeton, Kentucky.

	1994 Cuts		1995 Cuts		1996 Cuts		1997 Cuts	
	1	2	1	2	1	2	1	2
	(Tons DM/A)							
Alamo	4.3	7.2	9.2	8.8	7.3	6.4	5.0	6.0
Kanlo	4.4	7.2	8.6	7.6	7.3	6.2	4.9	5.6
Cave-in-Rock	3.9	7.1	5.4	6.8	5.0	4.7	4.5	4.9
Shelter	3.4	5.0	5.4	5.8	4.1	4.4	3.6	3.7
NC-1	3.5	4.1	8.7	6.8	6.4	5.4	5.0	5.8
NC-2	1.6	5.3	8.3	6.3	7.2	5.3	5.3	5.3
Average	3.5	6.0	7.6	7.0	6.2	5.4	4.7	5.2

Forage Variety Differences Under Abusive Grazing

J.C. Henning, R. Spitaleri, T.D. Phillips, G.D. Lacefield, and E. Baker

The University of Kentucky has just concluded the first experiments to determine the survival of selected varieties of orchardgrass, tall fescue, and alfalfa under abusive continuous grazing management. Stands were established in the fall of 1994 and then closely and continuously grazed in 1995 and 1996. An initial hay harvest was made each year, and forage was allowed to grow to about six to eight inches before initiating grazing. Duplicate plots were maintained that were only harvested for hay. The data from these initial experiments are summarized below.

Orchardgrass

Orchardgrass was much less tolerant of grazing than tall fescue (Table 1). In general, the winter of 1996-97 was very damaging to orchardgrass stands. Plots managed for hay were thinned to one-third to one-half of a full stand. Continuous, close grazing of orchardgrass thinned the stands of all varieties to unacceptable levels.

Table 1. Effect of two years of close grazing or hay management on stands of orchardgrass varieties observed July 17, 1997, at Lexington, Kentucky.

Orchardgrass Variety	Grazing	Hay
	Percent Stand	
Shiloh	18.8*	41.5*
Benchmark	15.0*	50.0*
Dawn	11.3*	43.8*
Takena	11.3*	45.0*
Condor	7.5	32.5*
Potomac	7.5	38.8*
Hallmark	7.5	42.5*
Warrior	6.3	32.5*
Pizza	3.8	33.8*
LSD, %	8.2	18.6
CV, %	60.0	32.1
R-square	0.47	0.67

LSD is the least significant difference. CV is a measure of the variation within the study, and R-square is the amount of the variation that is due to variety.

*Not significantly different from the highest value in the column.

Tall Fescue

Tall fescue was more tolerant of abusive grazing and winter conditions (Table 2). The presence of the endophyte was not necessary for survival of tall fescue. Cattle Club and Richmond, both endophyte-free, were statistically equal to endophyte-infected Kentucky 31. Infected Kentucky 31 is generally considered to be the most grazing tolerant variety of tall fescue.

Alfalfa

Currently, there is a great expansion of alfalfa varieties being marketed as “grazing types.” The first of these was AlfaGraze, a product of the forage breeding program at the University of Georgia. Several others have been released and marketed subsequently such as Pasture Plus, Pro-Grazer, Haygrazer, Spredor 3, and Graze King. Many more are expected. Independent data on the grazing tolerance of these varieties are limited.

In general, the varieties selected for grazing tolerance held up well after two seasons of grazing (Table 3). Grazing tolerant types such as AlfaGraze and ABT 205 were much more tolerant of high, continuous stocking than traditional hay types (considered grazing intolerant) such as Apollo and Pioneer 5373.

Summary

Select a species based on its ability to yield, to persist, to supply the quality needed, and to meet the seasonal needs of the livestock to be fed. A species should be tolerant of the type of utilization and management that it will receive. Good varieties will be resistant to economically significant diseases, will be high yielding over many years and in many different locations, and will show good adaptation and persistence. Use objective sources of variety information such as university yield trials plus local experience to aid in the variety decision.

The grazing tolerance of varieties of orchardgrass, tall fescue, and alfalfa vary significantly. Trials at the University of Kentucky have demonstrated that fescue is more tolerant of overgrazing than orchardgrass. Endophyte-free tall fescues have been found to be as tolerant of overgrazing as endophyte-infected Kentucky 31. These grazing tolerant varieties of endophyte-free tall fescue could prove to be very useful to horse owners to replace acres now in endophyte-free tall fescue. Finally, new grazing tolerant varieties of alfalfa do represent an advance in persistence under grazing pressure compared to traditional hay types.

Table 2. Effect of two years of close grazing or hay management on stands of tall fescue varieties observed July 17, 1997, at Lexington, Kentucky.

Tall Fescue Variety	Grazing	Hay
	Percent Stand	
Cattle Club	83.8*	83.8*
Kentucky 31 - Infected	72.5*	86.3*
Richmond	72.5*	88.8*
Johnstone	56.3	76.3*
Kentucky 31 - Uninfected	56.3	88.8*
GaJesup - Uninfected	47.5	77.5*
Stargrazer	35.0	75.0*
LSD	21.6	17.8
CV, %	31.8	18.7
R-square	0.72	1.81

LSD is the least significant difference. CV is a measure of the variation within the study, and R-square is the amount of the variation that is due to variety.

*Not significantly different from the highest value in the column.

Table 3. Effect of two years of close grazing management on stands of alfalfa varieties on June 7, 1997, at Lexington, Kentucky.

Alfalfa Variety	% Stand
AlfaGraze	62.6*
Wintergreen	60.0*
ABT 205	57.5*
Quantum	45.0*
Spredor III	45.0*
ABT 405	45.0*
Cut-N-Graze	42.5*
Pasture Plus	37.5
Magnagraze	35.0
Apollo	30.0
Fortress	25.0
Legacy	20.0
Rushmore	20.0
Pioneer Brand 5373	12.5
LSD	21.0
CV, %	35.8
R-square	0.71

LSD is the least significant difference. CV is a measure of the variation within the study, and R-square is the amount of the variation that is due to variety.

*Not significantly different from the highest value in the column.

Effect of Overseeded Legume Species and Sod Disturbance on Subsequent Yield, Seasonal Dry Matter Distribution, and Forage Quality of Tall Fescue Sod

M. E. Prewitt, J. C. Henning, T. D. Phillips, J. Wyles, M. Collins, and D.G. Ely

A study was conducted to evaluate forage legume species and sod disturbance on legume establishment. Red clover (*Trifolium pratense L.*), annual lespedeza (*Kummerowia striata*), alfalfa (*Medicago sativa L.*), and a combination of red clover and lespedeza were inoculated and overseeded into fescue sod in late winter. Half of each plot was disturbed immediately prior to overseeding by twice dragging a chain harrow across the sod. Botanical composition and yield were determined from mid-summer and fall harvests.

The legume treatments were broadcast onto tall fescue sod on February 22, 1995, and March 2, 1996. Seeding rates were as follows: red clover (12 lb/A), lespedeza (25 lb/A), alfalfa (20 lb/A) and the red clover-lespedeza combination, (6 lb/A and 12.5 lb/A, respectively). To minimize competition, initial spring growth of tall fescue was removed on April 20 in 1995 and May 20 in 1996.

In 1995, the addition of legumes to the tall fescue significantly increased annual yield, but treatments containing lespedeza were more able to increase yield to fill the summer production slump of Kentucky 31 tall fescue in late June, July, and August (Table 1). In 1996, red clover was the better overall legume for increasing summer yield and total annual yield. The mixture of red clover and lespedeza was second only to that of red clover in harvest 1 of 1996 and was the top ranked treatment in harvest 2 (Table 1).

While lespedeza did increase yield in both 1995 and 1996, it should be noted that the annual did not reseed or reestablish in the following year (visual observation). Visual observations of plots in the year after establishment revealed that only red clover persisted. This lack of persistence could be due to the inability of the striate type of lespedeza to reseed in northern Kentucky.

Table 1. The effect of legume species on dry matter yield of a renovated tall fescue sod in the year of establishment on the Eden Shale Research Farm, Owen County, Kentucky.

	1995 Harvest			1996 Harvest		
Species	1	2	Total	1	2	Total
	lb/A					
Alfalfa**	1530	3560	5050*d	1464	1427	3235 e
Red Clover	2399	3538	5978 c	3096	2572	5665 a
Tall Fescue Control	1409	2758	4223 e	1411	1542	2956 d
Lespedeza	7256	2729	9961 a	2415	2354	4473 c
Mixture	6626	3238	9747 b	2713	2840	5553 b
Sp LSD (0.05)	184			59		
Sp X Har LSD (0.05)	201***			ns		

* Means in any column followed by the same letter are not significantly different at (0.05).

** Data for species combines harvests from disturbed and non-disturbed plots.

*** Means in both columns should be compared to determine significant interaction differences (0.05).

Table 2. The effect of overseeded legume species on legume percentage of a renovated tall fescue sod in the year of establishment on the Eden Shale Farm, Owen County, Kentucky.

	1995 Harvest			1996 Harvest		
Species	1	2	Weighted Average	1	2	Weighted Average
	Percent Legume					
Alfalfa**	14.5	14.3	14.5*d	1.3	1.7	1.5 d
Red Clover	51.4	38.5	43.2 c	51.7	53.1	52.9 a
Tall Fescue Control	0.0	0 .0	0.0 e	0.0	0.0	0.0 d
Lespedeza	60.3	13.2	48.8 b	36.6	38.8	38.6 c
Mixture	65.4	26.2	53.3 a	48.7	48.5	48.1 b
Sp LSD (0.05)	4.3			2.0		
Sp x Har LSD (0.05)	6.1***			ns		

* Means in any column followed by the same letter are not significantly different at (0.05).

** Data for species combines harvests from disturbed and non-disturbed plots.

*** Means in both columns should be compared to determine significant interaction differences (0.05).

The concentration of legume in the whole plots was high for red clover, lespedeza, and the mixture (Table 2). Alfalfa did not establish well compared to other legumes in this study, even when the sod was disturbed by dragging with a chain harrow. Even in 1995 when conditions were excellent for legume establishment, alfalfa concentrations were roughly a third of that for any other legume.

Disturbance did not increase forage yield in either year, but did increase legume concentration in 1996 (data not shown). In 1996, dragging the plots prior to seeding increased average legume concentration by 5 percent. The role of sod disturbance in legume establishment seems to be to ensure legume establishment in less than ideal years rather than to increase legume concentration in each year.

While production is important, forage quality determines the performance of livestock. Whole plot ADF concentrations were below 357 g/kg and 302 g/kg in 1995 and 1996, respectively (data not shown). These low ADF values would correspond to high digestibility by ruminant livestock. Where differences existed, the red clover treatment tended to have the lowest weighted average ADF concentration on a whole plot basis. The red clover component tended to have the lowest ADF concentration, leading to the low ADF in the red clover plots.

Weighted whole plot CP concentrations were consistently higher for red clover than for all other treatments (data not shown). These values reflect the combination of high CP concentration of red clover as a species as well as high concentrations of red clover in these plots.

Overseeding legumes into the fescue raised the CP concentration of the grass itself over the tall fescue control. This effect was seen even in the first harvest and was consistent over both years of the study. Nitrogen fixed by the root nodules of the legumes is evidently taken up by the companion grass, raising the CP concentration. The higher CP of the companion grass helps to explain the improved animal performance of livestock grazing grass-legume pastures.

The choice of legume species affected the success of renovation of tall fescue sod in the year of establishment and afterwards. Red clover tended to be very consistent, persistent, high producing, and excellent in overall quality while being least expensive to establish. Visual observations of plots in the year after establishment revealed that only red clover persisted into the second year. The mixture was harder to manage in a cutting system but offered a more diverse forage base for the summer slump. Annual lespedeza was a good summer yielding treatment but was inferior to red clover and the mixture in total quality. Additionally, the question of re-establishment of lespedeza makes it a more risky renovation choice considering the $50.00 per acre cost of establishment.

It should be pointed out that the lespedeza in this study was a striate type (cultivar Marion). Striate lespedezas tend to produce seed later during the year compared to Korean types. Therefore, there was a greater risk that these plants would not reseed adequately to produce a stand in the year following establishment. The cultivar Marion was selected for this study because research indicates that it produces seed earlier than other striate lespedezas, making it more likely to reseed under northern Kentucky conditions. However, this did not happen under the conditions of this study.

Alfalfa established poorly and contributed little to mixtures containing this species. Therefore, broadcasting seed into tall fescue sod in late winter is not a suitable method for establishment of alfalfa even when the sod is disturbed prior to seeding. Alfalfa's high seeding cost and poor establishment make alfalfa inferior to red clover or lespedeza as a renovation legume under the conditions of this study.

Increasing total yield and quality of tall fescue pastures is the goal of pasture renovation with legumes. Renovation requires additional inputs in the form of seed, and this cost varies with species. Per acre seed cost for the legume treatments in this study were approximately $60.00, $50.00, $37.00, $24.00 for alfalfa, lespedeza, mixture, and red clover, respectively. Considering ease of establishment, total production, seasonal distribution, persistence, and forage quality as well as seed cost, red clover was superior to the mixture, lespedeza, alfalfa, and tall fescue alone for increasing the yield and quality of tall fescue sod.

Fate of Loline Alkaloids of Tall Fescue Ingested by Beef Heifers

C.T. Dougherty, F.W. Knapp, L.P. Bush, J .Van Willigen, F.F. Fannin, and G.A. Davis

Tall fescue toxicosis costs Kentucky beef cattle enterprises between $70 and $100 million each year. Further development of Kentucky grasslands is dependent upon the identification of the causes of tall fescue toxicosis. The complex and sometimes debilitating syndrome only occurs in tall fescue pastures with a significant proportion of plants infected with an internal fungus (an endophyte). More than 90 percent of Kentucky tall fescue pastures are endophyte-infected. Endophyte-infected plants synthesize a number of complex alkaloids, which are in the same group of plant-synthesized chemicals as nicotine, and have wide and varied effects on animals. Typically, tall fescue contains low concentrations of the highly toxic ergopetides, abundant levels of less toxic lolines, low levels of peramine (a feeding deterrent of some insects), and perloline, which has little mammalian toxicity. It has been proposed that these alkaloids protect tall fescue from over-grazing (i.e., they are feeding deterrents). Alkaloids may be the reason endophyte-infected tall fescue is so well adapted to, and is the dominant species of, the Kentucky grasslands. Obviously, the endophyte of tall fescue causes very real problems for any livestock enterprise based on year-round grazing of pastures, grazing of stockpiled pastures, and meadow hay and grass silage.

We set up a field experiment at Spindletop to investigate the fate of alkaloids ingested by grazing heifers. First, we allowed 12 angus heifers to graze endophyte-free Kentucky 31 tall fescue for seven days. On the sixth and seventh days, we took samples of herbage and samples of blood, dung, and urine from each heifer. Then we grazed the heifers for seven days on an adjacent field of Kentucky 31 tall fescue that was 35 percent infected with the tall fescue endophyte. Again on the sixth and seventh days, we sampled herbage, blood, dung, and urine. Alkaloids were analyzed in the laboratory by gas chromatography, thin layer chromatography, and high pressure liquid chromatography. Horn fly larvae, which are very sensitive to the toxicity of tall fescue alkaloids, were also used in a bioassay to establish the toxicity of alkaloids in dung collected from individual heifers.

Results

N-formyl loline (190 ± 82 ppm) and N-acetyl loline (84 ± 36 ppm) were detected in the herbage from the endophyte-infected tall fescue. Ergovaline and peramine, if present, were below detection levels. No alkaloids were detected in the dung. Considerable amounts of loline were detected in the urine solids (99 ± 27 ppm), but only traces of N-formyl loline and N-acetyl loline were found. Only traces of loline and N-formyl loline were found in the blood. We concluded that essentially all of the biologically-active N-formyl loline and N-acetyl loline of the herbage were degraded to loline in the reticulo-rumen. Loline, which has low mammalian toxicity, was absorbed into the blood stream and excreted via the kidneys and concentrated in the urine. Further analyses of urine by gas chromatography mass spectroscopy indicated the possibility that other as yet unidentified loline alkaloids were synthesized from N-formyl loline and N-acetyl loline in the reticulo-rumen. Bioassays confirmed that the dung from endophyte-infected tall fescue herbage was of low biological activity towards horn fly larvae.

This research explains why N-formyl loline and N-acetyl loline, which are active in many mammalian systems, have low activity when ingested by foregut fiber digesters, such as ruminants. These experiments will be repeated in 1998 using tall fescue pastures with 100 percent endophyte infection. Samples of herbage, dung, urine, and blood will be taken, as in 1997, but in addition rumen fluid samples will be taken to study alkaloid degradation in the reticulo-rumen.

It is apparent that the causes of tall fescue toxicosis in livestock are complex and may involve conversions of alkaloids within the animal and may involve interactions between alkaloids. We anticipate that it will take more research before we have a thorough understanding of the tall fescue syndrome. Thus, the best management option for Kentucky grassland farmers is to convert to endophyte-free tall fescue cultivars and other grass species and to adopt pasture management practices that ensure their productivity and survival.

Pubescence, Drying Rate, and Dustiness In Red Clover

N.L. Taylor, M. Collins, and R.E. Mundell

A series of experiments was conducted over several years to elucidate the relationship of pubescence (hairiness) to drying rate and dustiness in red clover (*Trifolium pratense L.*). Faster drying rates and decreased dustiness are desirable attributes, and it is possible by selection to modify pubescence. Five cycles of recurrent selection reduced pubescence on stems of Kenland red clover, resulting in the development of the experimental strain, Freedom!, so named for its freedom from dustiness. Examination of 20 cultivars of red clover for dry matter yield, stem pubescence, and stem diameter revealed that Freedom! had the lowest score for pubescence among U.S. cultivars, and was only slightly more pubescent than the European cultivar Start. Start was very susceptible to the potato leafhopper (*Empoasca fabae Harris*) and the stand was decimated in 1997 cultivar trials. Freedom! was only slightly affected by leafhopper attack in the same trial. Dry matter yield and stem diameter of Freedom! were equal to Kenland and Kenstar.

Dustiness ratings of Freedom! and Kenstar (derived from and similar to Kenland) hay were compared using dry sieves with 450, 150, and 45µm openings. Use of these sieves divided the hay into four categories: above the 450µm sieve, intact leaves and stems; above the 150 µm sieve, shattered plant material; above the 45 µm sieve, detached whole trichomes; and through the 45 µm sieve, very fine trichome particles. Freedom! hay produced significantly less ($P<0.01$) dry matter that passed through the 150 µm sieve (6.0 lb/1000 lb) than Kenstar hay (9.9 lb/1000 lb) produced under the same conditions. Freedom! hay had 53 percent less dust passing through the 45 µm sieve than Kenstar, indicating much fewer trichomes in the air from Freedom! as compared to Kenstar.

In one trial, the drying rate of mechanically conditioned field cured hay of Freedom! during the first day of curing was 22.4 percent/hr compared with a slower ($P<0.07$) drying rate of 17.7 percent/hr for Kenstar under the same conditions. In another trial, mechanically conditioned hay of Freedom! dried at a rate of 18.2 percent compared with 15.7 percent/hr for Kenstar hay. Unconditioned hay of the same cultivars dried at rates of 14.0 and 13.1 percent, respectively. Conditioned hay of Cimarron alfalfa dried at 17.2 percent/hr.

In conclusion, Freedom! had equal dry matter yields and stem diameters, only slightly higher potato leafhopper susceptibility, less dustiness, and a higher drying rate compared to Kenland and Kenstar. Freedom! will be considered for release by the Kentucky Agricultural Experiment Station in late 1998.

Mined Land Grazing Research

M. Collins, C. Teutsch, D. Ditsch, L. Clay, C. May, J. Johns, and B. Larson

Kentucky has large tracts of reclaimed surface mined land revegetated with perennial and annual forage species that could provide grazing for livestock. A long-term experiment has been initiated to determine the productivity of pastures on reclaimed surface mined land for beef production and to assess the impact of grazing on vegetative cover and soil characteristics. The study is located on a 400-acre mountaintop removal mine site at Chavies, Kentucky, owned by D&D Ranch. The area was revegetated between 1991 and 1993 by hydroseeding to a typical mixture that included orchardgrass, tall fescue, birdsfoot trefoil, annual lespedeza, sericea lespedeza, and several clovers.

During spring of 1997, detailed maps of the experimental site were prepared using GPS/GIS technologies to establish pasture boundaries and to locate each of 334 permanent sampling points placed at a density of about one per acre. An additional 11,000 GPS sample points were collected to map aspect, slope, and elevation of the pastures. In addition to the experimental pastures, areas were identified on which all of the same measurements will be made in the absence of grazing. Two replicates of pastures measuring 30, 60, and 90 acres were measured and fenced. Each pasture was stocked with 10 Angus or Angus cross cow-calf pairs which were grazed continuously on the same pasture area throughout 1997. This resulted in allowances of three, six, or nine acres per cow-calf unit. Cows and calves were weighed at about two month intervals throughout the 1997 grazing season.

Plant samples were clipped and soil samples were collected at each sampling point over the 400-acre site. Calves were weaned and cow body condition scores were determined on October 2. Cows were overwintered on their respective pastures with hay.

Available DM was higher in May 1997 on the 60- and 90-acre pastures than on the 30-acre pastures. Cattle appeared to leave sloping areas and areas dominated by sericea lespedeza nearly ungrazed in the larger pastures where they had ample herbage to meet their needs. At an allowance of three acres per cow/calf unit, even the least accessible areas were very closely grazed by the end of the first growing season.

Grazing activity was heavier in the smaller pastures, as expected, but was also low in some areas of larger pastures where the density of ground cover was low. The dominant species in some lightly grazed areas was sericea lespedeza, which is well adapted to the mined land environment but which lacks palatability for livestock at advanced maturity stages.

Calf weaning weights were high for first-calf heifers and did not differ between the three treatments (Table 1). Early in the season calves gained better on the smallest (30-acre) pastures than on either larger pasture treatment. We believe this resulted from more intensive grazing of 30-acre pastures resulting in high quality, vegetative regrowth, when rainfall was good. When hot, dry conditions limited growth from summer onward, a three-acre allowance did not provide adequate forage and gains suffered.

Initial body weights of the cows when the experiment started were similar over the three treatments (Table 2). By the end of the grazing season, allowances of six or nine acres resulted in higher cow body condition scores and heavier cows than the three-acre allowance. Genetically similar bulls were used between late May and early August. Pregnancy rates in October were 90 to 100 percent on all treatments.

Table 1. Calf production on mined land pastures during 1997.

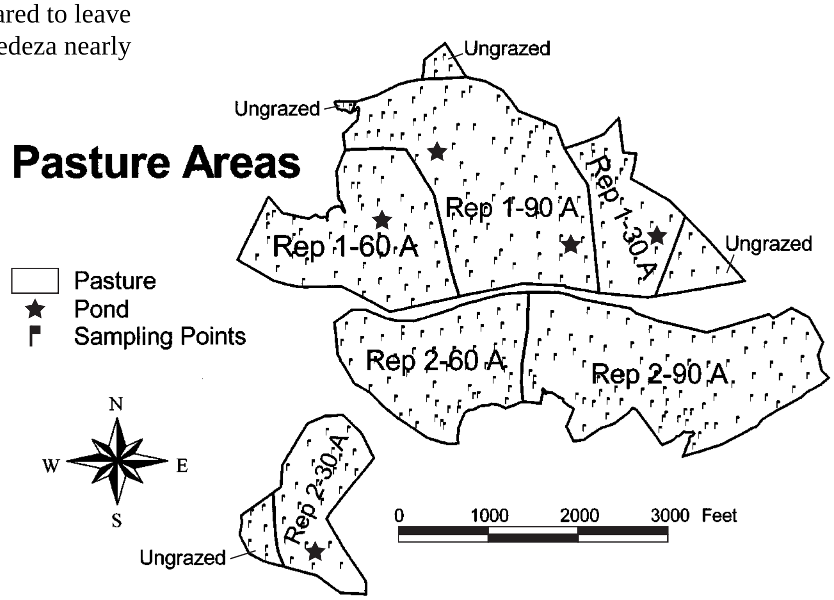
	Acres/Cow-Calf Unit		
Measurement	**3**	**6**	**9**
Calf weight (lb), 6/27	352 a*	326 b	319 b
Late season ADG 8/1 to 10/2 (lb/day)	1.65 c	2.27 b	2.42 a
Calf Weaning Weight (lb)	537 a	557 a	550 a

*Values followed by the same letter within a row are not significantly different (P=0.05) according to LSD.

Table 2. Stocking rate effects on brood cow weight and condition scores during 1997.

	Acres/Cow-Calf Unit		
Measurement	**3**	**6**	**9**
Cow weight (lb), 4/17	867 a*	865 a	860 a
Weight (kg), 10/2	953 b	1023 a	1012 a
Body condition score	5.1 b	5.5 a	5.7 a

*Values followed by the same letter within a row are not significantly different (P=0.05) according to LSD.



These results indicate that reclaimed surface mined land has potential for livestock production in Kentucky. Since some of the effects of grazing intensity may occur slowly and changes in soil fertility and other characteristics are gradual, this study will continue for a five-year period.

Direct and Residual Effects of Alfalfa Herbage on Grazing Cattle

C.T. Dougherty and P.L. Cornelius

Grazing systems and other feeding programs of livestock are typically based on the daily nutritional requirements for convenience and not because of the nutritional schedule of the animal. Depending on its chemical and physical properties, ingested herbage may take three days or more to pass through the gastrointestinal tract of ruminant livestock. Thus, we can anticipate that how much herbage a grazing animal eats today was influenced by what it ate the previous day, and to a lesser extent, the day before that, and so forth.

Statisticians refer to these effects as “residual” or “carryover effects” and have developed procedures to detect and analyze them. When we handle animal responses as 24-hour events, we ignore these carryover/residual effects and deal with them as error or “noise.”

We designed a grazing experiment with a balanced changeover design to measure direct, first residual, second residual, and overall effects of water, salt, and syrup solutions applied to alfalfa canopies in order to determine if angus heifers would eat more alfalfa if it was sweeter or saltier. We reasoned that cattle should detect salt and syrup-saturated canopies as taste responses and, as such, they should have an immediate effect on the amount of alfalfa ingested but have no residual effects. An immediate effect such as this is referred to as a pre-ingestive response. If the salt- or syrup-treated canopy affected herbage intake the next day, then we would refer to that as a residual effect or as a post-ingestive effect.

Grazing of sweetened canopies

Heifers grazed alfalfa sweetened with syrup much faster than they grazed alfalfa sprayed with water or saline solution (Table 1). This is not surprising because cattle are able to detect and respond to sweet, sour, salty, and bitter tastes. When grazing sweetened alfalfa, heifers took 16 more bites every minute. They ceased grazing sooner and idled 12 minutes more during each one hour grazing meal. There were no effects of the sweetened canopy expressed as first or second residual effects. Thus, we determined that the heifer response to the sweetness of the syrup-treated alfalfa herbage was solely a pre-ingestive response and that there were no post-ingestive consequences of the syrup treatment expressed in grazing behavior during subsequent grazing meals.

Table 1. Pre-ingestive (direct) effects of sweetened alfalfa canopies on the grazing behavior of angus heifers.

	Water-treated alfalfa	Syrup-treated alfalfa
Prehension, bites/min.	33	48
Idling time, min/hr	4	12
Intake, kg/100 kg/hr	0.55	0.64

Table 2. Direct, first and second residual, summed residual, and overall effects of salt-treated alfalfa canopies on the amount of herbage dry matter ingested by heifers in one hour of grazing.

Response	Water-treated alfalfa	Salt-treated alfalfa
Direct	2.45 kg	2.35 kg
1st + 2nd residuals	2.50 kg	3.00 kg
Total	2.52 kg	2.92 kg

Grazing of salt-treated canopies

Surprisingly, our heifers did not respond immediately to salt-treated canopies, although cattle are known to be salt-craving and we had withdrawn salt supplements before the start of our experiment (Table 2). Thus, we concluded that our heifers had no pre-ingestive response to the saline-treated alfalfa canopies.

We detected post-ingestive responses of our heifers to salt-treated alfalfa canopies that were expressed as first, second, summed residual, and overall responses to saline-treated alfalfa canopies in herbage intake (Table 2). As a result of the combined residual responses (0.5 kg), heifers assigned to the salt-treated canopies ingested 0.4 kg (0.9 lb) more alfalfa dry matter per hour of grazing than those assigned to water-treated canopies.

Sodium content of alfalfa herbage grown at Spindletop averages less than 0.4 g/kg, which is about one-quarter of the typical sodium requirement of livestock of 1.5 g/kg. Ingestion of alfalfa herbage, low in sodium and in the absence of free-choice salt supplements, resulted in sodium deficiency, and the resulting metabolic disorders caused post-ingestive responses.

In a series of lamb and stocker grazing trials on alfalfa in New Zealand, poor growth rates were attributed to low sodium content of alfalfa herbage dry matter (0.03 to 0.04 percent). In one grazing trial, more than 20 percent of lambs died from “red gut syndrome” within a few hours of being exposed to fresh alfalfa. Post-mortem examinations revealed that lambs did not die from legume bloat but from intestinal torsion associated with sodium deficiency. The hindgut rotated more than 270 degrees, interrupting blood flow of the mesenteric artery and causing massive hemorrhaging of the intestines. Cattle suffer from similar diseases known as abomasal displacement, and cecal dilatation and torsion.

We concluded that in order to more thoroughly understand the process of grazing and grazing management, we need to account for the post-ingestive (residual) effects of slow-moving herbage in the gastrointestinal tract as well as the metabolic consequences of the absorbed nutrients. We were able to demonstrate that cattle prefer “sweet” feeds. We also concluded that both bloat and intestinal torsion may cause death in cattle and sheep grazing alfalfa and it is imperative that salt be made available to livestock grazing alfalfa.

Common Pokeweed Control in No-Till Corn Production

J. D. Green

Introduction

Perennial broadleaf weeds are of increasing concern to corn producers in Kentucky. One such weed is common pokeweed (*Phytolacca americana L.*). Because of its large, deep taproot and growth habit, it has become more of a concern in no-tillage crop production. It does not survive in cropping systems where intensive tillage is practiced. Effective common pokeweed control options are limited in no-till crop production. The objective of this research was to evaluate postemergence herbicide options for common pokeweed control and other perennial dicot weeds in a continuous no-tillage production system.

Materials and Methods

On-farm field trials were conducted at two locations where common pokeweed has become well established. One experiment initiated in 1996 was conducted at the University of Kentucky (UK) Woodford Research Farm, and the other study in 1997 was conducted near Sonora in Hardin County. Experiments were designed to evaluate older herbicide products available along with more recently registered herbicides for use in field corn.

In 1996, herbicide treatments consisted of Banvel, Beacon, Exceed, Permit, and tank mixtures of Beacon plus Banvel, and Exceed plus Banvel. In addition to these broadcast treatments, Roundup as a spot treatment (2 percent v/v solution) was included as a standard comparison. Individual plots were 4 rows wide (30-inch spacing) by 75 feet in length arranged in a randomized complete block design with four replications. Corn was planted no-till on April 17. At time of postemergence herbicide application on May 23, corn height was approximately 12 inches, whereas common pokeweed height averaged 15 inches. Individual pokeweed height varied from 5 to 30 inches across the experimental area.

In 1997, treatments consisted of Banvel, Beacon, Exceed, Permit, Accent, and Basis Gold. Individual plots consisted of 4 rows wide (30-inch spacing) by 100 feet in length arranged in a randomized complete block design with four replications. Corn was planted no-till on April 7. At the time of postemergence herbicide application on June 12, corn height was 12 inches; common pokeweed height averaged 24 inches.

Data collected for each study consisted of percent visual control and height of common pokeweed plants and corn grain yield. Plant height was measured throughout the season on five marked pokeweed plants per plot. Field plots established in 1996 at the UK Woodford Research Farm site were also evaluated soon after crop establishment in 1997. The purpose was to determine the long-term effectiveness of treatments made in 1996. An evaluation of pokeweed density (number of emerged plants per 75 square feet) was conducted on June 11, 1997, approximately one year after treatments had been made in 1996.

Results and Discussion

The established common pokeweed population at the UK Woodford Research Farm had a slight impact on corn grain yield. The untreated check yielded 79 bu/A, which was lower than yield observed with postemergence herbicide treatments evaluated (Table 1). The lower yield observed with the Roundup spot treatment (90 bu/A) is attributed to spray contact that destroyed corn plants adjacent to treated pokeweed plants. At the earlier evaluation date (June 18), visual control of pokeweed ranged from 80 to 95 percent with broadcast treatments of Banvel 1 pt/A, Exceed 1 oz/A, Beacon 0.38 oz/A plus Banvel 0.5 pt/A, Exceed 1 oz/A plus Banvel 0.5 pt/A, and Roundup (2% v/v) as a spot treatment (Table 1). Fair results (60 to 70 percent control) were observed with the early evaluation of the Beacon 0.75 oz/A and Permit 1.33 pt/A treatments. In addition, pokeweed heights at the same time (June 18) were all reduced compared to the 28 inches observed in the untreated check plots.

At the later evaluation date before crop harvest (October 2), pokeweed suppression ranged from 68 to 88 percent with broadcast herbicide treatments that included Banvel 1 pt/A, Exceed 1 oz/A, or tank mixtures of Beacon 0.38 oz/A plus Banvel 0.5 pt/A, and Exceed 1 oz/A plus Banvel 0.5 pt/A. The average height of marked pokeweed plants ranged from 8 to 23 inches with these treatments compared to the 81 inches in the untreated check plots. Visual growth of pokeweed shoots in the Roundup spot treatment was evident from untreated plants which were missed at the time of treatment in each plot; thus, only a 60 percent visual suppression was observed, whereas the actual height reduction of marked plants in each plot with Roundup averaged 15 inches, which was as low as the best broadcast treatments. Significant regrowth of pokeweed shoots was observed with Beacon 0.75 oz/A (46 inches) and Permit 1.33 oz/A (41 inches), although pokeweed growth was observed to be suppressed at the earlier evaluation date with these broadcast treatments.

Common pokeweed regrowth was evaluated again in 1997 (approximately one year after treatment) in the field study initiated in 1996 at the UK Woodford Research Farm (Table 1). All herbicide treatments significantly reduced common pokeweed emergence and growth the following year. The number of pokeweed plants that had emerged on June 11, 1997, ranged from one to six plants per 75 square feet compared to 16 plants in the untreated check plots.

In the 1997 study at Hardin County, the effectiveness of seven different postemergence herbicides for control of common pokeweed was evaluated. Early (July 8) and late (September 16) visual evaluations indicated that Banvel 0.5 pt/A and Exceed provided 56 to 74 percent control (Table 2). Exceed 0.5 oz/A was as effective as Exceed applied at 1 oz/A. Nearly 60 percent control was obtained with Accent 0.67 oz/A. Common pokeweed

Table 1. Common pokeweed control in no-till corn production, University of Kentucky Woodford Research Farm, 1996.

Herbicide Treatment[1]	Rate per/A	Corn Yield (bu/A)	Pokeweed Control (%) 6/18	Pokeweed Control (%) 10/2	Pokeweed Height (in.) 6/18	Pokeweed Height (in.) 10/2	Pokeweed Regrowth[4] 6/11/97
Banvel 4S	1 pt	138	89	68	6	23	3
Beacon 75DF Crop Oil Conc.[2]	0.76 oz 1 qt	116	62	35	18	46	4
Exceed 57DF Crop Oil Conc.[2]	1 oz 1 qt	108	92	82	9	11	1
Permit 75DF Crop Oil Conc.[2]	1.33 oz 1 qt	104	70	38	15	41	6
Beacon 75DF Banvel 4S Surfactant[3]	0.38 oz 0.5 pt 0.25%	112	80	70	7	18	5
Exceed 57DF Banvel Surfactant[3]	1 oz 0.5 pt 0.25%	119	90	88	7	8	2
Roundup (spot treat)	2% v/v sol'n	90	94	60	2	15	4
Untreated Check		79	0	0	28	81	16
LSD (.05)		37	14	21	11	18	5

[1]Applied when common pokeweed averaged 15 inches and corn was 12 inches in height.
[2]Crop Surf Oil Concentrate manufactured by Universal Co-op.
[3]X-77 surfactant manufactured by Loveland Industries.
[4]Average number of pokeweed plants present per 75 sq ft

height was also greatly reduced by these treatments (Table 2). Poor results were observed with Beacon 0.76 oz/A, Permit 1.33 oz/A, and Basis Gold 14 oz/A. The late season pokeweed growth observed with these three treatments are evident in the height measurements reported in Table 2. Corn grain yield was not different among all treatments including an untreated check (data not shown).

Summary

The best suppression of common pokeweed growth during the crop season was observed with treatments that included Exceed and Banvel. Roundup as a spot treatment was also effective, but with spot treatments small plants at time of application may be left untreated, and potential corn yield may be reduced. Other broadcast herbicide treatments evaluated appeared to suppress pokeweed growth, but significant regrowth of shoots occurred later in the season. Based on evaluations taken one year after treatment, there may be some long-term benefits of herbicide treatments for subsequent crops since common pokeweed populations were reduced.

Table 2. Common pokeweed control in no-till corn production, Hardin County, Kentucky, 1997.

Herbicide Treatment[1]	Rate/A	Pokeweed Control (%) 7/8	Pokeweed Control (%) 9/1	Pokeweed Height (in.) 7/8	Pokeweed Height (in.) 9/16
Banvel 4S	0.5 pt	56	68	20	20
Beacon 75DF Crop Oil Conc.[2]	0.76 oz 1 qt	32	42	27	47
Exceed 57DF Crop Oil Conc.[2]	0.5 oz 1 qt	64	69	21	26
Exceed 57DF Crop Oil Conc.[2]	1 oz 1 qt	74	70	20	27
Permit 75DF Crop Oil Conc.[2]	1.33 oz 1 qt	18	18	35	63
Accent 75DF Crop Oil Conc.[2]	0.67 oz 1 qt	54	59	21	30
Basis Gold 90DF Crop Oil Conc.[2]	14 oz 1 qt	15	22	43	60
Untreated Check		0	0	47	65
LSD (.05)		20	19	12	12

[1]Applied when common pokeweed averaged 24 inches and corn was 12 inches height (4 to5 leaf stage).
[2]Crop Surf Oil Concentrate manufactured by Universal Co-op.

Trumpet Creeper Control during the Transition out of CRP

J. R. Martin and D. Call

Trumpet creeper is difficult to control because of its spreading perennial roots.The main problem with trumpet creeper is its woody vines that interfere with harvest and cause excessive wear of equipment.

A survey in 1995 showed that trumpet creeper was present in eight of 50 fields enrolled in the Conservation Reserve Program (CRP). The fescue sod and other vegetation will often suppress or conceal trumpet creeper's growth. Once the sod is killed during the transition out of CRP, trumpet creeper can become a dominant problem weed. Studies were conducted in a CRP field in Crittenden County to: 1) observe effects of tillage and cropping systems on trumpet creeper during the transition out of CRP, and 2) compare long-term trumpet creeper control with fall applications of postemergence herbicides.

Methods

Study 1: The percent ground cover of trumpet creeper was recorded soon after planting either corn or soybeans in a conventional or no-tillage system in 1995. In 1996, corn or soybeans were planted back either to the same area or were rotated. No-tillage practices were used for planting all crops in 1996. The percent ground cover of trumpet creeper was evaluated at crop maturity in the fall of 1996.

Study 2: Foliar applied herbicide treatments were made in the fall of 1995 and repeated on a different area in the fall of 1996. Plant counts were made in the center of each plot approximately nine months after application.

Results And Discussion

Study 1: The use of tillage in the first season helped manage trumpet creeper in both corn and soybeans (Table 1). At the end of the second season, trumpet creeper tended to be more abundant when either crop followed no-till soybeans than when they followed no-till corn. The application of Roundup during the process of replanting corn in the first season may have improved long-term control of trumpet creeper as indicated in the second season ratings for Treatments 7 and 8.

Study 2: The plant counts at approximately nine months after application tended to reflect long-term control achieved with the fall applied herbicides (Table 2). The amount of reduction in trumpet creeper population ranged from 77 to 92 percent for the treatments made in the fall of 1995. Although all treatments appeared to provide the same reduction in population, Roundup at 4 pt/A tended to have the greatest reduction.

The amount of reduction in 1997 ranged from 33 to 78 percent. Although the reductions in trumpet creeper densities were not as great in 1997 compared with the reductions in 1996, the trends were similar for both years.

Table 1. Impact of crop and tillage systems on percent ground cover occupied by trumpet creeper after CRP, E. Hill Farm, Crittenden County, 1995-1996.

	Treatment								
1995	CV	CV	CV	CV	NT	NT	NT	NT	
	SB	SB	CN	CN	SB	SB	CN	CN	
1996	NT	NT	NT	NT	NT	NT	NT	NT	
	CN	SB	CN	SB	CN	SB	CN	SB	
	Percent Ground Cover Occupied By Trumpet Creeper								LSD (.05)
1995	0	0	0	0	1.5	1.5	3.5	2.75	NS
1996	2.5	5	2.75	2.75	10.15	13.75	2.25	2	9.9

Ratings for percent weed cover were made on 5/29/95 and on 9/23/96. CV=Conventional, NT=No-tillage, CN=Corn, SB= Soybeans.

Table 2. Trumpet creeper plant counts approximately nine months after fall applications of postemergence herbicides, Crittenden County, 1995-1997.

Treatment[1]		Trumpet Creeper Plants /100 ft[2] 6/19/96	7/8/97
Roundup	4 pt/A	5.8	8.2
NIS	0.5% v/v		
AMS	2% v/v		
Banvel	4 pt/A	11.7	18.5
Crossbow	4 pt/A	14.1	20
Crossbow	8 pt/A	13.0	24.7
Roundup	3 pt/A	16.7	25.3
Banvel	1 pt/A		
NIS	0.5% v/v		
AMS	2% v/v		
Non-treated Check		74.1	37.7
LSD (0.05)	25.7	25.7	16

[1]Herbicide treatments were applied 9/19/95 and 9/18/96.Treatment number 1 was applied in a spray volume of 10 gal of water per A. Other treatments were applied in a spray volume of 26 gal of water per A. NIS=nonionic surfactant AMS=Liquid Ammonium Sulfate

[2]Plant counts were made in the center of each plot in a 3 ft by 45 ft area. The numbers were adjusted to represent plants per 100 sq ft.

Conclusions

The potential for trumpet creeper becoming a dominant weed problem may be greater with no-tillage practices than with conventional tillage practices for killing vegetation in CPR fields.

Fall applications of certain translocated herbicides may provide a feasible alternative for achieving long-term control of trumpet creeper. Roundup may be a logical choice since it controls many annual and perennial weeds, including tall fescue sod and trumpet creeper.

Applying Roundup at 2 to 3 pt in a spray volume of 10 gal of water per acre should control much of the tall fescue sod. However, a rate of 4 pt of Roundup/A is needed for trumpet creeper control. Since trumpet creeper is usually sporadic, it may be feasible to mix Roundup according to the rate needed for tall fescue and double spray portions of the field that are heavily infested with trumpet creeper.

Roundup Ultra is a relatively new formulation of glyphosate that does not require additional surfactant in the tank mixture. Consult the label for recommendations.

Johnsongrass Control in Genetically Altered Corn Hybrids

C.H. Slack and W.W. Witt

Johnsongrass continues to be a troublesome weed in corn. Although it is not the problem it once was, about 50 percent of the corn acreage in Kentucky contains populations of johnsongrass that require a herbicide treatment to prevent corn yield reduction. A relatively new technique for johnsongrass control is the use of genetically altered corn hybrids. These hybrids have been altered so that a herbicide that would kill the corn plants can now be used without killing the corn. Examples of these are Roundup Ready corn for Roundup Ultra and Liberty Link corn for Liberty. This technology was evaluated in 1997 in a very heavy stand of seedling and rhizome johnsongrass to compare the relative control of these herbicides.

The following herbicides and hybrids were evaluated: Lightning, Pioneer 8541 IT; Poast Plus, Dekalb 683SR; Roundup Ultra, Natalie gene (no trade name designation of this hybrid); Liberty, Pioneer 34A55 LL. All herbicides were applied in water at 25 gpa. Corn was planted on May 7 in 30-inch rows. Accent and Exceed plus Accent were used as standard treatments for comparison. Johnsongrass control and corn injury were evaluated four and eight weeks after herbicide treatment (WAT).

No corn injury occurred with any treatment at either date of evaluation. Accent and Accent plus Exceed provided about 90 percent control 4 and 8 WAT. Lightning applied to 8- or 12-inch johnsongrass provided about the same level of control (90 percent). Poast Plus at 2.25 pt per acre also provided about 90 percent control, but when the rate was reduced to 1.5 pt per acre, the control of johnsongrass dropped to about 85 percent control. Johnsongrass control with Roundup Ultra ranged from about 60 to 85 percent. Liberty provided johnsongrass control from 69 to 80 percent.

These results show the potential for genetically altered crops to be a component of johnsongrass control in corn. Most of the treatments evaluated provided control equal to the commonly used herbicides. A great advantage of the genetically altered corn hybrids is the safety of the herbicides to the corn. Often, johnsongrass emerges late in the corn growing season, and late applications of either Accent or Exceed can cause corn injury at these later treatment times.

Table 1. Johnsongrass (Jg) control in genetically altered corn hybrids in 1997 at Lexington, Kentucky. The following hybrids were used in these studies: Lightning, Pioneer 8541 IT; Poast Plus, Dekalb 683SR; Roundup Ultra, Natalie; Liberty, Pioneer 34A55 LL.

			Corn injury		Jg control	
	Amount	Jg. Size	Weeks after Application			
Treatment	Per Acre	(inches)	4	8	4	8
Lightning 70 DG Activator 90 Liquid N	1.28 oz	8	0	0	92	90
Lightning 70 DG Activator 90 Liquid N	1.28 oz	12	0	0	93	87
Liberty 1.67E AMS	1.75 pt	12	0	0	68	80
Liberty 1.67E AMS	1.75 pt	12	0	0	72	67
Liberty 1.67E AMS	1.4 pt	12	0	0	75	73
Liberty 1.67E AMS	1.4 pt	12				
Roundup Ultra	2 pt	8	0	0	78	65
Roundup Ultra	3 pt	8	0	0	85	82
Roundup Ultra	3 pt	16	0	0	78	57
Poast Plus 1E COC	2.25 pt	12	0	0	92	90
Poast Plus 1E COC	1.5 pt	12	0	0	87	85
Exceed 57 DG	1 oz	12	0	0	93	92
Accent 75 DF Activator 90	0.33 oz	12				
Accent 75 DG 7 COC	0.67 oz	12	0	0	90	88

Relative Competitiveness of an Acetolactate Synthase Resistant and Susceptible Smooth Pigweeds

J.A. Farrell, M.P. Crotser, R.E. Schmenk, M. Barrett, and W.W. Witt

Smooth pigweed (*Amaranthus hybridus*) is the most commonly occurring broadleaf weed in soybeans and corn in Kentucky. Heavy infestations can reduce yield of soybean by about 50 percent and will interfere with harvesting of the crop. Traditionally, control of this weed has been achieved with herbicides of different modes of action, especially with the acetolactate synthase (ALS) inhibiting products. These include Scepter, Pursuit, Classic, and numerous others. A population of ALS resistant smooth pigweed was identified in 1994 in a field in western Kentucky. This pigweed had developed resistance after seven years of continuous ALS herbicide use.

The presence of this ALS herbicide resistant smooth pigweed population is important to the farmers of Kentucky because of the widespread use of ALS herbicides in soybeans, corn, and wheat. Therefore, experiments were conducted to learn more about this resistant pigweed compared to the normal pigweeds which are susceptible to the ALS herbicides.

Study 1

Field studies confirmed that this pigweed population was resistant to several ALS soybean herbicides, but additional information was needed on the resistance of this population to other ALS herbicides. A greenhouse study compared the relative susceptibility or resistance of all ALS herbicides used in Kentucky or surrounding states. A resistance factor was calculated for each herbicide with the larger number indicating greater resistance. The resistant smooth pigweed was resistant to all of the herbicides evaluated, including those used in corn and wheat. This finding could be of immense importance for Kentucky's grain producers because of the potential for other ALS resistant weeds to develop in our crops.

Table 1. Response of an ALS resistant smooth pigweed to several ALS inhibiting herbicides. The resistance factor was calculated by comparing the amount of each herbicide to control a susceptible smooth pigweed with the resistant smooth pigweed.

Trade Name	ALS Inhibiting Active Ingredient	Resistance Factor
Pursuit	imazethapyr	>70
Scepter	imazaquin	>35
FirstRate	cloransulam	766
Broadstrike	flumetsulam	>86
Accent	nicosulfuron	>20
Basis Gold	rimsulfuron, nicosulfuron	>420 (rimsulfuron)
Beacon	primisulfuron	213
Canopy	chlorimuron	520
Classic	chlorimuron	520
Exceed	primisulfuron, prosulfuron	>590 (prosulfuron)
Harmony Extra	thifensulfuron	>90
Permit	halosulfuron	>1430
Pinnacle	thifensulfuron	>90
Staple	pyrithiobac	>10,000

Table 2. Relative growth of an ALS resistant and susceptible smooth pigweeds in the field in 1996 at Lexington.

Weeks after planting	Plant Volume (cubic cm)	
	Resistant	Susceptible
2	2	2
4	10	10
6	20	30
8	310	245

Study 2

Also of interest is the relative competitiveness of the resistant pigweed compared to the susceptible pigweed. Studies were conducted to determine the competitive ability of each pigweed with soybean and to determine the growth rate of each pigweed.

The growth of the ALS resistant and susceptible pigweeds was monitored over an eight week period in the field (Table 2). Plant volume was calculated based on the height and width of the pigweeds. This nondestructive measurement allows for an approximation of weed size. The susceptible pigweeds grew more rapidly up to six weeks but lagged behind the resistant pigweeds after eight weeks of growth. There was not a statistical difference in the growth of the two pigweeds at any time growth period. These data clearly indicate that the resistant smooth pigweeds are equally robust compared to the more commonly occurring ALS susceptible smooth pigweed.

Replacement series experiments were conducted in the field in 1997 at Lexington. A de Wit replacement experiment compares the competitive ability of a weed with the soybean crop at differing populations of weeds and soybeans. The proportion of either pigweed population to soybean was 100:0, 75:25, 50:50, 25:75, and 100:0. The dry weight of the weeds and soybeans was determined after eight weeks of growth and a plant relative yield value calculated by dividing the dry weight of the soybean by the dry weight of the smooth pigweed.

The plant relative yield values for the ALS resistant smooth pigweed grown with soybean were about one (Table 3). This indicated that the resistant pigweed plants compete for resources (water, light, nutrients) with other pigweed plants and soybeans on an equal basis; that is, interspecific and intraspecific competition was equal. The ALS susceptible smooth pigweed competed more with soybean at the 50:50 proportion; however, at the other two proportions, it appeared that these pigweeds competed more with each other than with soybean.

Table 3. Plant relative yield values for an ALS resistant and susceptible smooth pigweed with soybean cv Flyer in 1996 at Lexington.

Species proportion (pigweed:soybean)	Resistant	Susceptible
75:25	1.15	0.79
50:50	0.97	1.31
25:75	1.02	0.76

In summary, the ALS resistant smooth pigweed population is resistant to all ALS inhibiting herbicides currently available to Kentucky's farmers. Also, this ALS resistant smooth pigweed grows as large as, and competes equally well, with soybeans as the more commonly occurring ALS susceptible smooth pigweeds. These data point out the seriousness of herbicide resistant weeds and farmers should pay particular attention to using herbicides with differing modes-of-action in their crop rotations.

Ivyleaf Morning Glory Control in Burley Tobacco

W.W. Witt and C.H. Slack

Morning glories are considered to be the most troublesome weeds in tobacco production in Kentucky. There are several species of annual morning glories that occur in Kentucky: ivyleaf, tall, entireleaf, and pitted. Of these, ivyleaf occurs across Kentucky and is the species that is found most often. Research for morning glory control in tobacco has been ongoing for more than 20 years. However, until recently, herbicidal control of morning glories did not exist. Spartan (active ingredient sulfentrazone) was registered for use in tobacco in 1997 at rates of 6.7 to 8 ounces per acre.

Spartan herbicide has been evaluated for tobacco weed control for the past four years. The data reported here are from 1997 at Lexington and demonstrates the strengths and weaknesses of this herbicide. Spartan was evaluated for weed control in burley tobacco at two different times of application and three different methods of application (Table 1). It was applied either 14 days before transplanting or the same day of transplanting. Also, different methods of applying Spartan were tested. These included a shallow blend (or incorporation) where the soil is lightly mixed to a depth of about one inch; incorporation into the soil to a depth of 2 to 3 inches; and applied to the soil surface with the only soil disturbance being by the transplanter. All herbicide treatments were made in water at 25 gpa, and burley tobacco (14xL8) was transplanted into the plots on May 22.

Table 1. Weed control with Spartan in burley tobacco at Lexington, Kentucky, in 1997.

Spartan DF Rate oz/A	MOA[a]	TOA[b]	Species[c] Gifo	Smpw	Ilmg	Tob
			Weeks after application 4	4	4	8
			% control			
6.7	Surface Blend	14 days	95	98	50	0
6.7	Pretransplant inc.	14 days	97	98	87	0
6.7	Soil Surface	14 days	98	100	83	0
8.0	Surface Blend	14 days	97	95	90	2
8.0	Pretransplant inc.	14 days	90	95	90	5
8.0	Soil Surface	14 days	93	98	90	0
6.7	Surface Blend	0	78	75	87	2
6.7	Pretransplant inc.	0	77	83	87	0
6.7	Soil Surface	0	90	93	83	0
8.0	Surface Blend	0	85	88	98	0
8.0	Pretransplant inc.	0	63	87	95	0
8.0	Soil Surface	0	82	90	100	3

[a]MOA--Method of herbicide application. SB-shallow blend incorporation about one inch; pretransplant incorporated about 2 to 3 inches; SUR-applied to soil surface without incorporation.

[b]TOA--Time of herbicide application. 14 days--number of days after herbicide application before transplanting; 0--herbicides applied the same day as transplanting.

[c]Gifo-giant foxtail; smpw-smooth pigweed; ilmg-ivyleaf morning glory; tob-burley tobacco.

Giant foxtail control was 90 percent or more at all rates and methods of application when Spartan was applied 14 days before transplanting. However, giant foxtail control declined at all rates and methods of application when applied the same day as transplanting. Similar results were noted for smooth pigweed. Ivyleaf morning glory control was consistently greater at the 8-ounce rate for all methods of application at both times of application. Slight tobacco injury was noted in a few treatments eight weeks after transplanting. This injury was in the form of yellowing of leaves, and the injury symptoms were not noticeable at harvest.

While Spartan is excellent for morning glory control, it does not provide consistent control of the annual grasses, such as giant foxtail and large crabgrass. A study (see above for dates and variety) was conducted in 1997 to compare Spartan with Spartan plus other herbicides to determine mixtures that would provide broad spectrum control (Table 2). Ivyleaf morning glory control was greatest at the 8-ounce rate when lightly incorporated into the soil. Spartan plus Prowl, either incorporated or applied to the soil surface, provided greater than 90 percent control of giant foxtail, smooth pigweed, and ivyleaf morning glory. A soil surface treatment of Spartan and Command provided greater than 88 percent control of these three species. Some tobacco injury from Spartan was noted four weeks after herbicide application, but the injury was not apparent eight weeks after treatment.

Table 2. Control of giant foxtail, smooth pigweed, and ivyleaf morning glory in burley tobacco at Lexington, Kentucky, in 1997.

Treatment	Amount per A	MOA[a]	Species[b]			
			Tob	Gifo	Smpw	Ilmg
Command 3 ME	2. 67 pt	Soil Surface	3	95	73	53
Spartan 75 DF	6.7 oz	Soil Surface	2	90	92	83
Spartan 75 DF	8 oz	Soil Surface	7	95	93	95
Spartan 75 DF	6.7 oz	Incorporated	3	93	87	90
Spartan 75 DF	8 oz	Incorporated	10	88	88	97
Spartan 75 DF	6.7 oz	Soil Surface				
Command 3 ME	2 pt	Soil Surface	0	95	96	88
Spartan 75 DF	6.7 oz	Incorporated				
Command 3 ME	2 pt	Incorporated	0	60	77	88
Spartan 75 DF	8 oz	Soil Surface				
Prowl 3.3 EC	1.8 pt	Soil Surface	4	93	93	97
Spartan 75 DF	8 oz	Incorporated				
Prowl 3.3 EC	1.8 pt	Incorporated	2	93	90	95

[a]MOA-Method of herbicide application.

[b]Gifo-giant foxtail; smpw-smooth pigweed; ilmg-ivyleaf morning glory; tob-burley tobacco

Suppression of Ground Suckers in Burley Tobacco Fields

R.C. Pearce, G. K. Palmer, and J.M. Zeleznik

One of the most common complaints by burley tobacco growers the last several years is the apparent increase in the occurrence of ground sucker problems. Suckers arising from the base of the stalk often rival the main stalk in terms of size, and create problems for the grower during harvest and stripping.

Though the exact cause(s) of ground suckers is not known, there is general agreement that the problems are related to chill injury during transplant production. The typical symptoms of chill injury in transplants are upward cupping of the leaves, and yellowing or whitening of the bud. These symptoms are ordinarily observed two to four days after the plants have been chilled. The discoloration of the bud area indicates that the main growing point has been damaged by the chill. The bud will regain its color in a few days, and normal transplant growth will resume, resulting in a useable transplant. However, the temporary loss of apical dominance may cause the lateral buds to break dormancy and begin growing. Careful examination of the base of chill-injured plants often reveals tiny suckers, that may grow to be dime-sized by transplanting time.

After transplanting, tobacco plants generally go through a period of transplant shock. During this time lateral buds which have broken dormancy may be observed to increase in size. This is especially true when the plants are under stress, such as during an extended period of cool, wet conditions. By four to five weeks after transplanting, the suckers may reach four to six inches long. This is when many growers first discover the problem. During the middle of the season, when the main stalk is growing rapidly and apical dominance is strong, ground suckers often do not appear to increase in size. However, after topping and the total loss of apical dominance, the laterals may grow unchecked because they are too large to be controlled by sucker control chemicals. Within four weeks after topping, ground suckers can reach a size which makes them difficult to distinguish from the main stalk.

It is well known that large ground suckers at harvest cause tobacco growers a lot of aggravation and extra labor. Large ground suckers obviously compete with the main stalk for resources, but the extent to which ground suckers may reduce cured leaf yields is not known. The objectives of this study were to determine the effect of ground suckers on cured leaf yields, and to evaluate practical methods to reduce the impact of ground suckers.

Materials and Methods

Burley tobacco (Tn90) was transplanted into six-row strips in the spring of 1997. Approximately four weeks after transplanting the plants were observed to have two to three ground suckers (at least four inches in length) per plant. The strips were divided into 20 plots, each 20 feet long. Each plot was assigned one of five treatments arranged in randomized complete block fashion with four replications of each treatment. The treatments were: 1) check, 2) all ground suckers removed by hand, 3) suckers and lower leaves removed by scraping, 4) lower third of plant covered by soil, and 5) lower third of plant sprayed with 1 percent solution of Prime+.

At harvest the two center rows were cut. Ground suckers were speared separately from the main stalks so their contribution to cured leaf yield could be determined. The tobacco was air cured for three months and stripped into three grades plus sucker leaves.

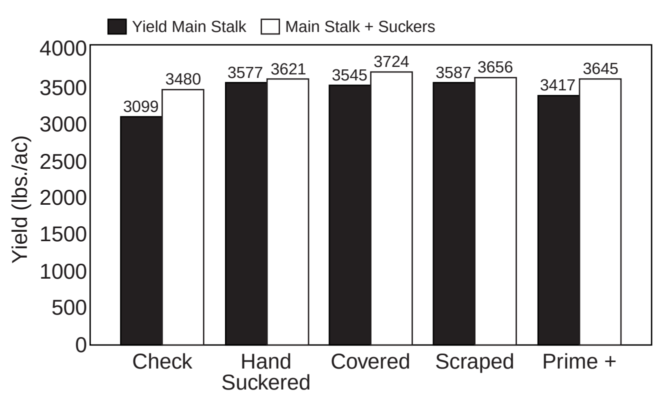
Results and Discussion

The effect of ground suckers on cured leaf yields can be readily seen by comparing the main stalk cured leaf yields of the check plot to the hand suckered plots (Figure 1). Hand suckering increased the main stalk yield by 478 lbs/A. Some of the lost yield could be recovered by harvesting and stripping all of the suckers from check plots; however, the extra labor involved represents greater expense for the grower.

All of the treatments resulted in improved main stalk yield over the check plot. The most practical treatment was covering the ground suckers with soil, even though this did not completely eliminate the ground suckers. The base of the plant can be easily covered during the final cultivation by removing the fenders and setting the cultivator shanks to move soil around the base of the plant. The loss of a few lower leaves was of little consequence to yield. Both hand suckering and scraping are very labor intensive. Treatment with Prime+ at this stage of growth is not a labeled application, and would be unwise due to the potential damage to the main bud.

These are only preliminary data. Research into the cause and prevention of ground suckers is continuing. This study will be repeated at several locations to determine the best methods of managing ground suckers.

Figure 1. Influence of ground suckers on cured leaf of burley tobacco—1997.



Comparison of Tobacco Setters for Container Transplants

B. Maksymowicz

The shift in transplant production from traditional outdoor beds to container (float) systems has given tobacco producers the opportunity to use carousel type transplanters. Developed for the vegetable industry, they are now being adopted by tobacco producers because of labor savings. Pocket type setters generally require two people per row while the carousel only requires one. Carousel transplanters from three manufacturers were compared with a pocket setter and disk opener setter to evaluate their relative efficiency.

Methods

Transplanters evaluated were Holland, Mechanical, and R & J Equipment carousel units, Powell disk opener, and Mechanical pocket setter. Within-row spacing was set at 32 inches, and dark tobacco transplants from 288 cell float trays were transplanted. Plot size was one row, 150 feet long, replicated four times. Evaluation included rate of transplanting (plants per minute), uniformity of spacing (measured in inches two weeks after transplanting,) and final stand (percent, two weeks after transplanting.)

Table 1. Comparison of tobacco setters.

Transplanter	Transplant Rate (plants/min.)	Within Row Spacing (inches)	Final Stand %
Holland	37.6a	30.61a	94.3b
Mechanical	33.8b	***	90.9b
R & J Equipment	36.5a	32.31b	99.2a
Powell	31.3b	33.72bc	98.7a
Mechanical Pocket Setter	21.4c	34.65c	94.6ab

Means with same letter in a column are not significantly different.

***Mechanical problem at time of evaluation precludes use of this data. This does not indicate a problem with the unit, but reflects poor maintenance.

Conclusions

All three carousel setters gave a significant increase in transplant rate. It should be noted that the Mechanical pocket setter required two people per row, so labor efficiency is less than what is reflected in the table. The R & J and Powell were most consistent in maintaining the 32-inch within-row spacing and had the best final stand.

All units would provide acceptable results if used on a production scale, but the carousel transplanter units do show a definite benefit in labor savings.

Effects of Tobacco Production on Soil Tilth

E. Perfect, J. Haszler, and B. Pearce

The Bluegrass region is the major tobacco production area in Kentucky. However, information is lacking on the impact of long-term tobacco production on soil tilth in this region and on the possible effects of declining soil tilth on subsequent yields.

Methods

In 1996, a preliminary tobacco experiment was carried out at the University of Kentucky's Woodford County Research Farm. Three cropping histories were studied: continuous tobacco (three years), fallow (two years tobacco followed by one year fallow), and continuous sod (at least 10 years). These cropping sequences were located in adjacent strips of a single field. Transects were set out across each strip. Twenty-one sampling points were located along each transect with 35 feet between successive sampling points.

Prior to cultivation, soil samples were taken at the one- to three-inch depth and tested for selected soil physical and chemical properties. The two main physical analyses were bulk density (a measure of compaction) and soil water content at field capacity (that is, after drainage by gravity). The chemical analyses were pH and organic matter (related to structural stability). After sampling, all of the cropping treatments were moldboard plowed and disked. The same number of tillage passes was used for each cropping history to ensure a constant tillage energy input. After the completion of land preparation, the transects were reestablished and surface samples were taken from the resulting planting beds. The samples were air-dried and sieved into five size fractions: < 2, 2-4, 4-8, 8-16 and > 16 millimeters (mm). The weight percentage of soil aggregates in each fraction was then determined.

Tobacco was planted in all three treatments. Between 8 and 14 stalks were harvested from the area around each sampling point. An average weight per plant was determined and multiplied by plant a population of 8,000 plants per acre to calculate the variation in yield (expressed as pounds per acre) along the transects.

Results

Table 1 shows the means of the soil analyses performed before cultivation. The continuous tobacco plot had the lowest bulk density of all three treatments, indicating the least amount of compaction. This result was probably due to the residual effects of previous tillage operations in this treatment. The continuous tobacco treatment had been disked in the fall to establish a cover crop. As a result of looser soil conditions under continuous tobacco, the water content at field capacity for this treatment was less than that for the fallow and sod treatments. Assuming the same value for permanent wilting point in all three treatments implies less available water in the tobacco treatment as compared to the fallow and sod treatments.

The pH for the sod treatment was quite low (Table 1), but this measurement was taken before any preparation of the field. On average, the tobacco treatment had the same organic matter content as the sod treatment. This result was somewhat surprising since the intensive tillage involved in tobacco production would be expected to reduce organic matter contents over time. However, the mean values were strongly influenced by variation in organic matter contents along the transects due to landscape position. The sod strip was located on a more sloping section of the field, and there were several places where erosion may have removed some of the surface organic matter. Closer examination of the data revealed the organic matter contents in tobacco were less than those in fallow and sod at 57 and 71 percent of the sampling locations, respectively. Reduced organic matter contents are associated with reductions in aggregate stability, and reduced aggregate stability can lead to dispersion and a more cloddy planting bed.

The tobacco treatment had fewer small aggregates and more large aggregates than the other two treatments following tillage (Figure 1). It is generally accepted that finer planting beds are preferable over coarser ones for tobacco production. The increased cloddiness under continuous tobacco may be related to reduced soil organic matter at a majority of the locations. The aggregate-size distribution measurements were made after the same tillage energy input. Increasing tillage energy (number of passes) may reduce the number of clods in tobacco to that observed following fallow and sod. However, this practice is a vicious circle since increasing tillage energy will further reduce organic matter contents, promoting dispersion and increasing the cloddiness of subsequent planting beds. This may be one reason why more tobacco growers have been using rototillers to prepare tobacco fields. In the short term the rototiller gets the job done of preparing a fine planting bed, but in the long-term there may be more potential for further structural degradation.

On average, the tobacco treatment yielded the lowest, while the fallow treatment yielded the highest, with the sod treatment having an intermediate yield (Table 1). However, there were no significant differences among these values. It is interesting to note that the tobacco treatment also had the highest variation in yield at ± 415 pounds per acre, as compared to ± 349 pounds per acre for fallow and ± 321 pounds per acre for sod. The best (statistically significant) predictor of final yield was soil organic matter content; this property explained 13 percent of the total variation in final yields. Tobacco yields increased as soil organic matter contents increased.

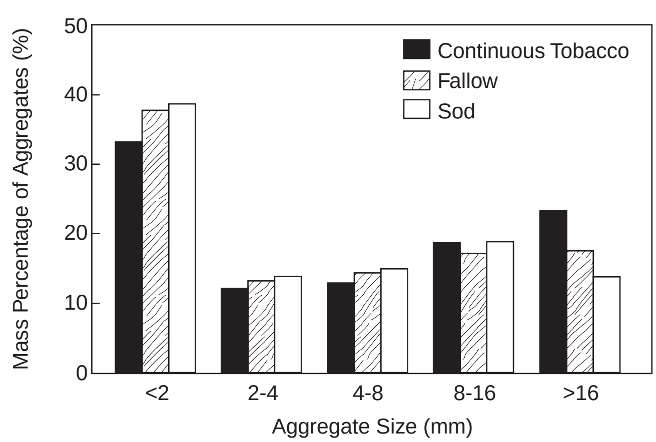
The trend towards a lower yield as tobacco is planted in the same field year after year may partly be due to the size of soil aggregates during the planting and growing season. An increase in cloddiness of the planting bed decreases the optimum conditions for healthy plant growth. Quoting from Sims and Wells (1985, AGR-109): "Plowing under a good sod will enhance the development of granular soil structure that tobacco roots can readily penetrate. The continuous production of tobacco in one location often leads to deteriorated soil structure, less soil aeration, increased danger of manganese toxicity, and increased risk for incidence of such diseases as black root rot and black shank. Ideally, a good plan is a crop rotation of two years tobacco, with a winter cover crop between crops of tobacco."

This preliminary evidence of soil organic matter depletion and reduced yields following continuous tobacco suggests that a stable soil structure is important for the production of high yielding tobacco in the Bluegrass region.

Table 1. Soil properties before cultivation and final yields in the three management treatments at the Woodford Farm Tobacco Experiment.

Plot	Bulk Density	Field Capacity (g/cm3)	pH (g/g)	Organic Matter (%)	Yield (lbs/A)
Continuous Tobacco	1.30	0.258	6.63	2.22	2096
Fallow	1.46	0.274	6.59	2.33	2281
Sod	1.42	0.278	5.90	2.22	2141

Figure 1. Soil aggregate size distributions for the three management treatments.



Dark Tobacco Genetics And Breeding

P. D. Legg

Genetics and breeding research with dark tobacco at the West Kentucky Research Station considers many aspects from disease resistance to cured leaf chemistry. Development of high yielding, good quality varieties with resistance to major tobacco diseases has been a long-term objective. In recent years, the program has been expanded to examine various growth properties like leaf angle, stalk size, and chemical components such as nicotine, nitrates, and nitrosamines. The following discussion highlights two aspects of the program.

Development of Black Shank Resistant Varieties

Breeding efforts to develop black shank resistant varieties have primarily involved the use of resistant genes from a cigar tobacco called Florida 301. Plants with Florida 301 resistant genes are moderately tolerant to both races of black shank found in Kentucky. However, under favorable disease conditions, a resistant cultivar can sustain considerable damage. Several varieties with this resistance have been released to growers, but yield and especially quality are inferior when compared with susceptible varieties. A severe problem encountered in recent years has been leaf deterioration due to brown spots as plants approach maturity. Research studies are underway to identify the reason for this leaf deterioration and to improve the overall quality of black shank resistant varieties.

In addition, an extensive crossing and selection program has been conducted at the University of Kentucky to utilize black shank immunity found in the cigar strain, Beinhart 1000. To date, all resistant lines developed from this resistant source have possessed undesirable morphological and quality traits like tallness, large stalks, and an off flavor and aroma.

Development of Lines with Altered Morphology and Chemistry

Investigations continue with four traits that have potential use in the production of dark tobacco. These traits, which have all been transferred to dark tobacco at the West Kentucky Research Station, are mammoth, short internode, pale yellow, and lower nicotine level. Plants with the mammoth trait do not flower until late summer and thus produce a large amount of biomass. Such lines have potential use if tobacco is grown for the production and extraction of drugs or other chemical substances.

Short internode plants are very compact, producing forty or more leaves on stalks half the length of those for normal plants. Such plants might be useful in a mechanized harvesting system. Plants that combine the mammoth and short internode traits have been developed and have potentially useful properties. These plants produce forty or more leaves on stalks of normal length. The major problem is stalk diameter which can be two or three times that of normal tobacco.

Pale yellow is expressed late in the season and plants with this trait lose much of their green color as harvest maturity approaches. This loss of chlorophyll prior to or immediately after harvest helps reduce the green color often found in cured leaves of dark tobacco.

The fourth characteristic under investigation is lower nicotine levels. Tobacco lines with lower nicotine levels are not presently desirable in the marketplace, but recent developments might change this in future years. Alkaloid levels (nicotine) seem to play a key role in the curing process due perhaps to helping maintain better leaf moisture levels and reduced levels of pathogens on the leaves. Use of the pale yellow trait has helped reduce the green color in cured leaves and has thus improved the quality of lower nicotine materials. Presently, curing and aging studies are underway to evaluate procedures for handling pale yellow, low nicotine materials in the post harvest periods.

Dark tobacco genetics research at the University of Kentucky is supported by a grant from U.S. Tobacco.

Progress in Tobacco Biotechnology at THRI

M. Davies

The past year has seen strong progress in the Tobacco and Health Research Institute's (THRI) new tobacco biotechnology program. A critical goal of this program is to develop commercial interest in using new tobacco-based crops as sources of materials and products. It is those companies who will be the eventual customers for the tobacco farmer growing genetically engineered tobacco crops. This is an ongoing endeavor for THRI, but we are already making good progress. For example, jointly with the University of Kentucky Agronomy Department we have received a contract from a large multinational company to investigate aspects of microbial metabolism to lay the groundwork for eventual production of some novel materials in plants.

Several other industry collaborations are in discussion, or underway, and making progress. The Institute has developed productive ties with Biosource, the company which is pioneering the use of tobacco as a vehicle plant for pharmaceutical production at its impressive new facility in Owensboro, Kentucky. Our research collaboration with the private company Interlink has been renewed for a second year. Good progress is being made by the THRI Core Group with the introduction into tobacco plants of Interlink's genes for novel anti-microbial peptides, and the company has provided THRI with samples of additional peptides for testing against blue mold. Work with these additional peptides is launching the new THRI in-house blue mold research effort (see below).

The Institute has entered into a collaborative agreement with Inhibitex, a new company formed to develop applications for tobacco in the field of metal protection. Inhibitex holds a patent on the use of tobacco extracts to inhibit corrosion and decay on metal surfaces. They are in the process of soliciting interest from the manufacturers of paints and protectants, especially for testing the performance of tobacco preparations in formulations of real paint, coating, and so forth. It will be important to see if the anti-corrosion property of the tobacco extracts is accompanied by any interference with paint curing, adhesion, and color. Research could then be undertaken with a view to developing a tobacco variety adapted for this application, showing enhanced anti-corrosion properties and a reduction or elimination of any undesirable attributes. Under the terms of the collaboration THRI is supplying Inhibitex with samples of tobacco leaf and stem extracts which the company can then share with the paints and coatings specialists for testing purposes. The results of these tests will be available to THRI so that Institute investigators will have the opportunity to propose further research as necessary. Inhibitex has identified several large companies who are anxious to test the tobacco preparations, and THRI has already commenced supplying the samples.

This collaboration with Inhibitex is an excellent example of how THRI's new mission is working to facilitate and promote the development of new, alternative uses for the tobacco plant. Neither Inhibitex nor the large paints/coatings companies would have ready access to tobacco samples and to the tobacco fractionation expertise they need if it were not for THRI's participation. The Institute's involvement is also helping to ensure that Kentucky will benefit from Inhibitex's endeavors.

An event which deserves special mention is the establishment of a license agreement with a major agricultural products company. This is a "first" for THRI, and it clearly demonstrates the relevance and importance to crop agriculture of THRI's plant biotechnology program. The license enables the company to develop new genetically engineered crop plants using a genetic promoter that was developed over the past few years at the Institute by Drs. Shepherd (now retired) and Maiti. Such relationships with industry serve the additional purpose of facilitating discussions with them concerning future prospects for genetically engineered tobacco; the company that has taken out the license is currently in discussion with THRI about several new projects of potential practical value.

The Institute is currently in discussion with several other companies about collaborative projects and research relationships. One of these companies has expressed a strong interest in establishing a new facility in Kentucky for extraction of useful products from plants. They are receptive to the idea of processing substances from genetically engineered tobacco, and we are assisting them as they begin to develop their ideas and plans.

THRI is pleased to have been able to respond to the urgent call for more research aimed at developing blue mold resistance in tobacco. This challenge is being approached in two complementary ways, i.e., by a new in-house project at THRI and by a new THRI grant program. The in-house blue mold project essentially comprises a survey of existing genetically engineered tobacco plants and appropriate anti-fungal agents to see if any offer the potential for control of the disease. It is a near-term strategy, designed to search for the possibility of early progress in the development of resistant tobacco plants. This project is being managed by our new Plant Fungal Biologist, Dr. Christopher Lawrence, who arrived at THRI this January. While we undertake this survey, it would also be prudent to increase our knowledge of blue mold and its infection of tobacco, especially in ways which could contribute to the design of new resistance strategies. To this end, THRI has designed a new grant program and has requested research proposals from interested investigators. Four proposals have been received, reviewed, and recommended for funding.

A particularly exciting project that we anticipate will take place this year is THRI's first field trial of genetically engineered tobacco. Drs. Susheng Gan, Robert Pearce, and Orlando Chambers have designed a trial in order to obtain valuable information concerning the performance of the genetically engineered plants which Dr. Gan developed prior to joining THRI. These plants, which exhibit reduced aging of the lower leaves, offer the potential to improve the economics of using tobacco as a production vehicle for recombinant products. Dr. Chambers' examination of the economics of current tobacco production in relation to other crops indicates that considerable economies of production will need to be achieved to ensure that the special benefits of tobacco are realized. This field trial will represent the start of a new and very important project at THRI in the development of tobacco varieties customized for economic molecular farming applications.

No-till Wheat: Making it Work on Kentucky Farms

L. Grabau, C. Steele, and J. Grove

Recently, the Virginia Small Grain Board and the Kentucky Small Grain Growers Association (KySGGA) asked Mark Alley of Virginia Tech and Lloyd Murdock of the University of Kentucky to cooperatively assess the current status of wheat production systems in the South. Their key finding was that more work is needed to help Southern region grain producers become more successful at no-tilling wheat.

In Kentucky, conversion of wheat area to no-till methods has been considerably slower than for soybeans or corn. Two major factors appear to be involved. First, stand establishment has been somewhat irregular with no-till methods. Second, heavy corn residue may depress spring tillering by keeping soils cool longer. In addition, some no-till wheat farmers have not planted their seed deep enough, leading to problems with heaving. Also, there are questions about a greater potential for some diseases (perhaps head scab) to cause problems under no-till management. Finally, nitrogen rates and timing may need to be adjusted.

With these concerns impeding no-till adoption by wheat farmers, it was our goal to try to find out, using strip plots in farmers' fields, what specific practices would help them succeed. With the support of the KySGGA, we set up on-farm experiments with eight cooperating farmers in the fall of 1996. This preliminary report provides a first look at the results.

Experimental Techniques

Eight on-farm tests, each with two replications, were established in eight different counties. Planting dates were between September 25 and October 24. Each farmer had two tillage treatments (no-till and conventional tillage) and two different varieties (Pioneer 2552 and Jackson). Mike Ellis (Shelby County) asked to substitute Cardinal for Jackson (since he was going to plant so early), and we agreed. We also applied fall nitrogen (about 50 lbs/A) to one-half of each strip plot on all eight tests. We measured the weight of corn residue (lbs/A) on the soil surface on each farm, and did initial stand counts (plants/sq ft) between two and three weeks after planting. We also took overhead slide shots to get a percentage soil cover by corn residue for each plot. We have not yet analyzed the soil cover data; the rest of the initial data is shown below. In March, we did tiller counts, took general chlorophyll meter readings, and evaluated the overall condition of each farmer's test.

Results

Table 1 shows that corn residue on the soil surface averaged about twice as much for no-till as for conventional tillage. However, individual farms differed greatly, especially under conventional tillage. The most intense tillage was done by Steve Hunt (Christian County), followed by Mike Stratton (Simpson County), and Mike Ellis (Shelby County). On the other extreme, conventional tillage by Ben O'Bryan (Daviess County) and Hugh Johns (Henderson County) did not significantly reduce corn residue on the surface. Percent residue cover, as assessed through the use of slide photographs, seemed to provide a clearer picture of what the corn residue situation really was, and should be considered for use in later studies. Residue cover most obviously varied under conventional tillage, ranging from two percent for Steve Hunt's test to 71 percent for Steve Roger's test.

Table 2 shows that the initial stands averaged on the low side, and were slightly higher for conventional tillage than for no-tillage. Most consistent stands were achieved by Allen and Tim Franks (Todd County); their stands were closest to our goals (35 plants/sq ft in no-till and 32 plants/sq ft in conventional tillage). Steve Hunt planted much thicker than we would have liked. On the other extreme, Hugh Johns' stands were disappointingly low

Table 1. Corn residue comparison for wheat trials in the 1996-1997 on-farm tests.

		Residue (lbs/A)		% Cover (slides)	
County	Cooperator	NT	CT	NT	CT
Shelby	M. Ellis	5606	1572[a]	89	20
Hardin	S. Rogers	5853	4114	98	71
Daviess	B. O'Bryan	4936	4074	88	57
Henderson	H. Johns	4207	3497	63	64
Christian	S. Hunt	5161	763	62	2
Todd	A. & T. Franks	5829	2717	84	27
Logan	E. Wright	7527	5143	89	56
Simpson	M. & K. Stratton	5212	1435	92	25
Average of 8 counties		5541	2914	83	40

[a]The LSD (.10) to compare tillage treatments within a county was 1350 lbs/A or 10 percentage points.

Table 2. Initial stand and March tiller comparisons for wheat trials in the 1996-1997 on-farm tests.

		Plants/ft^2		Tillers/ft^2	
County	Cooperator	NT	CT	NT	CT
Shelby	M. Ellis	19	24[a]	142	163[b]
Hardin	S. Rogers	20	22	83	87
Daviess	B. O'Bryan	20	22	90	81
Henderson	H. Johns	13	14	46	52
Christian	S. Hunt	48	39	181	131
Todd	A. & T. Franks	28	29	159	143
Logan	E. Wright	20	24	93	111
Simpson	M. & K. Stratton	21	28	88	128
Average of 8 counties		24	25	110	112

[a]LSD(.10) to compare the effect of tillage treatment on initial stands within a county was 1.

[b]LSD(.10) to compare the effect of tillage treatment on March tillers within a county was 24.

(both to him and to us). Several growers had slightly better stands under conventional tillage (Ellis, Rogers, O'Bryan, and Wright). Stratton's conventional tillage stands were higher than his no-till stands, probably due to his especially shallow planting under no-till. On the other hand, Hunt's conventional tillage had lower stands. This was due to several wet spots in one strip of Pioneer 2552. Stands were slightly greater for Jackson than for Pioneer 2552 (26 versus 23 plants/sq ft). This was probably because we did not compensate quite enough for the larger seed size of the Pioneer variety.

March tiller counts averaged 110 tillers/sq ft for no-till and 112 tillers/sq ft for conventional tillage, indicating that, overall, spring tillering was not different between the tillage treatments (Table 2). However, the impact of tillage depended on individual farmer's initial stand establishment. This effect was most pronounced for Mike Stratton's Simpson County test where conventional tillage stands were 50 percent better than were no-till stands. On the other hand, Steve Hunt's stands were much better in the spring under conventional tillage, probably because some of his conventional till strips suffered some water damage.

Fall nitrogen did boost spring tiller counts by about 10 percent for both tillage treatments (data not shown). However, this effect depended upon individual grower's conditions. Fall N was most helpful for no-till in Stratton's late-planted test, and also helped tiller counts more for no-till than for conventional till in both the Franks and Wright tests. In the other five tests, fall N boosted spring tillers more in conventional till than in no-till.

No-till and conventionally tilled yields were similar only in the Rogers' and Franks' tests (Table 3). In the other cases, we saw an 8 to 10 bu/A advantage for conventional tillage. Overall, conventional tillage produced 6.6 bu/A more than did no-till under the environmental conditions encountered and management schemes used by this group of growers. Table 4 shows that no-till plants were slightly shorter and lodged a little bit less than did conventionally tilled plots. In Table 5, we could not show a consistent difference in heads/sq ft between tillage systems, but kernel size was consistently bigger under conventional tillage.

Table 3. Yield and test weight from six completed tests.

		Yield (bu/A)		Test Weight (lbs/bu)	
County	**Cooperator**	**NT**	**CT**	**NT**	**CT**
Shelby	Mike Ellis	57.8	68.0	56.6	56.6
Hardin	Steve Rogers	60.7	63.1	57.4	57.6
Henderson	Hugh Johns	53.5	61.5	57.9	58.1
Christian	Steve Hunt	61.5	70.5	59.6	59.1
Todd	Allen & Tim Franks	70.2	71.8	60.1	61.3
Logan	Earl Wright	46.1	54.9	58.3	58.6
Average		58.3	64.9	58.3	58.5

Table 4. Plant height and lodging for wheat trials in the 1996-97 on-farm tests.

		Plant height (in.)		Lodging (1-9 scale)	
County	**Cooperator**	**NT**	**CT**	**NT**	**CT**
Shelby	Mike Ellis	36	35	5.2	4.7
Hardin	Steve Rogers	28	29	1.6	1.6
Henderson	Hugh Johns	28	28	1.4	1.5
Christian	Steve Hunt	29	30	2.8	3.7
Todd	Allen & Tim Franks	32	34	2.2	2.5
Logan	Earl Wright	26	27	1.6	1.7
Average		30	31	2.5	2.6

Kernels per head was greatest for the Johns test, where stand establishment was poor. For the Rogers, Franks, and Wright tests, tillage did not influence kernels per head. However, the two tests with the greatest number of heads under no-till management (Ellis and Hunt) had the fewest kernels per head.

In summary, no-till yield potential may be somewhat lower than that of conventionally tilled wheat. However, there may be a configuration of management practices which will allow no-till growers to more closely approach conventional tillage yields.

Table 5. Heads per unit area, kernels per head, and kernel size for wheat trials in the 1996-97 on-farm tests.

		Heads/sq. ft.		Kernels/head		Kernel size	
County	**Cooperator**	**NT**	**CT**	**NT**	**CT**	**NT**	**CT**
Shelby	Mike Ellis	90	76	14	20	29	30
Hardin	Steve Rogers	64	63	19	20	33	33
Henderson	Hugh Johns	28	32	46	41	32	33
Christian	Steve Hunt	81	66	13	19	36	37
Todd	Allen & Tim Franks	59	59	20	20	37	39
Logan	Earl Wright	44	49	20	20	34	36
Average		61	58	22	23	34	35

Influence of Corn Residue Level and Fertilizer Nitrogen Timing on Tillering and Yield of No-Till Winter Wheat

J. H. Grove and L. J. Grabau

Long-term rotation research suggests that the yield of no-till winter wheat is reduced as the yield of the prior corn crop rises. This is believed to be due to the larger amounts of residue left after high yielding corn. This residue interferes with: a) no-till drill performance and subsequent stand establishment, and/or b) wheat development, especially tillering, in both fall and early spring.

This experiment was designed to: a) separate the drill performance and crop development issues, and b) examine the role of residue rate on wheat tillering. Fall and early spring nitrogen applications are known to stimulate earlier tillering in wheat. So, another question was whether such applications could overcome any negative effect(s) of corn residue on wheat tillering.

Table 1. The influence of corn residue on no-till wheat tillering and yield components in 1995 and 1996.

Corn Residue Rate	Tillering In: March	Tillering In: April	Tillering In: June	Yield Components: Plant Stand	Kernel Set	Kernel Size	Grain Yield
	#/ft^2				#/head	mg	bu/A
1995							
0	75.5a*	63.2a	39.2a	18.7a	24.1a	33.3a	51.7a
3330	66.4b	62.7a	54.3a	18.0a	23.8a	31.8b	52.1a
6670	59.5b	63.7a	54.3a	17.3a	24.5a	30.7b	49.9ab
10000	46.3c	55.6b	52.7a	14.8b	24.5a	29.1c	47.0b
1996							
0	58.0a	64.4a	60.4a	26.0a	26.1a	30.9a	68.2a
3330	43.9b	56.1b	60.7a	24.7ab	23.9b	29.8ab	61.4b
6670	37.8b	49.2c	59.6a	21.3bc	23.7b	27.8b	53.8c
10000	25.8c	33.6d	54.5b	18.3c	22.0b	26.1c	43.3d

*Means within a column (for a given year) followed by the same letter are not significantly different at the 90 percent level of confidence.

The experiment was conducted for two years at the University of Kentucky Spindletop Farm near Lexington, Kentucky. A large block of corn was grown prior to the wheat crop, combine harvested, and then corn stalks were cut at ground level with a sicklebar haybine. The corn residues were raked and removed from the plot area. The Pioneer 2684 wheat was planted in late October at rates of 26 and 36 seed/sq ft in 1994 and 1995, respectively, using a Lilliston 9680 no-till drill.

Corn residue was returned to the soil surface in large plots at rates of 0, 3330, 6670, and 10,000 pounds per acre. Fall nitrogen rates (0 versus 40 lb N/A, as ammonium nitrate) were applied in early November, while early spring nitrogen (0 versus 40 lb N/A) and late spring nitrogen (40 versus 80 lb N/A) were applied in mid-March and early April, respectively. All possible combinations of nitrogen application times (2 X 2 X 2 = 8 nitrogen treatments) were applied to subplots within each of the corn residue rate main plots. Four replications were used.

Wheat development was monitored by counting tillers throughout the season in sections of row marked in each subplot. Just prior to wheat harvest, these sections were removed by hand and the final plant stand determined. The wheat was combine harvested in late June or early July and samples of grain were taken from each subplot for determination of kernel size and subsequent calculation of the average kernel number per head.

In 1995, increasing levels of corn residue significantly reduced the number of wheat plants established and the number of tillers formed as of March (Table 1). By harvest, wheat plants under heavy residue had greater tiller numbers, while those at lighter residue rates had fewer tillers. These trends resulted in similar tiller densities across all residue rates at harvest. Kernel set per head was not affected by corn residue rate (Table 1). Still, delayed tiller development at heavier corn residue rates was associated with reduced kernel size, presumably because of a reduced time for grain filling in these late tillers. In this year, the reduction in yield was only modest (10 percent) and barely significant (Table 1).

The 1996 results were essentially a repeat of 1995, albeit at a greater average yield level. Again, an increased residue rate was associated with decreased stand establishment and early tillering (Table 1). At lower corn residue rates, tiller densities recovered greatly later in the growing season, but again this was associated with smaller average kernel size. Additionally, it was observed in 1996 that the kernel set per head was reduced where corn residue was applied (Table 1).

Nitrogen addition, regardless of application timing, significantly improved wheat yields in both years (data not shown). Spring nitrogen applications were more beneficial (average of +8.0 bu/A) than were fall applications (average of +2.4 bu/A), and early spring applications were much more beneficial (average of +11.3 bu/A) than were late spring applications (average of +4.8 bu/A). However, there were no positive interactions between any of the nitrogen applications and corn residue rate. In other words, though nitrogen was generally beneficial, nitrogen applications did not directly overcome (even partially) the negative effect of corn residue on wheat grain yields.

These results suggest that the negative effect of corn residue on wheat development has the potential to be quite significant and will not be overcome with more, or different times of, nitrogen application. Other strategies more likely to result in adequate early tillering, such as earlier planting and greater seeding rates, need to be evaluated under these conditions.

Sulfur Fertilization of No-Till Corn

K.L. Wells, J.E. Dollarhide, D.C. Ditsch, and W. Turner

Sulfur (S) is one of the three secondary elements required for plant growth and often is present in plant tissue in concentrations similar to that of the primary plant nutrient, phosphorus (P). Beyond its importance for plant growth, it is a component of two essential amino acids necessary for animal growth, methionine and cystine, thus adding to its relevance as a necessary plant nutrient. Over the past 15 to 20 years the S content of phosphatic fertilizers has declined, as has atmospheric fallout of S, thereby putting a greater stress on the soil to supply adequate amounts of S for high yielding crops. Yet Murdock (*Soil Science News & Views* (2)7, 1981, UK Agronomy Department) concluded that soil levels of S in Kentucky were still adequate. With the spread of intensive wheat production technology during the mid-1980s, concern was again raised that naturally occurring levels of soil S were insufficient for high yields. Rasnake (*Soil Science News & Views* (11)1,1990, UK Agronomy Department) conducted field trials in Todd and Logan Counties during 1988-89 and showed that there was no yield response to S fertilization in the wheat yield range of 70 to 114 bu/A. Reported yield responses by wheat and corn to fertilizer S applications in sandy textured soils of some states during the 1990s have again created concern that fertilizer S is needed in Kentucky. During the past year, we have conducted fertilizer studies with no-till corn at three locations in Kentucky to test the effect of sulfur fertilization.

Description of the Studies

A study was conducted during 1997 on a Pope silt loam soil at University of Kentucky's Robinson Experiment Station at Quicksand, Kentucky, to determine what effect ammonium sulfate (AS) in a nitrogen (N) fertilization program would have on yields of no-till corn. The study tested rates of N (0, 80, 160, and 240 lb/A), sources of N (ammonium nitrate (AN), half AN and half from AS), and AN plus S (from granular elemental S). All fertilizer was broadcast over the corn about five weeks after emergence.

In Hardin County, Kentucky, another field trial with no-till corn on a Crider silt loam soil was conducted. Several P-K-Zn treatments were applied with (13 lb S/A) and without S. All fertilizer was broadcast over the corn about five weeks after emergence. Application of N (as anhydrous ammonia) was uniformly applied to all treatments at 160 lb/A. Extremely dry weather during July and August limited yields at this site.

Another test of S application was conducted in Larue County, Kentucky, on a Crider silt loam soil where S was applied as either gypsum, zinc sulfate, or a mixture of the two by topdressing onto no-till corn in May of 1996. Yield of corn was measured in 1996. In 1997, ear leaf samples were taken to test for carryover effect of S, but due to extremely dry conditions, grain yield was not measured. A uniform application of N, as AN, was topdressed over all treatments at 150 lb/A about five weeks after emergence each year.

Table 1. Effect of N-rate and sulfur on no-till corn yield on a Pope silt loam soil, University of Kentucky Robinson Substation, 1997.

Fertilizer Treatment (lb/A)			Ear Leaf (%)		Corn Yield
N	N-Source	Sulfur	N	S	(bu/A)
0	—	0	2.96e	.150c	54.9 g
80	AN[1]	0	2.51d	.160bc	114.7ef
80	AN/AS[2]	45	2.23e	.173abc	98.5f
80	AN	45[3]	2.63cd	.168bc	122.3de
160	AN	0	3.06b	.188ab	137.2abcd
160	AN/AS[2]	90	3.14ab	.188ab	132.8bcde
160	AN	90[3]	2.82c	.185ab	124.0cde
240	AN	0	3.29a	.175abc	152.5a
240	AN/AS[2]	135	3.27ab	.200a	143.9ab
240	AN	135[3]	3.23ab	.203a	142.7abc
LSD (.05)			0.22	.03	19.5

[1]AN=ammonium nitrate; AS=ammonium sulfate
[2]half the N as AN and half as AS
[3]S applied as granular elemental S

Table 2. Effect of S fertilization on no-till corn on a Crider silt loam soil, Hardin County, Kentucky, 1997.

	Ear Leaf (%)		Yield
Sulfur (lb/A)	N	S	(bu/A)
0	2.77	0.195	107
13	2.80	0.190	105
LSD (.05)	NS	NS	NS

Table 3. Effect of S and Zn fertilization on no-till corn on a Crider silt loam soil, Larue County, Kentucky, 1996-1997.

Fertilizer (lbs/A)		Yield, 1996	Ear Leaf Content, 1997 (%)		
S	Zn	(bu/A)	N	S	Zn
0	0	142	2.39	0.15 ab	0.18 ab
16	30	157	2.48	0.15 ab	0.21 a
30	0	150	2.47	0.17 a	0.17 b
46	30	129	2.35	0.14 b	0.21 a
LSD (.05)		NS	NS	0.027	0.02

Results

As shown in Table 1, use of fertilizer S, either as AS or elemental sulfur, did not increase either ear leaf content at silking and tasselling or grain yields at three rates of N, as compared to no S, on a Pope silt loam soil. Applications of S to a Crider silt loam soil in Hardin County (Table 2) did not increase either ear leaf content of S or grain yields, although yields were depressed by drought. In Larue County (Table 3) on another Crider silt loam soil, there was no significant difference in yields during 1996 due to either S or Zn application. The average yield differences shown were not significant because of a high degree of variability within and among replications. No ear leaf samples were taken in 1996. Ear leaf samples were taken in 1997, although severe drought decimated grain yields at this site. Results indicate no residual effect on S content from the previous year's application but show a significant residual carryover effect of Zn applied the previous year.

In summary, results from three sites showed no effect of S applications on either ear leaf content of S or on grain yield of no-till corn.

Effect of Narrow Corn Rows and Plant Populations on Grain Yields

M. J. Bitzer and J. H. Herbek

In recent years, there has been considerable interest in using corn rows that are less than 30 inches wide. Most of the prior research on narrow rows has been done in the northern part of the corn belt. With much publicity in popular magazines, farmers in more southern states started exploring the use of narrow rows for corn. Research was initiated in Kentucky in 1995 looking at three row widths—20, 30 and 36 inches—and three plant populations—22,000, 26,000 and 30,000 plants per acre. The corn hybrid Pioneer Brand 3163 was used each year. In 1995 and 1996, plots were on Bob Wade's farm in Hardin County and Roger Williams' farm in McLean County. In 1996 and 1997, additional sites were added in Hickman County on Tom Webb's farm and Jim Long's farm, respectively. The average yields at each location in 1995, 1996 and 1997, respectively, were: Hardin County, 183.7, 120.5 and 99.3 bu/a, McLean County, 185.4, 173.8 and 175.5 bu/a, and Hickman (96 and 97), 214.8 and 203.4 bu/a. In no year and no location was there any difference between 20- and 30-inch row widths. At some locations and across all locations, the 36-inch row width was lower yielding than the narrower rows. In 1995 and 1996, the highest plant population (30,000 pl/a) was higher yielding than 26,000, but in 1997, there was no yield increase at the highest population.

Since there were no significant row width by plant population interactions within any year or across years, both within or across locations, the data can be averaged across row widths and plant populations. As can be seen in the following table, which summarizes data across all eight locations for three years, there was no yield difference between the 20- and 30-inch rows or between the 20- and 36-inch rows, but the 30-inch rows yielded significantly more than the 36-inch rows. However, there was a significant yield increase for each increase in plant populations. These data definitely suggest that plant population is much more important for obtaining high yields than narrow rows and that in Kentucky, there is no increase from 30- to 20-inch rows. These results for row width are consistent with those obtained in southern Illinois, Missouri, and Tennessee. This research was partially funded by the Kentucky Corn Promotion Council.

Row width and plant population effect on corn yields. (Eight location average, 1995-7)

Treatment		Yield
Row Width	20 inch	170ab*
	30 inch	175a
	36 inch	169b
Plant Population	22,000	164a
	26,000	171b
	30,000	178c

*0.10 level of significance for row width, 0.05 level of significance for plant population.

Water Stress during Seed Filling and Soybean Yield

P.I. de Souza, D.B. Egli and W.P. Bruening

Water stress during seed filling of soybean may not cause the plant symptoms normally associated with drought but still may reduce yield. We investigated this phenomenon in the greenhouse by applying moderate or severe stress to soybean plants (variety Elgin 87) during the seed filling period. The treatments were imposed early in the seed filling period (Growth Stage R6) by supplying the moderately stressed plants with 60 percent of the water applied to the well watered control, while the severely stressed plants received only 30 percent of the water given the controls.

Yield was reduced by water stress during seed filling (Table 1) with the severe stress causing a larger reduction (45 percent) than moderate stress (20 percent). Even though the stress was not applied until after seed filling had started, stress reduced the number of seeds per plant. Apparently, seed number remains flexible during the early stages of seed filling. Stress also shortened the seed filling period, as shown by the earlier occurrence of physiological maturity (Table 1). The shorter seed filling period resulted in smaller seeds on the stress treatments which contributed to the reduction in yield. The stress accelerated leaf senescence, the loss of chlorophyll, N, and photosynthetic activity from the leaves, causing the shorter seed filling period.

Water stress during the seed filling period can reduce soybean yield. But, the effects may not be evident during growth because the plants follow a normal senescence pattern, and the acceleration of the process by the stress is only apparent in comparison to a well-watered control.

Table 1. Water stress during seed filling and soybean yield.

Treatment	Yield	Number of Seeds	Seed Size	Physiological maturity
	g/plant	no./plant	mg/seed	days
Well Watered	40	165	240	24[1]
Moderate stress	32	153	207	20
Severe stress	22	136	163	17

[1]Days after growth stage R6

KY91-1214 Soybean

T. Pfeiffer

In 1998, the Kentucky Agricultural Experiment Station released the soybean line KY91-1214. This variety will be named later. KY91-1214 was released because of its superiority in seed yield in the Kentucky Soybean Performance Tests compared with the public varieties of similar maturity. Marketing rights for KY91-1214 will be assigned to a company with a marketing plan for Kentucky.

KY91-1214 originated as an F4 plant selection from the cross Pioneer 9391 x KY84-1616. The line was evaluated in Kentucky from 1993 through 1997 and in the Uniform Soybean Tests - Southern States maturity group IVS in 1995 through 1997. KY91-1214 is a late group IV line with a relative maturity of 4.9 (maturing about one day earlier than Manokin). KY91-1214 is an indeterminate line, rare for a line with this late maturity. However, it does not attain an excessive height (average of 35 inches) and has a low lodging score (1.6 on a 1 to 5 scale). KY91-1214 has purple flower color, tawny pubescence, and imperfect black hila. Its protein and oil concentrations are acceptable, approximately 41 percent protein and 21 percent oil on a dry weight basis. KY91-1214 is resistant to stem canker but susceptible to SCN, SDS, and SMV.

In regional testing, KY91-1214 has averaged 48.4 bushels per acre compared to 49.0 bushels per acre for Manokin, which was the regional check variety. In 19 Kentucky environments, however, KY91-1214 averaged 51.1 bushels per acre compared to 47.1 for Manokin. In the Kentucky Soybean Performance Tests KY91-1214 ranked fifth out of 33 maturity group IV varieties for its two-year average yield. The highest yielding variety in the maturity group IV was DP 3478 at 51.3 bushels per acre, while KY91-1214 yielded 50.2 bushels per acre. Comparisons of KY91-1214 with other publicly released varieties are shown in Table 1.

The Kentucky Soybean Promotion Board has provided partial support for the University of Kentucky soybean breeding. Testing of KY91-1214 in Kentucky has been conducted by David Pilcher, Eugene Lacefield, and Charles Tutt.

Table 1. Statewide average yield of KY91-1214 compared to other varieties in the Kentucky Soybean Performance Tests, 1996-97. (Ten single-crop and three double-crop tests are included.)

Variety	Yield
	bu/A
KY91-1214	50.2
DP3478[a]	51.3
Manokin	47.6
CF461	47.5
CF492	48.6
Stressland	49.5
A4715	46.6
Hutcheson	46.8

[a]MGIV variety with highest two-year yield

Kentucky Soybean Performance Tests

E. Lacefield, C. Tutt, and T. Pfeiffer

The Kentucky Soybean Performance Tests are grown annually to evaluate soybean varieties marketed in Kentucky. This provides farmers and seedsmen with unbiased information for variety selection. In 1998, the Kentucky Soybean Performance Tests expanded to meet the needs of Kentucky soybean producers. In 1997, about 80 varieties from commercial companies and 25 varieties from public institutions were tested in six locations. Eight of the commercial varieties were Roundup-Ready. The number and acceptance of Roundup-Ready varieties is, however, expanding. In 1998, a separate test for Roundup-Ready varieties is being grown at two locations, the University of Kentucky farms at Lexington and Princeton. Approximately 65 Roundup-Ready varieties from 20 companies are being tested. The Kentucky Soybean Promotion Board has provided support for conducting the Roundup-Ready variety performance tests.

Also in 1988 about 65 varieties from 17 companies are being tested at six Kentucky locations in the conventional variety tests. An evaluation of soybean cyst nematode resistant varieties has been conducted in two locations in both 1997 and 1998. The Kentucky Soybean Performance Tests also provides multiple environments for the latter stages of testing of soybean lines considered for release by the University of Kentucky soybean breeding project. For example, the newly released soybean line KY91-1214 was tested in ten environments during two years within these tests.

Zinc Fertility Study on Corn

L. W. Murdock and P. Howe

As corn yields continue to increase, management of soil nutrients becomes more important. Intensive cropping in which large amounts of plant nutrients are removed increases the likelihood of micronutrient deficiencies. Zinc is one of the micronutrients which has been proven to affect corn yields.

Zinc deficiency has been found to be related to sandy soils with low organic matter, a high pH, and high available soil phosphorus levels. Zinc deficiency symptoms are more severe in years with a cold, wet spring. It is recommended that tissue samples and soil tests be taken to determine soil zinc availability when deficiency is suspected. The critical level of zinc in the corn ear leaf tissue in Kentucky was determined to be 17 ppm.

The University of Kentucky soil testing laboratories use Mehlich III extract for zinc. The soil test zinc level for adequacy increases as the pH and phosphorus in the soil increase. The zinc soil test levels of adequacy were based on a previous study using zinc soil test values extracted with 0.1 N HCl. The previous study was conducted in central and south central Kentucky and corn yield response to zinc fertilizer was determined with these soils which are naturally high in phosphorus.

The objectives of this study were to determine the accuracy of the Mehlich III zinc soil test as related to zinc deficiency in corn with less than 17 ppm zinc in the ear leaf. This was done by surveying Kentucky soils not naturally high in phosphorus. Second, we attempted to determine the amount of zinc fertilizer needed to raise the zinc ear leaf above the critical level.

Field Survey

A field survey was used to determine the accuracy of Mehlich III zinc soil test by relating soil test to zinc deficiency shown by corn tissue analysis. The survey was conducted on 33 corn fields in six counties in west Kentucky. Soil samples at 2-, 4-, and 6-inch depths, and tissue samples were collected at each site. Given the phosphorus, pH, and zinc soil test values, the available zinc for the corn plant could be predicted. The tissue analysis allowed a confirmation of the soil analysis using Mehlich III.

Table 1. Zinc soil test level of adequacy compared to tissue analysis in corn.

				% Error	
Number Fields	Tillage	Sample Depth	Correct %	Type 1[a] %	Type 2[b] %
26	No-till	0-4"	76	15.5	8.5
7	Conventional	0-6"	95	4.5	0

[a]Type 1 error - Recommends zinc when not needed
[b]Type 2 error - Zinc not recommended but needed

As can be seen in Table 1, of the 33 fields, 26 were no-till fields and 7 were conventional. In the no-till fields with a sample depth of 0 to 4 inches, the predicted zinc soil test level of adequacy, as stated in AGR 1, was correct 76 percent of the time as compared to tissue analysis. The conventional till fields with a sample depth of 0 to 6 inches were correct in predicting the level of adequacy as compared to tissue analysis 95 percent of the time. In 24 percent of the no-till fields the zinc soil test level of adequacy was incorrect, but 15.5 percent of those erred on the safe side, where zinc was sufficient in the corn ear leaf, but zinc fertilizer was recommended.

Zinc Fertilizer Rate Study

A zinc fertilizer rate study was conducted to determine the rate at which zinc fertilizer raises the zinc ear leaf. A replicated study on corn was established on a Clifty Gravelly silt loam soil in Trigg County.

Five levels of zinc in the form of ZnSO4 were added to each of four replications. Corn ear leaf samples from each treatment were collected and analyzed. The ear leaf zinc increased by approximately 1.75 ppm per 5 lb/A of fertilizer zinc added. The zinc in the ear leaf would increase by about 3.5 ppm if 10 lb/A zinc were added and about 5.3 ppm if 15 lb/A zinc were added. Based on the field survey, if zinc is deficient, 10 lb/A of added zinc fertilizer will be sufficient 83 percent of the time and 15 lb/A additional zinc would be sufficient in 100 percent of the cases. It is concluded that the zinc fertilizer recommendation should be 10 to 20 lbs zinc/A for soil with less that 150 lb/A soil test phosphorus. This recommendation is based on Mehlich III zinc and phosphorus soil test levels.

Food and Specialty Corn Breeding and Genetics

C. G. Poneleit, R. Green, G. Swango, W. Pearce, and J. Roberts.

Breeding corn for food quality has been done at the University of Kentucky (UK) since the earliest days of hybrid corn breeding. Improving white corn for food use has always been an objective of the corn breeding project. Many white endosperm inbred and hybrid releases have been recorded. The most recent improvement programs began in 1979 with the participation of the UK corn breeding project in the National White Food Corn Test. At the same time, breeding for white endosperm food corn was renewed. The National White Food Corn Test is a cooperative test among at least six public and an equal or greater number of private breeding research programs. The American Corn Millers Federation provides funds to conduct the tests which evaluate newly released and prospective white endosperm hybrids. Most of the hybrids are privately developed but often contain inbred lines derived from publicly developed germplasms. Development of improved white endosperm germplasm is the primary objective of the Kentucky corn breeding project and is also supported by the American Corn Millers Federation as well as by public funding. Seven narrow base, white endosperm food corn germplasms have been developed and released by the Kentucky program. Although these germplasm releases are not used directly as corn hybrids, private seed company breeders use them within their own programs to extract new white endosperm inbreds directly or to improve the genetic basis of their other breeding lines. Most recently, the Kentucky breeding program has begun individual conversions of white endosperm lines and populations, previously developed by the Kentucky breeding program, to hi-lysine, waxy, or hi-amylose endosperm types. Each of these conversions has specific potential uses as food corn or as a unique value-added grain commodity. Future improvements in white endosperm corn are likely to provide protein and starch modified lines and populations that can add value to the Kentucky corn crop.

The breeding work for hi-lysine, waxy, and hi-amylose breeding is aided by the Corn Quality Laboratory now in operation in the Agronomy Department as part of the corn breeding program. Analyses for these chemical components of the corn endosperm are facilitated by large numbers of analyses possible by the Near Infrared Reflectance Spectroscopy instrument in the lab. The Corn Quality Laboratory is a cooperative project with the Kentucky Corn Promotion Council.

Hybrid Corn Performance Test

W. L. Pearce, C.G. Poneleit, and J. Roberts.

The Hybrid Corn Performance Test provides unbiased performance data of commercially available corn hybrids sold in Kentucky. This year, 124 hybrids will be evaluated for agronomic performance at seven locations in the state. In 1997, the data were made available to county agents, seedsmen, and farmers on a data diskette with convenient user friendly software, along with the customary printed progress report. The diskette and software allow the user to examine all of the data presented in the progress report using a desktop computer. Also, evaluations of crude grain protein were obtained from all 132 hybrids at seven locations in 1997. In 1998, the performance test will be evaluating the hybrids in three tests—Early, Medium, and Late—at seven locations. Also, we will be testing 16 TC High Oil Blends at two locations. We will be releasing this data in the 1998 Progress Report. In 1998, cooperative support of the Kentucky Corn Promotion Council will allow the acquisition of up-to-date field equipment which will significantly improve the efficiency of corn performance testing.

Resistance to Fusarium Head Blight in Soft Red Winter Wheat

D. A. Van Sanford, B. Zeng, and C. S. Swanson

In 1991, Fusarium head blight, or head scab, caused losses approaching $50 million in the soft red winter (SRW) wheat crop in Kentucky and much of the eastern wheat region. Each year since then at least some of our wheat producing counties have been hard hit by head scab. Conservation tillage has been cited as a major reason for the increased incidence of head scab in the spring and SRW wheat crops. As our farmers plant more of their wheat no-till into corn residue, the incidence of head scab may increase.

Head scab can greatly reduce wheat yield and test weight as well as food and feed quality. Direct yield losses come from shriveled "tombstone" kernels that are expelled from the combine, while test weight is reduced by the shriveled kernels that remain. Indirect yield losses come from reduced seed germination and vigor, resulting in poor stands.

Scab causes additional losses through the production of mycotoxins such as doxynivalenol (DON), a vomitoxin, which can cause livestock toxicosis or feed refusal. Grain with mycotoxins may be severely downgraded or rejected entirely in commerce.

Resistance to Scab

There appear to be two components of resistance to head scab: 1) initial resistance to infection and 2) resistance to the spread of the fungus through the wheat head. Initial resistance to infection is thought to be controlled by many genes (difficult to breed for, like yield), while resistance to spread of infection may be under the control of just a few genes (easier to select for). Chinese wheats such as Sumai 3 and Ning 7840 are widely regarded as the most resistant wheats, possessing both components of resistance. Both of these wheats are Chinese spring types, completely unadapted to Kentucky and probably possessing numerous undesirable traits. To transfer this resistance into our material will be very time consuming and require a great deal of effort. Prior to undertaking this project, we have begun to screen adapted SRW wheats along with 30 Chinese winter wheats from Shandong Agricultural University for resistance to head scab. In 1997, we screened a number of adapted SRW varieties and breeding lines in the field near Lexington, Kentucky. Resistance to initial infection (Type I) was evaluated under mist irrigation (Table 1). Yield levels of all entries were quite low due to the very high levels of head scab. We did observe varietal differences, however. The University of Kentucky's recent release, "Foster," showed some apparent tolerance to the disease. This research will be repeated in the field and greenhouse in 1998.

Table 1. Response of SRW wheats to infestation of Fusarium graminearum under mist irrigation, Lexington, Kentucky, 1997.

Variety	Incidence	Severity	Index	Grain Yield (bu/A)
Coker9803	60.33	31.67	19.11	23.58
Foster	63.00	25.33	15.96	24.60
Coker9633	73.00	43.33	31.63	20.14
Cardinal	73.33	27.33	20.04	17.64
Patterson	74.00	43.00	31.82	16.62
Pio2510	76.67	34.00	26.07	21.90
Pio2552	77.67	49.00	38.06	17.02
Madison	78.33	45.00	35.25	21.15
Caldwell	78.67	38.67	30.42	17.36
Clemens	78.67	38.33	30.16	20.11
Jackson	79.33	37.00	29.35	17.71
Elkhart	80.00	65.67	52.53	16.63
KY86c-61-8	81.33	36.00	29.28	17.13
Pio2540	81.33	51.67	42.02	19.36
Pio2684	83.33	62.00	51.67	12.45
Verne	84.33	55.33	46.66	17.58
Clark	85.33	27.67	41.24	22.78
Pio2568	85.33	48.33	23.61	19.30
Pocahontas	85.67	50.00	42.83	15.06
Becker	86.33	48.67	42.02	14.27
Ernie	86.67	55.33	47.96	13.07
FFR555	87.00	54.00	46.98	13.99
Mean	79.00	43.90	35.20	18.10
CV (%)	13.60	16.90	22.10	20.70
LSD (0.05)	17.60	12.10	12.70	6.10

No-Till Wheat

L.W. Murdock, J.H. Herbek, J.R. Martin, D.E. Hershman, D.W. Johnson, and J. James

No-till wheat production has been practiced in Kentucky for many years. Currently, about 26 percent of the wheat acres in Kentucky are no-till planted. Many farmers remain skeptical of the practice and feel significant yield is sacrificed with the practice.

Previous research in the 1980s by the University of Kentucky showed favorable results. With these conflicting reports and experiences, the Kentucky Small Grain Growers Association entered into a cooperative effort with the University of Kentucky to take an intensive look into no-till wheat.

Research Approach

A replicated trial was established on a Huntington Silt loam soil at Princeton, Kentucky, in the fall of 1992. Two small adjacent fields were placed in a three-crop, two-year rotation of corn, wheat, and double-cropped soybeans. Both no-till and conventionally tilled (chisel-disk) wheat were planted and compared with different nitrogen, fungicide, and herbicide treatments. The corn and double-cropped soybean crops were planted no-till. Stand counts, weed control ratings, disease, and insecticide ratings, as well as yield and compaction results, were obtained for wheat. The long-term effects of the two different wheat tillage practices on the succeeding soybean and corn crops was also measured.

Results

Five years of results (1993-1997) are presented in this report.

Yields. The five-year average yields have been high (Table 1). The conventional till planted wheat averaged about five bu/A more than the no-till wheat. The yields of no-till wheat have been significantly lower than wheat planted with tillage two of the five years, due to compaction one year (1993) and severe winter-kill in 1996. The yields of no-till wheat have been similar or exceeded that of conventionally tilled wheat the other three years.

Stands. The number of emerged plants was lower with no-till. Planting at the rate of 32 viable seeds/sq ft, the final stands averaged 25 and 28 plants/sq ft for no-till and conventional till, respectively. Both stands were high enough for maximum yields. Seeding rates may need to be increased by ten percent as one moves from conventional till to no-till seeding.

Nitrogen Rates. No-till wheat may require more nitrogen than conventional tilled wheat. Nitrogen in this trial was managed for intensive production with one-third applied at Feekes stage 3 (early February) and the remainder at Feekes stage 5 (mid-March). The no-till wheat sometimes appeared to be slightly nitrogen deficient before the second application, but in most years this had little effect on yield. Increasing the nitrogen rate from 90 to 120 lbs/A had only a small effect on yield for the five years (Table 1). Although more nitrogen is recommended for no-till plantings, it may not always be justified. The years that the high rate of nitrogen resulted in higher yields were when severe, late winter freezes resulted in wheat damage and when excessive amounts of rain fell after the first application of spring nitrogen.

Table 1. Summary of five year wheat results (1993-97).

Treatment Comparison	Yield (bu/A)	Wheat Stands (plants/sq ft)
Tillage Effect		
Conventional	95	25
No-Till	90	28
Nitrogen Rate (lb/A)		
No-Till (90)	88	
No-Till (120)	90	
Conventional (90)	93	
Conventional (120)	96	
Fungicide		
No-Till with Fungicide	91	
No-Till no Fungicide	88	
Conventional with Fungicide	95	
Conventional no Fungicide	94	
Weed Control		
No-Till Fall Gramoxone Extra + Spring Harmony Extra	92	
No-Till Fall Harmony Extra	92	
No-Till Spring Harmony Extra	90	
No-Till Check	75	

Nitrogen Application Time. The last two years (1996 and 1997) have included treatments with different rates of nitrogen applied at different times. Each year, the highest yield has been obtained with a 120 lb/A nitrogen rate with half of the nitrogen applied in early February and the remaining half applied in late March just prior to jointing.

Fungicides. Preventive disease control applications of fungicides were managed for intensive production. Two fungicide applications were made each year: prior to flag leaf emergence (Tilt) and at heading (Bayleton + Mancozeb). Varieties susceptible to the common foliar diseases were selected for planting. Diseases which can be controlled by a fungicide were of no significance during the five years of this study. Therefore, fungicide applications had little effect on either tillage system (Table 1).

Weed Control. Good weed control was obtained in no-till wheat by three treatments: 1) Harmony Extra applied in the fall, 2) a contact herbicide at planting plus Harmony Extra in the spring, and 3) Harmony Extra in the spring (Table 1). Yields were equivalent for all three herbicide treatments. Wild garlic, which is sometimes associated with no-till wheat, was not a significant problem when Harmony was used. Without fall or spring herbicides, weed competition was a problem (especially with common chickweed and brome grasses) and resulted in lower yields (no-till check).

Insects. Insects were monitored by use of scouting and traps. No significant insect infestations occurred. A few aphids, true army worms, and cereal leaf beetles were present but never approached the economic threshold. The wheat seed was treated with Gaucho before planting for Barley Yellow Dwarf protection the last four years of the trial. In the first year, Barley Yellow Dwarf was present and was vectored by a small number of aphids.

Diseases. There was no significant disease on any treatments over the five years except for Barley Yellow Dwarf during the first year. This is consistent with no yield increases from the use of fungicides. Also, head scab, which is sometimes associated with no-till, was practically absent. The Barley Yellow Dwarf Virus symptoms were significantly higher in the no-till treatments the first year of the trial (1993). This was probably one of the factors which reduced yields in the no-till plots that year.

Soil Compaction. Corn harvest on a wet soil prior to wheat planting left a compacted and depressed zone in each plot the first year (1993). This was removed with tillage in the conventionally tilled wheat, but caused decreased yields in the no-till planted wheat. There has been no evidence of its continued effect after the first year.

Corn and Soybean Yields After Wheat. Soybeans are planted no-till immediately after wheat harvest and corn is no-till planted the next year. Both crops resulted in a higher yield when planted after no-till wheat as compared to the conventionally tilled wheat. The differences were about five percent and are not statistically different. The soybean yields were 43.4 versus 41.8 bu/A and the corn yields were 201.3 versus 189.4 bu/A after no-till and conventionally tilled wheat, respectively.

Soil Property Changes. The main difference between the two planting systems and their effect on soil properties is the amount of organic matter in the top three inches of soil. There appears to be about 0.3 percent more organic matter in this layer if the soil is continuously no-tilled as compared to tillage every second year to plant wheat. There appears to be little difference in soil density, soil strength, and soil nutrients between the two tillage systems.

Summary

No-till wheat can produce as well as conventionally tilled wheat when intensively managed. Stand establishment and weed control appear to be where the greatest changes in management are necessary.

Chlorine Fertilization Of Wheat

L.W. Murdock

Chlorine (Cl) is an essential nutrient for plant growth that receives very little attention because it is usually available in adequate amounts for most conditions and crops. There have been a few documented cases of Cl deficiency in some crops in the Great Plains. Most of this was on wheat. In addition to its importance for plant growth, adequate Cl levels also seem to help suppress some foliar and root diseases of wheat with take-all being the most notable. Cl deficiency in the eastern United States is very rare, and there is little research on the subject. Deficiencies will mainly occur on very sandy soils where very little potassium fertilizer (in the form of potassium chloride) has been used. Chlorine is supplied in the wind and rain, especially in areas with coastal influence. Another major source of chlorine is from muriate of potash (KCl), the most common form of potassium fertilizer. It is 50 percent chlorine and widely used on U.S. croplands.

A trial was established in 1993-94 looking at Cl fertilization of wheat and its effect on yield and residual soil test levels.

Methods

This trial was established on a Tilsit silt loam soil at the West Kentucky Research and Education Center in Princeton, Kentucky. The soil had received little fertilizer prior to 1980. Between 1980 and 1989, the soil received medium to high rates of KCl as recommended for K by soil tests. No fertilizer was applied from 1990-1993. The soil test was 200 lbs/A of K in the fall of 1993. Cl was added at the rate of 40 lbs/A to one treatment (in the form of KCl) and none to the other. The non-chlorine treatment received the same amount of K in the form of K2SO4. The amount of Cl in the soil was tested prior to the fertilizer additions.

Table 1. Effect of chlorine on wheat yield and test weight.

Chlorine (lb/A)	Yield (bu/A)	Test Weight (lb/bu)
0	91.7a*	56.8a*
40	88.1a	57.7a

*Values with the same letter in each column are not significantly different.

Results

Soil Test: Research in South Dakota indicates that the top two feet of soil should be sampled and the soil is deficient if less than 30 lb/A of chlorine is available. The soil at this site had 320 lbs/A of chlorine available in the top two feet before fertilizer additions. This is a high amount of Cl, but is probably not much different from most fields in Kentucky. This field had received no KCl in the four years prior to the soil test. There would be no expected response from chlorine additions.

Yields and Test Weights: The yields from this experiment were high and were not affected by chlorine fertilization (Table 1). Since the chlorine in the soil was at such high levels, the lack of response was expected. There was also no effect of the chlorine fertilization on test weight.

Summary

Although chlorine fertilization is a concern for wheat in the Great Plains, it probably has no merit in Kentucky. Most potash is supplied by KCl which is 50 percent Cl and should supply large amounts of chlorine to most fields. The soil test levels of chlorine are probably high in the top two feet of soil in most Kentucky fields due to past fertilization with KCl and natural sources.

Nitrogen Rates For High Yield Wheat

L.W. Murdock, J. James, C. Bowley, and S. Jones

The farmers in Kentucky have made large strides in increasing the production levels of wheat over the last ten years. The state average yields have increased from about 40 bu/A to about 55 bu/A. One of the important input changes was the amount of nitrogen and the application time. High yields are more commonly obtained by producers who manage each practice in their wheat program to improve the chance of a high yield. This is termed intensive management. In order to determine the proper rate of nitrogen for intensively managed wheat a series of studies over a four-year period (1992-1996) was accomplished in cooperation with Miles Intensive Wheat division, Wheat Tech, and the University of Kentucky. The Kentucky Small Grain Grower's Association helped fund the program.

Table 1. Effect of different nitrogen rates and time of application on intensively managed wheat.

Nitrogen Rate (lb/A)		Yield (bu/A)	
February	March	Average	Range
0	0	56	36-73
0	40	70	58-85
0	60	87	69-104
0	80	86	76-104
0	100	93	76-121
0	120	93	81-117
40	0	73	54-102
40	40	90	75-119
40	60	98	88-114
40	80	99	76-129
80	0	87	77-118
80	20	97	79-127
80	40	98	85-129

Table 2. Nitrogen rates resulting in maximum yields for intensively managed wheat.

N Added in February	N Needed in March for Optimum Production	Total N
(lb/A)	(lb/A)	(lb/A)
0	95	95
40	65	105
80	25	105

Methods

The studies were carried out at three locations in Kentucky on soils that were well adapted for wheat production. The management practices (planting date, seeding rate, disease and insect control, etc.) were all managed for high yields. The nitrogen was added at two times during the spring: 1) green-up (Feekes 3) in early February and 2) just prior to joint (Feekes 5) in late March (usually). The nitrogen sources were either 28 percent UAN or ammonium nitrate. Yields were determined by harvesting with small plot combines and all yields were adjusted to 13.5 percent moisture.

Results

Table 1 shows the results for each nitrogen treatment. The average yields include the three locations over the four-year period and the range is the highest and lowest yield obtained in any of the four years at any of the three locations. It is easy to see from the range that even with intensive management, yields vary greatly between years and locations. There was a 5 bu/A advantage for a nitrogen application split between Feekes 3 (green-up) and Feekes 5 (just prior to jointing) as opposed to a single application at Feekes 5. All of the yield advantage had been realized when the total spring application reached about 100 lb/A of nitrogen. There was almost no difference in yield between the 40 lb/A nitrogen added at Feekes 3 and the 80 lb/A nitrogen added at Feekes 3.

When the yields and nitrogen rates were analyzed more carefully, one can find the nitrogen rate which resulted in maximum yields for each nitrogen regime (Table 2). These nitrogen rates are excellent guides for farmers with intensively managed wheat, but will need to be adjusted for any unusual conditions such as excessive rainfall, severe freeze damage, manure applications, or easily lodged varieties.

Summary

Spring nitrogen rates on intensively managed wheat in Kentucky should be about 95 lb/A for a single application at Feekes 5 and about 105 lbs/A for an application split between Feekes 3 and Feekes 5. Adjustments for any unusual conditions would need to be made.

Amisorb Effect On Corn

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Amisorb is a product that is being marketed as a nutrient absorption enhancer. It is a polyaspartate, a very large molecule that never enters the plant root, but is reported to affect root growth and increase nutrient uptake. This material has been investigated by the University of Illinois in hydroponic conditions and shown to result in large increases in root growth in several different crops. Does this mean it will improve corn production in the field? Amisorb was evaluated in field conditions on corn in 1996 and 1997 to see if it would improve crop uptake of nitrogen and improve yields. Two different experiments were carried out in 1996 and 1997 to help answer these questions.

Methods

1996: Corn was no-till planted on a well drained soil with excellent weather conditions for high yields. Nitrogen was added at three different rates with and without Amisorb. The nitrogen was added one-half at planting and one-half five weeks after planting. The Amisorb was added with the nitrogen at the rate of 1 qt/A at each application for a total of 2 qts/A. Nitrogen concentration in the ear leaf at silking was measured as well as the yield.

1997: The corn was no-till planted on somewhat poorly drained soils. Excessive rainfall early caused long periods of saturated soils which resulted in crop stress, nitrogen losses, and lower yields. Amisorb was applied at the rate of 2 qt/A either broadcast with the nitrogen or beside the row with a row fertilizer. The nitrogen rate was 150 lb/A of N, all broadcast at planting or with 22-20-0 lbs/A of N-P2O5-K2O applied beside the row and the remainder broadcast.

Results

1996: The yields and nitrogen ear leaf results are shown in Table 1. The nitrogen increased both yield and ear leaf concentrations with increased rates. Amisorb increased yield and ear leaf concentration only where no nitrogen was added. When nitrogen fertilizer was added the Amisorb had no effect. It also had no effect on the concentration of the other tested nutrients in the ear leaf.

Table 1. Effect of Amisorb and nitrogen rates on yield and ear leaf nitrogen concentrations of corn in 1996.

N Rate (lb/A)	Amisorb (qt/A)	Yield (bu/A)	Ear Leaf N (%)
0	0	79a*	1.5 a*
0	2	98b	1.7bc
75	0	173c	2.5cd
75	2	177c	2.4cd
150	0	206d	2.6d
150	2	196d	2.7d

Values with different letters in the same column are significantly different.

Table 2. Effect of Amisorb and nitrogen placement and timing on yield and ear leaf nitrogen concentrations of corn in 1997.

Treatment	Yield (bu/A)	Ear Leaf N (%)
1. N at planting	80 b*	2.5 ab*
2. N at planting + Amisorb	81 b	2.3 bc
3. Row fertilizer	91 ab	2.4 bc
4. Row fertilizer + Amisorb	81 b	2.2 c

Values with different letters in the same column are significantly different.

1997: The yields and nitrogen ear leaf results are shown in Table 2. Amisorb had no effect on the yield or the ear leaf concentration. If this material was going to enhance the nutrient uptake, this situation should have been an ideal opportunity.

Summary

The use of Amisorb to enhance the root growth and nutrient uptake of corn in a field situation appears to have limited possibilities. In these trials, there was no evidence of it increasing the performance of the corn under normal production conditions.

Relationship between Soybean Mosaic Virus and *Phomopsis* spp. Infection of Soybean Seed

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Phomopsis seed decay caused by the *Phomopsis/Diaporthe* fungal complex is generally recognized as a major cause of poor soybean quality, and may significantly reduce yield under severe conditions. Seed infection by these fungi occurs primarily during or after physiological maturity (growth stage R7), and under favorable weather conditions (high temperature, rainfall, and relative humidity).

It has been suggested that infection by soybean mosaic virus (SMV) increases the incidence of Phomopsis seed decay. SMV is carried from one season to the next by infected seeds. Infected plants growing from infected seeds provide the source of the virus that is transmitted by aphids to other healthy plants in the field.

This investigation tested the hypothesis that infection by SMV predisposes soybean seed to *Phomopsis spp.* infection. Since genetic resistance to SMV exists, it was possible to compare the incidence of Phomopsis seed decay in both the presence and absence of SMV. The value of a genetic trait, however, often depends on the background genotype in which the trait is expressed. Two pairs of soybean lines were used in which one member of each pair was susceptible to SMV (Clark and Williams cultivars) and the other member was resistant due to the fact that it carried the resistance gene Rsv1 (Clark-Rsv1 and Williams-Rsv1 isolines).

The lines were planted as hill plots in 1996 and 1997 at Spindletop Farm in Lexington, Kentucky. For each susceptible line, two plots were planted: one plot was hand-inoculated with SMV during vegetative growth to ensure SMV infection, while the other plot remained virus-free. To prevent SMV transmission by aphids between plots, a cage (wooden support frame covered with a mesh screen) was erected to enclose the plots. A source of *Phomopsis spp.* (infested straw and spore suspension) was provided for both the susceptible and the resistant plots.

Pods were marked with acrylic paint at the beginning stage of seed development (seeds were 3-5mm in diameter), so as to later identify seeds at the same stage of development. Marked pods were sampled at two different stages of seed maturation: the yellow pod stage, where both the pod and seeds were yellow in color and the seeds were at approximately 55 percent moisture content; and at harvest maturity, where the pods had turned brown in color, but had dried down to about 14 percent moisture content. The influence of SMV infection on the incidence of Phomopsis seed decay was evaluated on the sampled seeds by a bioassay test on acidified potato dextrose agar.

Table 1. Incidence of Phomopsis seed decay on SMV susceptible and resistant soybean lines, 1996-1997. Data were collected at the yellow pod stage (YP) and at harvest maturity (HM).

	Incidence of Phomopsis spp.			
	1996		1997	
Treatment	YP	HM	YP	HM
	%			
Clark-Rsv_1	10	7	5	8
Clark -- no SMV	0	17	12	7
Clark -- SMV infected	57	65	82	50
Williams-Rsv_1	0	10	2	0
Williams -- no SMV	3	3	3	0
Williams -- SMV infected	30	63	85	19

The results show that in the absence of SMV infection, whether in the SMV resistant plots, or the SMV susceptible plots that were not inoculated with the virus, the incidence of Phomopsis seed decay was very low at both stages of seed maturation (Table 1). However, in the presence of SMV infection the incidence of *Phomopsis spp.* infection increased significantly across both years and cultivars. We therefore concluded that the data suggest that infection by SMV predisposes soybean seed to Phomopsis seed decay.

Several studies have shown that Phomopsis seed decay causes poor germination and vigor in infected soybean plants, and is a primary factor in reducing soybean seed quality during hot, humid weather. Seed infection by *Phomopsis spp*. must be controlled so as to produce high quality soybean seed. Our results indicate that soybean seed producers in Kentucky would benefit by selecting soybean varieties with SMV resistance.

The Saturated Cold Test for Corn Seed Vigor

J. Woltz and D. TeKrony

The soil cold test is the most popular method of determining corn seed vigor. The cold test uses low temperatures (50ºF), high soil moisture, and the presence of soil-borne plant pathogens to simulate stressful environmental conditions that can be associated with early-season corn planting. Three methods for conducting the cold test are presently described by the major seed testing associations; however, a new cold test method, the saturated method, has recently been proposed. This study evaluated the factors that cause variability using the saturated cold test method.

Topsoil from a Lanton silty clay loam soil was used to conduct this experiment. The soil was sieved through a 6 mm screen prior to treatment. Three soil treatments were tested : (1) dry soil with eight percent moisture content, (2) wet soil with 20 percent moisture content, and (3) finely ground dry soil sieved through a 1 mm screen. Four Captan-treated seed lots that had high germination (>88 percent) were planted with the embryo in contact with the soil surface into the three soil treatments using two procedures : (1) the seeds were placed on the soil surface or (2) the seeds were firmly pressed into the soil. After the seeds were planted, the trays were placed in a 50ºF chamber for seven days, followed by four days at 78ºF. The seedlings were classified as normal and abnormal, with the ungerminated seed classified as dead.

There were no differences in cold test germination between the wet and dry soil treatments for any seed lot (Table 1). Differences between the ground and the raw soil only occurred for the lowest vigor seed lot (1) when the seeds were placed on the soil surface. When the seed was pressed into the raw, dry soil treatment, only seed lot 1 had reduced germination. Cold test germination was reduced by 15 to 30 percentage points for all seed lots when the seeds were pressed into the finely ground, dry soil.

The saturated method was satisfactory for conducting the cold test, provided the seeds were not pressed into the soil at planting. Previous experiments have shown that this method yields results that are similar to other cold test methods. Caution must be used, however, with the saturated method. The soil moisture is approximately 60 percent, which is much higher than the field capacity (~30 percent) for this soil. At high soil moisture levels (above field capacity), anaerobic conditions occur within the soil as water fills the pore spaces among the soil particles. The use of finely ground soil also contributes to these anaerobic conditions by further reducing pore space. When the seeds were pressed into the finely ground soil, germination was greatly reduced for all seed lots. Therefore, caution should be used when planting seeds in the saturated cold test to ensure that the seeds are placed on the soil surface (not pressed in). Under these conditions, the saturated cold test can be used as a valuable tool for the identification of high quality seed lots that will give farmers adequate stands in stressful, early-season conditions.

Table 1. Cold test germination for treated seed lots from four different hybrids and five test variables for the saturated method.

	Seed Lot			
Soil Treatment†	**1**	**2**	**3**	**4**
		%		
Raw - Wet	63	82	80	95
Raw - Dry	69	85	81	97
Raw - Dry, EP	51	89	87	97
Screened - Dry	43	88	79	95
Screened - Dry, EP	25	73	54	65
LSD (.05)	9	11	15	5

†Soil Treatment:

Raw - Wet	Raw soil with particle size less than 6 mm, moisture content 20%
Raw - Dry	Same as above except soil was dried to 8% moisture
Raw - Dry, EP	Same as Raw-Dry except seeds pressed into soil at planting
Screened - Dry	Screened soil with particle size less than 1 mm, moisture content 8%
Screened - Dry, EP	Same as Screened-Dry except seeds pressed into soil at planting

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