Benefiting Farmers, Society, and the Environment

24th Annual

SOUTHERN CONSERVATION TILLAGE CONFERENCE for SUSTAINABLE AGRICULTURE

July 9-11, 2001
Oklahoma City, Oklahoma

USDA NRCS
Natural Resources Conservation Service

OSU

Proceedings of the

24th Annual Southern Conservation Tillage Conference for Sustainable Agriculture

Conservation Tillage: Benefiting Farmers, Society, and the Environment

Oklahoma Cooperative Extension Service
Oklahoma State University
Stillwater, Oklahoma 74078

Oklahoma Agricultural Experiment Station
Misc. Pub. MP – 151

July 9-11, 2001
Embassy Suites
Oklahoma City, Oklahoma

Edited by
James H. Stiegler

Plant and Soil Sciences Department, Oklahoma Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma 74078

Suggested Reference Citation:

Unger, P. W. and R. L. Baumhardt. 2001. Historical development of conservation tillage in the southern Great Plains. p. 1-19. *In* J. Stiegler (ed.) Proceedings of the 24th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Oklahoma City, Oklahoma. July 9-11.

This proceedings and the companion Southern Conservation Tillage Conference for Sustainable Agriculture are activities of the Southern Extension and Research Activity – Information Exchange Group 20 (SERA-IEG-20), which is sponsored by the Oklahoma Agriculture Experiment Station, the Southern Association of Agricultural Experiment Station Directors, the Southern Association of Agricultural Extension Services Directors, and the Cooperative State Research, Education, and Extension Service (CSREES).

Foreword

Less than 100 years as a state, Oklahoma still retains much frontier flavor. People are friendly always with a quick greeting, a kind word, and little pretense. Agriculture and petroleum remain vital industries, though in recent years there are many manufacturing and service industries that are adding to the state's economic diversity.

Not only is Oklahoma's economy diverse, the geography and climate are also. In sections of Southeastern Oklahoma, annual rainfall exceeds 50 inches. Forests similar to those in the plains of the Gulf States abound and forest products are an important part of the economy. In moving from east to west, for every 15 miles there is one less inch of rain per year. At the western end of the Panhandle adjacent to New Mexico, annual precipitation is approximately 14 inches. In the eastern part of the state, elevations are as low as 500 feet above sea level. In the High Plains at the western end of the Panhandle elevations exceed 4000 feet.

Each year there are parts of Oklahoma, if not the entire state that have extended periods of no precipitation. Undoubtedly, you have heard of the Dust Bowl era in the late 1930's. During a prolonged drought and because there was little ground cover, winds picked up large quantities of soil and dust and created a cloud that many reported virtually blocked the sun. However, as you travel in the state you will see flood control structures - when precipitation does occur, rates can be very high. These conditions - both lack of rain and excessive rain - present great challenges to agricultural producers and to the organizations and institutions that assist them.

Through much research and education, Oklahoma State University (OSU) has provided technology and information that has helped agriculturists to adopt systems that lead to enhanced productivity utilizing scarce moisture, yet able to maintain soils when heavy rains occur. Conservation tillage has been a vital part of these strategies. Occurrences such as the Dust Bowl and large amounts of soil being eroded into streams and rivers are virtually nonexistent. However, we continuously seek ever better procedures and practices.

Many of the techniques of conservation tillage have also helped lead to overall improved natural resource management. In addition to better crop and livestock productivity, there are enhanced practices that are aimed at concurrently improving wildlife habitat. These practices are helping to provide economic diversity in rural communities as fee based hunting, bird watching, and other activities become more prevalent.

OSU has worked with many partners including Federal and state agencies, agricultural and conservation organizations, and numerous individuals. Additionally, we have worked with many of you. Sharing of information and technology, even before it is published, is a great tradition in the Land Grant and agricultural communities.

The Southern Conservation Tillage Conference is an important forum for learning and for establishing new professional connections. Oklahoma and Oklahoma State are excited that you have chosen to be with us in 2001. You and we, all of us, and those whom we serve, will benefit greatly from sharing our knowledge and know how.

D.C. Coston
Associate Director
Oklahoma Agricultural Experiment Station

Conference Organizing Committee:

James H. Stiegler
Oklahoma State University
Plant and Soil Sciences Department
368 Ag. Hall
Stillwater, OK 74078
Phone: 405.744.6421
Fax: 405.744.5039
Email: jhs@mail.pss.okstate.edu

Jack Eckroat
Oklahoma State University
Plant and Soil Sciences Department
368 Ag. Hall
Stillwater, OK 74078
Phone: 405.744.7059
Fax: 405.744.5039
Email: eckroat@mail.pss.okstate.edu

Srinivas Rao, USDA Agricultural Research Service
John Daniel, USDA Agricultural Research Service
Ken Matlock, USDA Natural Resource Conservation Service
Keith Vaughan, USDA Natural Resource Conservation Service
Waddell Altom, Noble Research Foundation
Jeff Ball, Noble Research Foundation
Robert Woods, OSU NE Area Agronomist
Roger Gribble, OSU NW Area Agronomist
Mark Gregory, OSU SW Area Agronomist
Ron Justice, Grady Co., Extension Educator
Brad Tipton, Canadian Co., Extension Educator
David Nowlin, Caddo Co., Extension Educator

The organization committee for the 2001 SCTCSA gratefully acknowledges the special assistance and hard work of Vickie Brake, Oklahoma State University, and Ronnie Bloomfield, Noble Foundation, in the assembly and printing of these proceedings.

T A B L E   O F   C O N T E N T S

Posters

HISTORICAL DEVELOPMENT OF CONSERVATION TILLAGE IN THE SOUTHERN GREAT PLAINS

Paul W. Unger and R. Louis Baumhardt[1]

AUTHORS: [1]Soil Scientist (retired) and Soil Scientist, U.S. Dept. of Agriculture, Agricultural Research Service, P. O. Drawer 10, Bushland, TX 79012. Corresponding author: Paul W. Unger, USDA-ARS, P.O. Drawer 10, Bushland, TX 79012. Email: pwunger@tcac.net

ABSTRACT

Tillage that qualifies as conservation tillage according to the general and operational definitions of the term has been used in the southern Great Plains (SGP) for many years, well before the term as currently used became popular. In this report, we discuss early efforts to control soil losses, especially those that occurred during the drought of the 1930s and those associated with cotton (*Gossypium hirsutum* L.) production on sandy soils where soil erosion by wind commonly occurs. We also discuss the development of equipment and practices that are used to control erosion and conserve water throughout the region and their effects on crop production, soil conditions, and related factors. Although adoption of conservation tillage is limited in the SGP, we believe its use is important for conserving soil and water for successful dryland crop production, especially because water for irrigation is limited and being depleted in much of the SGP.

INTRODUCTION

Tillage methods designed to reduce soil losses became available in the southern Great Plains (SGP) following the devastating wind erosion during the 1930s 'Dust Bowl'. The methods used qualify as conservation tillage, based on the broad definition of the term, because they were and are used to control soil losses. Unfortunately, they do not meet the "operational" part of the conservation tillage definition (SSSA, 1997) because inadequate amounts of crop residues were or are available. This definition is based on a 30 percent cover of the soil surface after the next crop is planted. In this paper, we mainly discuss conservation tillage based on the operational definition, but also discuss tillage to conserve soil where adequate or effective residues are not available, as on the sandy soils devoted primarily to dryland cotton (*Gossypium hirsutum* L.) production. However, before discussing development of those and subsequent methods, we give some information about the SGP and the conditions that resulted in development of those methods.

CHARACTERISTICS OF THE REGION

The U.S. Great Plains cover the vast midcontinental region of the United States from about the 100th meridian westward to the Rocky Mountains and from Texas north to the Canadian border. Early explorers called it the "Great American Desert" (Webb, 1931) because precipitation was limited, there were few perennial rivers or springs, and the land was treeless and relatively flat. The explorers viewed the region as undesirable and wholly uninhabitable for people from the eastern United States, a view that persisted until after the Civil War, but it was native range for the bison and home for Native Americans.

The SGP region covers parts of Kansas, New Mexico, Oklahoma, and Texas (Fig. 1). Climate of the region is subhumid in the eastern part and semiarid in the western part. Annual precipitation ranges from about 24 inches at the east to about 12 inches at the west. For 1939 to 1999, it averaged 18.75 inches at the USDA-ARS Laboratory at Bushland, TX, near the center of the region. Besides being limited, much of the precipitation has little or no value for agricultural purposes because it occurs in low amounts per storm (Fig. 2). Other climatic factors at Bushland include average temperatures of 90EF maximum in August and 21EF minimum in January, mean annual wind run of 52,000 miles, and mean annual pan evaporation of 104 inches. In all months, average potential evaporation exceeds average precipitation at Bushland (Fig. 3).

Surface soil textures in the region range from sand to clay. Surface slopes range from <1% in the High Plains to up to 10% in the Rolling Plains. The Ogallala Aquifer, which underlies part of the High Plains, supplies water for irrigation. However, there is little recharge to the aquifer and the water supply is being depleted (Nativ and Smith, 1987). As a result, dryland (nonirrigated) crop production is gaining importance in that part of the region (Musick et al., 1990) and is the usual mode of crop production in other parts of the region. Because of the limited precipitation, water storage in soil is highly important for successful dryland crop production.

The major crops in the SGP are winter wheat (*Triticum aestivum* L.), grain sorghum [*Sorghum bicolor* (L.) Moench], and cotton, which are grown with and without irrigation, and corn (*Zea mays* L.), which is grown only with irrigation. Much of the wheat is grazed by cattle in the fall and winter, with cattle removed in time to allow for grain production. Some wheat is "grazed out," especially when prices are more favorable for cattle than for grain production.

DEVELOPMENT OF THE REGION

The region was settled for agricultural purposes mainly in the late 1800s and early 1900s by cattle and crop producers. Early crop production, however, was limited. For example, a total of only about 650 acres were cultivated in the 26 counties of the Texas Panhandle in 1879 (Price and Rathjen, 1986), but crop production expanded considerably when precipitation was favorable during the 1882 to 1887 and the 1895 to 1906 periods (Johnson and Davis, 1972). Further expansion of the cropland areas occurred during World War I due to the increased demand for wheat in Europe (Hurt, 1981). Expansion continued from 1918 to 1929 due to a "booming" wheat market and annual precipitation that averaged about 4 inches above average in the region. The expansion was aided by agricultural mechanization. As a result, about 40 million acres were developed for crop production by 1929, mainly for monoculture wheat, in the SGP and adjacent portions of the central Great Plains (CGP) (Johnson and Davis, 1972).

For crop production, farmers used tillage methods they had used in the eastern United States or Europe, from which they migrated. The common practice was to "plow up" the native sod, grow the crops, and continue to use clean tillage for successive crops. The method was satisfactory during the early years when precipitation was generally favorable (average or above average), but it led to a major "disaster" during the devastating drought of the 1930s (Johnson and Davis, 1972).

THE "DIRTY THIRTIES"

A major drought occurred in the region from 1931 until 1939, and clouds of dust filled the air for days at a time due to wind erosion on rangeland and cropland. The affected area totaled about 100 million acres. Most severely affected was roughly the area bounded by Big Spring, Texas (south of Lubbock); Pueblo, Colorado; Colby, Kansas; southwestern Nebraska; and Great Bend, Kansas. This area became known as the "Dust Bowl" with the most severely affected farmland being within 100 miles of Liberal, Kansas, which is at the northern edge of the SGP.

The severe wind erosion resulted from the drought that made crop growth largely impossible and the long-term use of clean tillage that buried all crop residues. Practices and equipment were not available to control the erosion, and many farmers abandoned the land when commodity markets collapsed.

Improved management practices now used throughout the "Dust Bowl" area of the 1930s have diminished the potential for wind erosion over much of the region. The cotton producing area on sandy soils around Big Spring and Lubbock, Texas, however, remains at risk, and wind erosion occurs in that area most years. In general, the emergency tillage practices used to control soil losses in that area are covered by the general definition of conservation tillage, but not necessarily the operational definition.

TILLAGE AND RELATED PRACTICES FOR WIND EROSION CONTROL IN THE COTTON-PRODUCING AREA

Dryland cotton on the South Plains of Texas produces small amounts of residues (usually less than 500 pounds per acre of small grain equivalent) (Dollar, 1988), with similar amounts produced on the Rolling Plains. The cotton usually is grown continually and the residue typically is destroyed soon after harvest, thus leaving the surface mostly bare and highly subject to wind erosion during winter and early spring months. Although many factors affect the potential for wind erosion in a given field, some type of tillage that roughens the surface usually is needed because adequate residues are not available to provide erosion control benefits. Most producers for many years have used some "clod-forming" tillage to roughen the soil surface.

Chisel implements often are used to bring large clods to the surface on medium-textured soils. These clods resist the forces of wind and shelter the other erodible soil on the surface. On more sandy soils, the lister-bedder is widely used to form ridges (12 inches tall at 30- to 40-inch spacing) that roughen the surface. The ridges and furrows alter the windspeed and deflect the wind energy away from the erodible soil particles. Lister-bedding is most effective when the ridges are made perpendicular to prevailing winds and when the soil water content is adequate to help form soil clods. Even use of the lister-bedder, however, may not be effective on soils with high sand contents to depths greater than the tillage depth. On such soils, deep plowing that brings clod-forming materials to the surface from the sandy clay loam subsoil horizon is effective for controlling erosion (Dollar, 1988).

Under emergency conditions, that is, when wind erosion is occurring, any practice that can be used to rapidly roughen a rain-smoothened soil surface can help bring erosion under control. For this purpose, commonly-used tools are the "sandfighter" (Woodruff et al., 1972) and rotary hoe. These tools provide a cloddy surface and can be operated at relatively high speeds, thus quickly helping control erosion on large areas. Use of a chisel implement or lister-bedder at wider-than-normal spacings can also provide for erosion control under emergency conditions (Soil Conservation Service, 1955). A major disadvantage of using any surface-roughing operation is that the benefits are not long lasting, often only until the next rain. For erosion control without surface-roughening tillage, practices that involve vegetative materials (residues) have received more attention in recent years.

Producers prefer to grow cotton annually rather than in a rotation with other crops because of economics, i.e., profitability. Growing crops that produce more residues in rotation with cotton that produces little residues can greatly reduce the amount of soil loss. For example, annual soil losses were estimated at 142.8 tons per acre from cotton fields and 3.2 tons per acre from adjacent grain sorghum fields in the Gaines-Dawson County, Texas, area (Brandt and Harris, 1988). When grown in rotation with sorghum and wheat, cotton yield was greater than when grown continually (Keeling et al., 1988; Lyle and Bordovsky, 1987). The use of a crop such as sorghum or millet (Pennisetum spp.) as a windbarrier that modifies the flow of air over the adjacent leeward area can reduce soil losses, but such crops compete with cotton for water and may reduce cotton yields (Bilbro and Fryrear, 1988).

To achieve the erosion-control benefits of residue-producing crops, several studies have used a green fallow approach where wheat is seeded directly where stalks remain standing after harvesting the cotton (Keeling et al., 1989). Using the late fall rain or an irrigation to establish the wheat, a residue cover is grown until March when the wheat is chemically terminated. The "terminated wheat" residues protect the soil during the high wind erosion spring months and, by using no- or reduced-tillage, cotton production can be resumed during the summer as the principle cash crop. Residues retained from terminated wheat provide an additional benefit in reducing evaporation losses from irrigation, thus providing more water for crop growth and yield (Lascano et al., 1994). However, under dryland conditions, rain in the fall may be inadequate to establish the wheat crop and rain in the spring may be inadequate to provide water for establishing the cotton (Baumhardt and Lascano, 1999).

EARLY SOIL CONSERVING TILLAGE

A consequence of the Dust Bowl era was the development of tillage implements to replace the plow or disk that inverted the surface soil and buried the crop residues and, when used excessively, contributed to the severe wind erosion. Included was the Hoeme[2] cultivator that could rip the soil and bring clods to the surface to help control wind erosion (Allen and Fenster, 1986). Crop residues also were retained on the soil surface, provided any were produced. Development of this implement began in 1933 by Fred Hoeme at Hooker, Oklahoma. Some 2000 Hoeme cultivators were distributed before the production and distribution rights for the cultivator were sold to W. T. Graham at Amarillo, Texas, in 1937. The cultivators had steel shanks, which along with similar plows developed by others, were forerunners of modern chisel ~~plows. They we~~re conservation tillage implements based on the general definition of the term. These cultivators also could be equipped with sweeps for subsurface tillage.

[2] The mention of trade or manufacturer names is made for information only and does not imply an endorsement, recommendation, or exclusion by the USDA-Agricultural Research Service. Mention of a pesticide does not constitute a recommendation for use not does it imply registration under FIFRA as amended.

An implement developed by C. S. Noble of Alberta, Canada, undercut rather than inverted the soil surface to control weeds, thus reducing soil disturbance and increasing crop residue retention on the soil surface to conserve soil and water (Allen and Fenster, 1986). When Noble was on a trip to southern California in 1936, he observed the operation of a machine that undercut the rows of carrots (*Daucus carota*) to simplify their harvesting. With this machine in mind, he immediately built the first Noble blade implement in a friend's workshop in Garden Grove, California; tested it in nearby fields; and towed it behind his car to Nobleford, Alberta. He subsequently promoted this implement as far south as the Texas Panhandle. This implement was the forerunner of the stubble-mulch tillage implement that was, in part, developed in the SGP.

STUBBLE-MULCH TILLAGE

Tillage with the Noble blade resulted in crop residue retention on the soil surface, but weed control proved to be a problem in moist, mulched soil. To overcome this problem, Professor J. C. Russel joined Dr. F. L. Duley at Lincoln, Nebraska, to form a team in 1938 that would make soil and water conservation history (Russel, 1976). They adapted sweeps that were used to control bindweed to an implement that undercut the soil surface to control weeds while retaining crop residues on the soil surface to control erosion. The sweeps, which were manufactured by the Case Plow Company, were 22 inches wide with an 85-degree V angle. When mounted on shanks that provided a 22-inch clearance, large amounts of residue could pass through without clogging the implement. Although erosion control was of concern, much of their early research dealt with the effects of crop residues retained on the soil surface for enhancing infiltration and reducing runoff and soil water evaporation. When Duley and Russel in 1939 were debating what to call the tillage method — "noninversion," "subtillage," or "subsurface tillage" — for a manuscript, Director of the Soil Conservation Service, Hugh Hammond Bennett, changed the name to "stubble-mulch tillage," which still is used.

Russel and Duley exchanged information with Noble starting in 1939 (Allen and Fenster, 1986). As a result, Noble replaced the 10-foot wide blade with two 6-foot wide V-shaped sweeps to his implement. The implement with the V-sweeps required less draft and quickly became popular. The early stubble-mulch tillage implements had rigid frames and such implements are still widely used. Also available are hinged-frame models that may have 9 to 11 sweeps for a total width of over 50 feet. These large models can be hydraulically folded into compact units for transport.

Russel, Duley, Noble, and Hoeme did much of the pioneering work leading to or with stubble-mulch tillage. However, they were joined in the early 1940s by others at locations throughout the Great Plains, including Bushland, where the work was done by C. J. Whitfield, F. G. Ackerman, W. C. Johnson, and C. E. Van Doren (Allen and Fenster, 1986). Whereas the early work was directed mainly toward adapting the implement to the hardland soils of the region, subsequent research, which continues to the present time, addresses stubble-mulch tillage effects on storm-water runoff, soil water conservation, crop yields, and soil physical and chemical conditions. A critically important finding for SGP dryland agriculture was that stubble-mulch tillage increased precipitation conservation as soil water. For example, in a review by McCalla and Army (1961), the value of stubble-mulch tillage in conserving soil water was clearly demonstrated together with its fundamental impact for increasing dryland crop production, especially in the semiarid portion of the Great Plains. Provided adequate crop residues are produced, using stubble-mulch tillage results in retaining enough residues on the soil surface to qualify as conservation tillage. Regardless of definitions, stubble-mulch tillage is an effective and widely used management practice for conserving soil and water under dryland conditions.

NO-TILLAGE

A major goal of no-tillage studies in the semiarid SGP was to increase precipitation storage as soil water, which is of major importance for dryland crop production. Although erosion, especially by wind, remains a constant threat throughout the region, it can be controlled by use of conservation tillage methods, provided crops produce adequate amounts of residues. Improving soil water conservation increases the potential for greater plant growth and, hence, more residues become available, thus minimizing the threat of soil erosion.

Chemicals for controlling weeds were developed and marketed during the late 1940s-early 1950s period. Soon thereafter, Allen Wiese and others (Wiese and Army, 1958, 1960; Wiese et al., 1960, 1967) conducted no-tillage research with dryland winter wheat and grain sorghum at Bushland. Soil water contents at planting and grain yields with no-tillage generally were lower or not different than those obtained by using sweep (stubble-mulch) tillage. The generally poor early results obtained with no-tillage were attributed to less than desirable weed control with herbicides available at the time and the lack of sufficient crop residues to adequately suppress soil water evaporation.

Improved herbicides and equipment became available in the late1950s and were coupled with innovative management practices. Phillips (1964) reported that atrazine applied after harvesting wheat controlled all vegetation until grain sorghum was planted by the no-tillage method at Hays, Kansas, in the CGP. The cropping system was a wheat-fallow-sorghum-fallow rotation that results in two crops in 3-years. No weed control measures were needed during the sorghum growing season, and sorghum grain yields on no-tillage plots were greater than on cultivated plots (4220 vs. 2710 pounds per acre). Compared with cultivation, weed control costs (1961-1962) were more with no-tillage ($10.00 vs. $8.25 per acre), but profits were greater with no-tillage ($65.96 vs. $40.53 per acre).

Climatic conditions and cropping practices in Hays, Kansas, are not greatly different from those in the High Plains region of the SGP. Hence, renewed interest in no-tillage soon developed. Instrumental in fostering renewed no-tillage research in the SGP was Jack Musick, Director of the USDA-ARS Laboratory at Bushland in the late 1960s. In an early field study, no-, sweep-, and disk-tillage weed control methods were used during the fallow period after harvesting irrigated winter wheat that produced about 10,000 pounds of straw per acre. Herbicides applied were atrazine at 3 pounds per acre and 2,4-D at 1 pound per acre. At sorghum planting about 11 months later, soil water contents to the 6-foot depth were 8.0, 6.4, and 5.7 inches for the respective treatments (Unger et al., 1971). Sorghum grain yields were not determined, but the study clearly showed that no-tillage had potential for conserving soil water and, thereby, increasing crop yields in the semiarid SGP when adequate crop residues were present.

In subsequent studies that relied on irrigation of wheat to produce large amounts of residues, the use of no-tillage rather than other tillage methods (sweep, disk, rotary, or moldboard) improved soil water contents at planting and subsequent yields of dryland grain sorghum (Baumhardt et. al., 1985; Unger, 1984; Unger and Wiese, 1979) or cotton (Keeling et al., 1988; Lyle and Bordovsky, 1987) in most years. Yields of irrigated corn (Unger, 1986), cotton (Keeling et al., 1988; Lyle and Bordovsky, 1987), and grain sorghum (Baumhardt et al., 1985) usually were not improved when using no-tillage because water stress was prevented. However, under deficit irrigation conditions, residues reduce soil water evaporation and increase transpiration and crop yield (Lascano et al., 1994).

When residue amounts were limited as often is the case with dryland wheat or grain sorghum and for a crop such as cotton in the SGP, yields using no-tillage generally were similar to those with other tillage methods (Jones et al., 1994; Jones and Popham, 1997; Unger, 1994). Contributing to the lack of response was inadequate surface cover to prevent soil surface sealing due to raindrop impact, which then resulted in greater runoff than where tillage was used to disrupt the sealed surface layer (Jones et al., 1994). However, even though runoff was greater, soil water contents at planting usually were greater with no-tillage because evaporation from the undisturbed soil was less. In contrast, tillage brought moist soil to the surface, thereby increasing evaporation that often dried the soil to the tillage depth. The dry soil had to be rewet before any water storage at greater depths could occur. A study involving wheat residues placed on the surface (Unger, 1978) and an analysis of long-term grain sorghum yields (Unger and Baumhardt, 1999) clearly illustrated the crop residue effects for increasing soil water storage and dryland crop yields (Table 1, Fig. 4).

No-tillage is the “ultimate” type of conservation tillage. Other tillage methods, however, are also conservation tillage methods, provided adequate crop residues are retained on the soil surface. They usually are referred to as reduced or minimum tillage.

The wheat-fallow-sorghum-fallow rotation used in the semiarid portion of the SGP has 10 to 11 months of fallow after each crop. In contrast, the period between annual wheat crops is 3 to 4 months. A “Lo-Till” farming system developed in western Oklahoma involves the use of herbicides alone or in combination with tillage to control weeds during the period between wheat crops (Stiegler et al., 1984). Lo-Till provides for a favorable seedbed for the following crop, lower soil temperatures, and better soil water, which allows for more timely planting. Earlier planted Lo-Till wheat can be grazed by cattle and the additional profit offsets the cost of herbicides in many cases. Yields of non-irrigated wheat at three demonstration sites (one site excluded because of storm damage) in Oklahoma in 1983 averaged 3350 pounds per acre with Lo-Till and 2770 pounds per acre on conventionally-tilled cooperator fields. The surface residues reduced evaporation by 15 to 25 percent in some years (Stiegler et al., 1984). Use of the Lo-Till system for annual wheat, however, resulted in severe weed problems [mainly cheatgrass (*Bromus secalinus* L.)] in some locations after several years, which could be overcome by major tillage every 3 or 4 years.

In a study with winter wheat from 1983 to 1991 at El Reno, Oklahoma, the soil water content to the 4-foot depth was consistently higher in no-tillage soil than in plowed soil, except in late fall or early spring when root-zone recharge was similar in both cases (Dao, 1993). In addition, water infiltration into no-tillage soil was higher than into plowed soil when soil water contents were similar, which enhanced precipitation storage as soil water.

For irrigated wheat in the Rolling Plains at Munday, Texas, grain yield with reduced tillage averaged less than with clean tillage (3110 vs. 3690 pounds per acre). The lower yield with reduced tillage was attributed to planting problems and less tillering when large amounts or residue were present (Gerard and Bordovsky, 1984). In other studies at Munday and Chillicothe (also in the Rolling Plains in Texas), crop yields usually were as good or better with reduced tillage than with clean tillage (Clark, 1981; Clark et al., 1991; Unger et al., 1988). In one study with cotton, net return to land, management, and risk was 50 percent greater with reduced tillage than with clean tillage (Clark et al., 1991).

Although water conservation and its effect on crop yields received the main attention in SGP conservation tillage studies, other issues studied include insect populations, soil chemical and physical conditions, and economics. Burton and Krenzer (1985) and Burton et al. (1987) showed that greenbug (*Schizaphis graminum* Rondani) infestations and damage to wheat and grain sorghum were lower under conservation than under conventional tillage conditions. Eck and Jones (1992) found that nitrates moved to a greater depth under no-tillage than under stubble-mulch tillage conditions, which was attributed to greater soil water contents with no-tillage. They suggested that more intensive cropping (less time between crops) than the commonly used wheat-fallow-sorghum-fallow rotation may be possible with no-tillage. Other studies showed that long-term use of no-tillage resulted in an accumulation of organic matter (or carbon) at the soil surface and for the entire profile in some cases (Gerard and Bordovsky, 1984; Potter et al., 1997, 1998; Unger, 1991, 1997). Some physical conditions (aggregate stability, bulk density, and penetration resistance) of a clay loam were affected by using no-tillage, but the trends usually were not consistent and apparently none were severe enough to detrimentally affect crop growth and yield (Unger, 1984, 1997, 2001; Unger and Jones, 1998; Unger et al., 1998). At El Reno, Oklahoma, end-of-season bulk density of a silt loam was lower with no-tillage than with moldboard plowing and stubble mulch tillage treatments (Dao, 1996). Gerard and Bordovsky (1984), however, found that use of conservation tillage for a sandy soil (Miles series, 79% sand) decreased the rate of soil drying. As a result of the prolonged wetter soil condition, they found an increase in bulk density that could decrease crop growth and yield.

In addition to the results of Clark et al. (1991), the economic feasibility of various conservation tillage systems that are adaptable to the SGP have been shown by others (Harman and Martin, 1987; Harman and Wiese, 1985; Harman et al., 1989; Keeling et al., 1989; Wiese et al., 1994a, b), especially when long-term equipment costs and depreciation were considered in the analyses. However, other analyses sometimes showed that conservation tillage was less economical because of high herbicide costs for some systems (Epplin et al., 1983, 1988; Wiese et al., 1994a, b). Certainly, many factors affect the economics of a given conservation tillage system and, hence, whether it will be economically advantageous for producers to use it in their crop production enterprise.

Studies on conservation tillage methods continue throughout the SGP. The use of conservation tillage improves soil water conservation, which potentially makes more intensive cropping possible (reducing the length or eliminating the long fallow periods). More intensive cropping is possible in the CGP (Wood et al., 1990) and the SGP (Unger, 2001), and is being studied at Bushland involving crops other than wheat and grain sorghum. Also, because soil water storage during non-crop periods increases as the amount of crop residues retained on the soil surface increases, methods to increase the carry-over of residues from one crop to the next are being sought. For this purpose, the effect of using a stripper-header for harvesting wheat on residue carry-over, soil water storage during fallow, and subsequent grain sorghum yield is being studied at Bushland. Use of the stripper-header allows more of the plant to remain standing, thus potentially decreasing the rate of residue decomposition and providing conditions for increasing soil water storage. Preliminary results during a growing-season with below average rainfall showed that grain sorghum yielded slightly more where the stripper-header rather than a conventional header was used for harvesting the previous wheat. Further study is needed to determine the potential of such practice for increasing soil water storage and grain yields.

CURRENT STATUS OF CONSERVATION TILLAGE IN THE SOUTHERN GREAT PLAINS

Adoption of conservation tillage varies with crops being grown and areas within the region. Stubble-mulch tillage is commonly used for winter wheat in the drier western areas, but seldom used in the more humid eastern areas where the wheat is grown continually. Problems with cheatgrass control, crop establishment with large amounts of residues on the surface, and poor seedling vigor contribute to low adoption in the more humid areas. Patterns of adoption of conservation tillage for sorghum are similar to those for winter wheat. Stubble-mulch tillage is used in the drier areas, especially when the sorghum is rotated with wheat. Stubble-mulch tillage is seldom used in the more humid areas where the sorghum is grown continually (Unger and Skidmore, 1994).

Under irrigated conditions, some producers use conservation tillage when wheat and sorghum are grown in rotation. For continually-grown wheat, however, some producers view surface residues as a hindrance to economical wheat production and may burn them. Fortunately, with irrigation, timely tillage can provide a rough soil surface to control erosion and the ensuing crop can be established, even when timely precipitation does not occur. For irrigated sorghum and corn, surface residue amounts usually are reduced by disking and other tillage methods that form ridges on which subsequent crops are planted. As for wheat, non-use of conservation tillage is not a major problem under irrigated conditions for these crops because water can be applied as needed for timely tillage and crop establishment.

Although adoption of conservation tillage currently is limited in the SGP, we believe its use is important for conserving soil and water resources. Because water for irrigation is being depleted in part of the region and dryland crops are replacing the irrigated crops, we further believe that use of some type of conservation tillage will be necessary to conserve soil and water for successful crop production.

REFERENCES

Allen, R.R., and C.R. Fenster. 1986. Stubble-mulch equipment for soil and water conservation in the Great Plains. J. Soil Water Conserv. 41:11–16.

Baumhardt, R.L., and R.J. Lascano. 1999. Water budget and yield of dryland cotton intercropped with terminated winter wheat. Agron. J. 91:922–927.

Baumhardt, R.L., R.E. Zartman, and P.W. Unger. 1985. Grain sorghum response to tillage method used during fallow and to limited irrigation. Agron. J. 77:643–646.

Bilbro, J.D., and D.W. Fryrear. 1988. Plant materials for windbarriers in semiarid regions. pp. 150–157. In: Proc. 1988 Wind Erosion Conf., April 1988, Lubbock, TX.

Brandt, J.E., and B.L. Harris. 1988. Assessment of selected wind erosion control practices in Texas. p. 13–22. In: Proc. 1988 Wind Erosion Conf., April 1988, Lubbock, TX.

Burton, R.L., O.R. Jones, J.D. Burd, G.A. Wicks, and E.G. Krenzer, Jr. 1987. Damage by greenbug (*Homoptera: Aphididae*) to grain sorghum as affected by tillage, surface residues, and canopy. J. Econ. Entomol. 80:792–798.

Burton, R.L., and E.G. Krenzer, Jr. 1985. Reduction of greenbug (*Homoptera: Aphididae*) populations by surface residues in wheat tillage studies. J. Econ. Entomol. 78:390–394.

Clark, L.E. 1981. Response of cotton to cultural practices. Progr. Rpt. PR-4175, Texas Agric. Exp. Stn., College Station, TX.

Clark, L.E., H.T. Wiedemann, C.J. Gerard, and J.R. Martin. 1991. A reduced tillage system with furrow diking for cotton production. Trans. ASAE 34:1597–1603.

Dao, T.H. 1993. Tillage and winter wheat residue management effects on water infiltration and storage. Soil Sci. Soc. Am. J. 57:1586–1595.

Dao, T.H. 1996. Tillage system and crop residue effects on surface compaction of a Paleustoll. Agron. J. 88:141–148.

Dollar, M. 1988. Problems and controls of wind erosion in West Texas. p. 7–12. In: Proc. 1988 Wind Erosion Conf., April 1988, Lubbock, TX.

Eck, H.V., and O.R. Jones. 1992. Soil nitrogen status as affected by tillage, crops, and crop sequences. Agron. J. 84:660–668.

Epplin, F.M., K. Berte, E.G. Krenzer, Jr., and W.F. Heer. 1988. Influence of alternative planting dates and tillage systems on winter wheat production response: A random coefficients approach. Professional Paper PP-2743, Dept. of Agric. Econ., Olka. State Univ., Stillwater, OK.

Epplin, F.M., T.F. Tice, S.J. Handke, T.F. Peeper, and E.G. Krenzer, Jr. 1983. Cost estimates of alternative wheat production systems for Garfield County. Bull. B-766, Agric. Exp. Stn., Okla. State Univ., Stillwater, OK.

Gerard, C.J., and D.G. Bordovsky. 1984. Conservation tillage studies in the Rolling Plains. p. 201–216. In: Conservation Tillage, Proc. Great Plains Conserv. Tillage Symp., North Platte, NE. Publ. 110, Great Plains Agric. Council, North Platte, NE.

Harman, W.L., and J.R. Martin. 1987. Economics of conservation tillage research in Texas. p. 24–37. In: T.J. Gerik and B.L. Harris (eds.), Conservation Tillage: Today and Tomorrow, Proc. Southern Region No-Tillage Conf., College Station, TX. Misc. Publ. MP-1636, Texas Agric. Exp. Stn., College Station, TX.

Harman, W.L., G.J. Michels, and A.F. Wiese. 1989. A conservation tillage system for profitable cotton production in the central Texas High Plains. Agron. J. 81:615–618.

Harman, W.L., and A. Wiese. 1985. An economic assessment of conservation tillage practices for the southern Great Plains. J. Am. Soc. Farm Managers and Rural Appraisers 49:14–19.

Hurt, R.D. 1981. The Dust Bowl, An Agricultural and Social History. Nelson-Hall, Chicago, IL.

Johnson, W.C., and R.G. Davis. 1972. Research on stubble-mulch farming of winter wheat. USDA Conserv. Rpt. 16, U.S. Gov. Print. Off., Washington, DC.

Jones, O.R., V.L. Hauser, and T.W. Popham. 1994. No-tillage effects on infiltration, runoff, and water conservation on dryland. Trans. ASAE 37:473–479.

Jones, O.R., and T.W. Popham. 1997. Cropping and tillage systems for dryland grain production in the Southern High Plains. Agron. J. 89:222–232.

Keeling, W.L., E. Segarra, and J.R. Abernathy. 1989. Evaluation of conservation tillage cropping systems for cotton on the Texas Southern High Plains. J. Prod. Agric. 2:269–273.

Keeling, J.W., C.W. Wendt, J.R. Gannaway, A.B. Onken, W.M. Lyles, R.J. Lascano, and J.R. Abernathy. 1988. Conservation tillage cropping systems for the Texas Southern High Plains. p. 19–21. In: K.H. Remy (ed.), Proc. 1988 Southern Conserv. Tillage Conf. Spec. Bull. 88-1, Mississippi Agric. and Forestry Exp. Stn., Mississippi State, MS.

Lascano, R.J., R.L. Baumhardt, S.K. Hicks, and J.L. Heilman. 1994. Soil and plant water evaporation from strip tilled cotton: Measurement and simulation. Agron. J. 86:987–994.

Lyle, W.M., and J.P. Bordovsky. 1987. Integrating irrigation and conservation tillage technology. p. 67–71. In: T.J. Gerik and B.L. Harris (eds.), Conservation Tillage: Today and Tomorrow, Proc. Southern Region No-Tillage Conf., College Station, TX. Misc. Publ. MP-1636, Texas Agric. Exp. Stn., College Station, TX.

McCalla, T.M., and T.J. Army. 1961. Stubble mulch farming. Adv. Agron. 13:125–196.

Musick, J.T., F.B. Pringle, W.L. Harman, and B.A. Stewart. 1990. Long-term irrigation trends--Texas High Plains. Applied Eng. Agric. 6:717–724.

Nativ, R., and D. A. Smith. 1987. Hydrogeology and geochemistry of the Ogallala Aquifer, Southern High Plains. J. Hydrol. 91:217–253.

Phillips, W.M. 1964. A new technique of controlling weeds in sorghum in a wheat-sorghum-fallow rotation in the Great Plains. Weeds 12:42–44.

Potter, K.N., O.R. Jones, H.A. Tolbert, and P.W. Unger. 1997. Crop rotation and tillage effects on organic carbon sequestration in the semiarid southern Great Plains. Soil Sci. 162:140–147.

Potter, K.N., H.A. Torbert, O.R. Jones, J.E. Matocha, J.E. Morrison, Jr., and P.W. Unger. 1998. Distribution and amount of soil organic C in long-term management systems in Texas. Soil Tillage Res. 47:309–321.

Price, B.B., and F.W. Rathjen. 1986. The Golden Spread: An Illustrated History of Amarillo and the Texas Panhandle. Windsor Publications, Northridge, CA.

Russel, J.C. 1976. Some historical aspects of stubble mulch tillage. Publ. 77, Great Plains Agric. Council, Lincoln, NE. 12 pp.

Soil Conservation Service. 1955. Facts about wind erosion and dust storms on the Great Plains. Leaflet 394, U.S. Dept. of Agric., U.S. Gov. Print. Off., Washington, DC.

SSSA (Soil Science Society of America). 1997. Glossary of Soil Science Terms, 1996. Soil Sci. Soc. Am., Madison, WI.

Stiegler, J., W. Downs, and F. Hawk. 1984. Lo-Till System. p. 197–200. In: Conservation Tillage, Proc. Great Plains Conserv. Tillage Symp., North Platte, NE. Publ. 110, Great Plains Agric. Council, North Platte, NE.

Unger, P.W. 1978. Straw-mulch rate effect on soil water storage and sorghum yield. Soil Sci. Soc. Am. J. 42:486–491.

Unger, P.W. 1984. Tillage and residue effects on wheat, sorghum, and sunflower grown in rotation. Soil Sci. Soc. Am. J. 48:885–891.

Unger, P.W. 1986. Wheat residue management effects on soil water storage and corn production. Soil Sci. Soc. Am. J. 50:764–770.

Unger, P.W. 1991. Organic matter, nutrient, and pH distribution in no-tillage and conventional-tillage semiarid soils. Agron. J. 83:186–189.

Unger, P.W.1994. Tillage effects on dryland wheat and sorghum production in the southern Great Plains. Agron. J. 86:310–314.

Unger, P.W. 1997. Aggregate and organic carbon interrelationships of a Torrertic Paleustoll. Soil Tillage Res. 43:95–113.

Unger, P.W. 2001. Alternative and opportunity dryland crops and related soil conditions in the southern Great Plains. Agron. J. 93:216–226.

Unger, P.W., R.R. Allen, and A.F. Wiese. 1971. Tillage and herbicides for surface residue maintenance, weed control, and water conservation. J. Soil Water Conserv. 26:147–150.

Unger, P.W., and R.L. Baumhardt. 1999. Factors related to dryland grain sorghum yield increases: 1939 through 1997. Agron. J. 91:870–875.

Unger, P.W., C.J. Gerard, J.E. Matocha, F.M. Hons, D.G. Bordovsky, and C.W. Wendt. 1988. p. 10–15. In: F.M. Hons (ed.), Conservation Tillage in Texas. Res. Monogr. 15, Texas Agric. Exp. Stn., College Station, TX.

Unger, P.W., and O.R. Jones. 1998. Long-term tillage and cropping systems affect bulk density and penetration resistance of soil cropped to dryland wheat and grain sorghum. Soil Tillage Res. 45:39–57.

Unger, P.W., O.R. Jones, J.D. McClenagan, and B.A. Stewart. 1998. Aggregation of soil cropped to dryland wheat and grain sorghum. Soil Sci. Soc. Am. J. 62:1659–1666.

Unger, P.W., and E.L. Skidmore. 1994. Conservation tillage in the southern United States Great Plains. p. 329–356. In: M.R. Carter (ed.), Conservation Tillage in Temperate Agroecosystems. Lewis Publishers, Boca Raton, Ann Arbor, London, and Tokyo.

Unger, P.W., and A.F. Wiese. 1979. Managing irrigated winter wheat residues for water storage and subsequent dryland grain sorghum production. Soil Sci. Soc. Am. J. 43:582–588.

Webb, W.P. 1931. The Great Plains. Ginn and Company, Boston.

Wiese, A.F., and T.J. Army. 1958. Effect of tillage and chemical weed control practices on soil moisture storage and losses. Agron. J. 50:465–468.

Wiese, A.F., and T.J. Army. 1960. Effect of chemical fallow on soil moisture storage. Agron. J. 52:612–613.

Wiese, A.F., J.J. Bond, and T.J. Army. 1960. Chemical fallow in the southern Great Plains. Weeds 8:284–290.

Wiese, A.F., E. Burnett, and J.E. Box, Jr. 1967. Chemical fallow in dryland cropping sequences. Agron. J. 59:175–177.

Wiese, A.F., W.L. Harman, B.W. Bean, and C.D. Salisbury. 1994a. Effectiveness and economics of dryland conservation tillage systems in the southern Great Plains. Agron. J. 86:725–730.

Wiese, A.F., W.L. Harman, and C. Regier. 1994b. Economic evaluation of conservation tillage systems for dryland and irrigated cotton (*Gossypium hirsutum*) in the southern Great Plains. Weed Sci. 42:316–321.

Wood, C.W., D.G. Westfall, G.A. Peterson, and I.C. Burke. 1990. Impacts of cropping intensity on carbon and nitrogen mineralization under no-till dryland agroecosystems. Agron. J. 82:1115–1120.

Woodruff, N.P., L. Lyles, F.H. Siddoway, and D.W. Fryrear. 1972. How to control wind erosion. Agric. Info. Bull. 354, U.S. Gov. Print. Off., Washington, DC.

Table 1. Wheat-straw mulch effect on soil water storage during an 11-month fallow before planting grain sorghum, water storage efficiency, and grain sorghum yield at Bushland, TX (adapted from Unger, 1978).

Mulch rate (pounds/acre)	Water storage† (inches)	Storage efficiency‡ (%)	Grain yield (pounds/acre)
0	2.8 c§	22.6 c	1590 c
900	3.9 b	31.1 b	2150 b
1800	3.9 b	31.4 b	2320 b
3600	4.6 b	36.5 b	2660 b
7200	5.5 a	43.7 a	3290 a
10800	5.8 a	46.2 a	3560 a

† Water storage determined to 6-foot depth. Precipitation averaged 12.5 inches.
‡ Based on water storage as a percent of precipitation received during fallow.
§ Column values followed by the same letter are not significantly different at the *P* # 0.05 level of probability based on Duncan's Multiple Range Test.

Figure 1. Map showing the extent of the southern Great Plains in Kansas, Oklahoma, New Mexico, and Texas.

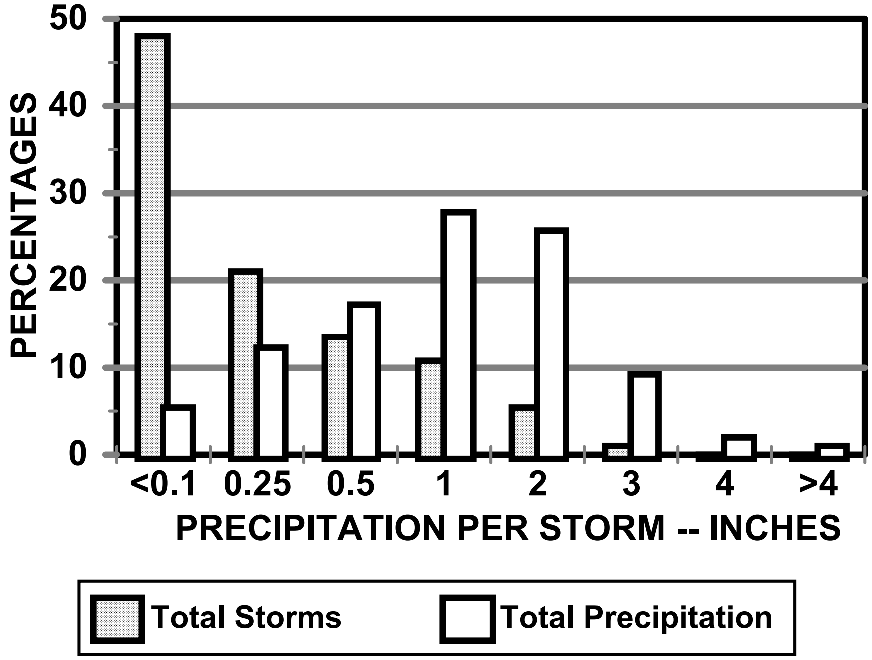


Figure 2. Size distribution of precipitation events (percentages of the total) and percentages of total precipitation associated with the events of different sizes at Bushland, TX, from 1939 to 1998. Total number of events was 4122 and total precipitation was 1126 inches (18.76 inches per year).

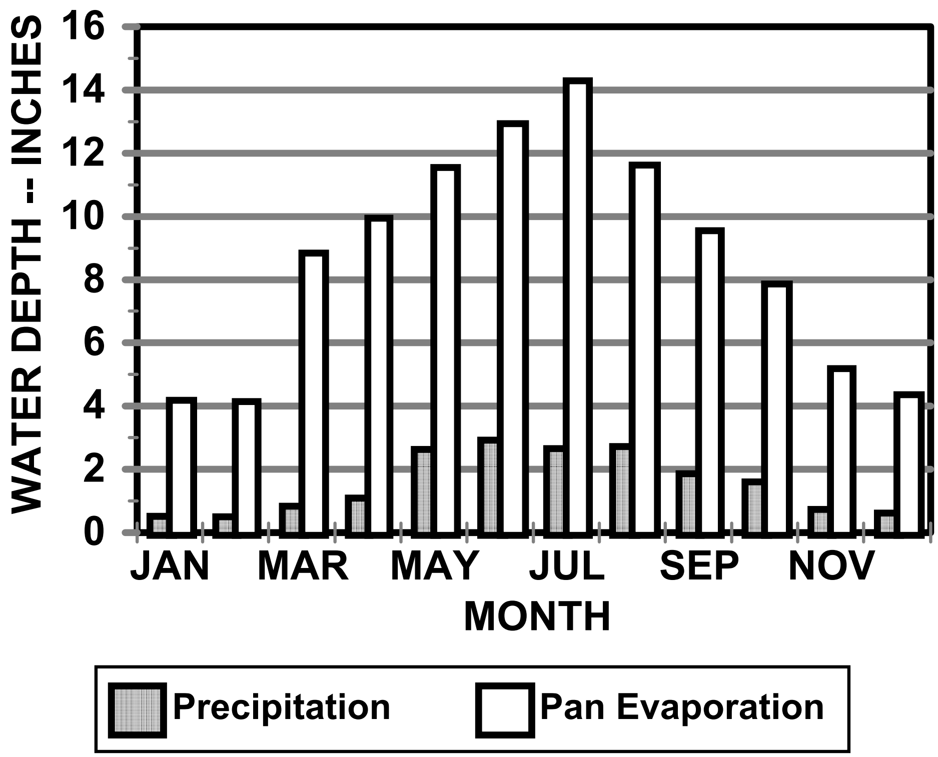


Figure 3. Average monthly precipitation and pan evaporation (4-foot pan) at Bushland, TX.

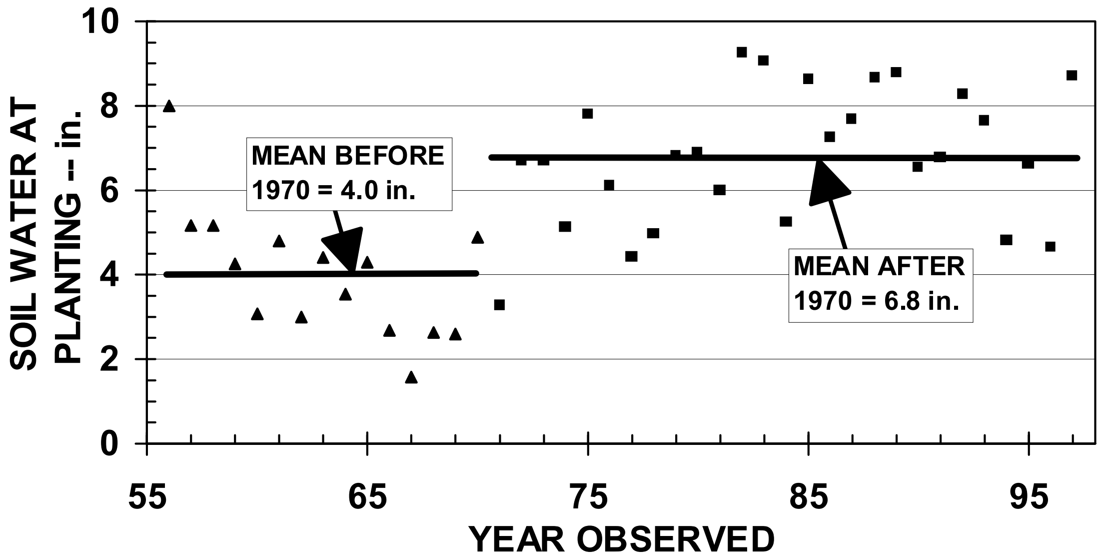


Figure 4. Illustration of crop residue effects on soil water contents at grain sorghum planting time at Bushland, TX. Use of no-tillage after 1970 resulted in retaining more residues on the surface (adapted from Unger and Baumhardt, 1999).

HISTORICAL DEVELOPMENT OF CONSERVATION TILLAGE IN THE SOUTHERN GREAT PLAINS

Paul W. Unger and R. Louis Baumhardt

INTERPRETIVE SUMMARY

The term “conservation tillage” is relatively new. As commonly used, it refers to any tillage method that results in at least 30 percent of the soil surface being covered with crop residues after a crop is planted. Such use of the term is covered by the “operational” definition given by the Soil Science Society of America. According to the general definition of the term, however, any tillage practice that helps to minimize or reduce the loss of soil and water is a type of conservation tillage. Such soil-conserving tillage practices were used in the southern Great Plains for many years before the term “conservation tillage” was introduced. Use of such soil-conserving tillage practices helps control wind erosion on the sandy soils of the southern portion of the region where cotton is the main crop. Cotton produces residues that provide little protection against wind erosion. Tillage practices developed to control wind erosion during the drought of the 1930s also were not based on retaining crop residues on the soil surface. In many cases, the crops failed and no residues were available. The effectiveness of the practices results from roughening the soil surface, either by forming ridges on the surface, forming clods on the surface or bringing clods to the surface, or by bringing less erodible materials to the surface by deep plowing (clayey materials to replace sandy materials at the surface).

The purpose of our report is to give a historical viewpoint of the tillage practices used in the southern Great Plains to conserve soil and water resources. We first give a general description of the characteristics of the region and agricultural development in the region, then discuss the different tillage practices used in the region and their effects of crop production, soil conditions, and related factors.

The region ranges from semiarid at the west to subhumid at the east. Agricultural development occurred in the late 1800s and early 1900s. Early tillage practices used by the settlers were those that they had used in the eastern United States or Europe, from which they immigrated. In the early years when precipitation was average or above average, those “clean” tillage practices were satisfactory. However, during the drought of the 1930s, those practices contributed to the severe wind erosion that plagued the region. Conditions of the 1930s led to the development of tillage practices that helped control wind erosion. Included were implements that roughened the soil surface or retained crop residues, if available, on the soil surface. Those implements were forerunners of the chisel and stubble mulch plows, which are still widely used in the region.

By the 1950s, herbicides for weed control became available, but early no-tillage results generally were poor because of inadequate weed control, improper equipment, and low amounts of crop residues under dryland conditions. Improved herbicides and equipment became available in the 1960s, which resulted in renewed interest in conservation tillage, including no-tillage. Since then, suitable practices have been developed for many crops. With adequate residues retained on the soil surface, erosion can be controlled and the residues also improve water infiltration and reduce soil water evaporation, thus providing more water for crop production. The additional soil water that results from using no-tillage (from 2 to 3 inches under some conditions) is especially beneficial for dryland crops in the semiarid portion of the region. While some crops are irrigated in the region, water for irrigation is limited and is being depleted in parts of the region. As a result, dryland crop production is becoming increasingly important. While adoption of conservation tillage currently is limited in the region, we believe some type of conservation tillage will be necessary to conserve soil and water for successful and sustained crop production in the southern Great Plains.

RESIDUE MANAGEMENT EFFECTS ON INFILTRATION INTO SEMI-ARID DRYLANDS

R.L. Baumhardt[1]

AUTHOR: [1]Louis Baumhardt, Soil Scientist, USDA-ARS Conservation & Production Res. Lab., P.O. Drawer 10, Bushland, TX 79012, email rlbaumhardt@cprl.ars.usda.gov., phone: 806.356.5766, fax: 806.356.5750.

ABSTRACT

Sustainable dryland production systems rely on effective methods of storing soil water for later use by crops. Residue-retaining conservation tillage systems first developed on the southern Great Plains for wind erosion control also have the added benefit of increasing the amount of precipitation stored as soil water. Residue in these conservation tillage systems intercepts raindrop impact, which reduces soil crust formation and surface compaction. Consequently, infiltration is greater and precipitation storage in the soil increased; however, in semiarid regions, dryland crops produce limited residue amounts that can render these residue management practices ineffective. This paper reviews and contrast studies characterizing residue effects on rain infiltration and annual storm runoff measured at Bushland and Lubbock, TX.

DRYLAND CROPPING SYSTEMS

This paper reviews research characterizing conservation tillage effects on rain infiltration and storm-water runoff. The High Plains portion of the southern Great Plains is at an elevation >3300 ft (1000 m) above mean sea level and has a semiarid continental climate characterized by high winds that promote evaporation. While pan evaporation over much of the region ranges from about 70 – 100 inches (1800 – 2500 mm) per year, precipitation (rain) is erratic in both temporal distribution and amount, ranging from 16 – 24 inches (400 – 600 mm) annually. For example, the mean annual precipitation at Bushland (Fig. 1) is ~19 in. (490 mm) or, ~25% of the 90 in. (2.3 m) annual pan evaporation (Dugas and Ainsworth, 1983). Precipitation stored as soil water and/or augmenting-irrigation is crucial to stabilize and increase summer crop yields. The importance of soil water storage was shown in separate studies, where the grain sorghum [*Sorghum bicolor* (L.) Moench] yield increased about 390 lbs ac^{-1} (430 kg ha^{-1}) (Jones and Hauser, 1975) to 430 lbs ac^{-1} (480 kg ha^{-1}) (Baumhardt et al., 1985) per inch (25 mm) stored soil water. Therefore, most dryland cropping systems in the southern Great Plains rely on fallow periods between crops to store precipitation.

Much of the southern Great Plains is suited to cotton (*Gossypium hirsutum* L.), wheat (*Triticum aestivum* L.), and grain sorghum crops that are often grown with an intervening fallow period. For example, the wheat-sorghum-fallow (WSF) rotation has an 11-month fallow period preceding each crop (Fig. 2) and results in two crops in three years (Jones and Popham, 1997). Soil water storage with the WSF rotation is increased with no-tillage (NT) compared to conventional stubblemulch tillage (SM). While both practices retain some crop residue, NT is a more effective means of retaining residues at the soil surface. In a more intensive dryland cropping sequence, cotton is grown as an annual summer crop where the length of growing season is adequate. Cotton does not produce adequate residue to protect the soil from wind erosion regardless of tillage system; therefore, a green fallow of wheat seeded after cotton harvest (Fig. 3) was proposed to provide needed residue (Keeling et al., 1989). This practice provides both cash and cover crops when fall and spring precipitation (or irrigation) is adequate to establish cotton and wheat crop. Baumhardt and Lascano (1999) reported that residues retained from the terminated wheat increased infiltration and reduced runoff; however, crop establishment risks severely limited the success of applying this practice under dryland conditions in years with below average precipitation.

INFILTRATION

Retaining residue at the soil surface is crucial to the overall water availability to dryland crops by reducing evaporation (Lascano and Baumhardt, 1996) and by reducing raindrop impact. That is, with interception of raindrops by residues, structural soil crust formation is reduced and consequently infiltration is increased (Duley, 1939; McIntyre, 1958; Morin and Benyamini, 1977; Baumhardt et al., 1990). Crust formation increases proportionally with increasing raindrop impact; therefore, residue retaining tillage practices typically increase infiltration and reduce runoff if residue production is sufficient.

The effects of conventional and no-tillage residue management with dryland crops on rain infiltration was measured at Bushland and Lubbock, TX in several studies using similar methods during the fallow or summer growing season. Cistern stored rainwater [pH of 7.3, electrolyte concentration of 16.0 mg kg^{-1}, and a SAR of 0.02 (mmol $L^{-1})^{-1/2}$] at Bushland or well water [pH of 7.3, electrolyte concentration of 16.0 mg kg^{-1}, and a SAR of 0.02 (mmol $L^{-1})^{-1/2}$] at Lubbock was applied using a rotating-disk rainfall simulator (Morin et al., 1967) that produced about 80% of normal rainstorm impact energy (22 J mm^{-1} m^{-2}). Water was applied for 60 minutes at 3 in. h^{-1} (80 mm h^{-1}) in Lubbock or at 2 in. h^{-1} (48 mm h^{-1}) until a steady infiltration rate was observed at Bushland. These are the average 15- and 60-minute rain intensities for this region (Frederick et al., 1977). The infiltration measurement was centered between wheel tracks (when present) and contained within a 60 in. by 60 in. square (area = 2.25 m^2) metal frame pressed 2 in. (50 mm) into the soil. Runoff water captured within the frame was removed by a peristaltic pump and collected in a graduated cylindrical tank for measurement during rain simulation. Infiltration rate and amount were calculated as the difference between applied water and collected runoff.

Cumulative infiltration after one hour for the Pullman clay loam (fine, mixed, superactive, thermic Torrertic Paleustoll) at Bushland, TX, is reported by crop and tillage practice (Table 1). Compared with NT, the SM tillage practice significantly (P=0.01) increased infiltration amount in fallowed sorghum residue plots but not in fallowed wheat residue plots. This was not attributed to differences in mean initial gravimetric water content, which were about 15% (15 g kg^{-1}) in 1994 and 23% (23 g kg^{-1}) in 2000 for the surface 6 in. (0.15 m) and did not vary with residue management. Wheat straw is less woody and smaller stemmed than grain sorghum stubble and, therefore, the residues more completely covered the soil, reduced crust formation by raindrop impact, and increased infiltration. The difference in cumulative infiltration observed between SM and NT tillage practices for the fallowed sorghum residue plots, however, suggest that continued exposure of the soil to rain during the fallow period consolidated the soil surface into a crust that limited infiltration until it was fractured by the SM tillage. Similarity in cumulative infiltration between SM and NT tillage by wheat residue treatment and SM tillage by sorghum residue treatment, further suggest that the more complete cover of residues during fallow after wheat reduced the gradual surface consolidation and crusting process.

Use of sub-soil tillage to offset the effects of surface consolidation and crusting that limited cumulative infiltration in NT but not in SM was ineffective. Residue management and one-time tillage effects on cumulative infiltration were measured during fallow after sorghum (Table 1). Infiltration with SM was greater than with NT residue management as expected, but the use of subsoil tillage resulted in no consistent change. The use of a single sweep tillage operation to fracture the soil early in the fallow period, also, did not increase infiltration. That is, tillage practices used to fracture the crusted soil surfaces did not have a sustained effect on infiltration. Because the amount of residue produced by dryland grain sorghum is limited and provides little protection from raindrop impact, infiltration is improved with periodic tillage used with SM residue management.

The three-year mean cumulative infiltration into conventionally disk tilled or NT Amarillo (fine-loamy, mixed, thermic Aridic Paleustalf) and Olton (fine, mixed, superactive, thermic Aridic Paleustoll) soil offer similar results for dryland cropping systems that produce limited residue. For example, cumulative rain infiltration was greater with disk tillage than NT for both the Amarillo and Olton soils when continuously cropped to cotton (Table 1). Cumulative infiltration after NT dryland sorghum, another limited residue producer, was the same or less than conventionally tilled cotton. Using NT systems for maintaining residue at the soil surface to intercept raindrop impact and, consequently, increase infiltration was unsupported by these data. However, the increased soil cover achieved with NT wheat, in contrast to NT cotton and sorghum, did result in comparable or greater cumulative infiltration than with conventional disk tillage. The initial surface 6 in. (0.15 m) volumetric water content was about 8% (8.0 $m^3\ m^{-3}$) for the Amarillo and 12% (12 $m^3\ m^{-3}$) for the Olton soils, but no residue management effect on water content was indicated.

Protecting the soil from raindrop impact with an energy barrier or with adequate wheat residue increased infiltration significantly over bare soil at Lubbock (Baumhardt and Lascano, 1996). In that study, cumulative infiltration after one hour increased with increasing residue until the amount approached 2200 lbs ac^{-1} (2.5 Mg ha^{-1}), which was sufficient to protect the soil from raindrop impact. Because additional wheat residue did not increase infiltration, they concluded that infiltration would increase with increasing residue until a threshold amount had been achieved, when further additions would not affect infiltration. Benefits of wheat residues to increase infiltration are consistent with results reported elsewhere (Alberts and Neibling, 1994); however, infiltration and crop water management in semiarid regions is governed by residue production under dryland conditions that, often, is insufficient to protect the soil.

STORM WATER RUNOFF

While residues retained at the soil surface were insufficient to increase infiltration regardless of management practices during a single observation, sustained residue management effects on infiltration can be deduced from storm-water runoff measurements. Seasonal runoff was measured during the WSF cropping sequence from gauged watersheds under conventional SM and NT residue management (Jones et al., 1994). Briefly, six contour-farmed gradedterraced watersheds ranging in area from ~ 6 to 10 acres (2.3 to 4.1 ha) with a gently sloping (1-2%) Pullman clay loam were instrumented with calibrated flumes and water level recorders. The watersheds were cropped in a WSF rotation, with each phase of the rotation present every year, using no-tillage and conventional stubblemulch tillage.

In that study, mean annual runoff measured since 1984 has averaged 1.7 inches (44 mm) more with no-tillage during the three year WSF cycle than with stubblemulch tillage. Most of the annual runoff was measured during fallow periods between crops when the available soil porespace filled. Tillage effects resulted in about 1.5 in. (40 mm) more runoff from NT than from SM watersheds during fallow after sorghum and 0.35 in. (~9 mm) more from NT than SM watersheds during fallow after wheat. This was attributed to i) greater precipitation during the spring fallow than during summer and winter fallow months, and ii) limited soil cover provided by sparse sorghum residues that favored the development of infiltration limiting soil crusts compared to more complete residue cover with wheat stubble. Runoff was limited during the wheat and sorghum growing seasons and resulted in < .25 inch (5.2 mm) difference between SM and NT residue management. This was attributed to i) crop water use that sufficiently depleted soil water to allow rain infiltration and minimize tillage effects, and ii) crop canopy cover that similarly intercepted raindrop impact for both tillage treatments.

In studies with comparable objectives, Baumhardt et al. (1993b) measured storm runoff from gauged micro-watersheds installed in field plots on Olton and Amarillo soils (Baumhardt and Lascano, 1999). Field plots were cropped to cotton in an annual cotton rotation with sorghum (Baumhardt et al., 1993b) or as continuous cotton using conventional clean tillage or a chemically terminated wheat green-fallow (Baumhardt and Lascano, 1999). Within these plots, runoff was measured from 10 ft. x 75-100 ft. (3m x 25-33m) micro-watersheds instrumented with calibrated flumes and water level recorders. These runoff measurements were made during studies of much shorter, 3-4 year, duration.

Runoff was usually measured during intense rainstorms with depths exceeding 1.5 in. (35 mm) that occurred during the fall, September and October, or summer, May through July, months. Residue cover was most effective in reducing runoff before the crop canopy had fully developed, thus closing the space between rows and intercepting raindrop impact. After cotton defoliation and harvest, very little plant material or residues were present to protect the soil, but the limited winter precipitation did not contribute to runoff. The measured runoff from an Amarillo soil cropped to conventionally tilled cotton averaged 1.8 in. (46 mm) more than from cotton grown in the terminated wheat green-fallow plots (Baumhardt and Lascano, 1999). That is, the terminated winter wheat green-fallow promoted better infiltration by providing a crop residue cover to intercept raindrops. Similarly, Baumhardt et al. (1993b) measured about 0.7 in. (16 mm) less runoff from an Olton soil cropped to cotton grown after no-till sorghum than after conventional disk tillage sorghum. Both the coarse-textured Amarillo and finer-textured Olton soils appeared to benefit from even limited residues that intercepted raindrops, reduced soil crust formation, and consequently increased infiltration.

SUMMARY

Dryland cropping systems of the semiarid southern Great Plains rely on fallow periods between crops to store sufficient precipitation in the soil for sustainable production (Jones and Popham, 1997). Because of the limited water available for dryland cropping systems in the semiarid Great Plains, both crop growth and the corresponding residue production is restricted. Consequently, the degree of protection provided against raindrop impact is inadequate and soil crust formation reduces infiltration. Soil crust formation and compaction of the surface reduces infiltration when using NT compared with conventional SM tillage regardless of soil type, but this may be more prevalent in fine textured soils. Infiltration was improved, however, when tillage practices disturbed the soil surface. When residues are limited, as in the case of semiarid dryland crop production, infiltration benefits from soil-disturbing SM tillage that fractures crusts.

Increased runoff from NT compared to SM residue management plots further corroborates infiltration measurements. That is, runoff data from Lubbock and Bushland revealed that runoff from plots with wheat residue was generally similar to runoff from conventionally managed plots, or less than from plots with sorghum or cotton residues. These results suggest that reduced runoff can be expected with the more complete residue cover achieved by wheat compared to sorghum that has not received tillage to fracture surface soil crusts. Compared to the conventional SM tillage, however, NT residue management increases the amount of water stored in the soil. The greater soil water conservation with NT is likely attributable to reduced evaporation.

REFERENCES

Alberts, E.E., and W.H. Neibling. 1994. Influence of crop residues on water erosion. p. 19-39. *In* P.W. Unger (ed.) Managing agricultural residues. Lewis Publ., Chelsea, MI.

Baumhardt, R.L., and O.R. Jones. 2000. Residue management and paratillage effects on rain infiltration. Proc. 15th Int. Soil Tillage Res. Org. Conf. July 3-7, 2000. Ft. Worth, TX. 9 pp.

Baumhardt, R.L., J.W. Keeling, and C.W. Wendt. 1993a. Tillage and residue effects on infiltration into soils cropped to cotton. Agron. J. 85: 379-383.

Baumhardt, R.L., and R.J. Lascano. 1996. Rain infiltration as affected by wheat residue amount and distribution in ridged tillage. Soil Sci. Soc. Am. J. 60: 1908-1913.

Baumhardt, R.L., and R.J. Lascano. 1999. Water budget and yield of dryland cotton intercropped with terminated winter wheat. Agron. J. 91:922–927

Baumhardt, R.L., M.J.M. Römkens, F.D. Whisler, and J.-Y. Parlange. 1990. Modeling infiltration into a sealing soil. Water Resour. Res. 26:2497-2505.

Baumhardt, R.L., C.W. Wendt, and J.W. Keeling. 1993b. Tillage and furrow diking effects on water balance and yields of sorghum and cotton. Soil Sci. Soc. Am. J. 57: 1077-1083.

Baumhardt, R.L., R.E. Zartman, and P.W. Unger. 1985. Grain sorghum response to tillage method used during fallow and to limited irrigation. Agron. J. 77:643-646.

Dugas, W.A., and C.G. Ainsworth. 1983. Agroclimatic atlas of Texas: Part 6. Potential evapotranspiration. Misc. Publ. MP-1543, Texas Agric. Exp. Stn., College Station, TX.

Duley, F.L. 1939. Surface factors affecting the rate of intake of water by soils. Soil Sci. Soc. Am. Proc. 4: 60-64.

Frederick, R.H., V.A. Myers, and E.P. Auciello. 1977. Five-to-60 minute precipitation frequency for the eastern and central United States. Natl. Oceanic and Atmos. Admin. Tech. Memo. Natl. Weather Serv. NWS HYDRO-35, U.S. Dept. Com., Washington, D.C.

Jones, O. R., and V. L. Hauser. 1975. Runoff utilization for grain production. pp. 277-283. *In* G. W. Frasier (ed.) Proc. Water Harvesting Symposium, Phoenix, AZ, March 1974. Publ. ARS W-22, USDA.

Jones, O.R., V.L. Hauser, and T.W. Popham. 1994. No-tillage effects on infiltration, runoff and water conservation on dryland. Trans. of ASAE. 37:473-479.

Jones, O.R., and T.W. Popham. 1997. Cropping and tillage systems for dryland grain production in the Southern High Plains. Agron. J. 89:222-232.

Keeling, W., E. Segarra, and J.R. Abernathy. 1989. Evaluation of conservation tillage cropping systems for cotton on the Texas Southern High Plains. J. Prod. Agric. 2:269-273.

Lascano, R.J., and R.L. Baumhardt. 1996. Effects of crop residue on soil and plant water evaporation in a dryland cotton system. Theor. Appl. Climatol. 54:69—84.

McIntyre, D.S. 1958. Permeability measurements of soil crusts formed by raindrop impact. Soil Sci. 85: 185-189.

Morin, J., and Y. Benyamini. 1977. Rainfall infiltration into bare soils. Water Resour. Res. 13: 813-817.

Morin, J., S. Goldberg, and I. Seginer. 1967. A rainfall simulator with a rotating disk. Trans. of ASAE. 10:74-79.

Table 1. Rain infiltration after one hour into Pullman, Olton, and Amarillo soils at Bushland and Lubbock with conventional tillage (Disk, SM) or no-tillage of cotton, sorghum, and wheat residues measured during fallow.

Location - Soil	Crop Residue	Tillage	Infiltration Amount, in. (mm)
At Bushland - Pullman	Sorghum	SM	1.69 (43)
(Jones et al., 1994)		NT	1.04 (27)
	Wheat	SM	1.73 (44)
		NT	1.65 (42)
Baumhardt and Jones (2000)	Sorghum	SM	1.34 (34)
		SM + Subsoil	1.22 (31)
		NT	0.75 (19)
		NT + Subsoil	0.91 (23)
		NT + Sweep	0.71 (18)
At Lubbock			
(Baumhardt et al. 1993a)			
Amarillo soil	Cotton	Disk	1.95 (50)
	Cotton	NT	1.78 (45)
	Sorghum	NT	1.95 (50)
	Wheat	NT	2.31 (59)
Olton soil	Cotton	Disk	2.31 (59)
	Cotton	NT	1.78 (52)
	Sorghum	NT	2.17 (55)
	Wheat	NT	2.31 (59)

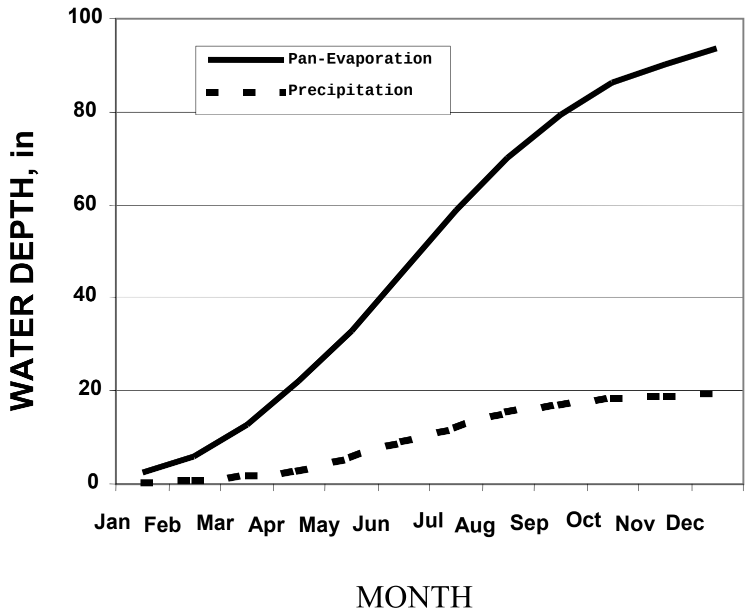


Fig. 1. Long-term monthly cumulative precipitation and pan evaporation at Bushland, TX.

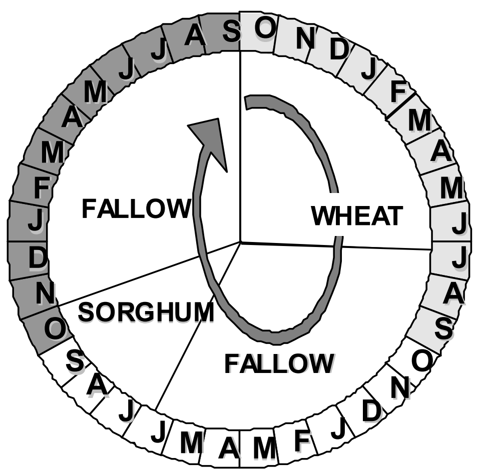


Fig. 2. The WSF crop rotation diagramed as a three year cycle beginning in October (top) with wheat establishment. Wheat is harvested 10-months later in July when the soil is fallowed until June of the second year (11-months). Grain sorghum is then grown using soil water stored during fallow to augment rainfall. After sorghum harvest in November of the third year the soil is again fallowed for 10-months when wheat is planted and the cycle repeated.

Fig. 3. Residue management of annually grown cotton with winter wheat sown as a green fallow crop after cotton harvest. Wheat is chemically terminated in the spring and cotton replanting.

NO-TILL AND RESIDUE REMOVAL EFFECTS ON SOIL CARBON CONTENT

K.N. Potter, J. de J. Velazquez G., and H. A. Torbert[1]

AUTHORS: [1]Dr. Kenneth Potter, USDA-ARS, Mr. Jaime Velazquez Garcia, INIFAP, and Dr. H. Allen Torbert, USDA-ARS. Corresponding author: K.N. Potter, 808 East Blackland Road, Temple, Texas,76502 Email:potter@brc.tamus.edu.

INTERPRETIVE SUMMARY

Soil organic carbon, an indicator of soil quality, generally increases with a conversion from inversion tillage to no-till management practices. However this assumes that the crop residue is left on the soil surface with no-till. In Mexico, crop residues are often utilized as animal fodder, even with no-till management practices. We conducted a study to determine the effect of removing different amounts of corn residue on soil organic carbon content with no-till. No-till practices with all the residue removed usually maintained organic carbon levels about that which occurred with moldboard plowing. Leaving residue generally increased soil organic carbon content. With higher mean annual temperatures, leaving residues on the surface were less effective in increasing soil carbon content than with lower mean annual temperatures. Higher rainfall usually increased soil carbon content with larger amounts of residue remaining on the surface. Leaving crop residues in the field with no-till management can increase soil carbon contents, but with some climatic conditions the residue may be better used as animal fodder.

ABSTRACT

No-till crop management often results in increased soil organic carbon contents. However, the effect of residue removal with no-till on soil carbon contents is not well understood. We conducted a multiyear study at six locations in central Mexico, with a wide range of soil and climatic conditions to determine the effect of varying rates of residue removal and no-till management on soil carbon contents. Treatments consisted of annual moldboard plowing and no-till management practices with 100%, 67%, 33% and none of the corn (Zea mays) crop residue remaining on the no-till soil surface. No-till practices maintained carbon levels above that of moldboard plowing at five of the six locations even when all crop residues were removed. Leaving crop residues on the soil surface increased soil carbon content, but at a much faster rate in cool conditions than in tropical conditions. Carbon content was greater with higher amounts of rainfall than in the drier regions. No-till will increase soil carbon contents, but climatic conditions should be considered to determine if crop residue would be more effectively utilized as animal fodder.

INTRODUCTION

Three hundred major watersheds in Mexico, with total annual water yield of about 40 billion cubic meters, are degrading due to reduction of vegetative cover, soil erosion, nutrient losses agrochemical pollution and lake eutrophication (Albert, 1996). Concurrent hillslope and gully erosion have been identified on 65 to 85% of the land (Bocco and Garcia-Oliva, 1992). Soil organic carbon (SOC) content has long been recognized as one indicator of soil quality that is susceptible to degradation with inversion tillage often practiced in Mexico. In the United States, soil organic carbon was reduced as much as 40% with the use of inversion tillage (Allmaras et al., 2000). Soil organic carbon reductions were likely to have been as great in Mexico because of the frequent use of inversion tillage practices.

While tillage usually results in a large decrease in SOC, less intensive tillage with residue management practiced for extended periods of time has been shown to increase SOC concentrations near the surface (Dick, 1983; Eghball et al., 1994). Several authors have related the change in SOC to type of tillage and the amount of biomass produced by the crop (Havlin et al., 1990; Reicosky et al., 1995; Robinson et al., 1996). Rates of carbon accumulation in soils under no-till or conservation till reported in the literature have varied widely, ranging from below zero to 1300 kg ha^{-1} yr^{-1} (Reicosky et al., 1995). The greatest increases in SOC have been reported in the colder, northern regions of the United States. Several authors have reported that SOC concentrations were increased near the surface with no-till management in the warmer southwest environment (Unger, 1991; Potter and Chichester, 1993; Christensen et al., 1994).

No-till as normally conducted in the United States involves leaving the crop residue on the soil surface. This is often not the case in Mexico, where crop residues are often harvested for livestock feed. The purpose of this study is to determine the effect of no-till management practices on soil organic carbon content with different amounts of crop residue remaining on the surface.

MATERIALS AND METHODS

Six locations were selected for study in the states of Michogan and Jalisco in central Mexico (Figure 1). The sites are locations where long-term studies of management effects on continuous corn (*Zea mays* L.) yield and soil erosion is being conducted. The management systems chosen for this study are conventional moldboard plowing and no-till with varying amounts of corn residues remaining on the soil surface. Residue treatments consisted of leaving 100%, 67%, 33%, or none of the crop residue on the soil surface. Bulk surface samples were collected and soil characterization tests performed to determine soil texture, predominant mineralogy, and organic carbon content.

Soil cores, 1.5 inches in diameter, were obtained from each site/surface condition using a hand-driven sampler with a plastic liner to limit soil compaction. If compaction was observed, the core was discarded and another core taken. Soils were sampled to a depth of 12 inches. Cores were segmented to obtain depth increments of 0-0.8, 0.8-1.6, 1.6-2.75, 2.75-3.9, 3.9-5.9, 5.9-7.9, 7.9-11.8 inches. Soil segment wet weight was determined. The soil core was then split lengthways. Half the soil core segment was weighed, oven dried at 221 $^{\circ}$F for 48 hours and the dry weight recorded. The soil water content was determined and used to correct the segment weight for calculating soil bulk density. The other half of the soil core was air dried until it easily crumbled and easily identified organic matter such as roots, stems, leaves, and plant crowns was removed. The remaining soil was crushed to pass through a 0.078-inch sieve. A subsample of the cleaned sample was ground in a rolling grinder (Kelley, 1994) in preparation of carbon analysis. The ground sample was oven dried for 3 hours at 150 $^{\circ}$F before burning.

Soil organic carbon was determined using a CR12 Carbon Determinator on samples weighing about one gram (Chichester and Chaison, 1991). Soil samples were burned at 1067 $^{\circ}$F and CO_2 concentration in the airflow determined with a solid state infrared detector. The combustion temperature was such that organic carbon was oxidized but inorganic carbon (i.e. CO_3) was not (Chichester and Chaison, 1991; Rabenhorst, 1988; Merry and Spouncer, 1988). The CO_2 concentration was integrated over the duration of the burn to determine the sample C concentration. Soil bulk density and water content were determined (Table 2). Soil organic carbon content was calculated based upon the equivalent soil mass as described by Ellert and Bettany (1995).

A regression analysis was used to determine statistical differences among soils and between conventional and no-till management practices within locations.

RESULTS

Sites locations are shown in Figure 1 and selected soil parameters are presented in Table 1. Length of time of continuous management, mean annual temperature and average rainfall amounts are presented in Table 2. Length of time of continuous management varied from four to nine years. Continuous management is an important factor as soil organic carbon differences among treatments can take several years to develop.

Soil organic carbon concentrations in the surface horizons are presented in Figure 2. No-till management with more than 67% residue retention increased soil organic carbon concentration in the surface ten cm of the soil profile compared to the conventional management practice. In most cases the conventional management practices resulted in soil carbon concentrations similar to the no-till with 0% residue retention. The exception was at Patzcuaro where no-till 0% residue had a lower carbon content than the conventional tillage treatment.

Organic carbon content in the surface 12 inches of the no-till soils is presented in Figure 3. Carbon content was related to residue retention by regression analysis. The soils varied a great deal in the amount of carbon present, generally depending on the amount of carbon present at the start of the experiment. For example, the carbon content at the Casas Blancas site was much greater than the rest of the experimental sites. Response to the amount of residue left on the soil surface varied among locations (Figure 3). While leaving residue on the surface increased soil carbon content, the response varied depending in part upon the length of time the management practices had been in place. The increase in soil carbon, as indicated by the slope of the regression between soil carbon and residue remaining, was corrected for length of time in management by dividing the slope by the number of years in continuous management. The normalized slope was then related to climatic factors such as the mean annual temperature and annual rainfall.

Change in carbon content varied in a nonlinear manner with mean annual temperature (Figure 3). At relatively low annual temperatures, leaving residue on the soil surface increased soil carbon content. At high mean annual temperatures, leaving crop residues on the soil surface had relatively little effect on the soil carbon content.

The amount of residue remaining on the soil surface tended to increase soil carbon contents in a linear manner across a rainfall gradient (Figure 4). At higher rainfall levels, leaving residue on the surface had a greater effect on soil carbon content than occurred at lower amounts of annual rainfall.

SUMMARY

In conclusion, no-till management practices generally increased soil organic carbon content above that occurring with conventional tillage if some residue was left on the soil surface. Leaving residue on the soil surface, while common in no-till management practices in the United States, does not always occur in Mexico were crop residues are often used for animal fodder. Leaving crop residues was most effective in increasing soil carbon content in the cooler regions of Mexico. Where mean annual temperatures were greater than 81 ºF, leaving crop residues on the soil had little effect on the soil carbon content.

Literature Cited

Albert, L., 1996. Sobreexplotadas las fuentes hídricas del país. In: La Jornada Ecológica 4, 3-7. (in Spanish).

Allmaras, A.A., H.H. Schomberg, C.L. Douglas Jr., and T.H. Dao. 2000. Soil organic carbon sequestration potential of adopting conservation tillage in U.S. croplands. J. Soil Water Conserv. 55:365-373.

Bocco, G., Garcia-Oliva, F., 1992. Researching gully erosion in Mexico. J. Soil and Water Conservation 47, 365-367.

Chichester, F.W. and R.F. Chaison. 1991. Analysis of carbon in calcareous soils using a two temperature dry combustion infrared instrumental procedure. Soil Science 153:237-241.

Christensen, N.B., Lindemann, W.C., Salazar-Sosa and Gill, L.R., 1994. Nitrogen and carbon dynamics in no-till and stubble mulch till systems. Agron. J., 86:298-303.

Dick, W.A., 1983. Organic carbon, nitrogen, and phosphorus concentrations and pH in soil profiles as affected by tillage intensity. Soil Sci. Soc. Am. J., 47:102-107.

Eghball, B., Mielke, L.N. McCallister, D.L. and Doran, J.W., 1994. Distribution of organic carbon and inorganic nitrogen in a soil under various tillage and crop sequences. J. Soil Water Conserv., 49:201-205.

Ellert, B.H. and J.R. Bettany. 1995. Calculation of organic matter and nutrients stored in soils under contrasting management regimes. Can. J. Soil Sci. 75:529-538.

Havlin, J.L., Kissel, D.E., Maddux, L.D., Claassen, M.M. and Long, J.H., 1990. Crop rotation and tillage effects on soil organic carbon and nitrogen. Soil Sci. Soc. Am. J., 54:448-452.

Kelley, K.R. 1994. Conveyor-belt apparatus for fine grinding of soil and plant materials. Soil Sci. Soc. Am. J. 58:144-146.

Merry, R.H., and L.R. Spouncer. 1988. The measurement of carbon in soils using a microprocessor controlled resistance furnace. Comm. Soil Sci. Plant Anal. 19:707-720.

Potter, K.N. and F.W. Chichester. 1993. Physical and chemical properties of a vertisol with continuous controlled-traffic, no-till management. Trans. ASAE 36:95-99.

Powlson, D.S., P. Smith, K Coleman, J. U. Smith, M.J. Glendining, M. Körschens, U. Franko. 1998. A European network of long-term sites for studies on soil organic matter. Soil Till. Res. 47(3-4) 263-274.

Rabenhorst, M.C. 1988. Determination of organic and inorganic carbon in calcareous soils using dry combustion. Soil Sci. Soc. Am. J. 52:965-969.

Reicosky, D.C., Kemper, W.D., Langdale, G.W., Douglas, C.L. Jr. and Rasmussen, P.E., 1995. Soil organic matter changes resulting from tillage and biomass production. J. Soil Water Conserv., 50:253-261.

Robinson, C.A., Cruse, R.M. and Ghaffarzadeh, M., 1996. Cropping system and nitrogen effects on mollisol organic carbon. Soil Sci. Soc. Am. J., 60:264-269.

Unger, P.W., 1991. Organic matter, nutrient, and pH distribution in no-tillage and conventional-tillage semiarid soils. Agron. J., 83:186-189.

Table 1. Selected properties for six soils.

Site	Clay (%<2μ)	Sand (0.05>%<2mm)	Textural Classification	Predominate Clay Mineralogy †	pH ±
Guzman	12.3	63.2	Sandy Loam	FD3	5.5
Patzcuaro	12.2	48.7	Loam	KK1	5.5
Casas Blancas	16.1	25.5	Silt Loam	NX6	5.3
Tipititlan	47.1	13.1	Clay	KK2, HE2	5.6
Apatzingan	58.9	21.7	Clay	MT4	7.8
Morelia	77.4	0.6	Clay	CR2, MT2	6.7

† MT = montorillonite, FD = feldspar, CR = cristobalite, NX = non-crystaline, KK = kaolinite, HE = hematite. The number refers to relative peak size: 1 = very small, 2 = small, 3 = medium, 4 = Large, 6 = no peak.
± pH is 1:1 H_2O paste.

Table 2. Climatic factors and length of continuous management.

Location	Temperature °F	Rainfall inches	Continuous Management Years
Cd. Guzman	68	30.9	7
Tepatitlan	64	32.6	8
Apatzingan	81	25.6	7
Patzcuaro	63	43.3	5
Casas Blancas	61	39.3	7
Morelia	68	31.5	4

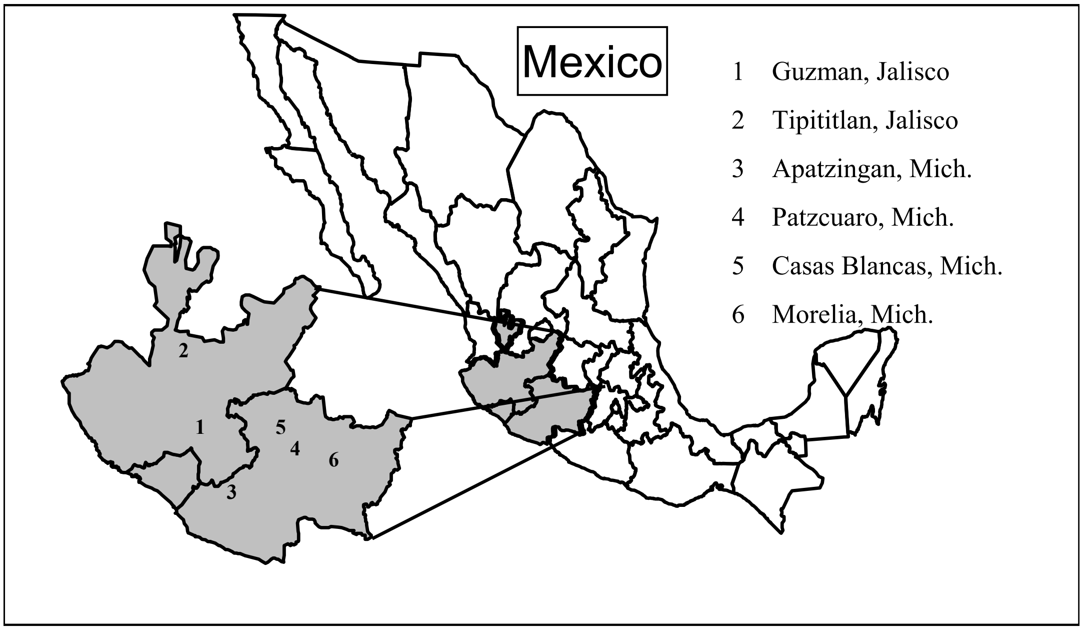


Figure 1. Location of the study sites.

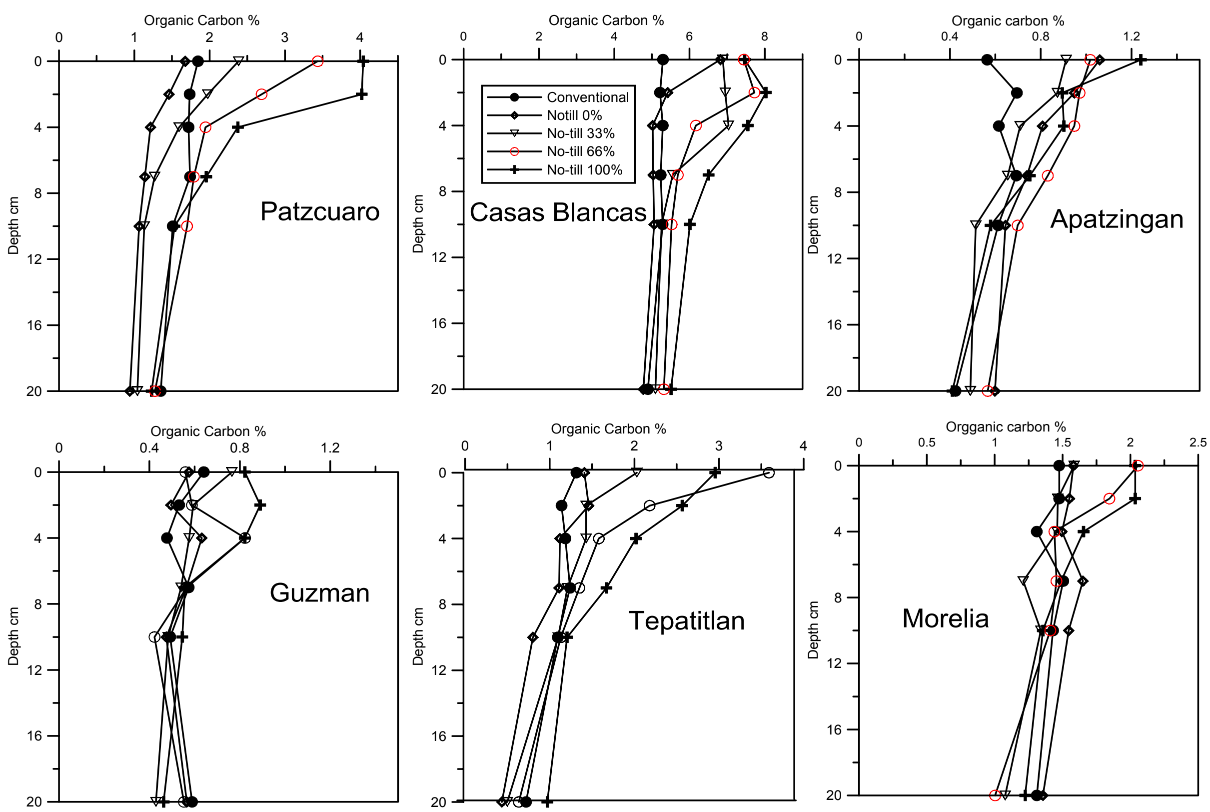


Figure 2. Organic carbon distribution in the surface 30 cm.

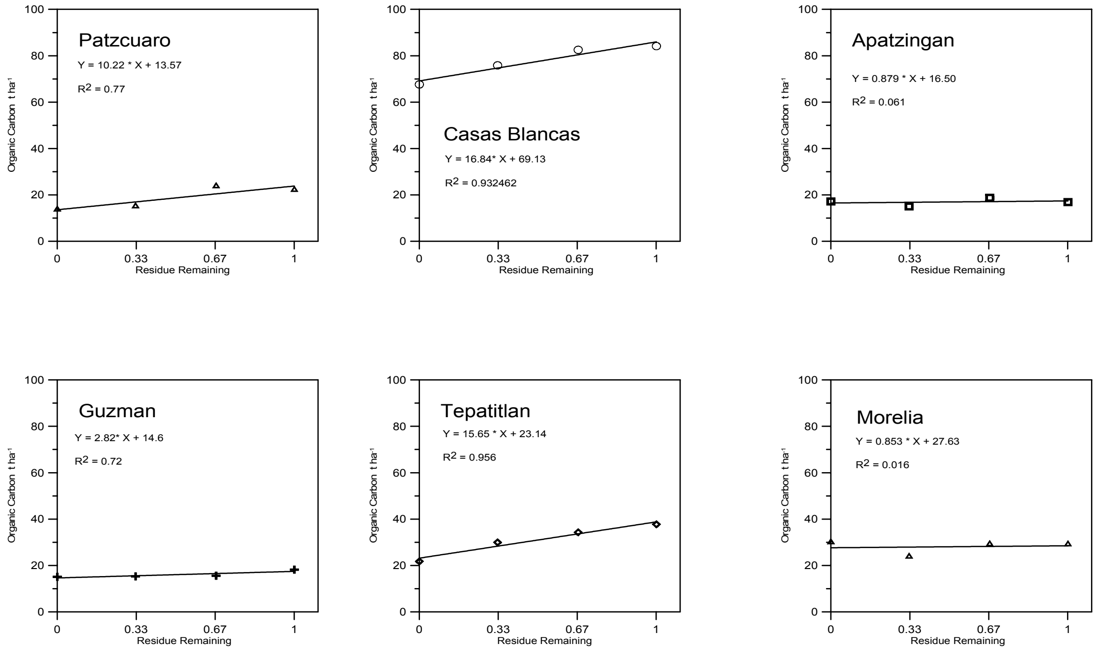


Figure 3. Regression analysis of change in soil carbon with the amount of residue left on the soil surface.

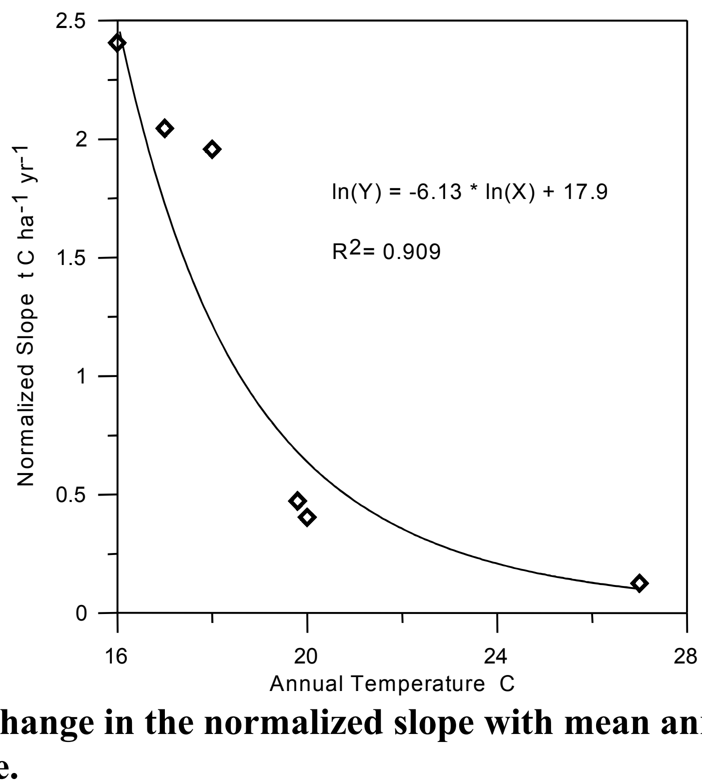


Figure 4. Change in the normalized slope with mean annual temperature.

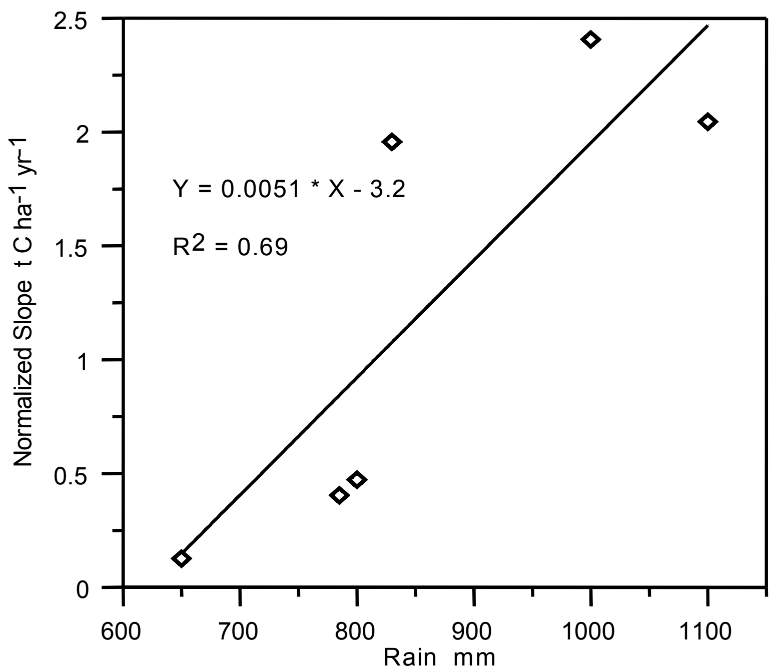


Figure 5. Change in the normalized slope with mean annual rainfall.

EFFECTS OF TRANSITIONAL CONSERVATION RESERVE PROGRAM LAND MANAGEMENT PRACTICES ON SOIL ORGANIC MATTER

Thanh H. Dao and J. H. Stiegler

AUTHORS: Corresponding author, USDA-ARS, BARC-East, Bldg. 306, Room 102, Beltsville, MD 20705 (e-mail thdao@anri.barc.usda.gov). USDA-ARS, Beltsville, MD 20705 and Department of Plant & Soil Sci., Oklahoma State Univ., Stillwater, OK.

ABSTRACT

Information was needed regarding changes in soil organic matter and management practices to conserve soil improvement accrued during the Conservation Reserve Program (CRP) upon returning these lands to agronomic production in semiarid regions. We determined the changes in soil carbon (C) in two CRP field soils after three years of intensive grass management and winter wheat production. The study sites were located on Dalhart fine sandy loam (Aridic Haplustalf) and La Casa-Aspermont clay loams (Typic Paleustoll) found near Forgan and Duke, OK, respectively. Management changes from CRP to intensive Old World bluestem (OWB) forage and no-till (NT) wheat production resulted in no overall change in soil total C but led to the stratification and small gains of organic C in the 0-2" soil depth of the Dalhart soil, compared to the OWBUF treatment where OWB forage was removed every year without the benefit of fertilizer applications. In the La Casa-Aspermont soil, only the NT wheat system showed similar organic C gains in the surface 0-2" depth. Otherwise the remaining alternative land management systems did not cause any significant change in soil total and organic C. Using shallow tillage to destroy the OWB sod and prepare crop seedbeds appeared to lower organic C content in the first 2" soil depth of the Dalhart soil, possibly preventing the development of a surface organic matter crust. Therefore, increased intensity of forage management or no-tillage wheat production systems allow land managers of former CRP grasslands to maintain the organic matter status found under the CRP sod in regions of limited rainfall.

INTRODUCTION

There were 1.2 million acres enrolled in the Conservation Reserve Program in Oklahoma after the 12th signup period. Most of this acreage was located in western counties along the Oklahoma-Texas border and was cropped annually to winter wheat and cotton. These lands suffered from moderate to severe soil erosion by wind and water. Old World bluestem (*Bothriochlora ischaemum* L.) and native grasses were extensively used to provide a permanent cover on highly erodible former croplands. The conservation program has been credited with substantial reduction in wind and water erosion of these former croplands (Lindstrom *et al.*, 1998). The program was reauthorized in 1996 adding environmental benefits to the requirements for contract renewal or new enrollment. Landowners must meet stricter environmental benefit criteria for re-enrollment or return these fields to livestock or crop production.

Changing these grasslands back to croplands once again generated substantial concerns that revolved around best-management practices to kill the sod, plant crops, how to best maintain erosion control on these former highly erodible croplands and conserve the benefits accrued under the CRP. A number of cropping studies were conducted across the Great Plains to provide integrated guidelines for tillage, chemical control of CRP grass and weeds, fertility, and crop management (Schuman et al., 1995; Tanaka, 1995; Medlin et al., 1998; Unger, 1999; Dao et al., 2000). A study of tillage treatments on Pullman clay loam indicated that retention or removal of the grass cover slightly affected sorghum and wheat yields (Unger, 1999). Vegetation retention interfered with crop planting and establishment, particularly with NT practices, because of limited planting slot closure in dry soil conditions. Nitrogen fertilization was found to increase wheat yields due to the low fertility status in CRP grassland and the large influx of C upon soil incorporation of the CRP sod (Medlin et al., 1998; Unger, 1999). Dao and co-workers found that removal of the old grass litter and regrowth vigor increased the success of suppressing and killing of the OWB cover and the uniformity of the crop stand. Early growth suppression of the OWB was essential to conserve stored soil water for growing a winter wheat crop in the year a CRP contract expires. Maintaining the CRP cover to support livestock production required annual forage harvest and improved soil fertility management. The intensive management increased forage quality and yields between 49 to 110% and 170 to 400%, respectively.

Another major concern of CRP landowners was how to best conserve the benefits to the soil that accrued during the CRP and sustain the increased production intensity. Soil C increased at an average rate of 980 lb/A/yr at selected CRP sites in the Central and Southern Great Plains (Gebhart *et al.* 1994). However, others have reported little or no change in soil organic C (Schuman *et al.*, 1995). Staben and co-workers (1995) found no significant difference in soil organic C and microbial biomass C between field soils under wheat-fallow and CRP management. Carbon mineralization potentials were 50% higher in the CRP soil than the wheat-fallow soil. Robles and Burke (1998) found minimal differences in total C between soils from CRP fields seeded to wheatgrass (*Agropyron smithii*) and brome (*Bromus inermis*) and wheat-fallow soils. However, the CRP soil had 8.8 lb mineralizable C /A/day or over 2.5 times more than that observed in a wheat-fallow field soil. Returning these highly erodible lands to row crop production may bring back the degraded conditions that made these lands eligible for the CRP in the first place. Observed soil degradation included reduced soil macroporosity and decreased water infiltration within one year of converting CRP grassland to croplands (Lindstrom *et al.*, 1998). Sediment loss was appreciably greater under disk-tillage used to destroy the CRP sod and averaged between 50 to 130 lb/A more than chemically killed sod for no-till wheat production (Gilley *et al.*, 1997). The objective of this study was to determine the changes in organic matter and improve our understanding of the process of soil C accretion from grass and crop residues as affected by land management under semiarid environments.

MATERIALS & METHODS

We conducted the study of transitional CRP systems on two producers' CRP fields. One experimental site was in northwest OK, near the town of Forgan. Annual precipitation averaged 18 in and mean minimum and maximum temperatures were 40 and 70 ^{o}F, respectively. The major soil at the Forgan site was Dalhart fine sandy loam on 1 to 3% slope. The second study site was near the town of Duke, OK. The annual precipitation was approximately 29 in. Annual minimum and maximum temperatures averaged 45 and 75 ^{o}F, respectively. The major soils at the Duke site were La Casa-Aspermont clay loams with a 1 to 3% slope. Selected soil properties are presented in Table 1. The old OWB growth in a 25-a block of the CRP fields was removed to establish four land management treatments in 1994. At Forgan, four replicated plots measuring 150 by 300 ft were established to evaluate: (i) OWBUF = minimum OWB management (no fertilizer added following the removal of the old biomass), (ii) OWBF = optimal grass management (fertilizer added following the removal of the old biomass), (iii) CT = conventional-tillage (i.e., sweep-tillage (ST)) conversion to wheat, and (iv) NT = no-till conversion to wheat. At Duke, field plots were established to evaluate the same four management systems, except that disk-tillage (DT) was used to destroy the sod before tillage and planting. The ST, DT, and NT plots were re-established after wheat harvest for the next three years. Soil samples were collected from both locations before grass mowing or burning of the old litter and before tillage/no-till operations in the cropped treatments. Soil cores were taken to 12" and separated into 0-2", 2-4", 4-8", and 8-12"samples using a 3" I.D. soil core sampler. Total sample weights and water content were measured to calculate soil bulk density. Samples were composited and split into halves; a set of soil samples was refrigerated at 40 ^{o}F for biological measurements. The remainder was air-dried, crushed and sieved to pass a sieve with 2-mm openings, and stored at room temperature until chemical analysis. Total soil C and organic C were determined before and after acid washing of the soil samples by dry combustion (Nelson and Sommers, 1996). One-g samples were weighed into ceramic boats and oxidized at 1400^{o}C to determine C concentrations using a CNS-2000 (LECO Corp., St Joseph, MI)[1]. To remove carbonate-C from another set of all soil samples, a 1*M* HCl solution was added incrementally to 5 g of soil until effervescence ceased. The sample was left standing overnight with an additional 25 mL of a 1*M* HCl solution. The supernatant was decanted and the residue was rewashed with deionized water until the supernatant pH was near neutral. The soil residue was subsequently dried and total C was determined as described above. Final C concentrations were adjusted for the weight loss due to carbonate removal.

At each location, the four management treatments were established with four replications based on a randomized complete block design. Triplicate subsamples of soils from each management plot were analyzed as described above for C. Significant differences in treatment means were detected following analysis of variance and a multiple range test at the 0.05 level of probability.

RESULTS AND DISCUSSION

A great deal of spatial variability existed in total C with soil depth at both field sites (Table 2). Both the Dalhart and La Casa-Aspermont soils had varying levels of free carbonate-C within the Ap horizon to account for the high variability in soil total C. The variations in both C fractions were high within 4 to 12" from the soil surface. The spatial variability made some treatment comparison difficult to resolve the effects of management on soil total C. For example, as management system x depth interactions were not statistically significant, total C means showed that OWBF, CT and NT treatments did not appear to have alter soil total C in the Dalhart soil, compared to the OWBUF treatment of continuing the CRP cover with annual forage harvest as the only management input (Table 3). Yet, the CT treatment had lower relative total C concentrations than the OWBUF, OWBF, and NT treatments, at all four depths. The total C

[1] The mention of a trade or manufacturer names is made for information only and does not imply an endorsement, recommendation, or exclusion by the USDA-ARS.

decrease in the 0-2” depth was not statistically significant but was corroborated by the low organic C in the same soil depth. The organic C results were contrary to the trend toward C stratification and surface gains in the other land management systems. Shallow tillage may have caused soil mixing and would prevent the formation of an organic C crust observed in the OWB and NT systems and thus resulted in low C concentrations at the CT soil surface of the Dalhart soil.

In the La Casa-Aspermont soil, the OWBF, CT, and NT treatments did not significantly alter soil total C any more than the OWBUF treatment did, at least in the 0-4” soil depth (Table 3). Total C distribution with depth in the La Casa-Aspermont soil was highly variable across the CRP field (Table 2). Close examination of the NT treatment revealed that low relative total C concentrations occurred in the 4 to 12” depths. It was concluded that these NT plots did not have high levels of free carbonate-C at these depths and that the low total C relative concentrations were not the results of deep C loss processes since no deep mechanical disturbance was introduced in this management system. Calculations yielded low relative concentration values when the NT total C concentrations were normalized against the high concentrations found in the OWBUF treatment.

The undisturbed conditions in the OWBF and NT systems resulted in the layered distribution of organic C with depth. There were small net gains in the surface 2” of the OWBF and NT treatments and the 2 and 4” depth of the OWBF treatment in the Dalhart soil, compared to the OWBUF treatment. The NT wheat system was the only system to show increased organic C in the surface 2” depth of the La Casa-Aspermont soil. Partially incorporated plant debris formed an organic crust to raise organic C concentrations of the 0-2” layer (McConnel and Quinn, 1988). Had we not done a shallow sampling of the soil, this small accumulation of C would have been diluted and gone undetected. Changes in soil total or organic C content remain hard to detect, particularly in the short timeframe since land use conversion. Changes in soil biological and biochemical properties may be more apparent, given the higher management intensity of cropping systems and soil perturbations that affect biological activities in the near-surface and root zones (Robles and Burke, 1998; T. H. Dao et al., unpublished data).

In summary, the re-vegetation of highly erodible Dalhart and La Casa-Aspermont soils to perennial warm-season OWB grasses may have reduced the erosion of these fragile soils. Given the heterogeneity of total and organic C concentrations in these eroded fields, intensive OWB forage and NT annual wheat production appeared to have maintained the C status found during the CRP. The challenge for land managers will be to sustain the C-rich environment that existed during the program, maintain the status quo in soil C levels coming out of the CRP, and possibly promote the development of surface organic crust and accumulation of organic C in highly erodible soils in regions of limited rainfall.

Literature Cited

Dao, T.H., J. H. Stiegler, J.C. Banks, L. Bogle-Boerngen, and B. Adams. 2000. Post-contract grassland management and winter wheat production on former CRP fields in the Southern Great Plains. Agron. J. 92:1109-1117.

Gebhart, D.L., H.B. Johnson, H.S. Mayeux, and H.W. Polley. 1994. The CRP increases soil organic carbon. J. Soil Water Conserv. 49:488-492.

Gilley, J.E., J.W. Doran, and T.H. Dao. 1997. Runoff, erosion, and soil quality characteristics of a former CRP site in SW Oklahoma. Appl. Engineer. Agric. 13:617-622.

Lindstrom, M.J., T.E. Schumacher, N.P. Cogo, and M.L. Blecha. 1998. Tillage effects on water runoff and soil erosion after sod. J. Soil Water Conserv. 53:59-63.

McConnel, S.G., and M.L. Quinn. Soil productivity of four land use systems in southeastern Montana. 1988. Soil Sci. Soc. Am. J. 52:500-506.

Medlin, C.R., T.F. Peeper, J.H. Stiegler, and J.B. Solie. 1998. Systems for returning CRP land to wheat (*Triticum aestivum*) production. Weed Tech. 12:286-292.

Nelson, D.W., and L.E. Sommers. 1996. Total carbon, organic carbon, and organic matter. p. 961-1010. *In*: D.L. Sparks *et al.* (eds). Methods of soil analysis. Part 3. Chemical Methods. Soil Sci. Soc. Am. Book Series No. 5. Soil Sci. Soc. Am., Madison, WI.

Robles, M.D., and I.C. Burke. 1998. Soil organic matter recovery on Conservation Reserve Program fields in southeastern Wyoming. Soil Sci. Soc. Am. J. 62:725-730.

Schuman, G.E., J.D. Reeder, R.A. Bowman, and S.R. Gullion. 1995. CRP lands in Wyoming: Soil organic matter improvement, forage management and production, and economic evaluation. p. 17-18. *In* Converting CRP lands to cropland and grazing: Conservation technologies for the transition. Soil Water Conserv. Soc., June 6-8, 1995. Lincoln, NE.

Staben, M.L., D.F. Bezdicek, J.L. Smith, and M.F. Fauci. 1997. Assessment of soil quality in Conservation Reserve Program and wheat-fallow soils. Soil Sci. Soc. Am. J. 61:124-130.

Tanaka , D.L. 1995. Methods for converting CRP land to sustainable production systems in North Dakota. p. 8-9. *In* Converting CRP lands to cropland and grazing: Conservation technologies for the transition. Soil Water Conserv. Soc., June 6-8. Lincoln, NE.

Unger, P.W. 1999. Conversion of Conservation Reserve Program (CRP) grassland for dryland crops in a semiarid region. Agron. J. 91:753-760.

INTERPRETIVE SUMMARY

Large-scale re-vegetation efforts to promote soil conservation and support farm income under the Conservation Reserve program (CRP) was beneficial to air and water quality by controlling soil erosion on highly erodible croplands across the U.S. To CRP landowners faced with expired contracts, alternate land use options include forage-livestock production or killing the grass cover and conversion back to row crop production. However, changes in soil organic matter and integrated management systems to conserve soil improvement accumulated during the CRP upon converting back to forage and crop production in semiarid regions are not well understood. After three years, management changes from CRP to intensive OWB forage and NT wheat production resulted in no overall change in soil total carbon content and may have led to small gain in organic matter at the very surface of the soil, compared to the OWBUF treatment, where OWB forage was harvested every year without the benefit of fertilizer applications. Using tillage to incorporate the OWB sod and prepare clean seedbeds resulted in lower soil organic matter in the first 2" soil depth by ruling out the formation of a surface organic crust. In the short term, increasing the intensity of grass management or no-tillage production systems appeared to allow former CRP land managers to control erosion and maintain the organic matter status found under the CRP sod in regions of limited rainfall.

Table 1: Selected properties of the Dalhart and La Casa-Aspermont soils

Series Name	Particle-size analysis			pH (0.01 *M* $CaCl_2$)	Organic C	Organic N
	sand	silt	Clay			
	%	%	%		%	%
Dalhart	61	25	14	6.6	0.52	0.06
La Casa-Aspermont	30	57	13	7.7	1.41	0.13

Table 2: Soil C and N in CRP fields under an OWB sod before the establishment of land management treatments in 1994

Series Name	Depth	Total C	Organic C	Organic N
	Inch	lb/ft^3	lb/ft^3	lb/ft^3
Dalhart	0 – 2	0.42 ± 0.07 †	0.40 ± 0.06	0.04 ± 0.01
	2 – 4	0.34 ± 0.07	0.34 ± 0.06	0.03 ± 0.01
	4 – 8	0.44 ± 0.11	0.45 ± 0.11	0.04 ± 0.01
	8 – 12	0.46 ± 0.09	0.45 ± 0.07	0.05 ± 0.01
La Casa-Aspermont	0 – 2	1.23 ± 0.24	0.96 ± 0.14	0.10 ± 0.02
	2 – 4	1.01 ± 0.18	0.80 ± 0.09	0.08 ± 0.01
	4 – 8	1.19 ± 0.28	0.93 ± 0.14	0.08 ± 0.01
	8 – 12	1.28 ± 0.45	0.84 ± 0.12	0.08 ± 0.01

† Means and standard deviation (n = 12)

Table 3: Effects of land management change from minimum-input Old World bluestem production to intensive forage and wheat production on selected C pools of the Dalhart and La Casa-Aspermont soils in 1997.

Land management system	Depth	Dalhart fine sandy loam			La Casa-Aspermont clay loam		
		Total C	Total C system means‡	Organic C	Total C	Total C system means	Organic C
	Inch	%		%	%		%
OWBUF	0 – 2	100 †		100	100		100
	2 – 4	100		100	100		100
	4 – 8	100		100	100		100
	8 – 12	100	100 a	100	100	100 a	100
OWBF	0 – 2	112		137	110		107
	2 – 4	105		131	100		84
	4 – 8	93		113	86		99
	8 – 12	86	96 a	78	84	92 a	112
CT	0 – 2	69		72	96		106
	2 – 4	86		112	108		91
	4 – 8	88		117	97		103
	8 – 12	90	82 a	65	86	95 a	96
NT	0 – 2	100		137	99		121
	2 – 4	84		108	88		82
	4 – 8	89		112	60		91
	8 – 12	111	95 a	74	55	75 a	105
	$LSD_{0.05}$			18§			15§

† Expressed as fraction of the C concentrations occurring at the same depth of the OWBUF treatment in 1997. (OWBUF = Old World bluestem-unfertilized; OWBF = Old World bluestem-fertilized; CT = Conservation tillage wheat; NT = No-till wheat).
‡ Treatment means followed by same letter are not significantly different at the 0.05 level of probability.
§ Significant land management system by depth interactions.

REDUCING SOIL COMPACTION AND IMPROVING COTTON YIELD WITH CONSERVATION TILLAGE IN THE TENNESSEE VALLEY

E.B. Schwab[1], D.W. Reeves[1], C.H. Burmester[2], and R.L. Raper[1]

AUTHORS: [1]USDA-ARS National Soil Dynamics Laboratory, Auburn, AL. Corresponding author: E.B. Schwab (schwaeb@eng.auburn.edu). [2]Department of Agronomy and Soils, Auburn University.

ABSTRACT

Yield reductions with strict no-tillage in the Tennessee Valley of north Alabama jeopardized adoption of conservation systems in this region. Consequently, we implemented a four year study on a Decatur silt loam (fine, kaolinitic, thermic Rhodic Paleudults) in 1994 to develop a practical conservation tillage system that results in competitive cotton yields. Treatments included a factorial combination of fall ridging (ridged and non-ridged) and fall deep tillage (none, in-row subsoiling, paratilling); along with spring strip tillage and conventional tillage. With the exception of the conventional tillage, all treatments were established with a rye (*Secale cereale* L.) cover crop. Tillage systems were evaluated for plant population, soil compaction, soil water content, and seed cotton yield. Cotton populations with conservation tillage were similar to the conventional tillage system and adequate stands were obtained in all treatments far all years. Soil compaction index (function of compaction intensity and volume of affected soil) was reduced by fall paratilling (29%-31%) and in-row subsoiling (12-15%), compared to conventional tillage and strict no-tillage, respectively. Both fall subsoiling and paratilling reduced soil water content (increased soil water removal by cotton roots) under the row compared to strict no-tillage. Fall deep tillage, either paratilling or in-row subsoiling, resulted in the highest seed cotton yields (2,760 lb ac^{-1}); 16% greater than conventional tillage, and 10% greater than strict no-tillage over a 4 y duration. Deep tillage (subsoiling or paratilling) and the use of cover crops is the most competitive system for farmers trying to convert to conservation tillage in this region.

INTRODUCTION

Long-term continuous cotton production on soils in the Tennessee River Valley of northern Alabama has resulted in soil degradation due to soil erosion, loss of organic matter, and soil compaction. Degradation of soil quality and increasing governmental regulations on the 60 to 70% of cropland classified as highly erodible land (HEL) in the region resulted in some farmers turning to conservation tillage systems in the early 1990's. The common method of conservation tillage, i.e., no-tillage cotton planted into existing cotton stubble, increases soil surface compaction; restricting root growth and reduces yields in the region (Burmester et al., 1993). Management decisions for conservation tillage systems are further complicated by slow accumulation of growing degree days (DD60s) in the spring and early fall freezes, resulting in a short growing season (Norfleet et al., 1997). Thus, many farmers were reluctant to adopt conservation tillage on a large scale, despite the possible long-term benefits of improved soil quality. To facilitate widespread adoption of conservation tillage in the region, a study was implemented in the fall of 1994 to develop a conservation tillage system for cotton that would reduce soil compaction and maintain competitive yields.

MATERIALS AND METHODS

The study was initiated in November of 1994 on the Tennessee Valley Research and Extension Center of the Alabama Agriculture Experiment Station, Belle Mina, AL. The soil type is a Decatur silt loam, the major soil type in the region. The experimental area had been cropped continuously to no-till cotton without a cover crop for four years prior to study.

The experimental design was a randomized complete block design with four replications, with a two by three augmented factorial treatment arrangement. Plots consisted of eight, 40-in wide rows which were 50 feet long. Treatments were a factorial combination of fall ridging (ridging and non-ridged) in combination with fall deep tillage (none, in-row subsoiling and paratilling). The augmented treatments were spring strip tillage and conventional tillage. Non-ridging without deep tillage is considered a strict no-tillage control. All treatments were accomplished with four-row equipment. Subsoiling was implemented under the row with a KMC® (Kelley Manufacturing Co., Tifton, GA 31793)[1] ripper bedder to a depth of 17 in. Paratilling was done with a Paratill® (Bigham Brothers, Inc., Lubbock, TX 79452)[1] to a depth of 18 in. In the fall of 1994, all ridging operations were accomplished using a KMC® ripper bedder equipped with disk bedders. The ripper subsoiler shanks were removed for implementation of fall ridging without deep tillage and ridging with paratilling. Data from the fall ridging with subsoiling treatment is not available for 1995 because of difficulties implementing this treatment in the fall of 1994, however, in fall of 1995 and consecutive years, all ridged plots were successfully created with ridging listers rather than disk bedders. Spring strip tillage in 1995 was implemented with an experimental Yetter® (Yetter Farm Equipment, Colchester, IL 62326)[1] implement. This implement has an in-row subsoiler that ran 8 to 10 in deep, with a series of in-row disks, coulters and spider tines to create a disturbed zone 12 to 14 in wide. In all other years (1996 to 1999) a specially designed KMC® implement was used for the spring strip tillage treatment. This implement has a shorter subsoil shank that ran 6 to 7 in deep in the row, and a series of in-row disks and coulters that disturbed a zone 12 in wide. Conventional tillage consisted of fall disking and chiseling (8 to 10 in deep) followed by disking and field cultivating in the spring.

All plots, except the conventional tilled plots, were seeded in rye (*Secale cereale* L.) with a grain drill immediately after fall tillage. The cover crop was terminated prior to spring planting with an application of glyphosate [N-(phosphonomethyl) glycine].

A four-row John Deere Maxi-Emerge® (Deere & Company, Moline, IL 61265)[1] planter equipped with Martin® (Martin & Company, Elkton, KY 42220)[1] row cleaners was used to plant 'DP 51' cotton on 12 May 1995, 'NuCOTN 33[B]' on 1 May 1996, 'DP

20[B]' on 7 May 1997 and 'PM 1220 BG/RR' on May 6 and May 5 in 1998 and 1999, respectively. Following planting, 15 lb N and 6 lb P ac^{-1} was applied in a band over the row. Nitrogen was also sidedressed at a rate of 90 lb ac^{-1} in all years. An additional 30 lb N ac^{-1} was applied in 1996 because of visual N deficiency at first bloom. Auburn University Extension recommendations were used to apply all herbicides, insecticides, and defoliants.

Average volumetric water content was determined in the top 15-in of soil under the row approximately twice a week from squaring to maturity in 1995 and 1996, and from early bloom to maturity in 1997 using time-domain reflectometry (TDR) (Topp, 1980).

A tractor-mounted, hydraulically driven, soil cone penetrometer was used for determination of soil strength after planting in 1995, 1996, and 1997 (Raper et al., 1999). The tractor-mounted penetrometer determined soil strength in five positions simultaneously: in-row, and 10 and 20 in from the row in both the trafficked and non-trafficked middles. Readings were taken continuously throughout the soil profile to a depth of 16 in and were averaged every two in. A soil compaction index was also determined for the evaluation of soil strength. Data were plotted to give scaled contour graphs using Surfer® for Windows (Golden Software Inc., Golden, CO 80401)[3]. Using this software, the area of the graph (cm^2) occupied by each incremental 0.5 MPa of soil strength was multiplied by the soil strength at the upper end of each increment and summed for all increments using the following formula:

$$SCI = \frac{1}{100}\sum_{I=1}^{N}\left[A_{I/2} - A_{(I/2 - 1/2)}\right]\frac{I}{2}$$

Where: SCI = soil compaction index (MPa-100 cm^2)
A = respective scaled area (cm^2) of contour graph between the isoline of cone index equal to (I/2) - (½) MPa and isoline of cone index equal to (I/2) MPa.
I = cone index of the isoline multiplied by 2 (MPa)
N = maximum cone index isoline multiplied by 2 (MPa)

Cotton populations were determined in 1995, 1996, 1997, and 1998 by counting the number of plants in two 5-ft sections of row from each plot. In all years, the middle 4 rows of cotton were harvested with a spindle cotton picker for the determination of seed cotton yield.

Data were subjected to analysis of variance using the Statistical Analysis System (SAS Institute, 1988). Preplanned single degree of freedom contrasts and Fisher's protected least significant difference (LSD) were used for mean comparisons. A significance level of $P \leq 0.10$ was established *a priori*.

[3] Reference to a trade or company name is for specific information only and does not imply approval or recommendation of the company by the USDA or Auburn University to the exclusion of others that may be suitable.

RESULTS AND DISCUSSION

Cotton Population

Contrary to previously reported research from the region (Touchton et al., 1984 and Brown et al., 1985), all conservation tillage treatments resulted in similar cotton populations compared to the conventional tillage treatment in all years with the exception of 1997 (Table 1). Delaying planting until 1 May or later and removing residue in the seeding zone with planter-equipped row cleaners likely minimized the soil temperature effects on cotton stands. Despite minor differences in plant populations, adequate stands were obtained in all treatments for all years.

Soil Compaction

Soil compaction as indicated by the soil compaction index was affected by tillage treatments in all measured years. The three year mean shows that conventional tillage, strict no-tillage, non-ridging without deep tillage, and spring strip tillage had greater soil compaction than all treatments with fall subsoiling or paratilling (Table 2). Fall paratilling also significantly reduced soil compaction compared to the fall subsoiled treatments. Fall subsoiling was effective in reducing soil compaction directly under the row, however, it had little effect in row middles. The bent shank of the paratill lifts the soil, causing a wide zone of disruption, unlike the subsoiler shank, which disrupts a narrow zone.

Soil Water

Tillage treatment had a significant effect on in-row soil water content in two of the three years measured (Table 3). In 1995, fall paratilling, with or without ridging, had significantly lower in-row soil water content compared to conventional tillage and strict no-tillage. This pattern of lower soil water contents in treatments with reduced compaction and higher soil water contents in treatments with greater compaction is consistent with expected differences in cotton rooting, i.e., greater root growth and soil water extraction in systems with lower soil compaction. However, average in-row soil water content for the non-ridged subsoiled treatment was not significantly lower than conventional tillage and strict no-tillage in 1995, despite reduced soil compaction. In 1996, fall ridging with paratilling had significantly lower in-row soil water content compared to all other treatments. Similar trends were seen in 1997, with fall ridging with paratilling having lower average soil water content compared to all other treatments, however this was not significantly different.

Yield

Seed cotton yields from all conservation tillage treatments were greater than or equal to conventional tillage in all five years of the study (Table 4). Despite extreme drought and severe outbreaks of tobacco budworm (*Heliothis virescens* F.), which visually appeared to have the greatest feeding pressure on the larger, less drought-stressed treatments, seed cotton yield averaged 1,480 lb ac^{-1} in 1995. Fall ridging produced greater yield compared to non-ridged treatments, as indicated by single degree of freedom contrast in 1995 (1770 vs. 1570 kg ha^{-1}, $P \leq 0.08$).

In 1996, an improved year for cotton production in the region due to adequate rainfall during the critical bloom period and the use of Bt varieties to control tobacco budworm, seed cotton yield averaged 3540 lb ac^{-1}. In 1996, non-ridging resulted in greater seed cotton yields compared to fall ridging (4210 vs. 3870 kg ha^{-1}, $P \leq 0.06$). Paratilling without ridging had greater yield than fall ridging with paratilling or subsoiling, spring strip tillage, conventional tillage and the strict no-till treatment (non-ridging without deep tillage) (Table 4). Low rainfall early in the season of 1996 resulted in dry soil conditions, which may have impacted treatments with fall ridging more then non-ridged treatments. Raised beds in the fall ridged treatments may have increased drainage from the small volume of soil occupied by the young cotton roots, consequently increasing drought stress and reducing yield potential relative to non-ridged treatments.

In 1997, rainfall was near or above normal for the early part of the season, however, rainfall was severely below normal in the critical blooming period (July through early August). Fall subsoiling (2,670 lb ac^{-1}) resulted in greater yield than treatments without deep tillage (2,420 lb ac^{-1}, $P \leq 0.08$). Compared to treatments without deep tillage, fall subsoiling reduced the soil compaction index, likely increasing rooting and allowing cotton to better cope with drier weather during the critical fruiting period. Although treatments with paratilling also reduced soil compaction, yields were not significantly greater than treatments without deep tillage (2,580 vs. 2,420 lb ac^{-1}, $P \leq 0.27$) in 1997. A delay in cotton maturity is believed to be responsible for reduced yields in treatments with paratilling.

Three of the first four weeks of the 1998 season had lower than normal rainfall and this early season drought continued midway into the critical blooming period. In this year, fall ridging (2,000 lb ac^{-1}) significantly reduced yields compared to non-ridged treatments (2,480 lb ac^{-1}, $P \leq 0.061$). As in 1996, we believe that early season drought stress resulted in lower yields with fall ridged treatments. However, despite this drought, all conservation tillage treatments had greater yields then conventional tillage, with the exception of fall ridging without deep tillage (Table 4).

In 1999, there was an extended drought from July through August, the critical fruiting period. Subsoiling without ridging had significantly greater yield than fall ridging with subsoiling, non-ridging with paratilling, strict no-tillage, and the conventionally tilled treatment (Table 4). Unlike 1996 and 1998, with drought stress in early June, fall ridged treatments were not significantly disadvantaged compared to treatments without fall ridging in 1999.

Average seed cotton yields during the study (1996-1999) were greater for all conservation tillage systems compared to conventional tillage, excluding 1995, a year with unusually heavy insect pressure. Highest yields were obtained with subsoiling or paratilling without ridging. Spring strip tillage yield was similar to paratilling or subsoiling without ridging but was not statistically greater than strict no-tillage. However, spring strip tillage did not reduce soil compaction compared to strict no-tillage and timing of this tillage system is often difficult because of wet soils in the spring, making this system impractical on a large scale.

CONCLUSION

Highly competitive yields were obtained with conservation tillage systems using a rye cover crop on fine-textured soils in the Tennessee Valley region of northern Alabama. Stand establishment problems from residue-induced cold/wet soil previously reported were overcome by delaying planting until the first of May and the use of row cleaners. Fall deep tillage (subsoiling or paratilling) reduced soil compaction and increased soil water removal by cotton roots in a conservation tillage system. Over a 4 year duration, seed cotton yields were greatest in fall subsoiled or paratilled treatments without ridging; 16% greater than conventional tillage and 10% greater than strict no-tillage. Spring strip tillage yield was reduced but statistically similar to fall deep tillage without ridging, and was not significantly different from strict no-tillage. Problems with wet soils in the spring further complicate implementation of spring strip tillage, making this system impractical. Consequently, farmers turning to conservation tillage in this region would benefit from a system that integrated fall non-inversion deep tillage and cover crops.

Literature Cited

Brown, S.M., T. Whitwell, J.T. Touchton, and C.H. Burmester. 1985. Conservation tillage system for cotton production. Soil Sci. Soc. Am. J. 49:1256-1260.

Burmester, C.H., M. Patterson, and D.W. Reeves. 1993. Cover system and starter fertilizer placement for no-till cotton. p. 1292-1294. *In* 1993 Southeast Conservation Tillage Conference for Sustainable Agriculture. Monroe, LA. 15-17 June 1993.

Norfleet, L., D.W. Reeves, C.H. Burmester, and D. Monks. 1997. Is planting cotton before May risky business in North Alabama? Highlights Agr. Res. 44(4):14-17. Ala. Agric. Exper. Stn., Auburn University, AL.

Raper, R.L., B.H. Washington and J.D. Jerrell. 1999. A tractor-mounted multiple-probe soil cone penetrometer. Appl. Eng. Agric. 15:287-290.

SAS Institute. 1988. SAS/STAT User's Guide. Version 6.03 ed. SAS Institute, Cary, NC.

Topp, G.C. 1980. Electromagnetic determination of soil water content: measurements in coaxial transmission lines. Water Resour. Res. 16:574-582.

Touchton, J.T., D.H. Rickerl, R.H. Walker, and C.E. Snipes. 1984. Winter legumes as a nitrogen source for no-tillage cotton. Soil Tillage Res. 4:391-401.

Table 1. Effect of tillage system on cotton plant populations (1995 - 1998).

Treatment	1995	1996	1997	1998
			plants ac^{-1}	
Conventional Tillage	39,600	32,800	47,000	34,900
Non-ridged without Deep Tillage †	31,700	29,900	33,900	32,700
Non-ridged with Subsoiling	38,200	30,700	29,600	24,500
Non-ridged with Paratilling	31,300	35,100	37,800	32,000
Fall Ridging without Deep Tillage	38,900	22,600	49,000	40,800
Fall Ridging with Subsoiling	‡	35,300	47,600	29,400
Fall Ridging with Paratilling	40,500	36,200	47,000	32,000
Spring Strip Tillage	37,900	33,800	39,400	33,500
$LSD_{(0.10)}$	*ns*	*ns*	*6,330*	*ns*

† Non-ridged without deep tillage is considered strict no-tillage.
‡ Fall ridging with subsoiling was not implemented in 1995.

Table 2. Effect of tillage on soil compaction index (1995 - 1997).

Treatment	
	— MPa-100
Conventional Tillage	6.563
Non-ridged without Deep	6.775
Non-ridged with Subsoiling	5.774
Non-ridged with Paratilling	4.683
Fall Ridging without Deep	6.619
Fall Ridging with Subsoiling	5.702
Fall Ridging with Paratilling	4.734
Spring Strip Tillage	6.872
$LSD_{(0.10)}$	*0.402*

† Non-ridged without deep tillage is considered strict no-tillage.

Table 3. Average in-row soil volumetric water content as affected by tillage treatment.

Treatment	1995	1996	1997
	Soil water (ft^3 ft^{-3})		
Conventional Tillage	0.238	0.311	0.286
Non-ridged without Deep Tillage	0.237	0.312	0.296
Non-ridged with Subsoiling	0.195	0.295	0.282
Non-ridged with Paratilling	0.187	0.294	0.286
Fall Ridging without Deep	0.225	0.318	0.288
Fall Ridging with Subsoiling	‡	0.292	0.246
Fall Ridging with Paratilling	0.144	0.243	0.239
Spring Strip Tillage	0.208	0.294	0.271
$LSD_{(0.10)}$	*0.045*	*0.039*	*ns*

† Non-ridged without deep tillage is considered strict no-tillage.
‡ Fall ridging with subsoiling was not implemented in 1995.

Table 4. Effect of tillage system on seed cotton yield (1995-1999) and percent open bolls prior to defoliation (1995-1998).

Treatment	1995	1996	1997	1998	1999	96-
	Seed cotton Yield					
	lb ac^{-1}					
Conventional Tillage	1,510	3,130	2,560	1,770	2,030	2,380
Non-ridged without Deep	1,490	3,500	2,300	2,180	2,060	2,510
Non-ridged with Subsoiling	1,560	3,780	2,740	2,250	2,420	2,790
Non-ridged with Paratilling	1,320	4,010	2,620	2,120	2,180	2,730
Fall ridging without Deep	1,620	3,730	2,530	2,850	2,300	2,600
Fall ridging with Subsoiling	‡	3,390	2,600	2,070	2,160	2,550
Fall ridging with Paratilling	1,530	3,230	2,540	2,120	2,370	2,550
Spring Strip Tillage	1,540	3,540	2,620	2,170	2,250	2,640
LSD(0.10)	*ns*	*462*	*ns*	*231*	*192*	*178*

† Non-ridged without deep tillage is strict no-tillage.
‡ Fall ridging with subsoiling was not implemented in 1995.
§ Mean excludes 1995 data because of unusually heavy insect pressure which disproportionately affected treatments with greatest yield potential.

USE OF CONVENTIONAL AND TRANSGENIC COTTON IN DIFFERENT TILLAGE SYSTEMS

D.L. Wright, P. Wiatrak and L. Majchrzak[1]

AUTHORS: [1] University Of Florida, Institute Of Food And Agricultural Sciences, Agricultural Experiment Station, North Florida Research And Education Center, Quincy, FL .

OBJECTIVES

1. To compare a conventional and transgenic cotton variety (ST 474 vs. SG 501 BRR) in conventional and strip tillage and herbicide programs for each
2. To compare economics of the different systems

METHODS

Two studies were conduced on a Dothan sandy loam (fine loamy siliceous, thermic Plinthic Kandiudult), at the North Florida Research and Education Center, Quincy, Fl in 2000. Both studies were planted after winter fallow. The experimental areas were fertilized with 5-10-15 N-P_2O_5- K_2O at 500 lbs/A and sprayed with Roundup Ultra @ 1.0 qt/A on 22 May. On 30 May the conventional sections of the study were disc harrowed and s-tined harrowed and studies were planted with Stoneville ST 474 (conventional) and SureGrow SG 501 BRR (Roundup Ready) cotton in strip-till and conventional using a Brown Ro-till implement and KMC planters at 4 seeds per 1 ft of row. Each plot (35 ft by 24 ft and 200 ft 36 ft) consisted of 8 and 10 rows, respectively with 3 ft row spacing. The conventional tillage and herbicide sections planted with ST 474 were broadcast sprayed with Prowl @ 1 qt/A + Cotoran @ 1 qt/A on 30 May. The entire study in the first location was irrigated with 1” water on 2 June. On 16 June the transgenic cotton in strip tillage, SG 501 BRR cotton, was broadcast sprayed with Roundup Ultra @ 1.5 pt/A + Orthene 97 for thrips @ 0.5 lb/A. The conventional variety was sprayed with Cotoran @ 1 qt/A + MSMA @ 1 pt/A on 23 June. The transgenic, strip tilled, SG 501 BRR cotton was sprayed with Roundup Ultra @ 1.5 pt/A on 29 June and ST 474 cotton was direct sprayed with Bladex @ 1 qt/A + MSMA @ 2 qt/A + Induce @ 2 pt/100 gal water on 5 July. On 14 July cotton was side-dressed with 60 lbs N/A. The SG 501 BRR cotton was direct sprayed with Roundup Ultra @ 1.5 pt/A on 8 August. On 9 and 28 August cotton was broadcast sprayed with Pix @ 16 oz/A + Agridex @ 2 pt/A. Cotton was broadcast sprayed with Karate @ 4 oz/A on 11 September. On 20 October cotton was defoliated with Finish @ 1.5 qt/A + Dropp @ 0.1 lb/A. Cotton was picked with an International 782 plot picker on 3 November.

Data were analyzed using SAS (1989) analysis of a variance, and means were separated using Fisher's Least Significant Difference Test at the 5% probability level.

RESULTS

First location

There was no difference between varieties and tillage systems on plant population even though both systems and varieties were planted at the same population. The influence of variety and tillage on plant height, number of nodes, and plant ratio at 60, 90, and 120 days after planting were collected but only the data at 120 days is shown in Tables 1 – 3. There was no difference between varieties and tillage for the plant height of cotton at 60, 90, and 120 days after planting (DAP) (Table1). The number of nodes was not significantly different between varieties and tillage at 60 and 90 DAP (data not shown). At 120 DAP (Table 2) higher number of nodes was obtained from ST 474 than SG 501 BRR cotton and higher from strip than conventional tillage. The plant ratio (plant height / node number) was significantly higher for SG 501 BRR than ST 474 cotton at 60 DAP, 90 DAP, and 120 DAP (Table 3). There was no difference between tillage systems for plant height to node ratio at 60, 90, and 120 DAP.

Tables 4 and 5 show the influence of variety and tillage on boll number per plant. The number of bolls on the first position (Table 4) and the number of total bolls per plant (Table 5) were higher from SG501 BRR than ST 474 cotton, and higher from strip than conventional tillage. There was no difference between varieties and tillage for the number of bolls per plant on the second, third, and forth position.

There was no significant difference between varieties and tillage for the seed cotton yields (Tables 6).

Second location

There was no difference between varieties and tillage systems on cotton for the plant population, data not shown. The influence of variety and tillage on plant height, number of nodes, and plant ratio at 60, 90, and 120 days were collected and data at 120 days after planting is shown in Table 1. There was no difference between varieties and tillage for the plant height, node number, and plant ratio of cotton at 90 DAP or between varieties for the plant height, but plants were significantly taller from strip than conventional tillage at 120 DAP (Table1). The number of nodes was significantly higher from ST 474 than SG 501 BRR cotton, but no different for tillage systems (Table 2). Higher plant ratio was obtained from SG 501 BRR than ST 474 and higher from strip than conventional tillage (Table 3).

Tables 4-5 show the number of bolls per plant. There was no difference between varieties and tillage systems for the number of bolls per plant on the first position, or the total number of bolls (Tables 4-5). The number of bolls per plant on the forth position was not different for variety, but it was higher for strip than conventional tillage (Data not shown).

The seed cotton yields are shown in Table 6. There was an interaction of the variety and tillage on the yields of cotton. The ST 474 cotton performed better in strip than conventional tillage, and SG 501 BRR cotton performed better in conventional than strip tillage. There was no significant difference between varieties or tillage systems for the yields of cotton.

Table 7 shows the economic comparison of strip vs. conventional tillage per acre. Generally, the overall cost was about 8% higher for conventional than strip tillage, mainly due to the cost of land preparation and herbicide applications. When all factors are considered, strip till resulted in about $8/A more profit than conventional tillage while the transgenic cotton resulted in about $8 more profit than the conventional variety in these two trials. Overall ease of farming and labor were reduced by strip tillage and transgenic varieties of cotton. However, both systems over both trails performed very similar.

First Location

Table 1. Influence of variety and tillage on plant height (inch) (120 DAP) - Plant map – 1st location.

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	34.26	34.26	34.26
SG 501 BRR	35.16	33.78	34.47
Average	34.71	34.02	-

$LSD_{(0.05)}$ for variety = NS
$LSD_{(0.05)}$ for tillage = NS
$LSD_{(0.05)}$ for interaction = NS

Table 2. Influence of variety and tillage on number of nodes per plant (120 DAP) - Plant map – 1st location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	16.20	16.10	16.15
SG 501 BRR	16.15	14.10	15.13
Average	16.18	15.10	-

$LSD_{(0.05)}$ for variety = 0.942
$LSD_{(0.05)}$ for tillage = 0.942
$LSD_{(0.05)}$ for interaction = 1.332

Table 3. Influence of variety and tillage on plant ratio (height/number of nodes) (120 DAP) - Plant map – 1st location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	2.15	2.15	2.15
SG 501 BRR	2.20	2.41	2.31
Average	2.18	2.28	-

$LSD_{(0.05)}$ for variety = 0.124
$LSD_{(0.05)}$ for tillage = NS
$LSD_{(0.05)}$ for interaction = NS

Table 4. Influence of variety and tillage on boll number per plant on the first position (120 DAP) - Plant map – 1st location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	6.20	5.40	5.80
SG 501 BRR	7.25	5.75	6.50
Average	6.73	5.58	-

$LSD_{(0.05)}$ for variety = 0.638
$LSD_{(0.05)}$ for tillage = 0.638
$LSD_{(0.05)}$ for interaction = NS

Table 5. Influence of variety and tillage on total boll number per plant (120 DAP) - Plant map – 1st location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	10.80	9.95	10.38
SG 501 BRR	13.65	10.85	12.25
Average	12.23	10.40	-

$LSD_{(0.05)}$ for variety = 1.65
$LSD_{(0.05)}$ for tillage = 1.65
$LSD_{(0.05)}$ for interaction = NS

Table 6. Influence of variety and tillage on seed yield of cotton (lb/A) – 1st location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	2087.8	2159.6	2123.7
SG 501 BRR	2139.7	2170.9	2155.3
Average	2113.8	2165.3	-

$LSD_{(0.05)}$ for variety = NS
$LSD_{(0.05)}$ for tillage = NS
$LSD_{(0.05)}$ for interaction = NS

Second Location

Table 1. Influence of variety and tillage on plant height (inch) (120 DAP) - Plant map – 2nd location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	33.60	29.04	31.32
SG 501 BRR	35.16	29.64	32.40
Average	34.98	29.34	-

$LSD_{(0.05)}$ for variety = NS
$LSD_{(0.05)}$ for tillage = 1.792
$LSD_{(0.05)}$ for interaction = NS

Table 2. Influence of variety and tillage on number of nodes per plant (120 DAP) - Plant map – 2nd location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	18.50	17.20	17.85
SG 501 BRR	15.60	15.60	15.60
Average	17.05	16.40	-

$LSD_{(0.05)}$ for variety = 0.972
$LSD_{(0.05)}$ for tillage = NS
$LSD_{(0.05)}$ for interaction = NS

Table 3. Influence of variety and tillage on plant ratio (height/number of nodes) (120 DAP) - Plant map – 2nd location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	1.82	1.70	1.76
SG 501 BRR	2.27	1.91	2.09
Average	2.05	1.80	-

$LSD_{(0.05)}$ for variety = 0.132
$LSD_{(0.05)}$ for tillage = 0.132
$LSD_{(0.05)}$ for interaction = NS

Table 4. Influence of variety and tillage on boll number per plant on the first position (120 DAP) - Plant map – 2nd location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	5.80	6.70	6.25
SG 501 BRR	6.10	7.30	6.7
Average	5.95	7.00	-

$LSD_{(0.05)}$ for variety = NS
$LSD_{(0.05)}$ for tillage = NS
$LSD_{(0.05)}$ for interaction = NS

Table 5. Influence of variety and tillage on total boll number per plant (120 DAP) - Plant map – 2nd location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	12.00	11.70	11.85
SG 501 BRR	12.80	12.50	12.65
Average	12.40	12.10	-

$LSD_{(0.05)}$ for variety = NS
$LSD_{(0.05)}$ for tillage = NS
$LSD_{(0.05)}$ for interaction = NS

Table 6. Influence of variety and tillage on seed yield of cotton (lb/A) – 2nd location

Variety	Tillage system		Average
	Strip till	Conventional	
ST 474	1505.8	1356.4	1431.1
SG 501 BRR	1306.4	1613.7	1460.0
Average	1406.1	1485.1	-

$LSD_{(0.05)}$ for variety = NS
$LSD_{(0.05)}$ for tillage = NS
$LSD_{(0.05)}$ for interaction = 323.0

Table 15. Economic comparison of strip vs. conventional tillage per acre

Treatment	Unit	Quantity	Price	Cost in $	
				Strip tillage	Conventional
Seed	lb	10	0.75/lb	7.50	7.50
Fertilizer					
Nitrogen (N)	lb	85	0.32/lb	27.20	27.20
Phosphate (P_2O_5)	lb	50	0.23lb	11.50	11.50
Potash (K_20)	lb	75	0.15/lb	11.25	11.25
Fertilizer Spreader	acre			4.00	4.00
Spray Roundup 4L Ultra	qt	1	32.00/gal	8.00	8.00
Spray Roundup 4L Ultra	qt	(3 x 1.5)	32.00/gal	36.00	-
Orthene 97	lb	0.5	12.00/lb	6.00	-
Brown Ro-till	acre			15.00	-
Disc harrowed	acre	2 x	10.00/A	-	20.00
Ripper Planter	acre		15.00/A	-	15.00
Prowl 3.3E	qt	1	25.62/gal	-	6.41
Cotoran 4L	qt	2	40.40/gal	-	20.20
Bladex 4L	qt	1	27.00/gal	-	6.75
MSMA	qt	2	19.00/gal	-	9.50
Induce	pt	2	15.00/gal	-	3.80
Pix	oz	16	0.90/oz	14.40	14.40
Agridex	pt	2	20.00/gal	5.00	5.00
Karate	oz	4	600.00/gal	19.00	19.00
Finish	qt	1.5	81.00/gal	31.00	31.00
Dropp Ultra	lb	0.1	56.00/lb	5.60	5.60
Direct Spray	times	2 x	6.00/A	12.00	12.00
Sprayer	times	5 x	3.00/A	15.00	15.00
International Spindle Picker	acre			70.00	70.00
Truck	mi.	50.00	0.17/mi	8.50	8.50
Total costs				**306.95**	**331.71**

TILLAGE SYSTEMS AND N FERTILIZER PRACTICES EFFECT ON CORN YIELDS IN THE TEXAS BLACKLAND PRAIRIE

H.A. Torbert, K.N. Potter, and J.E. Morrison[1]

AUTHORS: [1] H. A. Torbert, K. N. Potter, and J. E. Morrison, USDA-ARS Grassland, Soil and Water Research Laboratory, 808 East Blackland Rd., Temple, TX 76502. Corresponding author – H. A. Torbert, 808 East Blackland Rd., Temple, TX 76502, torbert@brc.tamus.edu.

ABSTRACT

In the Blackland Prairie of Texas conservation tillage systems are needed to reduce erosion losses and to improve agricultural sustainability. Fertilizer N practices with conservation tillage systems in this region have not been well developed. In 1994, an experiment was established to determine plant response to N fertilizer rate and timing within three different tillage systems. A split plot experiment with 4 replications was established on a Houston Black clay (Fine, smectitic, thermic Udic Haplusterts) soil. The main plots were a chisel tillage system without beds (conventional for the area), a chisel tillage system with raised wide beds, and a no tillage system with raised wide beds. The subplots were seven soil fertility treatments, consisting of [11] four fertility rates (0, 56, 112, and 168 kg N ha^{-1}) applied at planting and three fertilizer application timing treatments (fall, at planting, and split between at planting and 30 d later). The crop rotation was wheat (*Tritcum aestivum* L.) followed by corn (*Zea mays* L.) which was followed by grain sorghum (*Sorghum bicolor* L.). The experimental treatments were imposed on corn each year for four years. Plant samples were collected for grain yield, biomass production, and N uptake. The results from this study indicate that corn yields in the Texas Blackland Prairie may respond positively to planting corn rows on beds and particularly to a change to a conservation tillage system. Large differences were observed between years due to soil moisture conditions during the growing season, with two years of low rainfall conditions and two years of high rainfall conditions during the growing season. The highest yields were observed with the no tillage system, with large differences observed between no tillage and the other tillage systems in low rainfall years. In wet years, grain yields and N uptake increased with N application up to 168 kg N ha^{-1}, while little effect to fertilizer N application was observed in the dry years. There was no indication of N limitations in the no-till system compared to the other tillage systems, indicating that there was no need to increase N application rates when using well established conservation tillage systems. While no benefit was realized from split application of fertilizer N after planting, large reductions in corn yields were observed with fall application of fertilizer N in wet years. Fall application of N reduced yields 30% when compared with fertilizer application at planting. In this study, the highest yields were observed with the no-till system indicating that a conservation tillage system may be the most reliable tillage system in these Vertisol soils.

A SPLIT-FIELD COMPARISON OF TRADITIONAL AND NEW CROPPING PRACTICES

Philip Bauer, James Frederick, John Hayes, Jeffrey Novak, Warren Busscher, Donald Manley, Bruce Fortnum and Horace Skipper[1]

AUTHORS: [1]Philip Bauer, Research Agronomist, Jeffrey Novak and Warren Busscher, Soil Scientists, USDA-ARS, Florence, SC. James Frederick, Associate Professor, John Hayes, Donald Manley, Bruce Fortnum, and Horace Skipper, Professors, Clemson University. Corresponding Author: Philip Bauer, USDA-ARS, 2611 West Lucas Street, Florence, SC 29501, bauer@Florence.ars.usda.gov.

Interpretive Summary

A research-education-extension program was initiated at Clemson University's Pee Dee Research and Education Center near Florence, SC in 1997. The program consists of numerous satellite experiments investigating aspects of conservation tillage, site-specific management, and optimizing use of new genetic technology. Information from these experiments are used to design management practices for a large (14 acre) split-field study where new technologies are compared to the traditional technologies that were used by growers in South Carolina in 1995. Crops grown on the split field were wheat and soybean (double crop) in 1997-98, corn in 1999, and cotton in 2000. Conservation tillage, narrow row spacing (for soybean and corn), herbicide and/or insect resistant crop genotypes, and site-specific application of P and K were used on the side of the field designated to receive the new technologies. Conventional tillage, wide row spacing, and non-transgenic crop genotypes were used on the traditional side of the field. Three runoff plots (approximately 1/8 acre in size) were installed on each side of the field. These runoff plots were equipped to measure runoff volume and to collect runoff water for nutrient and sediment analysis. Each half of the field was grid sampled after each crop for soil chemical properties and nematode populations. Soil organic matter was measured on specific soil types within the field, and the number and size of fire ant mounds were determined. Yield monitors were used on the combine and cotton picker to provide site-specific analysis of yield. Yields on the new technology side were not always higher than those on the conventional practices side. Yields on the traditional side of the field were 36 bu/ac for wheat, 26 bu/ac for soybean, 85 bu/ac for corn, and 530 lb lint/ac for cotton. On the new technology side of the field, yields were 38 bu/ac for wheat, 21 bu/acre for soybean, 91 bu/ac for corn, and 682 lb lint/ac for cotton. Results of the project are posted on a website (http://agroecology.clemson.edu) and provided to farmers throughout South Carolina in a semi-annual newsletter.

Centers of Excellence

Alesii Bruno[1]

AUTHOR: [1] Manager of Technical Development, Cordillera Ranch 106 Pebble Creek, Boerne, TX 78006, Phone: 830.336.4179, FAX: 830.336.4175, Organization: Monsanto

Summary

In 1997 Monsanto created Centers of Excellence across the Midwest. The purpose of these centers is to develop and refine viable Conservation Tillage systems a the local level. The goal is to utilize large-scale, farm-sized research areas to develop practices that can be adopted by growers to increase productivity while saving resources.

Centers of Excellence display long-term (3-5 year) demonstration projects in conservation tillage. They serve as local solution centers for:

Overcoming agronomic barriers to conservation tillage
Generating data comparing the benefits of conservation tillage versus conventional tillage
Developing alternative conservation tillage practices
Demonstrating, training and educating growers, retailers, crop consultants, academics, and other influential parties on the benefits and how-to's of conservation tillage
Providing solutions to overcome local agronomic barriers
Establishing local partnerships with boards of directors of various organizations o get community involvement.

The presentation will give additional information on the Centers of Excellence and the results to date.

Status of Conservation Tillage in United States For Year 2000

John Hassel[1]

AUTHOR: [1] Executive Director, Conservation Technology Information Center, 1220 Potter Drive, Suite 170, West Lafayette, Indiana 47906 Email: hassell@ctic.purdue.edu, phone: 765-494-6956, fax: 765-494-5969

Summary

The Conservation Technology Information Center has been collecting national data on conservation tillage since 1982. The most recent Crop Residue Management Survey was published in October 2000. The presentation will address the current status of Crop Residue Management adoption in the United States, comparisons with the past and how the current Core 4 Conservation initiative can be used to promote crop residue management in the future.

RESPONSE OF COWPEA (*VIGNA UNGUICULATA*) TO TILLAGE AND HERBICIDE MANAGEMENT

A. Higuera[1], R.N. Gallaher and G. E. MacDonald[2]

AUTHORS: [1] Visiting Professor, Universidad del Zulia, Facultad de Agronomía, Venezuela, Professor and Assistant Professor, Department of Agronomy, University of Florida, Institute of Food and Agricultural Sciences (IFAS)
[2]Putting Florida First. Corresponding Author, R. N. Gallaher, P. O. box 110730, University of Florida, Gainesville, FL 32611, Email (rngallaher@mail.ifas.ufl.edu).

ABSTRACT

Cowpea, *Vigna unguiculata* is used both for human food and animal forage. It may become important as a fall grown forage that fits well into multiple cropping systems in the southern USA and other areas of the world with similar climate. The objectives of this study were to: 1) compare above ground plant cowpea yield, and plant N content under three tillage treatments and 2) determine potential injury and the effectiveness of five weed management programs under these tillage regimes. 'Iron Clay' cowpea was planted 24 August on Millhopper sand in 10 inch wide rows with a no-till Tye drill. Conventional tillage and no-till treatments were main plots with five herbicide combinations as split plots, replicated four times. Above ground dry matter production was determined at late bloom stage (60 days after planting) followed by Kjeldahl N analyses. Crop injury ratings and percent control of weeds were also determined at 15 and 45 days after herbicides were sprayed. This study found that best yields could be obtained with the use of glyphosate herbicide alone to provide a range of 1.27 to 1.55 ton dry matter acre^{-1}. No-till + use of broiler manure was the most consistent in providing best yield for all herbicide combinations except when using pendimethalin (Prowl) + flumioxazin (Valor) which resulted in significant cowpea plant injure (caused by the flumioxazin) for this tillage treatment. Nitrogen content (N concentration x dry matter yield acre^{-1}) mirrored dry matter yield. The use of no-till + broiler manure provided the greatest N content in the range of 75 to 79 pounds N acre^{-1} in dry matter of the above ground cowpea plant.

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp. is grown in over two-thirds of the developing world, usually as a companion or relay crop with small grains or corn *(Zea mays* L.). Its major importance is a staple in the diet of many millions of people. Development of new varieties resistant to insects and pests or have shorter life cycles have contributed to increased cultivation of this crop. Cowpea is adapted to warm weather and requires less rainfall than most crops, therefore it is primarily cultivated in the semiarid regions of the lowland tropics and subtropics, where soils are poor and rainfall is limited (Mortimore et al., 1997).

The use of cowpea as fodder is attractive in mixed crop/livestock systems where both grain and fodder can be obtained from the same crop (Tarawali et al., 1997). In addition, there is increasing emphasis on integrating crop livestock production to promote more sustainable agricultural systems. Cowpea can make a very important contribution towards livestock fodder and supply N to the soil (Lat et al., 1978). Its use as a dual-purpose crop, and providing both grain andfodder is attractive where land is becoming increasingly scarce. The use of cowpea as fodder is most advanced in India, where green material is used for grazing, or cut and mixed with dry cereals for stall feeding (Tarawali et al., 1997). According to Relwani et al., (1970) the use of cowpea in combination with cereals and other crops for lactating cows in India can maintain milk yields of > 1.5 gallon cow^{-1} day^{-1}. Inclusion of green cowpea pods in the fodder is considered important to raise nutritive value. Trials on fodder varieties of cowpea in India gave dry-matter yields of > 1.8 ton acre^{-1} and protein contents of up to 26% (Relwani et al., 1970). Cutting trials have indicated that harvesting 60 days after planting gave the best dry matter yields of highest quality (Kandaswamy et al., 1976).

Grain cowpea is planted in semiarid and arid zones of West Africa between millet rows 2 to 3 weeks after planting millet, followed by fodder cowpea 3 to 4 weeks later. Following millet harvest, the grain cowpea is harvested and the fodder cowpea is left to grow. Typical yields are 350 to 400 pounds dry cowpea fodder acre^{-1} (Singh 1993). Under appropriate management cowpea can provide good quality fodder for *in situ* grazing, silage (in combination with cereals) or hay. The management and cultivars selected will depend on the farming system requirements and the mode of use (Tarawali et al., 1997).

Farming is becoming a more labor-intensive system in many areas, driven by demographic and economic forces. Cowpea will provide a crucial role as it facilitates crop-livestock integration, which is associated with intensification and land conserving investments. In fixing N, cowpea also brings this plant nutrient into the cycle. Its economic function in the system is complementary to that of cereals (Mortimore et al., 1997).

A best management practice, which reduces soil erosion and conserves water, while at the same time increasing land productivity and conserving fuel, is conservation tillage. Any tillage and planting system that covers 30% or more of the soil surface with crop residue after planting is considered conservation tillage (Gallaher and Hawf, 1997). One tillage cycle destroyed the benefits derived from several years of no-tillage (Broome and Triplett, 1997).

Weed control is essential for no-tillage production. It is very important to carry out trials in order to study the response of cowpea to no-tillage and weed control with herbicides. Herbicides for no-tillage must 1) control vegetation present, 2) prevent growth of weeds from seed, 3) not injure the crop or succeeding crops, and 4) be economical (Triplett et al., 1964). Gutiérrez et al., (1999) carried out a no-tillage trial in Venezuela to evaluate different methods of weed control and to compare two cowpea genotypes. Glyphosate (2 lb ai acre^{-1}) gave the best economic profit and provided >90% weed control.

The public demands that dairy and poultry farmers include manure management as a part of their business operations. The utilization of manure must be protective of the environment. Plant food nutrients in the manure can be valuable resources for production of forage crops but it is important for these systems to produce sufficient yields of high quality forages to feed the animals producing the manure (Johnson et al., 1995). A reason to apply chicken manure as an organic matter source to the soil is to improve aeration, water retention, soil structure and drainage and also to feed earthworms and microorganisms that maintain the balance and biological activity in the soil. Nitrogen, in freshly excreted chicken manure, is in the organic form, which is converted to ammonium-N during storage or after application to the soil. Since ammonium is held firmly to the surfaces of soil particles, it does not leach easily but may, under certain conditions, be converted to volatile ammonia gas (Fraser, 1985). The main value of manure is the plant nutrient content and organic matter. Animals use only about 25% of the nutrients contained in feeds, with the remaining 75% of the original content of N, P and K excreted in manure and urine (Fraser, 1985). Broiler manure, like any fertilizer, should be applied to soil only at rates required to meet crop nutrient needs.

The objectives of this study were to: 1) compare above ground plant cowpea yield, and plant N content under three tillage treatments and 2) determine potential injury and the effectiveness of five herbicide weed management programs under these tillage regimes.

MATERIALS AND METHODS

'Iron Clay' cowpea was planted 24 August at the Agronomy Departments Field Teaching Laboratories, University of Florida. Soil at this site is classified as Millhopper sand (sandy siliceous hyperthermic grossarenic paleudult) (Soil Survey Staff, 1984). The field had been planted in the spring with corn and ears were removed near the end of July. Stalks were chopped and spread evenly over the field on 31 July 2000. Soil fertility test was obtained from samples collected on 1 August 2000. Conventional tillage treatments were tilled on 1 August 2000. Plots were sprayed with a uniform rate of 2 quarts (2 lb ai) roundup (Glyphosate) acre^{-1} five days prior to planting. 'Iron Clay' cowpea was planted with a Tye no-till drill on 31 August in 10 inch wide rows. Lannate (1 pint acre^{-1}) was applied to control leafhoppers and leaf miners three weeks after planting.

A split-plot experimental design with tillage treatments as main effects in a randomized complete block and 4 replications was used. Tillage treatments included: 1.Conventional tillage, 2. No-till directly into chopped cornstalks-residue from previous crop, and 3. No-till directly into chopped cornstalks-residue from previous crop + broiler manure application to provide the equivalent of 120 pounds N acre^{-1}. Conventional tillage plots were harrowed and tilled following chopped cornstalks. Initial tillage was done on 1 August 2000. The assumption was that N from the broiler manure would be 50% as efficient as if using ammonium nitrate as the N source. This assumption would result in fulfilling the Florida Cooperative Extension recommendation of 60 lb N acre^{-1} for cowpea.

The sub-effects were the herbicide treatments: 1. untreated check; 2. pendimethalin (Prowl)-0.75 lb ai acre^{-1}, pre-emergence treatment (PRE), 3. pendimethalin-0.75 lb ai/acre PRE + flumioxazin (Valor)-0.078 lb ai acre^{-1} PRE; 3. Pendimethalin-0.75 lb ai acre^{-1} PRE + flumioxazin (experimental, not registered for use on cowpea); 4. pendimethalin-0.75 lb ai acre^{-1} PRE + prometryn (experimental, not registered for use on cowpea)-1.25 lb ai acre^{-1} PRE; and 5. metalachlor (Dual Magnum) at 0.40-lb ai acre^{-1} PRE + imazethapyr (Pursuit)-0.032 lb ai acre^{-1} post-emergence (POST).

Based on soil test all plots were fertilized with 80 lb K_20 acre^{-1} using muriate of potash. Irrigation was applied as needed using overhead sprinklers. Black-eye Cowpea Mosaic Virus (BCMV) was identified on a few plants and destroyed (Plant Disease Diagnostic Clinic, University of Florida).

For N analysis a mixture of 0.100 g (100 mg) of dried plant tissue, 3.2 g of salt-catalyst (9:1 $K2SO_4$:$CuSO_4$), 2 Pyrex beads and 10 ml of H_2SO_4 was vortexed in a 100 ml Pyrex test-tube under a hood. To reduce frothing, 2 ml 30% H_2O_2 was added in small increments and tubes were digested in an aluminum block digester at 370 °C for 210 minutes (Gallaher et al., 1975). Tubes were capped with small funnels that allowed for evolving gasses to escape while preserving refluxing action. Cool digested solutions were vortexed with approximately 50 ml of deionized water, allowed to cool to room temperature, brought to 75 ml volume, transferred to square Nalgene storage bottles (Pyrex beads were filtered out), sealed, mixed and stored. Nitrogen trapped as $(NH_4)_2SO_4$ was analyzed on an automatic Technicon Sampler IV (solution sampler) and an Alpkem Corporation proportioning Pump III.

Cowpea injury (%) and weed control of purple nutsedge (*Cyperus rotundus*) and Florida pusley (*Richardia scabra*) were evaluated 15 and 45 days after herbicides were sprayed. Pre-emergence treatments were sprayed on 25 August 2000 at 2:30 pm, 95 °F (air temperature), 100 °F (soil temperature) and 60% relative humidity. The POST treatment (Pursuit + non-ionic surfactant, 0.25% v/v) was sprayed on 8 September 2000 at 10:00 am, 85 °F (air temperature), 80 °F (soil temperature) when the second trifoliate leaf appeared in cowpea and purple nutsedge plants were about 3 inches tall.

Data were placed in a Quatro-Pro (1987) spreadsheet for transformations and preparation of Ascii files. Data were analyzed using MSAT (1985). Analysis of variance was calculated to determine statistical significance. Means were compared using Fisher's Protected LSD test at p = 0.05 and p = 0.10.

RESULTS AND DISCUSSION

Plant Yield

Above ground dry plant yield showed an interaction between tillage and herbicides (Table 1). No differences in yield occurred between the conventional tillage and no-till treatments among the weed control treatments. Yield among these treatments ranged from 1.01 to 1.38 ton dry matter acre^{-1}. The no-till + broiler manure treatment was the most consistent in providing the best yield. This was especially true when using pendimethalin + prometryn or metalachlor + imazethapyr. However, yield for these two treatments were no different from the untreated check. Yield was lowest from the use of pendimethalin + flumioxazin in the no-till + broiler manure treatment (Table 1) and was positively related to cowpea crop injury (Table 3). Based on these data, the narrow row planting of cowpea resulted in quick canopy closure for excellent competition against weeds. This study suggests that best yield could be obtained with the use of glyphosate as a pre-plant burn-down treatment to provide a range of 1.27 to 1.55 ton dry matter acre^{-1}.

Table 1. Dry plant yield of 'Iron Clay' cowpea from tillage and herbicide treatments, fall 2000, Gainesville, Florida.

Herbicide Treatment	Tillage: Conventional	Tillage: No-till	Tillage: No-till+BM	Average
----- lb ai acre^{-1} ------	----------------------------- Dry plant yield, ton acre^{-1} ----------------------------			
Untreated Check	1.27 A b W	1.29 a w	1.55 a w	1.37
Pendimethalin (0.75 PRE)	1.20 A b W	1.38 a w	1.50 a w	1.36
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	1.37 A W	1.23 a W x	1.02 b x	1.21
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	1.10 A b X	1.30 a b W x	1.54 a w	1.31
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	1.07 b X	1.01 b x	1.58 a w	1.22
Average	1.20	1.24	1.44	

Tillage=NS; Herbicides=NS; Interaction=*; CV Herbicides=17.7%
Comparison of tillage means within a herbicide treatment: LSD@0.05 p=0.40; @0.10 p=0.33
Comparison of herbicide means within a tillage treatment: LSD@0.05 p=0.29; @0.10 p=0.24
BM=Broiler Manure; ai=active ingredient in lb acre^{-1}; PRE=pre emergence, POST=post emergence

Plant N Content (Yield)

Nitrogen content (N concentration x dry matter yield acre^{-1}) mirrored dry matter yield. Therefore, there was a significant interaction between tillage and herbicide treatments (Table 2). The low yield from use of pendimethalin + flumioxazin for the no-till + broiler manure (Table 1) resulted in the lowest N content. The use of no-till + broiler manure provided the greatest N content in the range of 75 to 79 pounds N acre^{-1}. As was the case for dry matter production (Table 1) the use of glyphosate as a pre-plant burn-down treatment could provide the highest N content (Table 2).

Table 2. Nitrogen content for cowpea from tillage and herbicide treatments, Gainesville, Florida, Fall 2000.

Herbicide Treatment	Tillage									
	Conventional			No-till			No-till+BM			Average
----- lb ai acre^{-1} ------	------------------------------------ Plant N, lbs acre^{-1} --------------------------------------									
Untreated Check	65.5	a	W	66.6	A	w	75.7	a	W	69.2
Pendimethalin (0.75 PRE)	60.8	a	W	67.8	A	w	76.3	a	W	68.3
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	65.7	a	W	66.0	A	w	49.0	b	X	60.3
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	57.1	a	X	63.6	A	X	79.4	a	W	66.8
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	57.8	a	X	54.4	A	X	74.9	a	W	62.4
Average	61.4			63.7			71.0			

Tillage=NS; Herbicides=NS; Interaction* =NS; CV herbicides = 16.6%
Mean separation for tillage within a herbicide: LSD @ 0.05 p = 16.1
Mean separation for herbicides within a tillage: LSD @ 0.05 p = 15.6
BM=Broiler Manure; ai=active ingredient in lb acre^{-1}; PRE=pre emergence, POST=post emergence

Cowpea injury (%) by herbicide treatments

Cowpea injury was not significant among tillage treatments (Table 3). However, injury was observed for three of the five herbicide treatments at the first sampling date. Pendimethalin + flumioxazin and metalachlor + imazethapyr both showed slight early season crop injury but symptoms had diminished by mid-season. Pendimethalin alone did not cause significant injury, therefore the treatment of pendimethalin + flumioxazin can be attributed to flumioxazin.

Table 3. Percent crop injury in a crop of Iron Clay cowpea from tillage and herbicide treatments, fall 2000, Gainesville, Florida.

Herbicide Treatment	Tillage: Conventional	No-till	No-till+BM	Average	
----- lb ai acre^{-1} ------	------------------------------ Cowpea injury, % (09/18/00)----------- ---------------				
Untreated Check	0.0	0.0	0.0	0.0	c
Pendimethalin (0.75 PRE)	0.0	0.0	0.0	0.0	c
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	27.5	21.3	26.3	25.0	a
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	12.5	3.8	3.8	6.7	b
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	16.3	11.3	5.0	10.8	b
Average	11.3	7.3	7.0 NS @ 0.05		

Tillage =NS; Herbicides = **; Interaction = NS; CV Herbicides = 90.0%
Comparison of herbicide means: LSD @ 0.05 p = 6.3; @0.10 p= 5.3

Herbicide Treatment	Conventional	No-till	No-till+BM	Average	
	------------------------------ Cowpea injury, % (10/18/00)----------- ---------------				
Untreated Check	6.3	1.3	7.5	5.0	b
Pendimethalin (0.75 PRE)	6.3	2.5	22.5	10.4	b
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	13.8	11.3	50.0	25.0	a
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	11.3	0.0	0.0	3.8	b
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	5.0	1.3	0.0	2.1	b
Average	8.5	3.3	16.0 NS	@ 0.05	

Tillage=NS; Herbicides=**; Interaction = +; CV Herbicides = 156.8%
Comparison of herbicide means: LSD @ 0.05 p=8.5; @0.10 p =6.9
BM=Broiler Manure; ai=active ingredient in lb acre^{-1}; PRE=pre emergence, POST=post emergence

Purple nutsedge (*Cyperus rotundus*) control (%)

Purple nutsedge was not affected by tillage (Table 4). Metalachlor + imazethapyr provided best early season control at 80%. By the second rating date even the control plots showed 55% control of purple nutsedge, which illustrates the importance of crop canopy shading. All other treatments were essentially equal and provided excellent purple nutsedge control by the time of the second rating time (90%).

Table 4. Control of purple nutsedge in a crop of Iron Clay cowpea from tillage and herbicide treatments, fall 2000, Gainesville, Florida.

	Tillage			
Herbicide Treatment	Conventional	No-till	No-till+BM	Average
----- lb ai $acre^{-1}$ ------	----------------------- Purple Nutsedge control, % (09/18/00) ---------------------			
Untreated Check	47.5	52.5	12.4	37.5 c
Pendimethalin (0.75 PRE)	62.5	60.0	29.9	50.8 b
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	83.8	60.0	40.1	61.3 b
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	50.0	67.5	32.5	50.0 b
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	79.8	80.0	79.0	79.6 A
Average	64.5 W	64.0 W	39.0 X @ 0.05	@ 0.05

Tillage=**; Herbicides=**; Interaction=NS; CV herbicides=31.8%
Comparison of tillage means: LSD @ 0.05 p = 9.1; @0.10 p = 8.7
Comparison of herbicide means: LSD @ 0.05 p = 14.7; @ 0.10 p = 12.2

	------------------------ Purple Nutsedge control, % (10/18/00) --------------------					
Untreated Check	47.5	62.5	55.0		55.0	c
Pendimethalin (0.75 PRE)	90.0	87.5	91.3		89.6	b
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	91.3	87.5	91.2		90.0	b
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	91.3	90.0	91.1		90.8	A
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	88.8	90.0	91.2		90.0	b
Average	81.8	83.5	84.0	NS		@ 0.05

Tillage = NS; Herbicides =**; Interaction =NS; CV herbicides=9.48%
Comparison of herbicide means: LSD @ 0.05 p = 64; @ 0.10 p = 0.7
BM=Broiler Manure; ai=active ingredient in lb acre^{-1}; PRE=pre emergence, POST=post emergence

Florida Pusley (*Richardia scabra*) control (%)

Florida pusley was not affected by tillage (Table 5). All herbicide treatments provided 66 to 90% control. Chemical weed control was rather effective in control during the early cowpea growth period compared to the untreated control. However, by the time of the second weed rating most herbicide treatments were no better in their control of Florida pusley then the control treatment. Pendimethalin + flumioxazin was the most consistent in control (Table 5), but this treatment caused the greatest crop injury (Table 3) and the lowest dry matter yield (Table 1) and N content (Table 2).

Table 5. Control of Florida pusley in a crop of Iron Clay cowpea from tillage and herbicide treatments, fall 2000, Gainesville, Florida.

	Tillage				
Herbicide Treatment	Conventional	No-till	No-till+BM	Average	
----- lb ai acre^{-1} ------	------------------------ Florida pusley control, % (09/18/00) -----------------------				
Untreated Check	0.0	0.0	0.0	0.0	c
Pendimethalin (0.75 PRE)	70.0	66.3	88.8	75.0	b
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	88.8	90.0	91.3	90.0	A
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	88.8	91.3	91.3	90.4	A
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	72.5	91.3	90.0	84.6	A b
Average	64.0	67.8	72.3 NS		@ 0.05

Tillage = NS; Herbicides =**; Interaction = NS; CV herbicides = 23.7%
Comparison of herbicide means: LSD @ 0.05 p = 13.4; @ 0.10 p = 11.1

	------------------------ Florida pusley Control, % (10/18/00) ----------------------				
Untreated Check	6.3	1.3	7.5	5.0	B
Pendimethalin (0.75 PRE)	6.3	2.5	22.4	10.4	AB
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	13.8	11.3	26.3	17.1	A
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	11.3	0.0	3.8	5.0	B
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	5.0	1.3	5.0	3.8	b
Average	8.5	3.3	13.0 NS		@ .05

Tillage = NS; Herbicides =**; Interaction =NS; CV Herbicides = 156.8 %
Comparison of herbicide means: LSD @ 0.05 p = 8.5; @ 0.10 p = 6.9
BM=Broiler Manure; ai=active ingredient in lb acre^{-1}; PRE=pre emergence, POST=post emergence

ACKNOWLEDGMENTS

Appreciation is extended to Jim Chichester, Howard Palmer, and Walter Davis for technical assistance.

Literature Cited

Broome, M.L., and G.B. Triplett. 1997. Weed control for corn planted into Sod. . P 245-247. *In* R.N. Gallaher and R. McSorley (eds.). Proceedings 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60. University of Florida Cooperative Extension Service, Gainesville, Florida.

Fraser, H. 1985. Manure characteristics. Resources management branch. Ministry of Agriculture, Food and rural Affairs. In Ontario Web site. Government of Ontario, Canada. 5 pp.

Gallaher, R.N., C.O. Weldon, and J.C. Futral. 1975. An Aluminum block digester for plant and soil analysis. Soil Sci. Soc. Amer. Proc. 39(4):803-806.

Gallaher, R. N., and L. Hawf. 1997. Roles of conservation tillage in production of a wholesome food supply. P 23-27. *In* R.N. Gallaher and R. McSorley (eds.). Proceedings 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60. University of Florida Cooperative Extension Service, Gainesville, Florida.

Gutiérrez, W. C. Medrano, A. Gómez, E. Urrutia, M. Urdaneta, E. Esparza, J. Báez, Y. Villalobos, and B. Medina. 1999. Rev. Fac. Agron. (LUZ). 16:597-609.

Johnson, J.C., Jr., G.L. Newton, J.G. Davis, and P.R. Utley. 1995. Forage production from two minimum-till cropping systems utilizing liquid dairy manure. Animal & Dairy Science. CAES/UGA. Annual Report. P 199-202.

Lat, R.B., D. Rajat, and D.J. Minson. 1978. Legume contribution to the fertilizer economy in legume-cereal rotations. Indian Journal of Agricultural Science 48(7):419-424.

Mortimore, M.J., B.B. Singh, F. Harris, and S.F. Blade. 1997. Cowpea in traditional cropping systems. In advances in cowpea research. Copublication of International Institute of tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS). Chapter 9. Sayce Publishing. Devon, UK. pp. 99-113.

MSTAT 4.0. 1985. Users Guide to MSAT, Version 4.0 Michigan State University, Lansing, U.S.A.

Kandaswamy, P., P. Muthuswamy, and K.K. Krishnamoorthy. 1976. Effect of stage of cutting on the crude protein, phosphorus content and yield of cowpea (*Vigna sinensis* L.) The Madras Agricultural Journal 63(3):178-180.

QUATTRO PRO 4.0. 1987. Manual for QUATTRO PRO 4.0, Getting Started. Borland International, Inc., 1800 Green Hills Road, P.O. Box 660001, Scotts Valley, CA 95067-0001.

Relwani, L.L., C.K. Kurar, and R.K. Bagga. 1970. Varietal trial on cowpea (*Vigna sinensis*) for fodder production. Indian Journal of Agriculture 15(2):166-168.

Singh, B.B. 1993. Cowpea breeding: Archival report (1988-1992). Crop Improvement Division, IITA, Ibadan, Nigeria.

Soil Survey Staff. 1984. Official series description of the Millhopper series. United States Government Printing Office, Wash. D.C.

Tarawali S.A., B.B. Singh, M. Peters, and S.F. Blade. 1997. Cowpea haulms fodder. In Advances in Cowpea Research. Copublication of International Institute of Tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS). Chapter 27. Sayce Publishing. Devon, UK. P 313-325.

EFFECT OF VARIETY AND HERBICIDE PROGRAM ON FRESH POD YIELD OF STRIP-TILL PEANUT AND WEED CONTROL IN TWO MULTIPLE CROPPING SYSTEMS.

R.S. Tubbs, R.N. Gallaher, and J.T. Ducar[1]

AUTHORS: [1] Graduate Student, Professor, and Assistant Professor of Agronomy, respectively, University of Florida. Corresponding author: R.S.. Tubbs, P.O. Box 110730, University of Florida, Gainesville, FL 32611.

ABSTRACT

Two separate experiments were conducted to determine fresh pod yield and weed control for six varieties of peanut (*Arachis hypogaea*) during 2000. One experiment used rye (*Secale cereale*) as the preceding crop and the other used lupin (*Lupinus angustifolius*) as the previous crop. The six varieties included 'Georgia Green', 'Andru 93', Sunoleic 97R', 'Florida MDR-98', 'C-99-R', and 'Florunner'. There was significance at the p = 0.01 level among varieties and between herbicides for fresh pod yield of peanut in both experiments and there was no interaction between varieties and herbicides. Sunoleic 97R produced the greatest yield for both systems (rye = 5074 lb/A; lupin = 4499 lb/A) and Andru produced the lowest yield in both systems (rye = 4160 lb/A; lupin = 3006 lb/A). Plots treated with Cadre yielded higher than plots treated with Gramoxone Max + Storm in both experiments. No interaction occurred between variety and herbicide for the rye experiment, and both were significant at the p = 0.01 level. Weed control was much greater in the Sunoleic 97R and Florunner varieties than in the other varieties, with the Cadre plots maintaining better control than Gramoxone Max + Storm. However, for the lupin experiment, there was an interaction between variety and herbicide. Weed control was greatest with the Florunner and Sunoleic 97R varieties coupled with Cadre (83% and 79% control, respectively) and these were the only treatment combinations to have higher than 50% weed control in the lupin experiment.

INTRODUCTION

Conservation tillage systems are gaining in popularity in the southeastern U.S. During the mid-1990's, acreage dedicated to conservation tillage increased nearly five-fold in the state of Florida (CTIC Staff, 1998). Some reasons for the increasing acceptance include savings in energy, labor, and time. Conservation tillage also helps prevent soil losses due to erosion and residues hold more water after rain or irrigation thus providing more moisture to crops. There are also reduced equipment costs from smaller inventory as well as less upkeep (Gallaher, 1980; Teare, 1989; Whitehead et al., 1999).

There have been numerous positive results associated with growing peanut (*Arachis hypogaea* L.) in strip-till management systems. Strip-till peanut in the early 1980's displayed favorable results (Costello, 1984; Costello and Gallaher, 1985; Gallaher, 1983), yet this management practice was not widely adopted. However, the renewed interest in the last decade has led to more research with promising results. Brenneman et al. (1999) showed equal yields for peanut planted with conventional tillage, peanut strip-tilled into rye (*Secale cereale* L.), and peanut strip-tilled in a stale seedbed. Those experiments, averaged over 5 years of data, had yields close to 3,000 pounds/acre. Similar research was conducted by Tubbs et al. (1999) comparing five tillage treatments (1. strip-till into undisturbed rye straw, 2. strip-till - rye straw mowed and removed, 3. strip-till - rye straw mowed and left, 4. strip-till - rye straw mowed then removed followed later by mechanical cultivation, and 5. a conventional tillage treatment). There were no significant differences among tillage treatments and high yields were observed, as much as 6,200 pounds/acre.

Additional research on strip-till peanut with chemical weed control provided good results with yields reaching 3,900 pounds/acre in 1998 (Edenfield et al., 1999). Above average yields (up to 4,000 lb/acre) were also reported using strip-till and no-till management methods for two years by Baldwin et al. (1999). Peanut yields in excess of 6,000 pounds/acre are possible with proper management and pest control (Overman and Gallaher, 1990).

Continued research can hopefully lead to competitive results for reduced tillage systems to benefit our environment and our peanut producers as well. The objectives of these experiments were to determine pod yield and annual grass control of six peanut varieties with two herbicide management programs using two double cropping systems. One experiment involved growing peanut strip-tilled into a winter cover crop of rye and the other experiment involved growing peanut strip-tilled into a winter crop of lupin (*Lupinus angustifolius* L.).

MATERIALS AND METHODS

Experiments were conducted at Green Acres Agronomy Field Research Laboratory in Gainesville, FL during 2000 on an Arredondo fine sand (Sandy Siliceous Thermic Paleudult) (Soil Survey Staff, 1994). Rye and lupin were planted on 20 November 1999 at 60 and 30 pounds seed/acre, respectively. Both areas were fertilized with 150 pounds/acre of 12-4-8 (N-P_2O_5-K_2O), 200 pounds/acre K-Mag, and 150 pounds/acre KCl (muriate of potash, 60% K_2O) on 20 January 2000. The experiments were set up as identical split-plot designs with six replications and two row (5 foot x 20 foot) plots. The main-plot effect was peanut variety which included 'Georgia Green', 'Andru 93', 'Sunoleic 97R', 'FL MDR-98', 'C-99-R', and 'Florunner'. The sub-plot effect consisted of two herbicide treatments: (A) Gramoxone Max (paraquat) + Storm (bentazon + acifluorfen) + Activate Plus and (B) Cadre (imazapic) + Activate Plus. The rye received an additional 85 pounds N/acre on 21 February.

Peanuts were initially planted on 10 May, but due to a poor stand from equipment malfunction, peanuts were burned down with Roundup Ultra (glyphosate) at 2 quarts/acre on 2 June. Strip-till rows were spaced 30 inches apart using the Brown-Harden in-row-subsoil planter on 7 June followed by re-planting of the peanuts on 8 June.

Roundup Ultra was applied to kill remaining vegetation on 9 June. On 15 June, KCl was applied at 50 pounds/acre according to soil test recommendations. The herbicide treatments (A) Gramoxone Max (0.125 lb ai/acre) + Storm (0.75 lb ai/acre) + Activate Plus (0.25 % v/v) and (B)

Cadre (0.063 lb ai/acre) + Activate Plus (0.25 % v/v) were applied to their respective plots on 5 July. Insects and diseases were controlled using labeled rates of Bravo (chlorothalonil), Lannate (methomyl), Folicur (tebuconazole), and Solubor (6.2% Boron). A single application of 900 pounds gypsum/acre in a 12 inch band over the row was made 25 July. Weed control evaluations were conducted 18 October 2000.

Peanuts were inverted on 25 October and thrashed on 30 October. Pods were weighed for fresh yield and then sub-samples (1000 g) were collected from each plot and dried in a forced air seed dryer at 100 degrees F for 48 hours. These sub-samples were removed and weighed to determine moisture loss.

Data were prepared using Quattro Pro Spreadsheets (Anon., 1993). MSTAT (Freed et al., 1987) was used to perform analysis of variance and mean separation for a split-plot design with whole plots in a randomized complete block design. Mean separation was by Duncan's New Mulriple Range Test at $p = 0.05$ for six peanut varieties and LSD at $p = 0.05$ for two herbicide treatments.

RESULTS AND DISCUSSION

No interactions occurred with variety and herbicide for pod yield in both experiments. Significance was detected at $p = 0.01$ for pod yield at 10% moisture among varieties and between herbicides (Table 1). The greatest yields in both experiments were from the Sunoleic 97R variety (rye = 4794 lb/acre, lupin = 4209 lb/acre). Varieties Andru 93 (rye = 3945 lb/acre, lupin = 2821 lb/acre) and FL-MDR-98 (rye = 4090 lb/acre, lupin = 2723 lb/acre) produced the lowest yields for the two double cropping systems. Plots treated with Cadre produced greater yields than those treated with Gramoxone Max + Storm in both systems.

The two weeds present in these experiments included fall panicum *(Panicum dichotomiflorum* L.) and large crabgrass (*Digitaria sanguinalis* L.). No interaction was observed in the rye experiment between peanut variety and herbicide for annual grass (fall panicum + large crabgrass) control (Table 2). Annual grass control among varieties and between herbicides was significant at $p = 0.01$. Sunoleic 97R (87%) had better annual grass control than the other varieties, and Florunner (74%) had the second highest annual grass control rating. Andru 93 plots (35%) had the least annual grass control. Cadre (76%) provided much greater control than Gramoxone Max + Storm (34%) for the rye experiment.

An interaction occurred in the lupin experiment between variety and herbicide for annual grass control (Table 3). No difference occurred between varieties with Gramoxone Max + Storm treatments. All treatment combinations (variety x Gramoxone Max + Storm) controlled 20% of the weeds or less (average = 9% for Gramoxone Max + Storm plots). Cadre treatments on the Sunoleic 97R and Florunner provided greater control (79% and 83% control, respectively) than Cadre on the other varieties and were the only treatment combinations to provide greater than 50% control. Andru 93 treated with Cadre resulted in the least annual grass control of the variety x Cadre combinations. Cadre plots averaged 48% annual grass control for the lupin experiment.

Sunoleic 97R produced high pod yields in both systems, and Cadre plots yielded higher than plots treated with Gramoxone Max + Storm. Sunoleic 97R and Cadre also had the best annual grass control in the rye experiment. The treatment combinations of Sunoleic 97R with Cadre and Florunner with Cadre provided the best annual grass control in the lupin experiment. Andru 93 yields were the lowest in both studies. Annual grass control in the rye study was lower for Andru 93 than for any other variety. Data from the lupin study revealed that Andru 93 treated with Cadre provided the least annual grass control of all variety x Cadre combinations.

Results indicate a positive correlation between weed control and peanut yield. Plots with the greatest weed pressure yielded the lowest while plots with good weed control provided much higher yields. More research would be necessary to determine whether weed control or differences in varieties are the causes of the yield differences.

ACKNOWLEDGEMENTS

The authors thank Mr. Howard Palmer, James Chichester, and Walter Davis for their technical assistance.

Literature Cited

Anonymous. 1993. Quattro Pro. Borland International, Inc., Scotts Valley, CA.

Baldwin, J.A., A.K. Culbreath, and S. Jones. 1999. Peanut cultivar response when planted in either twin or single row patterns by strip-tillage or no-tillage methods. pp. 87-89. In J.E. Hook (Ed.) Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture, Tifton, GA. 6-8 July 1999. Georgia Agr. Exp. Sta. Special Pub. 95, Athens, GA.

Brenneman, T.B., S.H. Baker, W.C. Johnson III, A.W. Johnson, and D.R. Sumner. 1999. Effects of tillage systems on peanut diseases, yield and fungicide performance in a peanut-cotton rotation. pg. 10. In J.E. Hook (Ed.) Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture, Tifton, GA. 6-8 July 1999. Georgia Agr. Exp. Sta. Special Pub. 95, Athens, GA.

Costello, S.R. 1984. No-Tillage Peanuts for Florida. MS Thesis, Agronomy Department, Univ. of Florida, Gainesville, Florida 32611.

Costello, S.R., and R.N. Gallaher. 1985. Weed populations in conventional and no-tillage peanuts. Agronomy Research Report AY-85-02. Univ. of Florida, Inst. Food & Agr. Sci., Gainesville, Florida 32611.

CTIC Staff. 1998. 17th Annual Crop Residue Management Survey. Conservation Tillage Information Center. 1220 Potter Drive, Room 170, West Lafayette, IN 47906.

Edenfield, M.W., R.N. Gallaher, B.J. Brecke, and J.A. Tredaway. 1999. Weed management programs in no-till cotton, peanut, and soybean. pp. 173-177. In J.E. Hook (Ed.) Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture, Tifton, GA. 6-8 July 1999. Georgia Agr. Exp. Sta. Special Pub. 95, Athens, GA.

Freed, R., S.P. Eisensmith, S. Goetz, D. Reicosky, V.W. Smail, and P. Wolbert. 1987. User's Guide to MSTAT (Version 4.0). Michigan State Univ., East Lansing, MI.

Gallaher, R.N. (Ed.). 1980. Proceedings of the Third Annual No-Tillage Systems Conference: Energy Relationships in Minimum Tillage Systems. 202 p. Univ. of Florida, Inst. of Food & Agr. Sci., Gainesville, Florida 32611.

Gallaher, R.N. 1983. No-tillage peanut succeeding rye grain. Agronomy Research Report A-83-06. Univ. of Florida, Inst. Food & Agr. Sci., Gainesville, Florida 32611.

Overman, D.L., and R.N. Gallaher. 1990. Growth relationships among plant parts of high yield peanut: N and P. Agronomy Research Report AY-90-02. Univ. of Florida, Inst. Food & Agr. Sci., Gainesville, Florida 32611.

Soil Survey Staff. 1984. Official soil series descriptions for the Arredondo series. United States Government Printing Office, Washington, D.C.

Teare, I.D. (Ed.). 1989. Proceedings, 1989 Southern Conservation Tillage Conference. 86p. 12-13 July 1989. Tallahassee, FL. Univ. of Florida, Inst. Food & Agr. Sci., Special Bulletin 89-1. NFREC Quincy, Florida 32351.

Tubbs, R.S., R.N. Gallaher, and J.A. Tredaway. 1999. Tillage and herbicide management of two varieties of peanut. pp. 165-169. In P.K. Bollich (Ed.). 23rd Annual Southern Conservation Tillage Conference for Sustainable Agriculture. 19-21 June 2000, Louisiana Agr. Exp. Sta., LSU Agr. Center, Manuscript No 00-86-0205, Box 1429, Crowley, LA 70527-1429.

Whitehead, Jr., A.J., D.L. Jordan, P.D. Johnson, J.M. Williams, J.S. Barnes, C.R. Bogle, G.C. Naderman, and G.T. Roberson. 1999. Evaluation of tillage systems in North Carolina peanut production. pp. 8-9. In J.E. Hook (Ed.) Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture, Tifton, GA. 6-8 July 1999. Georgia Agr. Exp. Sta. Special Pub. 95, Athens, GA.

Table 1. Total pod yield for six varieties of peanut averaged over replication and herbicide treatment, and two herbicide treatments averaged over replication and variety, Gainesville, FL, 2000.

	Rye system	Lupin system
Peanut Variety	----------- lb/ac at 10% moisture	---------------------
Georgia Green	4324 cd	3683 ab
Andru 93	3945 e	2821 c
Sunoleic 97R	4794 ab	4209 a
FL-MDR-98	4090 de	2723 c
C-99-R	5063 a	3430 b
Florunner	4586 bc	3696 ab
Significance	***	***
Herbicide		
A	4282	2937
B	4653	3917
Significance	***	***
CV	10.16	17.72

Herbicide A = Gramoxone Max + Storm + Activate Plus; Herbicide B = Cadre + Activate Plus.

Values among varieties in the same column not followed by the same letter are significantly different at p = 0.05 according to Duncan's New Multiple Range Test.

Table 2. Percent annual grass control using rye cover crop for six peanut varieties averaged over replication and herbicide, and two herbicide treatments averaged over replication and variety, Gainesville, FL, 2000.

	Annual grass control %
Peanut Variety	
Georgia Green	39 cd
Andru 93	35 d
Sunoleic 97R	87 a
FL-MDR-98	45 cd
C-99-R	50 c
Florunner	74 b
Significance	***
Herbicide	
A	34
B	76
Significance	***
CV	33.93

Herbicide A = Gramoxone Max + Storm + Activate Plus; Herbicide B = Cadre + Activate Plus.

Values among varieties not followed by the same letter are significantly different at p = 0.05 according to Duncan's New Multiple Range Test.

The two main weeds present in this experiment were fall panicum (*Panicum dichotomiflorum*) and large crabgrass (*Digitaria sanguinalis*).

Table 3. Percent annual grass control using lupin cover crop averaged over 6 replications, an interaction between variety and herbicide, Gainesville, FL, 2000.

Peanut Variety	Herb. A	Herb. B	Significance	Average
Georgia Green	5 a	22 c	NS	14
Andru 93	4 a	13 c	NS	9
Sunoleic 97R	12 a	79 a	*	46
FL-MDR-98	9 a	44 b	*	27
C-99-R	4 a	45 b	*	25
Florunner	20 a	83 a	*	52
Average	9	48		

Level of significance for varieties = ***; for herbicide = ***; for interaction = ***.
Herb. A = Gramoxone Max + Storm + Activate Plus; Herb. B = Cadre + Activate Plus.

Values among varieties within a herbicide treatment not followed by the same letter are significantly different at $p = 0.05$ according to Duncan's New Multiple Range Test.

Values between herbicides within a variety are significant at $p = 0.05$ (*) or not significant (NS).

The two main weeds present in this experiment were fall panicum (*Panicum dichotomiflorum*) and large crabgrass (*Digitaria sanguinalis*).

NO-HERBICIDE, NO-TILL SUMMER BROCCOLI—QUANTITY OF RYE AND HAIRY VETCH MULCH ON WEED SUPPRESSION AND CROP YIELD

R. D. Morse[1]

AUTHOR: [1] Department of Horticulture, Virginia Tech, 306C Saunders Hall, Blacksburg, VA 24061-0327 (morser@vt.edu).

ABSTRACT

In no-till systems, high-residue cover crop mulch can suppress weed growth and reduce or even eliminate the need for applied herbicides. The extent of weed suppression by cover crop residues is determined by many interacting factors, including seasonal weed pressure and quantity, type (legume vs. grass) and maturity of the residues. This study was conducted to evaluate the effectiveness of high-residue *in-situ* mulch on suppression of summer weeds and yield of broccoli (*Brassica oleracea* L. Gp. Italica). Experimental design was a split-plot with four replications. Main plot treatments were cover crops: hairy vetch, HV (*Vicia villosa* Roth); grain rye, R (*Secale cereale* L.); and a mixture of rye and hairy vetch, R/HV. Subplot treatments were residue management methods: rolled, flail-mowed and no-residues. Growth of all cover crops was excellent, achieving dry weight biomass levels of 2.8, 4.7 and 4.5 ton/acre of HV, R and R/HV, respectively. Persistence of cover crop residues and yield of broccoli were highest in rolled treatments. Broccoli yield was reduced by 23% in flail-mowed and by 71% in no-residues, compared to rolled treatments; these yield reductions were more severe in HV and R/HV than in R plots. Weed biomass was negatively correlated with broccoli yield. Based on these data, when high-residue levels of R or R/HV mulch (4.5-4.7 ton/acre) were left intact (rolled) and undisturbed over the soil surface, excellent yields of summer broccoli were grown without application of herbicides. The R/HV biculture mixture and rolling were the best combination for production of no-herbicide, no-till summer broccoli.

INTRODUCTION

High-residue (3-6 ton/acre), no-till (NT) systems have been successfully used in Virginia and other states for production of brassicas such as cabbage and broccoli (Hoyt et al, 1994; Morse 1999b). Organic growers have expressed interest in using high-residue cover crops as an *in-situ* NT mulch instead of as green manure (Morse, 2000). In the traditional organic system, cover crop residues are incorporated before planting vegetable crops, leaving the soil uncovered and prone to germination and proliferation of weeds. Under this traditional system, weed control has become the greatest production problem facing organic growers (Walz, 1999). Without access to modern herbicides, organic growers resort to integrated weed management strategies (Regnier and Janke, 1990). While mechanical cultivation can effectively control weeds, soil organic matter declines in cultivated fields. Organic mulches suppress weeds;

however, growing, harvesting and spreading cover crop mulch are both costly and labor intensive. Using legume cover crops as green manure will provide organic nitrogen; however, weeds flourish after leaving the soil surface bare when legume cover crops are incorporated.

Weed management with reduced or even total elimination of chemical herbicides is appealing to all crop producers, especially those who are concerned about reducing environmental pollution and improving soil quality (Gallandt et al., 2000; Regnier and Janke, 1990; Wicks et al., 1994). Soil organic matter and soil quality are increased more rapidly when high-residue cover crops are produced and remain intact as surface mulch than when incorporated as green manure (Schomberg et al., 1994).

In previous research, no-herbicide NT fall broccoli has been successfully produced using a monoculture of foxtail millet (*Setaria italica* L. P. Beauv.) or a biculture of millet and soybean (*Glycine max* L.) (Infante and Morse, 1996; Morse, 1999a). In recent years, several researchers have shown that mature annual cover crops can be effectively killed using mechanical methods (Ashford et al., 2000; Creamer et al., 1995; Dabney et al., 1991; Morse, 1999a). Since weed populations are more severe in summer than in the fall, a factorial experiment was conducted to evaluate the effectiveness of (1) high-residue mulch from three overwintering cover crops and (2) four mechanical residue management methods on suppression of summer weeds and yield of transplanted broccoli.

MATERIALS AND METHODS

An experiment was conducted in the summer of 1995 at the Virginia Polytechnic Institute and State University Kentland Agriculture Research Farm, Blacksburg. The soil was a Hayter loam (fine-loamy, mixed, mesic, Ultic Hapludalf), with a pH of 6.5. The experimental design was a split plot with four replications. Main plots (36 x 24 ft) were cover crops. On 6 October 1994, hairy vetch (HV), grain rye (R) and a mixture of rye and hairy vetch (R/HV) were drilled in rows 7 in. apart at a rate of 45, 168 and 90/40 lb/acre, respectively. The entire field had been planted with grain rye in the fall of 1993; straw was removed in early June and the plots left fallow and sprayed with N-(phosphonomethyl) glycine (glyphosate) at 2 qt/acre 3 wk before seeding the crops on 6 October 1995.

Subplot treatments (36 x 6 ft) were residue management methods. On 30 May 1995, designated plots were either rolled followed by application of 1,1'-dimethyl-4-4'-bipyridinium ion (paraquat), rolled(+H); rolled without paraquat, rolled(-H); flail mowed without paraquat, flail-mowed(-H); or flail mowed, residues removed, without paraquat, no-residues(-H). All plots were left untouched for 5 wk until broccoli transplants were set on 6 July 1995. Flail mowing was done with a reverse-rotor Alamo-Mott (Alamo Group Co., Sequin, TX), equipped with a rear-mounted, heavy-duty (6 in. wide) roller. Rolling was accomplished by pulling the disengaged Alamo-Mott flail mower across the plot. Flail mowing killed all cover crops; however, only rye was completely killed by rolling. The hairy vetch in the rolled(-H) HV and R/HV treatments was only partially killed. In the paraquat-untreated subplots, stems of hairy vetch grew erect after rolling, eventually leaving two residue layers--at the bottom a mat of dead material and above a layer of living stems. The double layer became pronounced in approximately 2 wk after rolling and the top living layer was mowed with the flail mower raised so as to kill the living stems without disturbing the dead layer.

Above ground cover crop dry weight was determined by taking residue samples from 20 x 20 in. sections of each subplot and drying them at 70ºC for 2 wk. Sampling was taken at initial residue management treatment (30 May), at transplanting (6 July, 5 wk after killing, WAK), and again on 10 August (10 WAK). Cover crop persistence was determined by calculating the percentage of cover crop biomass remaining at 5 WAK and 10 WAK [(DW remaining x 100)/(DW at initial residue management treatment)]. Weed growth in all subplots was determined by harvesting the above-ground portions of weed plants from 20 x 20 in. between-row sections at transplanting (5 WAK) and again at 5 wk after transplanting (10 WAK). The weed material was dried for biomass determination following procedures described earlier for determining biomass of cover crops.

On 6 July 1995, bareroot 'Arcadia' broccoli transplants were set with the Subsurface Tiller-Transplanter (SST-T) (Morse et al., 1993). Granular fertilizer was surface banded at planting 3 in. from both sides of each row at (in lb/acre) 45N-19P-75K-2B, using the SST-T. All plots were sidedressed by hand with calcium nitrate at 50 lb N/acre 2 wk and again 6 wk after transplanting. To ensure a complete stand, transplants that did not survive were replaced by hand. One twin row was planted in each subplot. Rows were spaced 18 in. apart and 54 in. between adjacent twin rows (72 in. center to center); in-row spacing was 12 in. between plants (14,520 plants/acre). Sprinkler irrigation was used throughout the growing season to minimize soil water stress. Pesticides were applied at planting and at regular intervals thereafter, according to the Virginia Commercial Vegetable Production Recommendations (Virginia, 1995).

Marketable broccoli yield was determined from plants in an interior section (6 ft long, 12 plants/plot) of each twin row. United States Department of Agriculture (UDA) grading standards were followed for head broccoli (USDA, 1943). The length of the flowers and stem from the uppermost tip of the dome to the cut stem was 8 in. Heads that were deformed or weighed less than 3 oz. were not considered marketable. Four harvests were made from 27August through 22 September.

Statistical Analysis System (SAS) was used to perform all statistical analysis procedures (Scholtzhauer and Littell, 1987). Percentage data for cover crop persistence were analyzed after arcsine transformation.

RESULTS AND DISCUSSION

Cover Crop Growth and Persistence

Growth of all cover crops was excellent, averaging 5,500, 9,100 and 8,700 lb/acre for hairy vetch (HV), rye (R) and rye/hairy vetch (R/HV), respectively (Table 1). The quantity of cover crop residues remaining (persistence) 10 wk after killing (WAK) varied considerably among cover crops, averaging 31, 66 and 59% for HV, R and R/HV, respectively (Table 1). These residue persistence data are similar to other studies, showing that rate of breakdown is relatively rapid with legumes and slow with mature grain residues (Abdul-Baki et al., 1997;

Morse, 1999a). Rolling delayed breakdown of cover crop residues (improved persistence), compared to flail mowing. Rolling tends to layer and thus expose less residue surface area in contact with the soil, compared to flail mowing, which shreds residues into small pieces (Dabney et., 1991; Morse, 1999a).

Weed Biomass

Weed biomass at 10 WAK (5 wk after transplanting broccoli) was affected by both the type of cover crop and method of residue management (Fig. 1). Except for rolled(+H) treatments, growth of weeds was highest in HV plots for all residue management methods, especially with treatments in which cover crops had been chopped (flail mowed) or removed (no residues). Weed growth in HV plots was inversely related to cover crop persistence at 10 WAK; level of weed biomass was highest in flail-mowed and lowest in rolled subplots (Fig. 1). More weed biomass in unmulched HV than unmulched R or R/HV treatments is attributed to high levels of plant-available N mineralized from the extensive N-rich root system of hairy vetch. These data illustrate why using NT systems and precision placement (band application near the row) of N fertilizer are highly recommended as a weed-control strategy (Morse, 1999b). Broadcasting and incorporating N fertilizer at planting or postplanting are both inefficient and promotes weed growth. In like manner, production and incorporation of HV residues simulates broadcast incorporation of N fertilizer. Thus, incorporation of HV residues before planting broccoli should be avoided, unless appropriate preemergence herbicides or mulch (organic or plastic) are applied to suppress weed growth (Infante and Morse, 1996).

In this experiment, broccoli transplants were set (6 July) 5 wk after killing the cover crops. If broccoli transplants had been set immediately after killing (30 May) the cover crops, probably weed growth would not have reduced broccoli yield (Morse, 1999a). Likewise, if contact herbicides such as paraquat had been applied just before planting broccoli to kill emerged weeds and achieve a stale seedbed, possibly weed growth (even in flail-mowed and no-residues treatments) would have been minimized before canopy closure of the broccoli plants, thus avoiding deleterious effects on broccoli yield (Infante and Morse, 1996; Morse, 1999a). Although weed biomass was low at transplanting (data not shown), emerged weed numbers were high in many plots, particularly in all HV and unmulched R and R/HV plots. When not removed before planting, these small weeds grew rapidly (especially in HV plots) and competed with the young broccoli transplants for light, water and nutrients.

Broccoli Yield

Cover crop effects. Overall across all residue management treatments, broccoli yield was higher in R and R/HV than in HV plots (Fig. 2). Lower broccoli yield in HV plots is attributed to (1) low residue persistence (Table 1), resulting from rapid breakdown of above-ground HV residues; and (2) early weed emergence and rapid weed growth, resulting from above- and below-ground mineralization of HV residues. Delayed weed emergence and relatively slow weed growth occurred in R and R/HV plots, presumably because allelochemicals leached from the thick rye mulch, resulting in no apparent broccoli yield-limiting effects. In the R/HV plots, 85% of the initial residues was rye and only 15% was hairy vetch (data not shown). Therefore, weed growth in R/HV plots was similar to that found with monocrop rye (Fig. 1).

Residue management effects. Although weed biomass tended to be lowest in rolled paraquat-treated subplots, broccoli yield and weed biomass differences between untreated and paraquat-treated were not significant (Fig. 1 and 2). Averaged across cover crops, broccoli yield was reduced by 23% in flail-mowed(-H) and by 71% in no-residues(-H), compared to rolled treatments. However, in R plots, flail mowing did not reduce broccoli yield, and yield in unmulched (no residues) was relatively high. These yield differences among cover crops in flail-mowed treatments probably occurred because weed growth in R plots was held in check because low levels of plant-available N and relatively high levels of allelopathic chemicals were released from the rye residues.

Selecting the best cover crop x residue management combination. Based on these data, a biculture mixture of R/HV and rolling to flatten and retain the cover crop is the best combination for production of no-herbicide, NT broccoli. In rolled treatments, broccoli yield was significantly higher in R/HV than in a monoculture of HV, probably because persistence of HV residues was low and consequently weeds were relatively high in HV plots. In monoculture R plots, low plant-available N probably limited broccoli yield. Applying higher N rates possibly would have increased broccoli yield in R plots (Abdul-Baki et al., 1997).

Determining which combination of cover crop x residue management is best is basically a compromise between the growers need for organic N or weed suppression. Selecting the best combination may depend on whether the grower uses organic or conventional production practices. For example, organic growers might favor a monoculture of hairy vetch because this legume supplies abundant organic N and weed growth could be managed using mechanical cultivation. Conventional growers, who can easily meet the high N demand for broccoli plants by using chemical fertilizer, may opt for a monocrop of rye to achieve excellent weed control and moisture conservation throughout the growing season. However, a mixture of R/HV may be readily suitable for both organic and conventional growers, providing excellent weed suppression and some organic N. In addition to weed suppression and high yields, cover crop mixtures often promote improvements in soil microbial biodiversity and soil quality (Creamer and Bennett, 1997; Magdoff and van Es, 2000).

CONCLUSIONS

High-residue, no-till systems are a viable option for production of transplanted broccoli. Effort and expense to produce and appropriately manage high-residue levels of *in-situ* mulch will be greatly rewarded later in terms of improved weed suppression, increased broccoli yield, and reduced production inputs such as water and nitrogen. In addition, using high-residue systems over time can result in improved soil quality and crop productivity.

The decision as to which cover crop x residue management combination is best often depends on whether the producer is an organic grower who needs the cover crop to supply organic N or a conventional grower who is looking for improved weed suppression and conservation of soil and water. In the former case, the organic grower may opt for a monocrop of HV, either rolled or flail mowed, and would rely on mechanical cultivation for weed suppression. In the latter case, the conventional grower may prefer a combination of monocrop rye and rolling to achieve conservation of soil and water and weed suppression without requiring herbicides. Regardless of the grower's production preference, the combination of R/HV biculture and rolling offers many advantages, including high residue persistence, no-herbicide weed suppression, high yields, and production of some organic N. Transplanting soon after killing the cover crop is recommended to optimize both weed suppression and N-use efficiency of the high-residue NT mulch.

With regard to the quantity of cover crop residues needed to suppress weed growth below yield-limiting levels for NT transplanted broccoli, two conclusion can be drawn, based on data from this experiment and other related studies. First, if three or more ton/acre of mulch are produced, distributed and retained evenly over the soil before transplanting, weed growth can be effectively suppressed below yield-limiting levels without application of herbicides. Second, and most important, when residues are left undisturbed and persist at two or more ton/acre throughout early canopy development (3-4 wk after transplanting), weed suppression lasts several weeks after transplanting and broccoli yield is not reduced.

Literature Cited

Abdul-Baki, A.A., R.D. Morse, T.E. Devine, and J.R. Teasdale. 1977. Broccoli production in forage soybean and foxtail millet cover crop mulches. HortScience 32:836-839.

Ashford, D.L., D.W. Reeves, M.G. Patterson, G.R. Wehtje, and M.S. Miller-Goodman. 2000. Roller vs. herbicides: An alternative kill method for cover crops. p. 64-69. *In* P. K. Bollich (ed.) Proc. Southern Conservation Tillage Conference for Sustainable Agriculture, Monroe, LA.

Creamer, N.G. and M.A. Bennett. 1997. Evaluation of cover crop mixtures for use in vegetable production systems. HortScience 32:866-870.

Creamer, N.G., B. Plassman, M.A. Bennett, R.K. Wood, B.R. Stinner, and J. Cardina. 1995. A method for mechanically killing cover crops to optimize weed suppression. Am. J. Alt. Agri. 10:156-161.

Dabney, S.M., N.W. Buehring, and D.B. Reginelli. 1991. Mechanical control of legume cover crops. p. 146-147. *In* W.L. Hargrove (ed.) Cover crops for clean water. Soil and Water Cons. Soc., Ankeny, IA.

Gallandt, E.R., M. Liebman, and D.R. Huggins. 2000. Improving soil quality: Implications for weed management. p. 95-121. *In* D.D. Buhler (ed.) Expanding the context of weed management. Food Products Press (Haworth Press), NY.

Hoyt, G.D., D.W. Monks, and T.J. Monaco. 1994. Conservation tillage for vegetable production. HortTechnology 4(2):129-135.

Infante, M.L. and R.D. Morse. 1996. Integration of no-tillage and overseeding legume living mulches for transplanted broccoli production. HortScience 31:376-379.

Magdoff, F. and H. van Es. 2000. Building soils for better crops, second ed. p. 87-98. Sustainable Agriculture Network, Burlington, VT.

Morse, R.D. 1999a. Cultural weed management methods for high-residue/no-till production of transplanted broccoli (*Brassica oleracea* L. Gp. Italica). *In* Liptay et al. (ed.) Proc. Sixth Symposium on Stand Establishment. Acta Horticulturae 504:121-128.

Morse, R.D. 1999b. No-till vegetable production--its time is now. HortTechnology 9:373-379.

Morse, R.D. 2000. High-residue, no-till systems for production of organic broccoli. p. 48-51. *In* P.A. Bollich (ed.). Proc. Southern Conservation Conference for Sustainable Agriculture, Monroe, LA.

Morse, R.D., D.H. Vaughan, and L.W. Belcher. 1993. Evolution of conservation tillage systems for transplanted crops: Potential role of the Subsurface Tiller-Transplanter (SST-T). p. 145-151. *In* P.A. Bollich (ed.) Proc. Southern Conservation Tillage Conference for Sustainable Agriculture, Monroe, LA.

Schlotzhauer, S.D. and R.C. Littell. 1987. SAS system for elementary statistical analysis. SAS Institute, Inc. Cary, NC.

Schomberg, H.H., P.B. Wood, and W.L. Hargrove. 1994. Influence of crop residues on nutrient cycling and soil chemical properties. p. 99-121. *In* P.A. Unger (ed.) Managing agricultural residues. Lewis Publ. Boca Raton, FL.

U. S. Department of Agriculture, Agricultural Marketing Service. 1943. United States standards for grading bunched Itialian sprouting broccoli. U. S. Govt. Printing Office, Washington, DC.

Virginia commercial vegetable production recommendations. 1995. VA Coop. Ext. Serv. Publ. 420-456.

Walz, E. 1999. Third biennial national organic farmers' survey. p. 19-47. Organic Farming Research Foundation, Santa Cruz, CA.

Wicks, G.A., O.C. Burnside, and W.L. Felton. 1994. Weed control in conservation systems. P. 211-244. *In* R.W. Unger (ed.) Managing agricultural residues. Lewis Publ., Boca Raton, FL.

Table 1. Initial quantity and persistence (10 wk after killing, WAK) of cover crop biomass as influenced by cover crop species and residue management method.

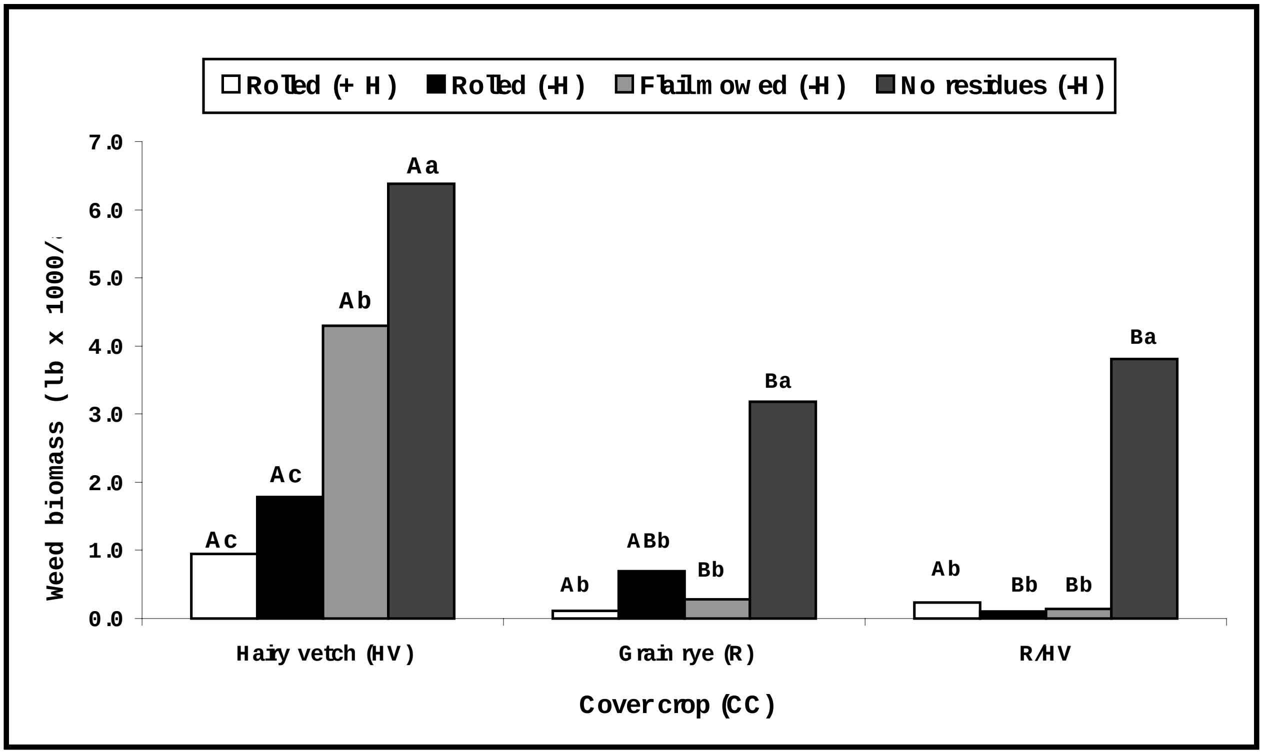
Residue management[z] (RM)	Time (WAK)	Cover crops (CC)							
		Hairy vetch (HV)		Grain rye (R)		R/HV		Mean (RM)	
		lb/a	RQ[y](%)	lb/a	RQ (%)	lb/a	RQ (%)	lb/a	RQ (%)
Rolled (+H)	0	5,610	---	9,500	---	9.200	---	8.200	---
	10	2,000	36	6,600	67	6.000	65	4.500	59a[x]
Rolled (-H)	0	5,800	---	9,010	---	8.800	---	7.800	---
	10	2,000	35	6,400	71	5.600	63	4.600	59a
Flail mowed (-H)	0	5,100	---	8,600	---	8.200	---	7.400	---
	10	1,200	24	5,000	58	3.800	46	3.400	46b
Mean (CC)	0	5,510	---	9,100	---	8.700	---		
	10	1,700	31b	6,000	66a	5,100	59a[x]		

[z]Residue management – After flattening the cover crops by rolling or flail mowing, paraquat was applied [rolled (+H)] or not applied [rolled(-H) or flail mowed(-H)].
[y]RQ = Relative quantity (persistence) in percentage of residues remaining 10 wk after killing (WAK) cover crops by rolling or flail mowing (100%).
[x]Mean separation of RM and CC by LSD ($P = 0.05$). There were no interactions among treatments at $P = 0.05$.

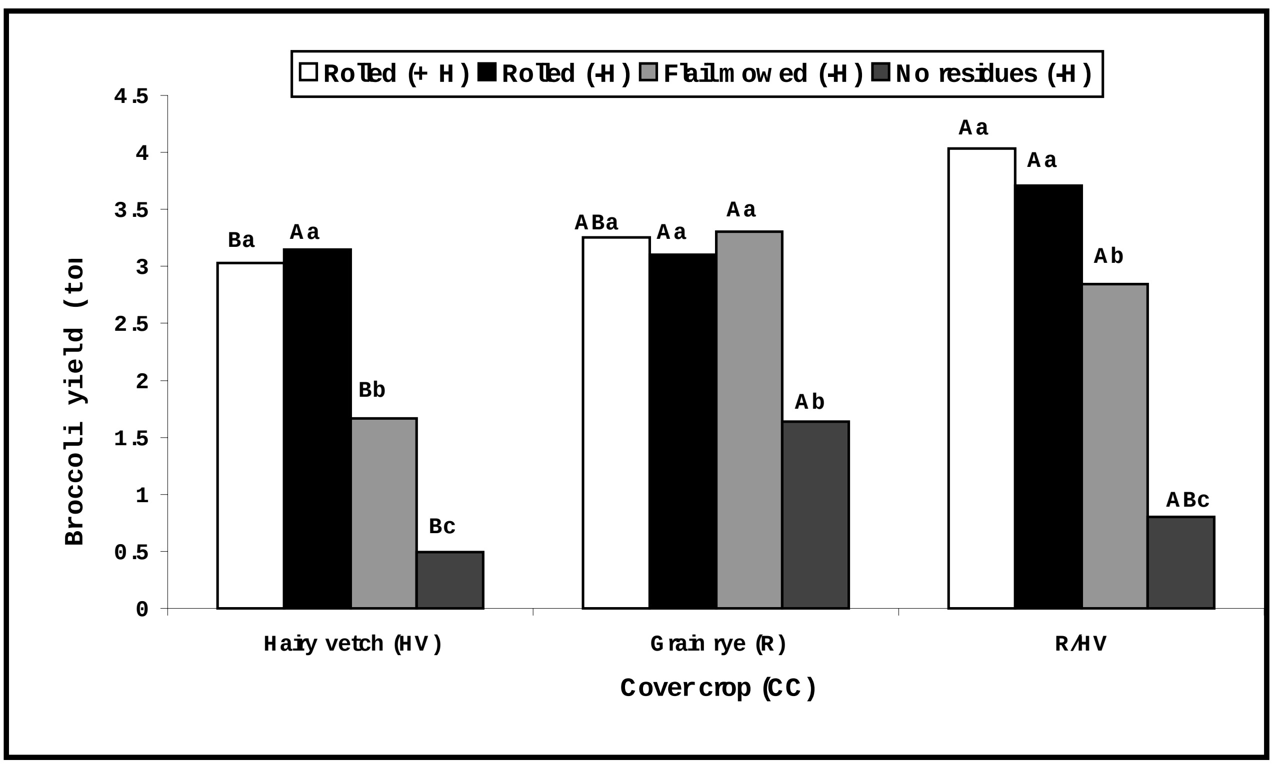
Figure Legends

Fig. 1. Weed biomass at 10 wk after killing (WAK), as influenced by cover crop (CC) and method of residue management (RM). The interaction (CC x RM) was significant ($P>F$ = 0.0076). Mean separation by Tukey's hsd at P = 0.05; lowercase letters indicate RM comparisons within a given CC and uppercase letters indicate CC comparisons within a given RM.

Fig. 2. Broccoli yield as influenced by cover crop (CC) and method of residue management (RM). The interaction (CC x RM) was significant ($P>F$ = 0.0414). Mean separation by Tukey's hsd at P = 0.05; lowercase letters letters indicate RM comparisons within a given CC and uppercase letters indicate CC comparisons within a given RM.



Rolled (+ H)
Rolled (-H)
Flail mowed (-H)
No residues (-H)
Weed biomass (lb x 1000/
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Aa
Ab
Ac
Ac
Ba
ABb
Bb
Ab
Ba
Ab
Bb
Bb
Hairy vetch (HV)
Grain rye (R)
R/HV
Cover crop (CC)



Rolled (+ H)
Rolled (-H)
Flail mowed (-H)
No residues (-H)
Broccoli yield (to
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Ba
Aa
Bb
Bc
ABa
Aa
Aa
Ab
Aa
Aa
Ab
ABc
Hairy vetch (HV)
Grain rye (R)
R/HV
Cover crop (CC)

WEED MANAGEMENT IN CONVENTIONAL AND NO-TILL WHEAT-SOYBEAN CROPPING SYSTEMS IN CENTRAL OKLAHOMA

B. S. Trusler[1], T. F. Peeper

AUTHORS: [1]Graduate Research Assistant, Oklahoma State University, Department of Plant and Soil Sciences, phone 405-744-9589, email truslec@okstate.edu.

Summary

Oklahoma wheat producers are seeking for alternative methods of controlling Italian ryegrass. Three experiments were established in Central Oklahoma to compare herbicide and grazing treatments in continuous wheat with rotating out of wheat for one growing season on I. ryegrass density in the final wheat crop of each cropping system. In the system where wheat was not grown for one year, the missed wheat crop was replaced with double-cropped soybeans followed by early season soybeans after which the final wheat crop in the system was seeded. Both cropping systems were evaluated under no-tillage and conventional tillage. The experiments were established in June 1999 following wheat harvest.

DRILLED SOYBEAN RESPONSE TO WIDE BED SYSTEMS

N. W. Buehring[1], G. R. Nice, and R. R. Dobbs

AUTHORS: [1] N.W. Buehring, Senior Agronomist; G.R. Nice, Research Assistant II; and R.R. Dobbs, Research Assistant I; Mississippi State University, North Mississippi Research and Extension Center, Post Office Box 1690, Verona, MS 38879. *Corresponding author (buehring@ra.msstate.edu).

INTERPRETIVE SUMMARY

In North Mississippi about 46% of the soybeans are grown in a drill-narrow row (≤ 20 inches) pattern on flood plain soils. Most of this acreage is planted in Maturity Group (MG) VI, which mature in mid to late October and most often are harvested in November under muddy field conditions that result in rutted fields. Rutted fields have increased compaction, reduced drainage, and the following year often delays spring tillage and soybean planting.

When planted in late April or early May, MG IV and V varieties are as productive as MG VI varieties and have the advantage of dry field harvest conditions for September/early October harvest. The September/October harvest also allows time for late-season fertilizer application and land preparation (if necessary). However, early planting of MG IV and V varieties under current flat tillage production systems on these flood plain soils may result in stand losses and poor growth, especially when wet soil conditions occur in late April and early May. Therefore, wide raised bed (80 and 120 inch) production systems were evaluated with a productive MG IV and V variety planted early May in 7.5 (1996 and 1997) and 15 inch rows (1998-2000).

A 5-year (1996-2000) study was conducted on a Leeper silty clay loam soil (fine, montmorillonitic nonacid, thermic chromudertic Haplaquepts) as a split-split plot with years as main plot, varieties as sub-plots and tillage as sub-subplots at the Northeast Branch Station. Plots were 20 ft x 500 ft long with 3 replications. Tillage treatments were: no-tillage wide-bed (80 and 120 inches), fall one-pass chisel-bedder-harrow wide bed (80 and 120 inches), flat stale seedbed (fall chisel-harrow), and flat no-tillage. The no-tillage wide beds were formed with a one-pass chisel-bedder-harrow in the fall of 1995 and repeated in the fall of 1998. MG IV and V soybeans were planted no-till on all treatments in early May. In the borders of each replication of the study, a disk twice in the spring (late April - early May) plus field cultivate (prior to planting MG VI soybean in early June) conventional farmer production system was included. Good agronomic practices were applied to all treatments and soybeans were harvested within 7 days after maturity.

Five year (1996-2000) yield analysis indicated a year by variety and a year by tillage interaction. Three (1996, 1997, and 1999) of 5 years tillage had no effect on yield. However,

the fall chisel-harrow system had higher yield than all other treatments in 1998 and had higher yield than flat no-tillage and no-tillage 80 inch wide beds in 2000. The MG V variety had higher yield than MG IV variety 4 (1996-99) of 5 years with 4-year average of 38.1 bu/A compared with 31.7 bu/A for MG IV. In 2000, MG IV soybean produced 36.6 bu/A compared to 32.7 bu/A for MG V. Observation indicated that all 5 years of the study, both MG IV and V soybean produced yield equal to or greater than the MG VI variety in the conventional farmer production system. However, the MG IV soybean, during extended dry periods, showed more sensitivity to iron-chlorosis than MG V or MG VI soybean with symptoms more prevalent in no-tillage. MG IV, V, and VI soybeans matured each year about mid-September, early October, and late October, respectively.

These 5-year results indicate that raised beds were not necessary for high yield with May planted MG IV or V soybeans. These results also indicate that North Mississippi soybean growers have the opportunity to improve profitability with stale seedbed production systems in combination with productive MG IV or MG V soybeans. Stale seedbed production systems would avoid rutting fields, allow growers to perform fall tillage when necessary, and focus on planting soybeans in a more timely manner in the spring of the year.

WHEAT/LUPINE DOUBLE CROP WITH COTTON

P. J. Wiatrak[1], D. L. Wright[1], W. Koziara[2], and J. Pudelko[2]

AUTHORS: [1] North Florida Research and Education Center, Quincy, FL 32351-9529;
[2] Agriculture University, Institute of Soil Cultivation and Plant Production, Mazowiecka 45/46, 60-623 Poznan, Poland; Corresponding author: P. J. Wiatrak, NFREC, 30 Research Rd., Quincy, FL 32351-9529; e-mail:pjwiatrak@mail.ifas.ufl.edu.

ABSTRACT

The research was conducted from 1995 to 1997 at the North Florida Research and Education Center (NFREC) in Quincy, FL, a unit of Univ. of Florida. Tests were conducted to define the influence of wheat (*Triticum aestivum ssp. vulgare* L.) and white lupine (*Lupinus albus* L.) (winter crops), and N rates (0, 60, 120, and 180 lb N/A) on cotton. The objectives of this experiment were to evaluate the yields, plant number, boll number, lint weight, and plant height of cotton grown after lupine as compared to cotton grown after wheat. According to regression functions, the maximum yields of cotton after wheat were obtained with almost 15% more N application than the maximum yields obtained after lupine; however, higher yields of lint were obtained after lupine than wheat. Differences in plant population due to nitrogen rates were smaller at 120 lb/A as compared to other N rates. Increasing N rates on cotton planted after wheat decreased the plant population, but after lupine higher cotton plant populations were obtained at 60 and 180 lb N/A. The number of bolls was significantly higher after lupine than wheat, and they were increasing with increasing nitrogen rates for cotton planted after lupine and wheat. The highest boll number per plant was obtained with almost 50% higher application of N after wheat than lupine, but generally boll number was higher for cotton planted after lupine than wheat with lower N application on cotton. Higher than 100 lb/A application of N significantly decreased the number of bolls on cotton planted after lupine. The lint weight per boll was higher from cotton grown after wheat than white lupine. Plants were generally taller after lupine than wheat. The regression functions for cotton grown after lupine show increasing plant height with increased N rate. The tallest cotton was grown after wheat at the maximum N application.

INTRODUCTION

The acreage of cotton grown (*Gossypium hirsutum* L.) in Florida increased from year to year, as it has in the southeast United States.

One of the most important agronomic benefits of growing legumes is their contribution to provide biological nitrogen, which may decrease the need of nitrogen fertilization of the next crop (Brown et al., 1985). Additionally growing legume crops tends to increase weed control, increase organic matter in the soil, reduce soil erosion, and decrease evaporation (Touchton et al., 1984, Brown et al., 1985, Varco 1993, Boquet et al., 1994). Field studies have shown that growing legumes as previous crops may reduce the need for nitrogen applications on cotton by 50% (Touchton and Reeves, 1988; Millhollon and Melville, 1991).

According to Boquet et al. (1994) growing cotton after vicia (*Vicia hirsuta*) increased the average cotton yield by 390 lb/acre as compared to cotton grown after no previous crop. Legume crops such as crimson clover (*Trifolium incarnatum* L.) and peas (*Pisum sativum* L.) may contribute up to 90 lb N/A for the next crop (Hoyt and Hargrove, 1986). Touchton et al. (1984) have shown that sufficient nitrogen is available after legume crops for cotton grown on sandy soils with low nitrogen content. Using legume crops as the only source of nitrogen for cotton resulted in the same or even higher cotton yields as compared to applying 120 lb N/A on monoculture. Measurements of fixed nitrogen in the soil suggest that 80 - 150 lb N/acre is produced by crimson clover and vicia during blooming in the spring (Mitchell, 1996). Nitrogen availability in the soil depends on previous crop, soil moisture, temperature, and plant maturity at desiccation (Ranells and Wagger, 1992; Wagger, 1989). According to Breintenbeck et al. (1994) cotton grown on clay soil after vicia didn't require high nitrogen fertilization to get a maximum yield. The balance of nitrogen fertilizer is generally negative (Brown et al., 1985; Wagger, 1989; Reeves and Touchton, 1991; Torbert and Reeves, 1994) due to a high C:N ratio in plant residues. After legume crops, nitrogen balance in the soil is from 13 to 180 lb N/A (Hoyt and Hargrove, 1986; Smith et al., 1987; Frye et al., 1988).

Touchton et al. (1995) have shown that is very important to provide the right rate, source, and application method of nitrogen for minimum tillage. This is partly due to the quality of plant residues after the previous crop. Using legume crops as previous crop contributes to significant increases of mineralized nitrogen and decreases the need for synthetic nitrogen to be applied to the next crop. Using rotation and growing winter crops may reduce leaching of nitrogen into the soil and degradation of the ground water. In reviewed literature, the optimum rate of nitrogen for cotton was from 31 to 120 lb N/A (Howard and Hoskinson, 1986; Lutrick et al., 1986; Maples and Frizzel, 1985; Phillips et al., 1987; Thom and Spurgeon, 1982; Touchton et al., 1981). To obtain maximum yield cotton should receive 81 - 200 lb N/A, but the optimum nitrogen rate is about 12 - 45 lb N/A lower than the rate giving a maximum yield (Constable and Rochester, 1988). According to research conducted by Wright et al. (1998), yield of lint was higher at 180 and 120 lb N/A, and it was, respectively 1250 and 1222 lb/A compared to rate of 60 lb N/A and without fertilization yield was, respectively, 1057 and 723 lb/A. The number of bolls per plant was higher at 180 and 120 lb N/A) and was, respectively, 15.1 and 13.7 bolls as compared to the application of 60 lb N/A and without nitrogen fertilization (respectively 11.2 and 7.4 bolls per plant).

The purpose of this work was to define the influence of a previous crop of lupine and wheat, and nitrogen rates on cotton grown in a multicropping system in Florida.

MATERIALS AND METHODS

The field research with cotton was conducted during 1995 - 1997 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) at the North Florida Research and Education Center / University of Florida in Quincy. In the experiment with cotton the following factors were: previous crop (white lupine - var. “Lunoble” and winter wheat - Pioneer 2684) and

N rate (0, 60, 120 and 180 lb N/A). Lupine was planted at the seeding rate of 155 lb/A in double rows during the last week of November. Winter wheat was planted at 90 lb/A in 7 inch wide rows at the end of November. Cotton was planted after harvest of white lupine and wheat in 36 inch row spacing at a seeding rate of 4 seeds per ft of row. The crop was grown from the last week of May to the second week of November. Nitrogen fertilizer in the form of ammonium nitrate was applied four weeks after planting of cotton, and 180 lb N/A rate, being divided into 120 lb N/A applied four weeks after planting and 60 lb N/A applied three weeks later.
The field experiments were static and conducted as split - plot with four replications. All results were analyzed statistically by analysis of variance for factor analysis, and means were separated using Fisher's Least Significant Difference Test at the 5% probability level. Analysis of linear and quadratic regression were added to the analysis of variance.

RESULTS

Significantly higher cotton lint yields were obtained after a previous crop of lupine than after wheat (Fig. 1). According to the regression functions, yields of cotton were highest with the application of 117 and 134 lbs N/A after lupine and wheat, respectively. The difference between previous crops was high at the rates of 0 and 60 lb N/A and 13.0 and 12.2% higher yields were obtained after lupine than wheat, respectively.

Plant number per square foot was influenced by nitrogen rates, and also by interaction of previous crop and nitrogen rates (Table 1). There was no difference in the plant number per square unit for previous crops. Differences in plant population due to nitrogen rates were smaller at 120 lb/A as compared to other N rates. Increasing nitrogen rates on cotton planted after wheat decreased plant population, but after lupine higher plant population was obtained at 60 and 180 lb N/A.

Boll number per square foot is shown in Fig. 2. The number of bolls was significantly higher after lupine than wheat, and was increased with increasing nitrogen rates for cotton planted after lupine and wheat. The maximum number of cotton bolls per square foot was obtained with the application of 180 lb N/A for both previous crops.

The regression functions for the boll number per plant are shown in Fig. 3. According to this regression, the highest theoretical boll number per plant was obtained with the application of 98 lb N/A after lupine and 145 lb N/A after wheat. Application of higher than 98 lb N/A after lupine significantly decreased the number of bolls per plant.

Table 2 shows the weight of lint per boll. The lint weight was influenced by previous crop. Lint weight of cotton after wheat averaged 2.12 gms and was 3.4% higher than the weight obtained from cotton grown after white lupine. There was no difference between N rates and no interaction of previous crop and N rates.

Plant heights were generally taller after lupine than wheat (Fig. 4). The regression functions show increased plant height with increasing N rate, and the highest value was obtained at 120 lb N/A after lupine. After wheat taller plants of cotton were obtained at the maximum application of nitrogen.

CONCLUSIONS

The lint yield of cotton was significantly higher after white lupine than wheat. The response of cotton to nitrogen fertilization was influenced by previous crop, but using higher than 60 lb N/A after lupine was not economically substantiated, and calculated theoretical rates to obtain maximum lint yields were 117 lb N/A after white lupine and 134 lb N/A after wheat.

Literature Cited

Boquet D. J., G. A. Breitenbech, and A. B. Coco. 1994. Cotton yield and growth on clay soil under different levels of tillage, nitrogen and cover crop. p. 1513-1515. In Proc. 1994 Beltwide Cotton Prod. Conf. 5-8 Jan., San Diego, CA.

Breintenbeck G. A., R. L. Hutchinson, and D. J. Boquet. 1994. Nitrogen status of cotton following winter cover crops. p. 1505-1507. In Proc. 1994 Beltwide Cotton Prod. Conf. 5-8 Jan., San Diego, CA..

Brown S. M., T. Whitewell, J. T. Touchton, and C. H. Burnster. 1985. Conservation tillage systems for cotton production. Soil Sci. Soc. Am. J. 49: 1256-1260.

Constable A. G. and J. Rochester. 1988. Nitrogen application to cotton on clay soil: timing and soil testing. Agron. J. 80: 498-502.

Frye W. W., R. L. Blevins, M. S. Smith, S. J. Corak, and J. J. Varco. 1988. Role of annual legume cover crops in efficient use of water and nitrogen. p. 129-154. In: W. L. Hargrove (ed.) Cropping Strategies for efficient use of water and nitrogen. Special Publication No. 51, American Society of Agronomy, Madison, WI.

Howard D. D. and P. E. Hoskinson. 1986. Nitrogen fertilization of cotton: Rate and time of application on a Loring silt loam soil. Tenn. Farm Home Sci. 138: 13-19.

Hoyt G. D. and W. L. Hargrove. 1986. Legume cover crops for improving crop and soil management in the southern United States. HortSci. 21: 397-402.

Lutrick M. C., H. A. Peacock, and J. A. Cornell. 1986. Nitrate monitoring for cotton lint production on a Typic Paleudult. Agron. J. 78: 1041-1046.

Maples R. and M. Frizzell. 1985. Effects of varying rates of nitrogen on three cotton cultivars. Ark. Agric. Exp. Stn. Bull. 882.

Millhollon, E. P. and D. R. Melville. 1991. The long-term effects of winter cover crops on cotton production on the Red River alluvial soils of Nothwest Louisiana. Louisiana Agric. Exp. Stn. Bull. 830.

Mitchell C. 1996. Alabama's "Old Rotation" 100 years of cotton research. p.1387 - 1390. In Proc. 1996 Beltwide Cotton Prod. Res. Conf. Nashville, TN.

Phillips S. A., D. R. Melville, L. G. Rodrigue III, R. H. Brupbacher, R. L. Rodgers, and J. S. Roussel. 1987. Nitrogen fertilization influences on cotton yields, petiole nitrate concentrations, and residual soil nitrate levels at the Macon Ridge, Northeast, and Red River Research Stations. La. Agric. Exp. Stn. Bull. 779.

Ranells N. N. and M. G. Wagger. 1992. Nitrogen release from crimson clover in relation to plant growth stage and composition. Agron. J. 84: 424-430.

Reeves D. W. and J. T. Touchton. 1991. Deep tillage ahead of cover crop planting reduces soil compaction for following crop. Highlights of Agricultural Res. 38:4. Alabama Agric. Exper. Stn., Auburn University, AL.

Smith M. S., W. W. Frye, and J. J. Varco. 1987. Legume winter cover crops. p. 95-139. In: B. A. Steward (ed.) Advances in Soil Science. Vol. 7. Springer-Velag, New York, NY.

Thom W. D. and W. Spurgeon. 1982. Effects of applied nitrogen on nitrates in soils and cotton petioles. Miss. Agric. For. Exp. Stn. Tech. Bull. 111.

Torbert H. A. and D. W. Reeves. 1994. Fertilizer nitrogen requirements for cotton production as affected by tillage and traffic. Soil Sci. Soc. Am. J. 58: 1416-1423.

Touchton J. T., D. H. Rickerl, R. H. Walker, and C. E. Snipes. 1984. Winter legumes as a nitrogen source for no-tillage cotton. Soil Tillage Res. 4: 391-401.

Touchton J. T., D. W. Reeves, and C. W. Wood. 1995. Fertilizer management. In Langdale G. W. and W. C. Moldenhauer (Ed.), Crop residue management to reduce erosion and improve soil quality. USDA. Cons. Res. Rep. 39: 13-15.

Touchton J. T., F. Adams, and C H. Burmester. 1981. Nitrogen fertilizer rates and cotton petiole analysis in Alabama field experiments. Ala. Agric. Exp. Stn. Bull. 528.

Touchton, J. T. and D. W. Reeves. 1988. A Beltwide look at conservation tillage for cotton. p. 36-41. In Proc. 1988 Beltwide Cotton Prod. Res. Conf. New Orleans, LA.

Varco, J. J. 1993. Fertilizer nitrogen and cover crop management for no-tillage cotton production. p. 63-65. *In:* Conservation-tillage systems for cotton. Ark. Ag. Exp. Stat. Spec. Report. 160.

Wagger M. G. 1989. Time of desiccation effects on plant composition and subsequent nitrogen release from several winter annual cover crops. Agron. J. 81: 236-241.

Wright D. L., S. Reed, F. M. Roads, and P. Wiatrak. 1998. Fate of nitrogen on cotton following winter fallow, small grains and legumes in conventional and conservation tillage systems. Univ. of Florida, NFREC. Res. Rep. 98-11.

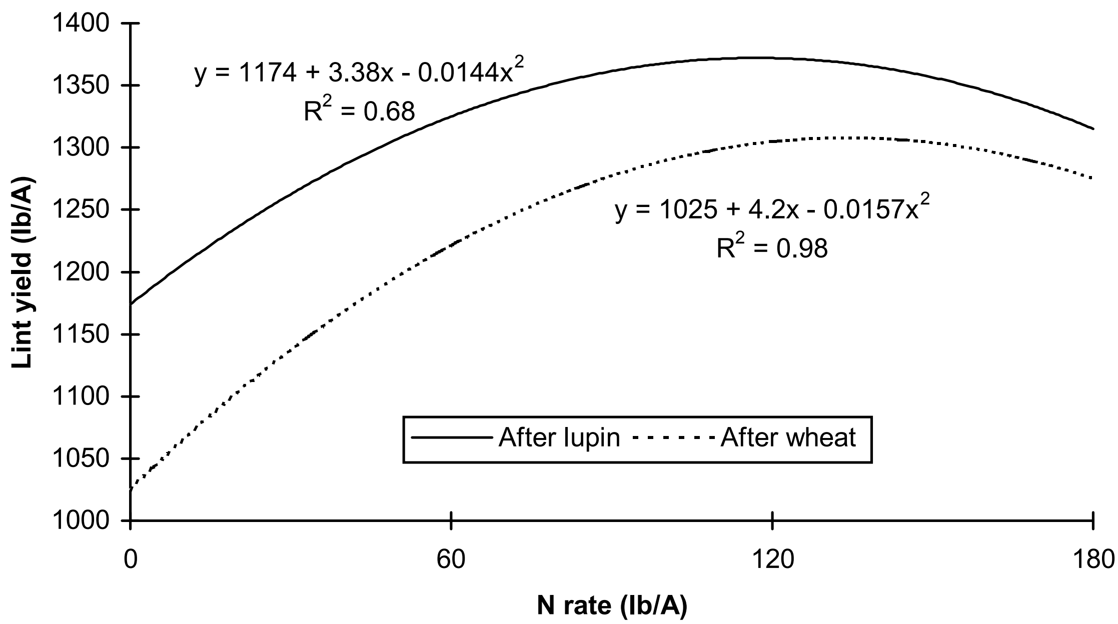


Fig. 1. Functions of nitrogen production for cotton yields after lupine and wheat.

Table 1. Influence of previous crop and nitrogen rates on plant number per sq. ft.

Previous crop	N rates (lb/A)				Mean
	0	60	120	180	
	------------------ plants / sq. ft. ------------------				
Lupine	53.8	58.0	51.2	57.7	55.2
Wheat	59.3	55.0	52.7	53.3	55.1
Mean	56.6	56.5	52.0	55.4	-

$LSD_{(0.05)}$ for previous crop - NS
$LSD_{(0.05)}$ for N rates - 1.39
$LSD_{(0.05)}$ for interaction - 1.96

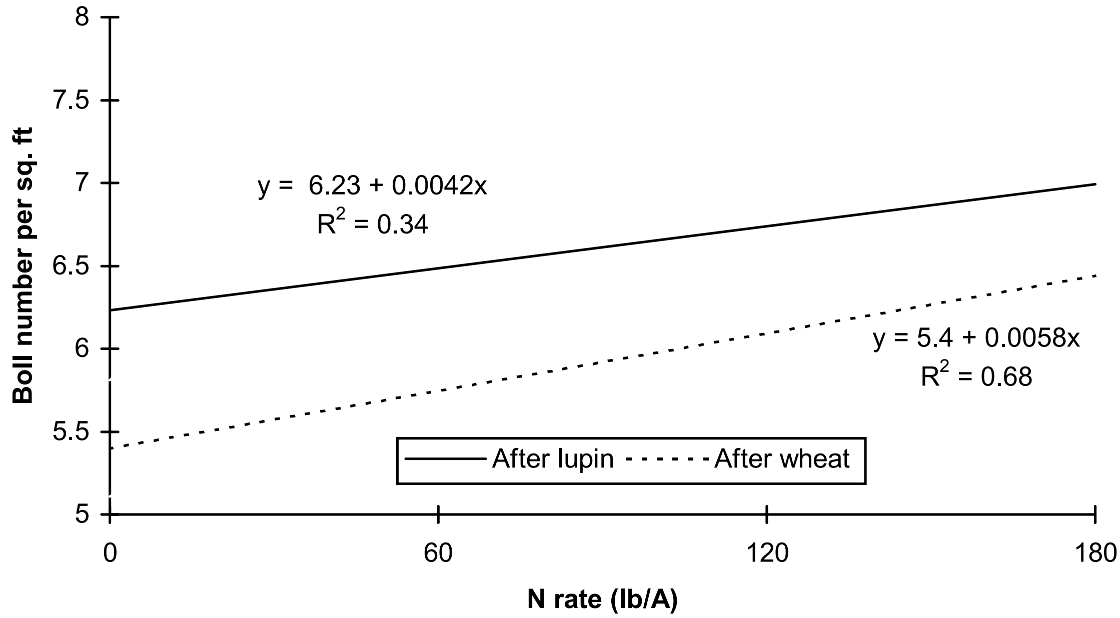


Fig. 2. Functions of nitrogen production for boll number per square foot.

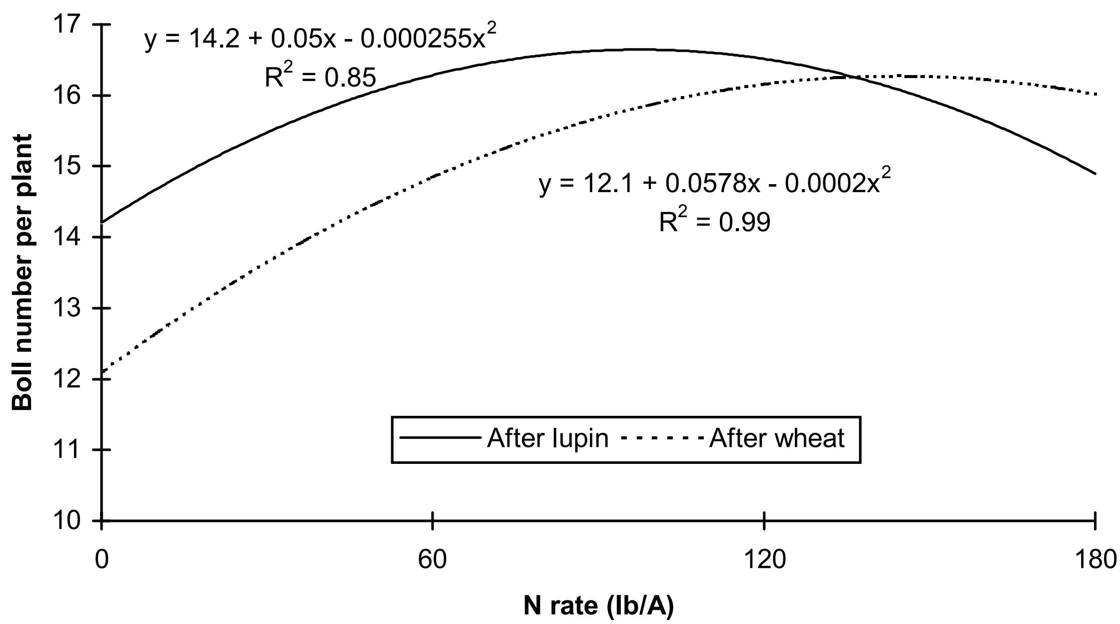


Fig. 3. Functions of nitrogen production for boll number per plant after lupine and wheat

Table 2. Influence of previous crop and nitrogen rates on lint weight per boll

Previous crop	N rates (lb/A)				Mean
	0	60	120	180	
	------------------ gram / boll ------------------				
Lupine	2.038	2.035	2.036	2.074	2.046
Wheat	2.071	2.106	2.197	2.110	2.121
Mean	2.054	2.071	2.117	2.092	-

$LSD_{(0.05)}$ for previous crop - 0.045
$LSD_{(0.05)}$ N rates - NS
$LSD_{(0.05)}$ for interaction - NS

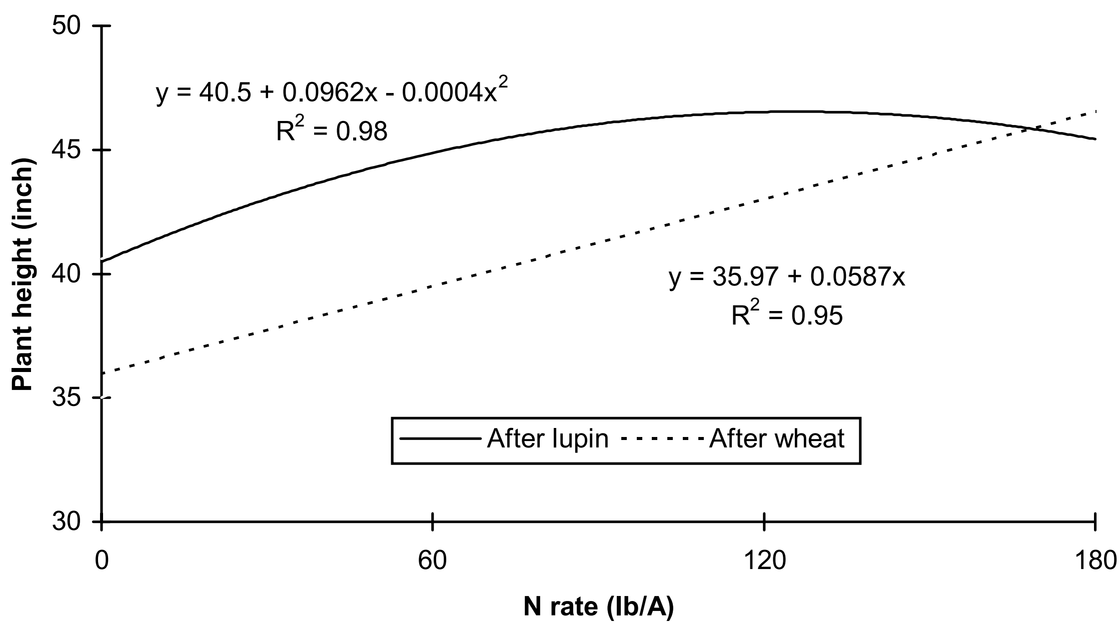


Fig. 4. Functions of nitrogen production for plant height

Nitrogen, Cover Crop, Tillage and Lime Effects On Soil Acidity In Cotton Production Systems

D.D. Tyler, E.L. Ritchey, M.E. Essington, M.D. Mullen, and A.M. Saxton[1]

AUTHORS: [1] E.L. Ritchey, Graduate Research Assistant, Agronomy Department; M.E. Essington, Professor; M.D. Mullen, Professor, Dept. Plant & Soil Science; A.M. Saxton, Professor, Statistical and Computing Services; D.D. Tyler, West Tennessee Experiment Station, 605 Airways Blvd., Jackson, TN 38301, dtyler@utk.edu

RESEARCH APPLICATION SUMMARY

Research Question

In no-tillage systems fertilizer and lime are surface applied and not incorporated into the soil. Questions remain as to whether this practice effectively neutralizes soil acidity. We examined this in a long term experiment involving tilled and no-tilled cotton grown with four nitrogen rates and a legume and no cover crop. These variables had produced a wide range of initial soil acidity levels based on pH, exchangeable Mn. This provided a unique opportunity to evaluate liming rate and application method.

Literature Summary

Most past data indicates that surface application of lime in no-tillage systems is effective in neutralizing acidity. When the University of Tennessee started using a buffer procedure in conjunction with water pH the amount of lime being recommended at a certain pH level dropped as compared to previous recommendations. This resulted in questions concerning lime rate. It was also observed that pH changes were not occurring as rapidly as expected. Since the reduction in exchangeable Al and Mn are the main goals of liming, the effect of application method, surface or incorporation, and lime rate needed further study. Past research had also shown that acidity can become stratified near the soil surface in notillage. This has led to speculation that less lime might be needed if a thinner zone of soil required lime as compared to recommendations based on liming the top six inches. Therefore, we compared our full rate of lime based on past correlations for liming the top six inches to a one half recommended rate.

Study Description

A study comparing nitrogen rate, cover crops and tillage for cotton was begun in 1981 at the West TN Agricultural Experiment Station in Jackson, TN.

Soil: Lexington silt loam

Experimental design: Randomized complete block with a split-split-split arrangement of treatments. Four replicates

Main plot: Nitrogen rates of 0, 30, 60, or 90 lb. N/acre as ammonium nitrate.
Split plot: Winter annual cover crops of hairy vetch, crimson clover, wheat, and no cover
Split-split plot: Tillage or no-tillage.
Split-split-split plot: full or one half recommended lime rate

Treatments were applied to the same plots each year. Tillage consisted of chisel plowing, disking, and leveling. No-tillage plots were planted after desiccation of cover with either paraquat or glyphosate. Both systems were planted with a smooth narrow coulter planter. Soil samples were analyzed for pH, exchangeable Al, and Mn. Lime was applied in 1995 as normally ground pelletized agricultural limestone that met state lime standards.

Applied Question

Does surface lime application adequately neutralize acidity over a wide range of pH values and are present techniques for lime recommendations reasonable and accurate.

Data from this test indicate that as long as total nitrogen in a system is adjusted for maximum crop yields, the present lime recommendations are adequate. Data does indicate that lime effect will take more than one year in both tillage and no-tillage systems. These data also indicate that levels of exchangeable Al and Mn decrease even before an affect on pH level is observed. A nitrogen adjustment for nitrogen released from a nitrogen fixing legume cover crop should be made or a much greater level of soil acidity will occur, especially in no-tillage systems. In this experiment this reduction could be about 90 lb. N/acre meaning no nitrogen fertilizer was needed for maximum cotton yields. With the advent of variable rate lime application more refinement in rates of lime for effective acidity management to achieve maximum profit will be needed.

ABSTRACT

Continuous long-term management practices are known to impact many soil properties. This study was conducted to document the influence of different continuous long-term (14 years) cotton (*Gossypium hirsutum L.*) management systems on selected soil properties of a loess-derived soil. The experiment was established in 1981 on a well-drained Lexington silt loam (fine-silty, mixed, thermic, Ultic Hapludalf) soil. The effects of four N-rates (0, 30, 60, and 90 lbs. ac^{-1}), two tillage practices (no-tillage (NT), and four cover crops (no cover, wheat, vetch, and clover) were quantified for selected soil properties. Soil samples were taken in the spring of 1995, prior to annual fertilization and analyzed for pH, exchangeable Al, and exchangeable Mn. Nitrogen rate and cover crop significantly influenced exchangeable Mn, and soil pH. As N-rate increased, soil pH values decreased, while exchangeable Mn values increased. Tillage practice significantly influenced exchangeable Al, and pH, with the NT treatments having higher concentrations of exchangeable Al, and lower soil pH values. Excessive amounts of acidity are

avoided when proper N-fertilizer practices are used, including credit for additional N from a legume cover. A study was initiated in the spring of 1995 to document the influence of two lime rates (recommended rate and ½ the recommended rate) on soil chemical properties, and evaluate the effectiveness of surface applied limestone. Pelletized limestone that met minimum State standards was applied in the spring of 1995 at the recommended rate and ½ the recommended rate. All treatments, with the exception of NT vetch plots that received 60 lb. N/acre, had pH values ≥6.1 by the spring of 1997, with either rate of limestone. Both rates of limestone significantly decreased the amount of exchangeable Al and Mn, regardless of tillage practice or choice of cover crop, usually within one year of application. Research is continuing to evaluate the duration of lime effectiveness and cotton yields.

INTRODUCTION

No-till (NT) and other types of conservation practices have gained popularity in recent years in order to comply with soil erosion guidelines, reduce fuel and labor cost associated with seedbed preparation, and to allow for row-crop production on steeply sloping farmland, while still maintaining profitable yields (Dick, 1983). In long-term NT cropping systems, the buildup of plant residues and surface fertilizer placement, especially nitrogen, can influence several soil properties, including soil pH, organic carbon (OC), base saturation, and the amount of exchangeable Al and Mn (Blevins et al., 1978; Blevins et al., 1983; Evangelou and Blevins, 1985; Kamprath, 1970 Ismail et al., 1994; Grove and Blevins, 1988; Dick, 1983).

Nitrogen is the most important fertilizer input in agriculture and is required in one of the largest quantities. Surface application of ammoniacal N fertilizer in NT systems can cause the top few centimeters of the soil surface to become highly acidic due to nitrification (Ismail et al., 1994; Blevins et al., 1978; Blevins et al., 1983). As the pH of the soil decreases, the total acidity and the concentration of exchangeable Al and Mn increase.

Exchangeable Al and Mn in a soil are influenced by several factors. As the soils weather, soluble silicate, basic cations, and acidic cations are released from soil parent material. Basic cations are more readily leached from the soil profile than acidic cations, thus resulting in more acidic cations on the exchange complex, and an acid soil. As the soil becomes more acidic in nature, both Al and Mn become more available for plant uptake with a concomitant decrease in the availability of Ca, Mg, and other essential nutrients (Howard, 1970; Foy, 1984; Adams, 1984). Yield reductions can occur if these elements reach elevated levels. Unless soil pH < 4.0-4.25, H^+ toxicity is usually not found, due to the amount of H^+ involved being very small when compared to exchangeable Al (Howard and Adams, 1965; Foy, 1984). Aluminum and Mn phytotoxicity can occur when sufficient levels of the exchange complex are occupied by Al and Mn, depending on soil organic carbon (SOC) content, soil pH, crop cultivar, soil type, and other crop stresses that might be incurred (Kamprath, 1970; Adams, 1981; Adams, 1984; Adams and Morre, 1983; Blevins et al., 1978). There are difficulties in determining exchange complex saturation by Al and Mn that will be toxic in different situations. Adams and Moore (1983) found phytotoxicity could occur in cotton when 2.2 – 77% of the exchange complex is occupied by Al. They also found in the same experiment phytotoxic symptoms to be absent when up to 60% of the exchange complex is occupied by Al.

Different crops and even different varieties of the same crop exhibit symptoms of phototoxicity at different levels of exchangeable Al and Mn (Foy et al., 1995). However it is generally agreed the problems from Mn and Al can occur with pH<5.55 (Adams, 1984; Foy, 1984; Fox, 1979, Ritchie, 1989). Nutrient solutions containing 5-10 ppm Mn appear to be toxic to cotton (Kennedy and Jones, 1991; Adams and Wear, 1957), and Adams (1984) reported that concentrations of easily reducible Mn around 50-100 ppm appear to be toxic.

Cotton (*Gossypium hirsutum L.*) is a crop that does not produce large amounts of biomass; therefore winter cover crops need to be grown for adequate residue management to reduce the potential of erosion (Reeves et al., 1995; Bauer and Bradow, 1993). Cover crops add organic carbon to the soil, "scavenge" fertilizer that would have otherwise been lost to leaching, provide a good mulch to compete against weeds dramatically reduce soil erosion, and help maintain soil productivity (Reeves et al., 1995; Bauer and Bradow, 1993). Three groups of cover crops are generally used in a conservation-tillage system; winter annual weeds, grass and small grains, and legumes. Wheat (*Triticum* spp.), rye (*Secale cerale* L.), clover (*Trifolium incarnatum* L.), and vetch (*Vicia villosa* L.) are commonly used as winter cover crops following cotton (Reeves et al., 1995; Bauer and Bradow, 1993; Keisling et al., 1995). In addition to the other benefits mentioned about cover crops, legume cover crops also fix N, which is released in the form of ammonium (NH_4^+). This N is then nitrified to nitrate (NO_3^-), which produces acidity reducing the pH of the soil. A legume cover crop can add from very little to about 60 to 90 lb. N/acre each year. The University of Tennessee recommends 60 to 80 lb. N/acre for cotton grown on upland soils and the additional N from legumes should be taken into consideration when applying N following a legume cover. The legume cover crop coupled with high nitrogen rates tends to accelerate the decrease in soil pH. When the soil pH reaches a critical level, limestone applications are recommended. Historically, Tennessee recommended the addition of 3 tons/acre limestone to increase soil pH one unit. In 1985 Tennessee started using the Adams and Evans buffer test in conjunction with the 1:1 water pH to determine the lime requirement (LR) of the soil (Adams and Evans, 1962). This method was still based on a sampling depth of 6 inches. The Adams and Evans buffer test generates lower lime recommendations in many instances as compared to the old method of applying 3 tons/acre to obtain a one unit change in pH.

As noted previously, the most important function of liming is to reduce the amount of exchangeable Al and Mn present in the soil profile (Kamprath, 1970; Blevins et al., 1983; Coleman et al., 1958). Soil pH, which is an indicator of total acidity and exchangeable Al and Mn, must be above a certain critical value for proper nutrient availability and optimal plant growth (which differs with different soils and crops grown). Therefore, the presence of acidic (and phytotoxic) cations on the soil's exchange complex and the absence of basic cations is the cause of most decreased plant growth, not the pH of the soil (Blevins et al., 1983).

The objectives of this study were (i) to document the influence of different continuous long-term (14 years) cotton (*Gossypium hirsutum L.*) management systems on selected soil properties of a loess-derived soil, using two tillage systems, four N rates (0, 30, 60, and 90 lb./acre), and two winter cover crops (no cover and vetch) (ii) document the changes in selected soil properties after limestone application, (iii) evaluate the effectiveness of surface applied lime for increasing soil pH, relative to soil incorporation using the Adams and Evans buffer test, and

(iv) evaluate the effectiveness of the ½ recommended rate of lime as compared to the full recommended rate of lime in raising soil pH.

MATERIALS AND METHODS

The experiment was conducted at the West Tennessee Experiment Station (WTES) located at Jackson, Tennessee, on a Lexington silt loam (fine-silty, mixed, thermic, Ultic Hapludalf) on long-term (14 yr.) NT and DT plots. The Lexington soil is a well-drained upland soil (0-2% slope) formed on an old river terrace with loess being deposited over sand.

The experimental plots were established in 1981 and replicated 4 times in a split-split randomized complete block (RCB) design. The experiment consisted of 4 blocks. Each block was split horizontally 4 times and randomly assigned 4 N rates (0, 30, 60, and 90 lb. N/acre). These blocks were further split into vertical blocks that consisted of randomly assigned cover crops (no cover, wheat, clover, and vetch). These blocks were again split into vertical blocks that were randomly assigned one of two tillage treatments (T and NT). Plots were 26.2 feet wide by 40 feet long. After all the splits were completed the experiment contained 128 plots. In this paper the no cover and vetch cover was chosen to demonstrate the two extremes for various soil properties in the experiment.

Soil samples were taken at random locations in each plot, in the spring of 1995 prior to planting, using a 1 inch diameter soil probe at 0-3, 3-6 and 0-6 inch depths. For the 0-3 and the 3-6 inch depths, a subsample was taken to 6 inches and divided into the two depths. For each plot, approximately 10 subsamples were taken to 6 inches for the 0-3 and 3-6 inch depths and 5 subsamples were taken for the 6 inch depths. The subsamples at each depth were combined for analyses.

Cotton (Stoneville 132) was planted May 15, 1995, following an April 28 burndown application of glyphosate at a rate of 1 quart/acre in all plots. Cotton was planted at a density of approximately 9,000 plants/acre using a John Deere NT planter. Aldicarb at 0.5 lb./acre active ingredients (ai) and quintozene (PCNB) 10G at 1.12 was applied in-furrow at planting. On May 16 fluometuron 4L at 1.5 lb./acre ai, pendimethalin at 1 lb./acre ai, norflurazon at 1 lb./acre ai, and paraquat at 0.6 lb./acre ai, with ½% surfactant were applied. The plots received 90lb/acre of P_2O_5 and K_2O on May 9, based on medium/low soil test results. On May 10 and 11, plots were subjected to an additional split and lime was applied at the full recommended rate and half the recommended rate according to the 1:1 water pH and the Adams and Evans buffer test (Adams and Evans, 1962). The ground agricultural limestone was pelletized and had a calcium carbonate equivalency of 80% and a relative neutralizing value of 80%. Nitrogen, in the form of ammonium nitrate (34% N), was hand broadcast at planting. Tillage on the T plots was accomplished by disking twice and leveling prior to planting. Weed control was accomplished by the above indicated herbicides and hand-hoeing when necessary. Cotton yields were taken from the inside two rows of each plot and ginned using a 1/5 scale gin. After the cotton was harvested the stalks were shredded and winter cover crops were drilled through the residue, except the no cover treatments, which remained fallow.

Soil samples were air dried and ground to pass a 2-mm sieve. All chemical analyses were reported for the 0-3 and 3-6 inch depths, with the exception of soil pH, which was also analyzed for the 0-6 inch depth. Soil pH was determined using 1:1 soil solution ratio using distilled-deionized water. Soils were extracted by using 1M KCl for exchangeable Al (Barnhisel and Bertsch, 1982). Exchangeable bases and Mn were determined using the 1M NH_4OAc (pH 7) method (Thomas, 1982). All extracts were analyzed using inductively coupled argon plasma-optical emission spectrometry (ICP-OES).

Statistics were performed using SAS version 6.12 (SAS Institute, 1989). The Mixed-model procedure was used for analysis of variance and significant differences among means were determined by LSD mean separation. Analysis by certain treatment levels was done in addition to an overall model to simplify mean separation results, and to address unequal variances, particularly across N-rates. The 0.05 probability level was used to define statistical significance. The 0-6 inch sample for pH was also included in the statistical analysis. All other analyses were performed on the 0-3 and 3-6 inch depth data.

Statistical analyses for pH were performed on (H^+), since pH is on a logarithmic scale, and then converted back and reported as pH values. For example, if concentration data are used, pH values of 4.0 and 5.0 average to pH=4.29, instead of pH 4.5 if pH data are used. Some inconsistencies in mean separation have occurred due to this transformation; however this was the most valid way of analyzing the pH variable, due to the pH variable being skewed to the lower pH value.

RESULTS AND DISCUSSION

Initial pH

The initial pH values for the 0 and 90 lb. N/acre rates for no winter cover (NC) and vetch winter cover (V) for the tilled and no-tilled systems at the two sampling depths are shown in Figures 1 and 2. Average pH values were above the 6.1 value for the 0 N rate in both systems at both depths. Values were lower at the 90 lb. N rate and were below the 6.1 pH value in both cover systems resulting in a lime recommendation. Values tended to be lower when vetch was the winter cover as compared to no cover. This difference was significantly lower for the 3 to 6 inch depth for the no-tillage system. This illustrates the additional acidifying effect of the nitrogen contributed from the vetch, a nitrogen fixing legume. If a recommended reduction in nitrogen of 60 lb. / acre is made in the system to account for nitrogen contribution from the legume the pH values are above 5.0 and similar to the 90 lb. rate in the no cover system (Figure 3.) An overall summary of the initial pH values across the four nitrogen rates, two cover systems, and two tillage systems indicated that as N rate increased , pH decreased. No-tillage systems generally had lower pH values than the corresponding tilled systems. Plots that had a nitrogen fixing legume cover crop tended to have lower pH values than those with no cover.

Lime effects on pH

The change in pH from the spring 1995 application of the full recommended lime rate for the 90 lb. N rate for NC tilled and no-tilled systems and the no-tilled system with vetch for 1996 and 1997 is shown in Figures 4, 5, and 6. In the tilled no cover treatment pH values increased in the first year after application to near the 6.1 cutoff value where no additional lime would be recommended. Values continued to increase in the second season after application (Figure 4.) In the no-tillage treatment changes from surface lime application were less one year after application than with the tilled treatment, especially at the 0 to 3 inch depth. Two years were required for the lime to adequately react to raise pH above the 6.1 value (Figure 5). In both situations the lime was effectively changing the pH at the 3 to 6 inch depth even though in no-tillage there was no incorporation of the lime. The effects of very low pH resulting from use of excessive nitrogen in a system and the effect of liming are shown in the V-NT treatment in Figure 6. Two years after lime application the pH values have not increased to the 6.1 value. This system has approximately twice the amount of nitrogen needed for maximum yields if it is assumed that the vetch contributes about 80 lb. of N to the system. This additional nitrogen is detrimental in creating excessive soil acidity. In the vetch treatments with only 0 or 30 lb. N the pH did increase above the 6.1 value by 1997 (data not shown). In both systems at least two years were required to achieve pH values consistently above 6.1. Excessive N when using a legume cover crop with a high N fertilizer application increases soil acidity and makes adequate liming much more difficult.

The comparison of the effect of the full rate of recommended lime to only one-half the rate relative to pH change between 1995 and 1997 is show in Figure 7. The half rate of lime was almost as affective in changing the pH as the full rate and the average of the two depths at the half rate were at the 6.1 cutoff value. Research is continuing to evaluate the yearly changes in pH for both rates of lime.

Exchangeable Aluminum and Manganese

The goal of lime application is to reduce the levels of exchangeable Al and Mn to below toxic levels. The levels of exchangeable Al did not increase in the initial 1995 sampling until the 90lb N rate. This corresponds to the pH value falling below about 5.3. From above 5.3 to 6.3 the values were not significantly affected by lime application in the following two years (Figure 8). This drop in Al occurred even though the pH at both sampling depths was below the 6.1 value in 1996. The initial Mn concentrations were significantly higher at the 60 and 90 lb. N rates with the increase occurring somewhere between a pH of 5.3 to 5.9. As with Al the values fell to the significantly lowest values at all N rates after the first year of liming (Figure 9). Very similar concentrations and changes in Al and Mn were observed for the tilled vetch treatment at the four N rates (Figures 10 and 11). However, with the NT vetch treatment the very acid (Figure 12.) 90 lb. N rate treatment initially had Al values about three times higher than the other two treatments. In this treatment the increase occurred somewhere below a pH of about 5.1. The levels in all treatments fell to their lowest in 1996 after liming even though there were no significant changes in pH (Figure 6.) The concentrations and change in Mn were similar to the other two treatments (Figure 13). Levels of both Al and Mn tended to increase at pH levels less than about 5.5. Lime application significantly lowered levels even with small or no changes in pH.

Changes in pH and Cotton yields

The changes in pH for the two lime rates across all treatments are continuing to be evaluated to determine the longevity of lime effectiveness. Cotton yields are also being evaluated for the two lime treatments. An economic analysis on various aspects of liming is in progress.

Summary

1. The recommended rate of lime, whether incorporated or surface applied, increased pH to greater than the 6.1 liming cutoff value in both tillage systems.
2. Neither rate of lime increased the pH value above 6.1 in NT vetch plots receiving 60 or 90 lb. N/acre.
3. The pH increased more slowly in NT than tilled plots.
4. Exchangeable Al values were the highest at the 90 lb. N/acre rate, with the vetch treatments having greater amounts of Al than no cover plots.
5. Within one year of application, the majority of exchangeable Al was displaced even though the soil pH did not always increase.
6. Exchangeable Mn was found in higher concentration than Al and was highest in treatments that received 60 lb. N/acre or greater.
7. The half rate of recommended lime was almost as effective as the full rate in changing pH.
8. Proper adjustments for fixed N from legume covers should be made to avoid excessive acidity and more frequent lime applications.

Literature Cited

Adams, F. 1981. Modifying the root environment to reduce crop stress. *In* H. M. Taylor (ed.) Alleviating chemical toxicities: Liming acid soils. ASAE 4:267-301. ASAE, St. Joseph, MI.

Adams, F. 1984. Crop response to lime in the southeastern United States. *In* F. Adams (ed.) Soil acidity and liming. Agronomy 12:211-265. ASA, Madison, WI.

Adams, F. and B. L. Moore. 1983. Chemical factors affecting roots growth in subsoil horizons of coastal plains soils. Soil Sci. Soc. Am. J. 47:99-102.

Adams, F. and C. E. Evans. 1962. A rapid method for measuring lime requirement of red-yellow podzolic soils. Soil Sci. Soc. Am. Proc. 26:355-357.

Adams, F. and J. I. Wear. 1957. Manganese toxicity and soil acidity in relation to crinkle leaf of cotton. Soil Sci. Soc. Am Proc. 21:305-308.

Barnhisel, R. and P. M. Bertsch. 1982. Aluminum. p. 275-300. *In* A. L. Page et al. (ed.) Methods of soil analysis. Part 2. 2nd ed. Agron. Monogr. 9. ASA, Madison, WI.

Bauer, P. J. and J. M. Bradow. 1993. Cover crops. p. 18-22. *In* N. G. Wyatt (ed.) Conservation-tillage systems for cotton. Spec. Rep. 160. Arkansas Agric. Exp. Stn., Fayetteville.

Blevins, R. L., L. W. Murdock, and G. W. Thomas. 1978. Effect of lime application on no-tillage and conventionally tilled corn. Agron. J. 70:322-326.

Blevins, R. L., M. S. Smith, G. W. Thomas, and W. W. Frye. 1983. Influence of conservation tillage on soil properties. J. Soil Water Cons. 38:301-305.

Coleman, N. T., E. J. Kamprath, and S. B. Weed. 1958. Liming. *In* A. G. Norman (ed.) Adv. Agron. 10:475-522. ASA, Madison, WI.

Dick, W. A. 1983. Organic carbon, nitrogen, and phosphorus concentrations and pH in soil profiles as affected by tillage intensity. Soil Sci. Soc. Am. J. 47:102-107.

Evangelou, V. P. and R. L. Blevins. 1985. Soil-solution phase interaction of basic cations in long-term tillage systems. Soil Sci. Soc. Am. J. 49:357-361.

Fox, R. H. 1979. Soil pH, aluminum saturation, and corn grain yield. Soil Sci.127:330-334.

Foy, C..D. 1984. Physiological effects of hydrogen, aluminum, and manganese toxicities in acid soil. p. 57-97. *In* F. Adams (ed.) Soil acidity and liming. 2nd ed. Agron. Monogr. 12. ASA, CSSA, SSSA, Madison, WI.

Foy, C. D., R.R. Weil, and C. A. Caradetti. 1995. Differential tolerances of cotton genotypes in nutrient solution. J. Plant Nutr. 18:685-706.

Grove, J. H. and R. L. Blevins. 1988. Correcting soil acidification in continuous corn: N-rate, tillage, and time. Comm. Soil Sci. Plant Anal. 19:1331-1342.

Howard, D. D. 1970. Adjust soil pH for profit. Publ. 599. The Univ. of Tennessee Agric. Ext. Serv., Knoxville.

Howard, D. and F. Adams. 1965. Calcium requirement for penetration of subsoils by primary cotton roots. Soil Sci. Soc. Am. Proc. 29:558-562.

Ismail, I., R. L. Blevins, and W. W. Frye. 1994. Long-term no-tillage effects on soil properties and continuous corn yields. Soil Sci. Soc. Am. J. 58:193-198.

Kamprath, E. J. 1970. Exchangeable Al as a criterion for liming leached mineral soils. Soil Sci. Soc. Am. Proc. 34:252-254.

Kennedy, C. W. and J. E. Jones. 1991. Evaluating quantitative screening methods for manganese toxicity in cotton genotypes. J. Plant Nutr. 14:1331-1339.

Keisling, T., C. S. Rothrock, and G. Palmer. 1995. Winter cover crops' influence on cotton yield. *In* W. L. Kingery and N. Buehring (ed.) Southern Cons. Tillage Conf. for Sustainable Agric., Jackson, MS.

Reeves, D. W., D. D. Tyler, and W. L. Hargrove. 1995. Winter cover crops. p. 27-30. *In* G. W. Langdale and W. C. Moldenhauer (ed.) Crop Residue Management to Reduce Erosion and Improve Soil Quality: Southeast. USDA, ARS, Cons. Res. Rep. 39. U. S. Gov. Print. Office, Washington, DC.

Ritchie, G. S. 1989. Aluminum, hydrogen, and manganese. p. 1-60. *In* A. D. Robson (ed.) Soil acidity and plant growth. Academic Press, Sidney.

SAS Institute. 1989. SAS/STAT user guide: Statistics. Version 6. SAS Inst, Cary, NC.

Thomas, G.W. 1982. Exchangeable cations. p. 159-165. *In* A. L. Page et al. (ed.) Methods of soil analysis. Part 2. 2nd ed. Agron. Monogr. 9. ASA, Madison, WI.

Figure Legends

Figure 1. Soil pH values in the Spring of 1995 for two soil depths in the 0 nitrogen (N) and 90 lb. N/acre treatments with no winter cover crop (NC) and a vetch (V) winter cover crop in the tilled (T) system. Values with different letters are significantly different at the 5% probability level.

Figure 2. Soil pH values in the Spring of 1995 for two soil depths in the 0 nitrogen (N) and 90 lb. N/acre treatments with no winter cover crop (NC) and a vetch (V) winter cover crop in the no-tilled (NT) system. Values with different letters are significantly different at the 5% probability level.

Figure 3. Soil pH values in the Spring of 1995 for two soil depths in the 90 nitrogen (N) and 30 lb. N/acre treatments with a vetch (V) and no cover (NC) for the no-tilled (NT) system. Values with different letters are significantly different at the 5% probability level.

Figure 4. Soil pH values in the Spring of 1995, 1996, and 1997 for two soil depths in the 90 lb. N/acre, no cover (NC), tilled (T) system after the full recommended lime rate was applied in the Spring of 1995. Values with different letters are significantly different at the 5% probability level.

Figure 5. Soil pH values in the Spring of 1995, 1996, and 1997 for two soil depths in the 90 lb. N/acre, no cover (NC), no-tilled (NT) system after the full recommended lime rate was applied in the Spring of 1995. Values with different letters are significantly different at the 5% probability level.

Figure 6. Soil pH values in the Spring of 1995, 1996, and 1997 for two soil depths in the 90 lb. N/acre, vetch (V), no-tilled (NT) system after the full recommended lime rate was applied in the Spring of 1995. Values with different letters are significantly different at the 5% probability level.

Figure 7. Soil pH values in the Spring of 1997 for two soil depths in the 90 lb. N/acre, no cover (NC), no-tilled (NT) system after the full and one half full recommended rates of lime were applied in the Spring of 1995. Values with different letters are significantly different at the 5% probability level.

Figure 8. Soil exchangeable aluminum (Al) concentrations for the 0 to 3 inch depth for the no cover, no tilled (NT) treatment at all four nitrogen rates in the Spring of 1995, 1996, and 1997 after application of lime at the full recommended rate in the Spring of 1995. Concentrations with different letters are significantly different at the 5% probability level.

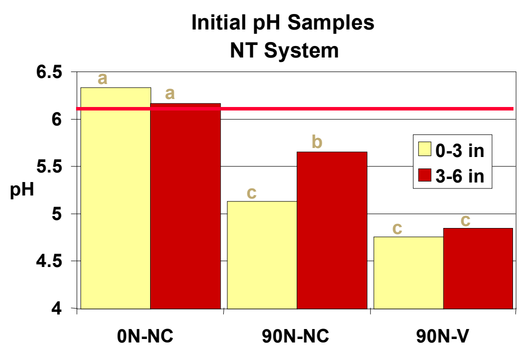
Figure 9. Soil exchangeable manganese (Mn) concentrations for the 0 to 3 inch depth for the no cover no-tilled (NT) treatment at all four nitrogen rates in the Spring of 1995, 1996, and 1997 after application of lime at the full recommended rate in the Spring of 1995. Concentrations with different letters are significantly different at the 5% probability level.

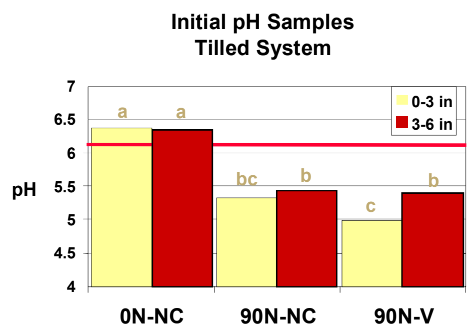
Figure 10. Soil exchangeable aluminum (Al) concentrations for the 0 to 3 inch depth for the vetch, tilled treatment at all four nitrogen rates in the Spring of 1995, 1996, and 1997 after application of lime at the full recommended rate in the Spring of 1995. Concentrations with different letters are significantly different at the 5% probability level.

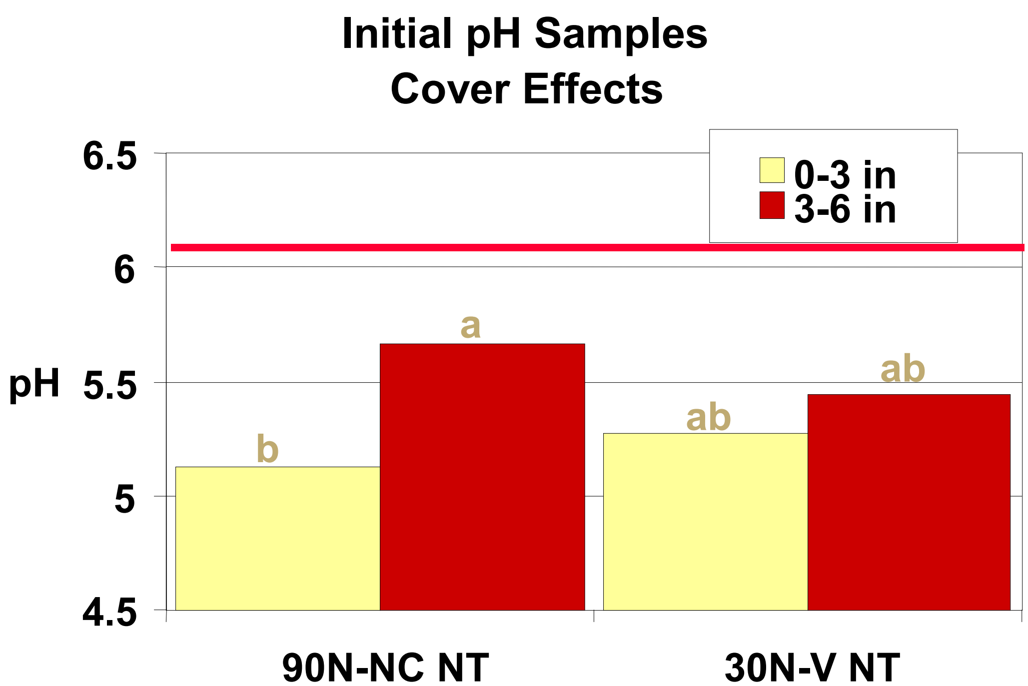
Figure 11. Soil exchangeable manganese (Mn) concentrations for the 0 to 3 inch depth for the vetch, tilled treatment at all four nitrogen rates in the Spring of 1995, 1996, and 1997 after application of lime at the full recommended rate in the Spring of 1995. Concentrations with different letters are significantly different at the 5% probability level.

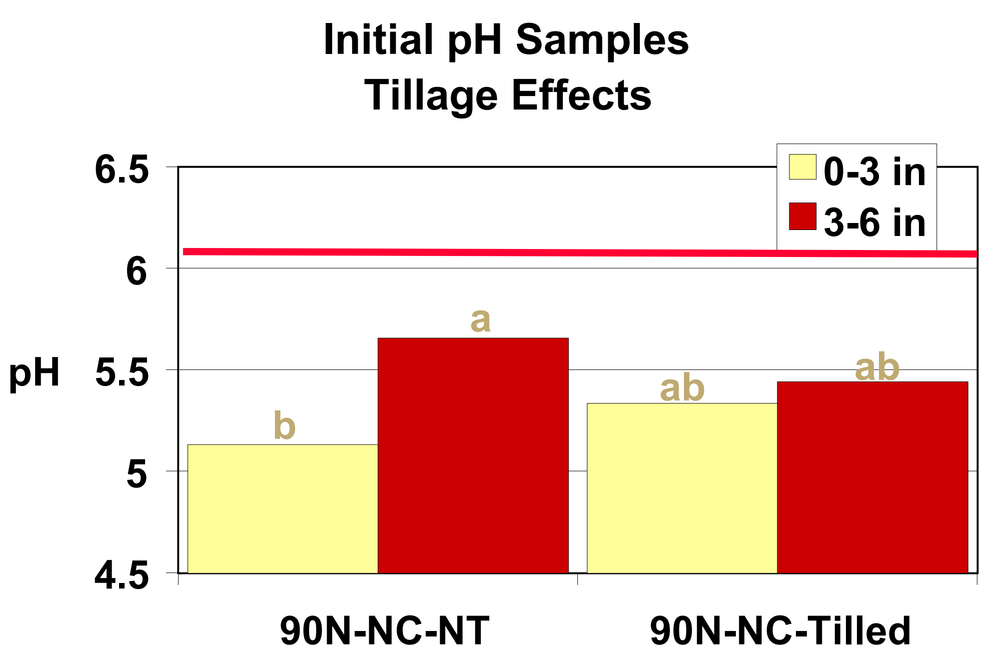
Figure 12. Soil exchangeable aluminum (Al) concentrations for the 0 to 3 inch depth for the vetch, no-tilled (NT) treatment at all four nitrogen rates in the Spring of 1995, 1996, and 1997 after application of lime at the full recommended rate in the Spring of 1995. Concentrations with different letters are significantly different at the 5% probability level.

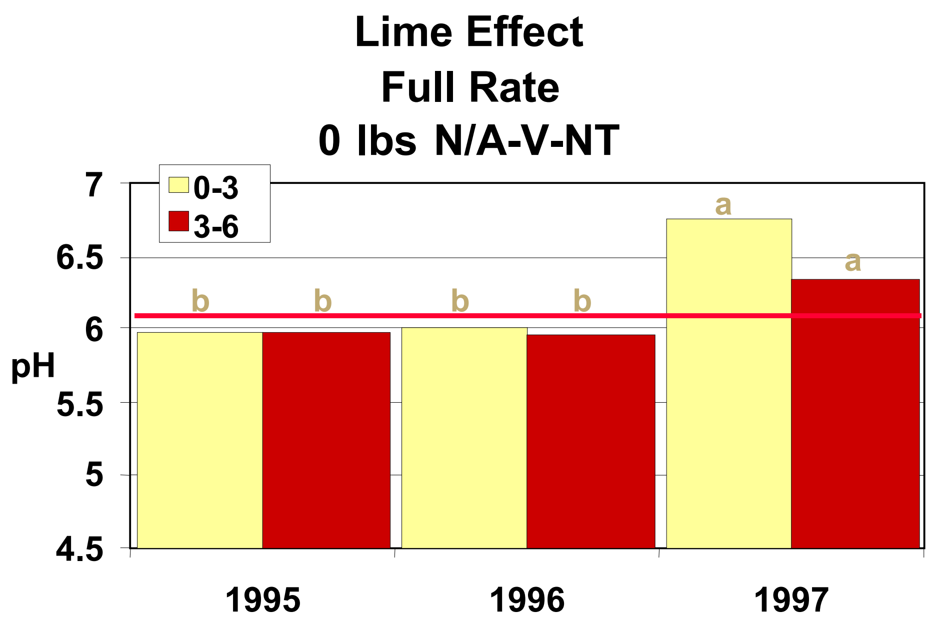
Figure 13. Soil exchangeable manganese (Mn) concentrations for the 0 to 3 inch depth for the vetch, no-tilled (NT) treatment at all four nitrogen rates in the Spring of 1995, 1996, and 1997 after application of lime at the full recommended rate in the Spring of 1995. Concentrations with different letters are significantly different at the 5% probability level.

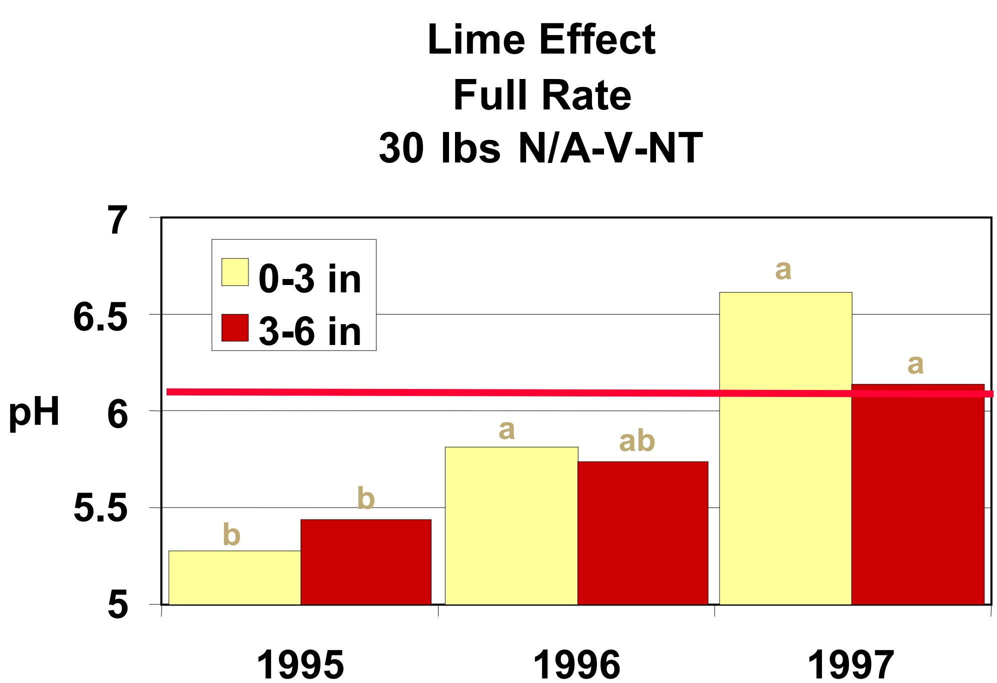




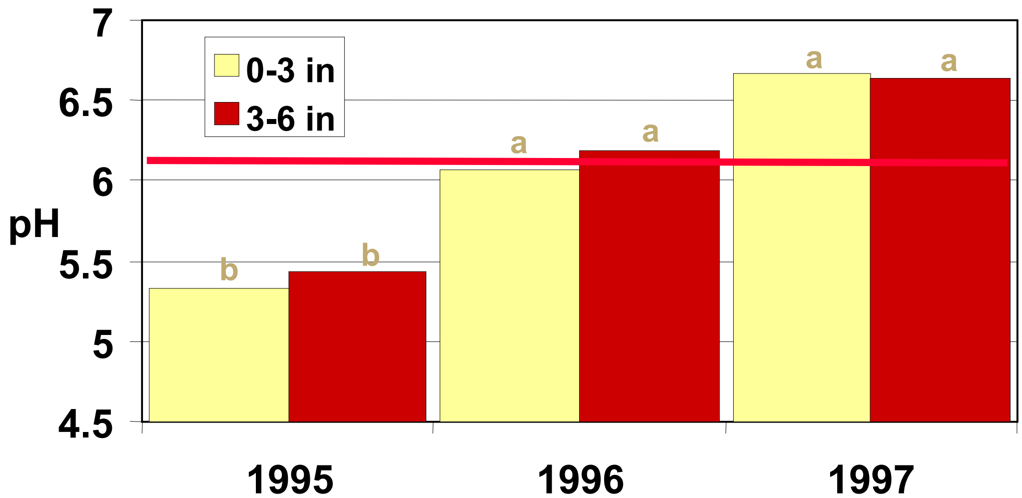

Initial pH Samples
Cover Effects
0-3 in
3-6 in
6.5
6
5.5
5
4.5
pH
a
b
ab
ab
90N-NC NT
30N-V NT


Initial pH Samples
Tillage Effects
0-3 in
3-6 in
6.5
6
5.5
5
4.5
pH
a
b
ab
ab
90N-NC-NT
90N-NC-Tilled

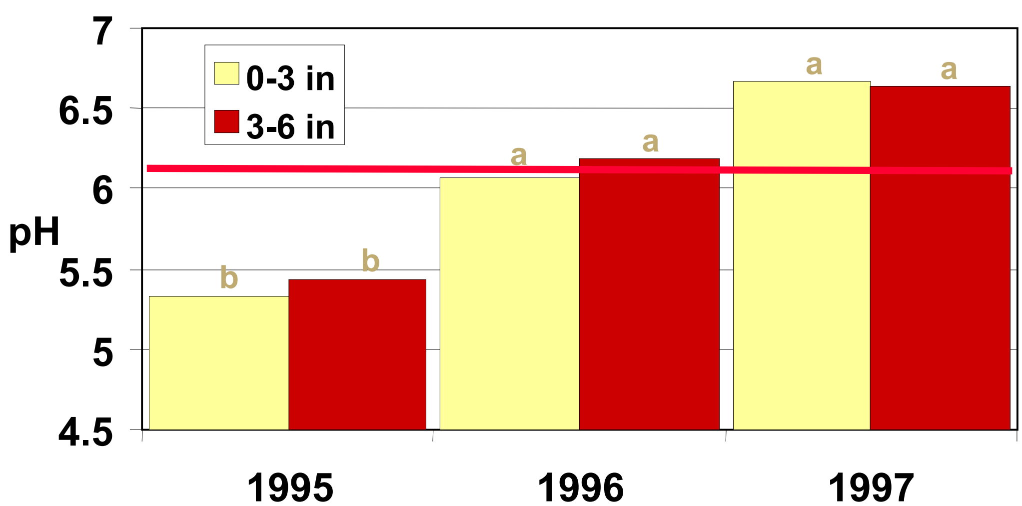

Lime Effect
Full Rate
0 lbs N/A-V-NT
0-3
3-6
pH
7
6.5
6
5.5
5
4.5
1995
1996
1997
a
a
b
b
b
b

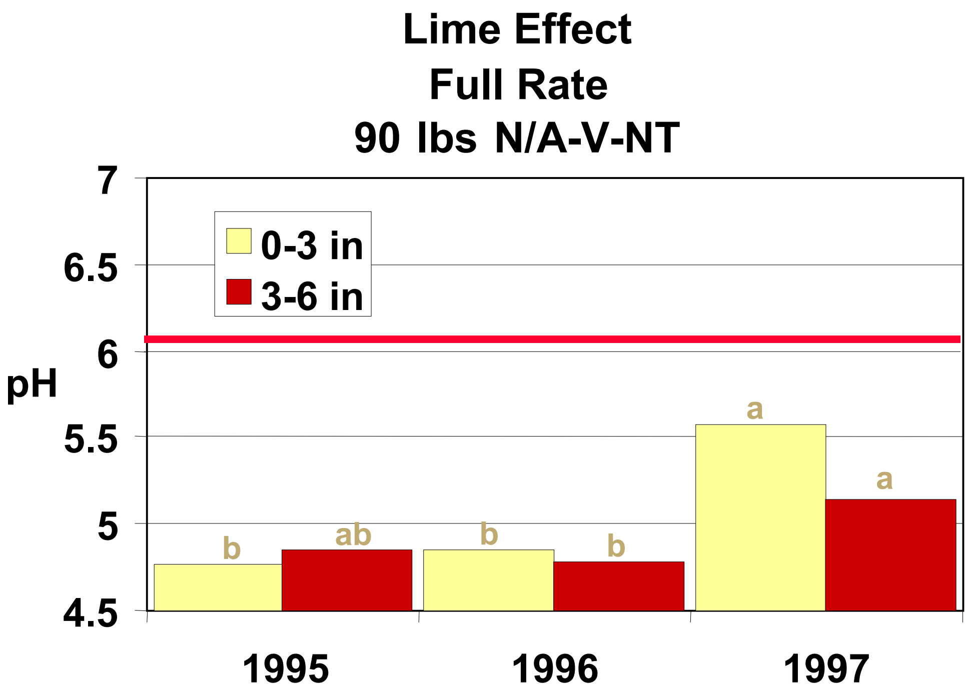

Lime Effect
Full Rate
30 lbs N/A-V-NT
0-3 in
3-6 in
pH
7
6.5
6
5.5
5
1995
1996
1997
a
a
a
ab
b
b

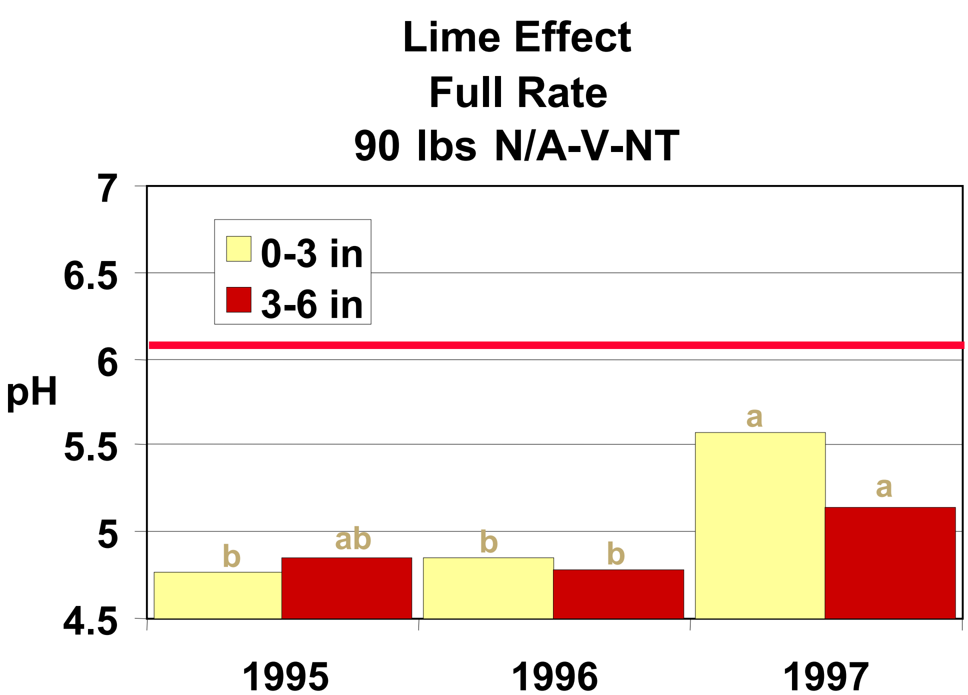
Lime Effect
Full Rate
90 lbs N/A-NC-T

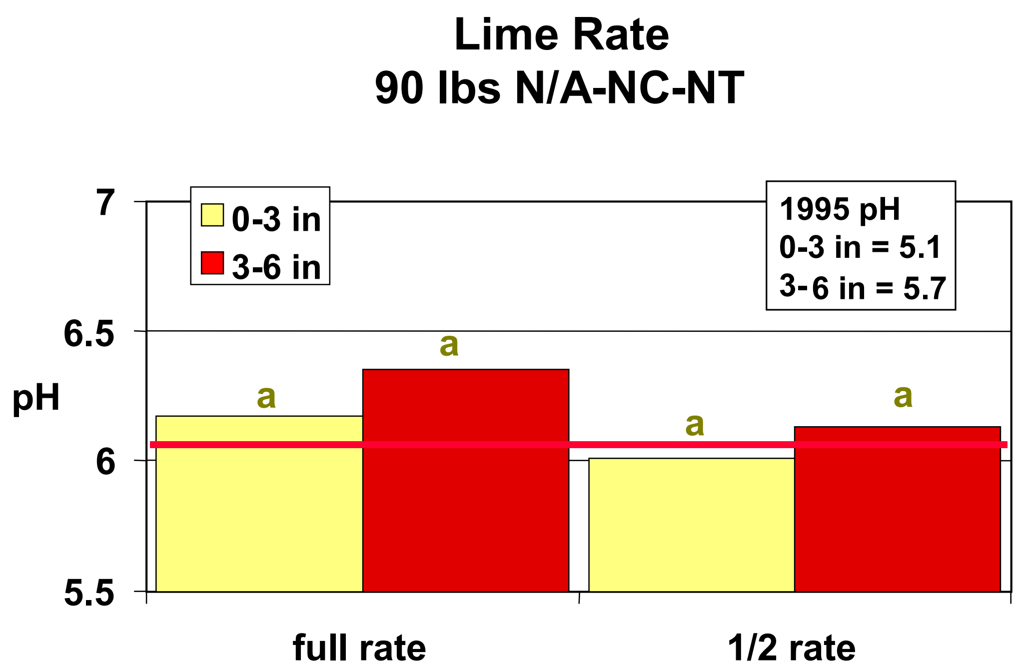


Lime Effect
Full Rate
90 lbs N/A-NC-T

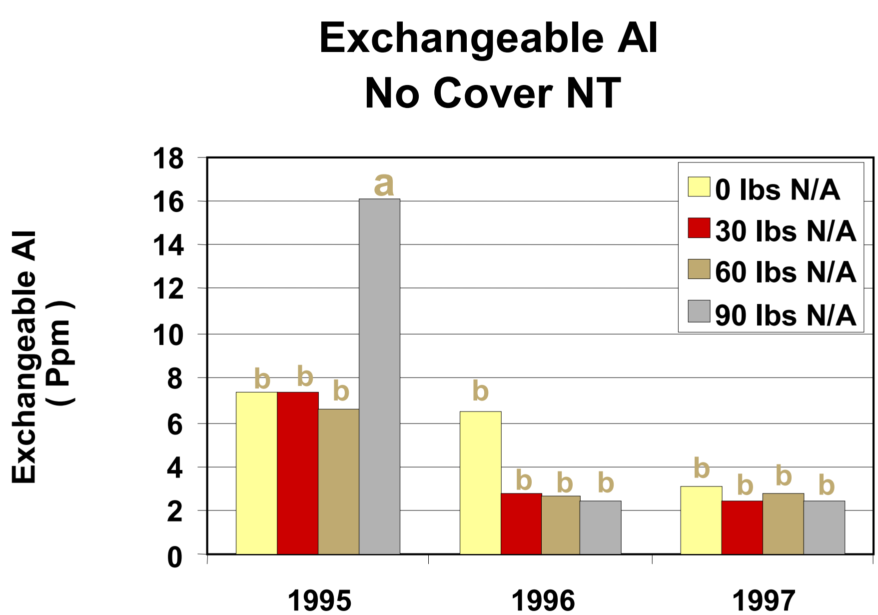



Lime Effect
Full Rate
90 lbs N/A-V-NT
pH
7
6.5
6
5.5
5
4.5
0-3 in
3-6 in
b
ab
b
b
a
a
1995
1996
1997

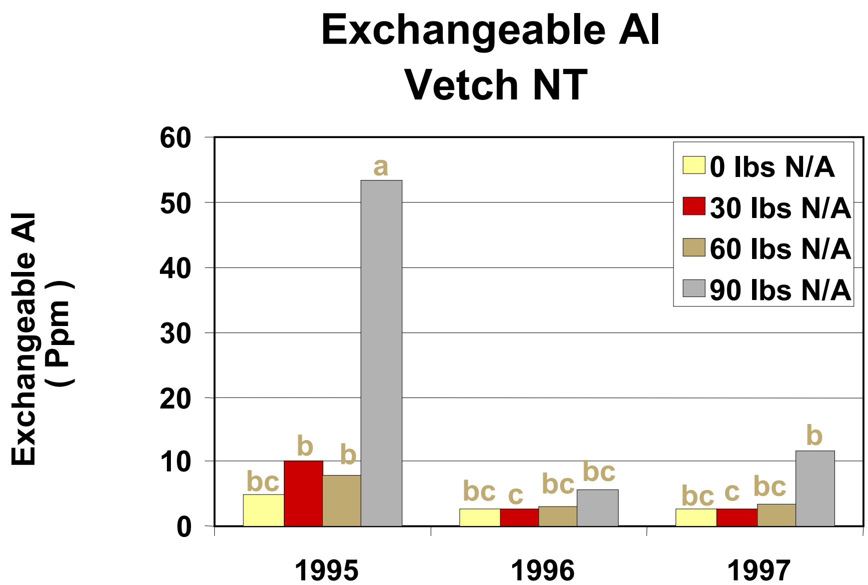

Lime Effect
Full Rate
90 lbs N/A-V-NT
pH
7
6.5
6
5.5
5
4.5
0-3 in
3-6 in
b
ab
b
b
a
a
1995
1996
1997

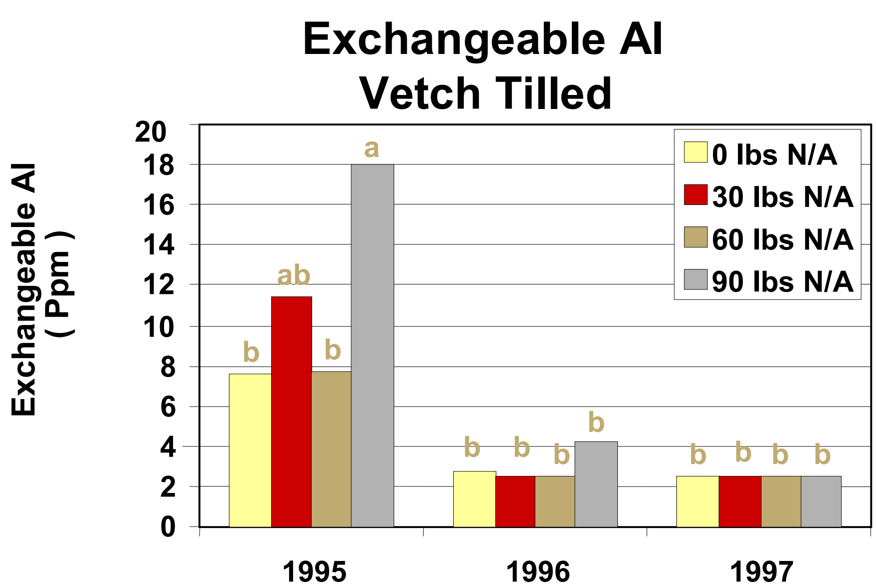


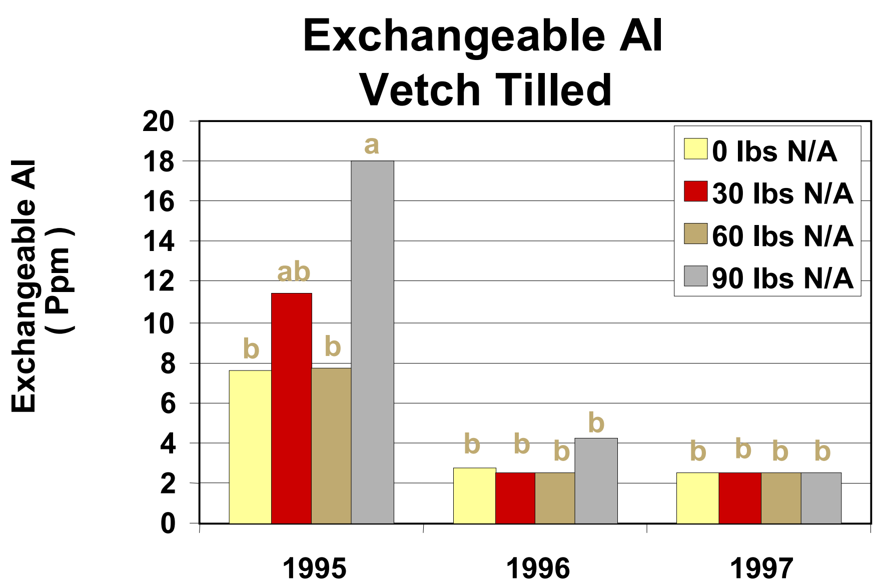
Lime Rate
90 lbs N/A-NC-NT
7
6.5
6
5.5
pH
0-3 in
3-6 in
1995 pH
0-3 in = 5.1
3-6 in = 5.7
a
a
a
a
full rate
1/2 rate

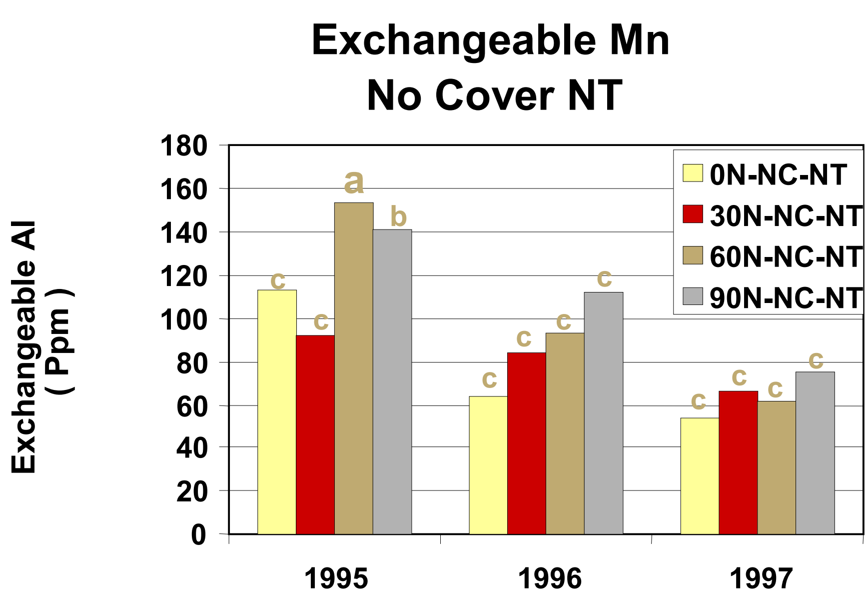


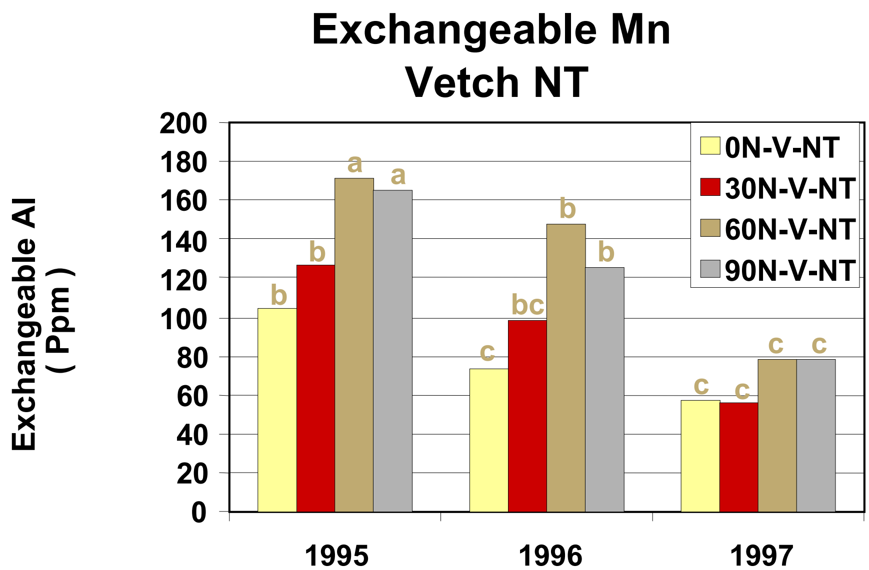
Exchangeable Al
No Cover NT
Exchangeable Al
(Ppm)
18
16
14
12
10
8
6
4
2
0
0 lbs N/A
30 lbs N/A
60 lbs N/A
90 lbs N/A
a
b
b
b
b
b
b
b
b
b
b
b
1995
1996
1997


Exchangeable Al
Vetch NT
Exchangeable Al
(Ppm)
60
50
40
30
20
10
0
a
b
b
bc
bc
c
bc
bc
bc
c
bc
b
0 lbs N/A
30 lbs N/A
60 lbs N/A
90 lbs N/A
1995
1996
1997


Exchangeable Al
Vetch Tilled
Exchangeable Al
(Ppm)
20
18
16
14
12
10
8
6
4
2
0
a
ab
b
b
b
b
b
b
b
b
b
b
0 lbs N/A
30 lbs N/A
60 lbs N/A
90 lbs N/A
1995
1996
1997


Exchangeable Al
Vetch Tilled
Exchangeable Al
(Ppm)
20
18
16
14
12
10
8
6
4
2
0
a
ab
b
b
b
b
b
b
b
b
b
b
1995
1996
1997
0 lbs N/A
30 lbs N/A
60 lbs N/A
90 lbs N/A


Exchangeable Mn
No Cover NT
Exchangeable Al
(Ppm)
180
160
140
120
100
80
60
40
20
0
a
b
c
c
c
c
c
c
c
c
c
c
1995
1996
1997
0N-NC-NT
30N-NC-NT
60N-NC-NT
90N-NC-NT


Exchangeable Mn
Vetch NT
Exchangeable Al
(Ppm)
200
180
160
140
120
100
80
60
40
20
0
1995
1996
1997
0N-V-NT
30N-V-NT
60N-V-NT
90N-V-NT
a
a
b
b
b
b
bc
c
b
c
c
c
c

POULTRY LITTER PHOSPHORUS UPTAKE BY EIGHT GRASSES

Tharel, Lance M., Conservation Agronomist, Assistant Manager, Plant Materials Center, 6883 So. St. Hwy 23, Booneville, AR 72927, Email: lance.tharel@ar.usda.gov, Phone: (501) 675-5182, Fax: (501) 675-5466, Organization: NRCS-Plant Materials Center,

SUMMARY

Poultry litter (0-, 4-, and 8-tons/acre) was applied to eight grass species. Harvested material was analyzed for phosphorus content and phosphorus uptake was (per grass species) was determined. Results may be used for selecting grass species for buffer and filter strips.

EVALUATION OF POULTRY LITTER AS A NITROGEN SOURCE FOR COTTON

Saunders, James R., Senior Research Assistant, 42 MAFES Circle, Hwy. 7 North, Mississippi State University, Holly Springs, MS 38635, Email: jrsaunders@ra.msstate.edu, Phone: (662) 252-4321, Fax: (662) 252-5680, Organization: Mississippi State University,

SUMMARY

Expansion of broiler production in South Central Mississippi has leveled off in the past years. This is partially due to state mandates for nutrient management planning, where application rates of litter are restricted to the level of crop or forage removal. New land areas and data for crop response to litter applications are needed in order for the broiler industry to continue expanding in Mississippi. The objective of our study was to evaluate chicken litter as a nitrogen source on cotton.

The study was conducted on the North Mississippi Branch Experiment Station at Holly Springs, Mississippi. Topography of the land is an upland with 3 to 5 percent slope. Soils are a Grenada silt loam (fine silty, mixed thermic Glossic fragidualf). Plot area was fertilized according to soil test recommendations with P and K in late March. Fragipan depths ranged from 12 to 14 inches within the study area. The experimental design was a split plot in a randomized complete block with three replications. Main plots consisted of two tillage types (conventional-till and no-till), with subplots having five nitrogen rates. Row widths were 38 inches and plot lengths were 50 feet. Plots consisted of four rows. Plots were planted the first week of May in a Roundup Ready variety of cotton with a four-row planter equipped for no-till planting. No-till plots were sprayed with a burndown in early April. Tillage for conventional-till plots was made the same day as the burndown application. Roundup (glyphosphate) was sprayed postemergence for weed control three weeks after planting. A second application of Roundup sprayed post direct at the base of the plant was made in the last week of June. Five application rates were studied consisting of chicken litter at two tons per acre and ammonia nitrate at 0, 30, 60, and 90 pounds per acre applied the first week of June. The litter and the inorganic nitrogen were left undisturbed on the soil surface of the no-till plots. In the conventional-till plots a cultivation was made after litter and nitrogen application.

Petiole sap analysis was significantly higher in the chicken litter plots than the 0 and 30 pound level in the inorganic nitrogen plots the first week of bloom. Petiole sap analysis was made using a hand held Minolta No3-N meter. In the fourth week of bloom the petiole sap analysis for the litter treatment was higher than the 0 and 90 pound level in the inorganic nitrogen plots.

Leaf fluorescence at the first and fourth week of bloom was higher for the litter than the 0 level on inorganic nitrogen. Yields were higher for the litter treatment than the 0 and 30 pound level of inorganic nitrogen.

ORGANIC VERSUS INORGANIC SOURCE AND RATES OF N FERTILIZER FOR FALL-GROWN BUSHBEAN

Marshall, A. J., Graduate Assistant, Agronomy Department, University of Florida, PO Box 110730, Gainsville, FL 32611, Email: ice9_a@yahoo.com, Phone: (352) 392-2325, Fax: (352) 392-9082, Organization: Agronomy Department, University of Florida,

ABSTRACT

A study was conducted on bush bean (*Phaseolus vulgaris*) to compare the effects of N fertilization rates (0, 45, 90, 135, and 180 pounds N acre-1) and fertilizer sources (hairy vetch, *Vicia villosa*, versus ammonium nitrate) on plant nutrition and possible nutrient deficiencies. Fresh pod yield was determined at two harvest dates. The most recent, fully developed leaves were sampled and nutrient concentrations for N, P, and K measured. Analysis of variance was performed to identify differences between N application rates and N source material. Fresh pod yields were equal for the two N sources and average total yield of 6050 pounds acre-1 was achieved at 135 pounds N acre-1. Differences in diagnostic leaf dry matter were observed due to N source and rate. Data show that not only was the vetch a good organic source of N but that it also provided additional K compared to ammonium nitrate.

INTRODUCTION

Use of diagnostic leaf tissue analyses for crop management is fundamental to modern agriculture. Correcting deficiencies of specific elements may result in strong positive yield response as other non-limiting resources are subsequently used more efficiently. Individual crops have specific levels of nutrients that are present when normal health and expected rates of growth occur. These ranges form the basis for published guidelines for recommended nutrient levels in plant tissues at specific ages such as those presented by Mills and Jones (1996). It is important to understand the process by which nutritional status is determined and integrated into nutrient recommendations.

Leguminous plants are known to accumulate higher N concentrations within their tissues through biological fixation of N than other species on similar soils. Green manure cover crops and mulches from leguminous hay provide an avenue for supplying some of the N requirements of associated crops as decomposition and N mineralization occurs (Hagendorf and Gallaher, 1992). While bush bean (*Phaseolus vulgaris*) is known to fix N, particularly when appropriate rhizobia are present in the soil, this crop's short duration results in yield responses to N fertilization greater than what occurs with fixation alone (Thies et al., 1995; Blaylock, 1995). The fresh pod yield of bush bean has been shown to increase with the application of clover straw (*Trifolium incarnatum*) applied at 3960 pounds acre-1 (Wade et al., 1997).

Hairy vetch (*Vicia villosa L.*) has been demonstrated to be an acceptable replacement to ammonia fertilization when used as a green manure before wheat (*Triticum aestivum L.*) (Badaruddin and Meyer, 1990). Similar results in maize (*Zea mays*) crops show that Vicia mulch treatments resulted in increased maize growth, N assimilation and grain yields over those in non-mulched treatments (Corak et al., 1991). The use of vetch has also been demonstrated to suppress weed growth when grown as a cover crop (Brandsaeter and Netland, 1999). The use of hairy vetch as mulch has been compared with black plastic mulches in tomato (*Lycopersicon esculentum Mill.*) crops. Hairy vetch mulches promoted greater leaf area and increased leaf area duration in tomato crops than did black plastic. Total yields of tomatoes were increased with vetch mulch; however, yields were later than with plastic and occurred over a longer season (Teasdale and Abdul-Baki, 1997). Additional study is merited to examine the possible benefits of mulching bush bean with vetch mulch and to explore the impact of decomposition and mineralization on the recommended N fertilization rates.

The principal objective of this study was to compare bush bean responses to an organic source versus an inorganic source of N and to rates of N. A further objective was to relate plant nutrient concentrations in leaf tissue to differences in the management and yield.

MATERIALS AND METHODS

This study was conducted at the Statistical Design Field Teaching Laboratory of the University of Florida. A split plot design with N source, hairy vetch (2.67% N) versus ammonium nitrate (34% N) as the main effects in a randomized complete block design, and N application rate as the sub-effect was used. 'Roma II' bush bean was planted in four rows in plots 5 feet wide and 6.5 feet long. A 2-foot wide alley separated each plot. Split plots were blocked three times (3 replications) across the field to account for possible effects of soil fertility and differences in water availability. Nitrogen was applied at rates of 0, 45, 90, 135, and 180 pounds N acre-1. With the use of hairy vetch, this corresponded to application values of up to 6850 pounds of air dry material acre-1. Leaf tissue was sampled in the early morning at the early bloom stage of growth (Mills and Jones, 1996). Within each replication, 10 trifoliate leaf blades from the youngest fully mature leaves were randomly sampled from the inner two rows of all 10 treatments (two sources X five levels). Determination of leaf maturity was made on positional and morphological characteristics. Leaves were stored in paper bags and transported to the plant nutrition lab of the University of Florida. Weight per 10 leaves was measured using a mass balance.

Fresh leaf material was washed to remove soil and air contaminants from the leaf surfaces. Leaves were individually scrubbed in 1% liquinox, rinsed in de-ionized water, then washed in 3% HCl solution and rinsed a second time in de-ionized water (Futch and Gallaher, 1996). Leaf samples were dried in a forced air oven at 70 °C for 24 hours. Samples were weighed a second time and dry weight recorded. Samples were ground individually in a Wiley mill with a 1 mm stainless steel screen. Following grinding, samples were equilibrated for moisture concentration by redrying for a minimum of 2 hours at 70 °C in a convection oven.

Nitrogen digestion and analysis were made using a modified micro-Kjeldahl technique (Gallaher et al., 1975). After digestion of samples in H2SO4, N was measured as (NH4)2 SO4 using an autoanalyzer. Nitrogen concentration was calculated using a linear regression of response to known standards measured immediately before sample analysis. For N analysis a plant standard was used every 40 samples. A standard colorimetry test was conducted to estimate P concentration. Tissue concentrations of K were estimated from flame emission spectrophotometry. Emission of element-specific wave lengths was calibrated against known standards. Additionally, a known plant standard was analyzed every 32 samples.

Soil samples were collected from the control plot (0 N rate) for each treatment replication. Three subsamples from each main effect treatment were combined (6 total) and mixed giving a sample for that replication. Soil samples were prepared for P and K analyses using a double acid extraction solution containing 0.05 N HCl and 0.025 N H2SO4 (Mehlich, 1963). Soil samples were analyzed concurrently with plant samples for nutrient concentrations for N, P, and K using identical procedures. Additionally, soil organic matter, soil pH, and soil texture were measured. Soil organic matter was measured using a modified version of the Walkley Black method (Walkley, 1947) and a diphenylamine indicator. Soil pH and buffer pH were measured using a 1:2 soil to water ratio by volume. Adams-Evans solution was used in buffer pH measurement (Adams and Evans, 1962). Soil texture was determined by allowing soil fractions to settle out of a water column containing 5% calgon solution. A "Bouyoucos" hydrometer was used to measure density at 40 seconds for determination of silt and clay fraction and again at 2 hours for clay. Sand fraction was determined as the difference (Bouyoucos, 1936). The soils at the teaching laboratory are classified as sandy siliceous hyperthermic grossarenic paleudults and are characterized as Millhopper sand (Soil Survey Staff, 1984).

Statistical Analysis

A split plot experimental design was selected, treating the hairy vetch and ammonium nitrate sources as the main effects and N application rates of 0, 45, 90, 135, and 180 pounds acre-1 as the sub-effects. Two degrees of freedom were given to blocks, one df to main effects and four df to sub-effects. Interaction effects had four degrees of freedom. MSTAT statistical analysis software (Freed et al, 1987) was used to conduct an analysis of variance (ANOVA) for each independent variable. Model effects were blocks, N source, blocks X N source, rate, N source X rate and error. When significant effects were observed (=.05), mean separation was made using Fischer's least significant difference (LSD). The hypothesis tested for each independent variable was that there were no differences of that variable due to N source or application rates. The alternative hypothesis was that there were significant differences.

RESULTS

Effects of N source (ammonium nitrate versus hairy vetch) and N rate on plant N, P, and K uptake were determined along with treatment effects on leaf dry weights and fresh pod yields at two harvest dates and total pod yields. Finally, results of soil analyses were examined and fertilizer recommendations specific for bush bean were made for crops on the Millhopper sand in north-central Florida.

TISSUE NUTRIENT CONCENTRATIONS

Nitrogen source and N rate did not affect leaf N concentrations (Table 1). The N sufficiency range of Mills and Jones (1996) for bush bean is 3.0 to 6.0 % (Table 9). Slight deficiencies were measured with application rates less than 90 pounds N acre-1 using ammonium nitrate and with application rates less than 180 pounds N acre-1 from vetch mulch. The CV of N analysis was 6.53 %.

Table 1. Concentration of N (%) in diagnostic leaf of Roma II bush bean

N Fertilization rate	Fertilizer source		
Pounds acre^{-1}	Hairy Vetch	Ammonium nitrate	Average
0	2.78	2.87	2.82
45	2.88	2.84	2.86
90	2.87	3.03	2.95
135	2.85	3.01	2.93
180	3.07	3.09	3.08
Average	2.89	2.97	

Main effects $_{NS}$ and sub-effects $_{NS}$. (=.05).

Table 2. Concentration of P (%) in diagnostic leaf of Roma II bush bean

N Fertilization rate	Fertilizer source		
Pounds acre^{-1}	Hairy Vetch	Ammonium nitrate	Average
0	0.35	0.34	0.34
45	0.32	0.33	0.33
90	0.32	0.31	0.31
135	0.32	0.30	0.31
180	0.33	0.31	0.32
Average	0.33	0.32	

Main effects $_{NS}$ and sub-effects $_{NS}$. (=.05).

There were no differences observed in the concentration of P in diagnostic tissues due to N source or N application rates (Table 2). The P sufficiency range for bush bean diagnostic tissues is 0.25 to 0.75 % (Table 9). All treatments observed had sufficient amounts of P by these criteria. The CV of P analysis was 12.05 %.

Both main-effects and sub-effects influenced potassium nutrition. Significant interactions occurred between N source and N application rate (Table 3). Potassium concentrations were higher in diagnostic leaves from plants receiving vetch mulch with N application rates of 135 and 180 pounds acre-1. No differences between N sources were observed at lower N application rates. For plants grown with vetch mulch, greater concentration of K occurred at 90, 135 and 180 pounds N acre-1 compared with 0 pounds N acre-1. The 180 pounds N acre-1 treatment also showed higher K concentrations compared to the 45 pounds N acre-1. When the N source was ammonium nitrate, no significant differences were observed due to application rate. The sufficiency range for K in bush bean diagnostic tissues is 1.80 to 4.00 % (Mills and Jones, 1996). Potassium deficiencies were observed when no nutrients were applied (0 pounds N acre-1). Under ammonium nitrate fertilization treatments, K deficiencies were present with application rates of 0, 45, 135, and 180 pounds N acre-1. The CV of K analysis was 20.3 %.

Table 3. Concentration of K (%) in diagnostic leaf of Roma II bush bean

N Fertilization rate	Fertilizer source		
Pounds acre^{-1}	Hairy Vetch	Ammonium nitrate	Average
0	1.54	1.69	1.62
45	2.08	1.48	1.78
90	2.68	2.00	2.34
135	2.97	1.60	2.29
180	3.21	1.773	2.49
Average	2.50	1.71	

Main effects* and sub-effects. Mean separation* of interactions by LSD = .738 (=.05).

Tissue Dry Matter

Dry leaf weights following oven drying were greatly affected by N fertilization rates. Significant interaction occurred between the N rates and the fertilizer type for leaf dry weights (Table 4). When the N source was hairy vetch, the greatest leaf weight was achieved by applying 135 pounds N acre-1. No difference was observed for rates below 135 pounds N acre-1. However, treatments that were fertilized at 180 pounds N acre-1 did not have a greater leaf weight compared to those receiving 45 pounds N acre-1. Ammonium nitrate fertilizer applied at 90 pounds N acre-1 had the highest leaf dry weight and values were greater than all other ammonium nitrate treatments. When comparing the source effects at each N application rate, ammonium nitrate fertilization resulted in greater dry weights at all treatment rates except 135 pounds N acre-1 which were equal. The CV for the analysis of tissue dry weight responses was 8.71%.

Table 4. Dry weight (g) (oven dried) per trifoliate leaf of Roma II bush bean treated with five N application rates from two fertilizer sources.

N Fertilization rate	Fertilizer source		
Pounds acre^{-1}	Hairy Vetch	Ammonium nitrate	Average
0	0.51	0.59	0.55
45	0.58	0.71	0.64
90	0.54	0.85	0.70
135	0.77	0.75	0.76
180	0.65	0.76	0.71
Average	0.61	0.73	

Main effects $_{NS}$ and sub-effects. Mean separation of interactions* by LSD = 0.10 (=.01) and LSD =0.08 (=.05) (Satterwaites procedure) for main effects at each sub-effect level.

Crop Yields

At the first harvest of fresh pods, N source did not affect pod weight (Table 5). Fertilization at 135 pounds N acre-1 resulted in higher fresh pod weights than rates of 0 or 45 pounds N acre-1. Rates of 90, 135, and 180 pounds N acre-1 had similar pod yields.

Table 5. Fresh pod yield of bush bean from use of two sources of N and five rates of N for first harvest.

	Fertilizer Source		
Nitrogen Rate	Hairy Vetch	Ammonium Nitrate	
Pounds acre^{-1}	First harvest date (pounds fresh pods acre^{-1})		Average
0	1763	1721	1742c
45	2639	2432	2536bc
90	2667	3317	2992ab
135	3451	4019	3735a
180	2509	3660	3084ab
Average	2606	3030 NS	

Main effects$_{NS}$ and sub-effects *. Mean separation of sub-effects by LSD = 1079 (=.05).

At the second harvest date, fertilizer source did not impact fresh pod yields. Nitrogen fertilization rates at 135 pounds N acre-1 resulted in higher pod yields than all other rates. Rates of 90 and 180 pounds N acre-1 produced greater yields than 0 pounds N acre-1 but were similar to the yields at 45 pounds N acre-1 (Table 6).

Table 6. Fresh pod yield of bush bean from use of two sources of N and five rates of N for second harvest.

	Fertilizer Source		
Nitrogen Rate	Hairy Vetch	Ammonium Nitrate	
Pounds acre^{-1}	Second harvest date (pounds fresh pods acre^{-1})		Average
0	1403	1263	1333c
45	1528	1685	1606bc
90	1955	2092	2024b
135	3404	2808	3106a
180	1906	2177	2042b
Average	2039	2005 NS	

Main effects$_{NS}$ and sub-effects **. Mean separation of sub-effects by LSD = 537 (=.05).

Table 7. Total fresh pod yield of bush bean from use of two sources of N and five rates of N fertilization for all harvest dates.

	Fertilizer Source		
Nitrogen Rate	Hairy Vetch	Ammonium Nitrate	
Pounds acre^{-1}	Total of two harvest dates	(pounds fresh pods acre^{-1})	Average
0	3166	2984	3075c
45	4167	4117	4142bc
90	4622	5409	5016b
135	6855	6827	6841a
180	4415	5837	5126b
Average	4645	5035 NS	

Main effects$_{NS}$ and sub-effects **. Mean separation of sub-effects by LSD = 1506 (=.05).

The total fresh pod yield during the cropping period was not influenced by the N fertilization source. A higher fresh pod yield was obtained when N was applied at 135 pounds acre-1 (Table 7). Yields were not different when either 90 or 180 pounds N acre-1 were applied although they were higher than the control which received no N fertilizer.

Soil Nutrient Concentrations

Soil samples from all three blocks were combined from both treatments and tested for the same nutrients as plant tissues. Nutrient levels are presented as means for the blocks (Table 8). Soil organic matter averaged 1.32% (data not shown). Unlike plant tissue tests, soil test results are more variable and are normally translated into categories. For making recommendations for fertilization of specific crops, additional factors must be taken into consideration.

Observed soil P concentrations were 67 ppm and therefore classified as very high (Table 10). As a result, no yield response would be expected from higher levels of P and it is not recommended to apply additional P (Hochmuth and Hanlon, 1995). Potassium concentration in this soil was considered to be low (Tables 8 and 10). Fertilizer recommendations for Florida type conditions indicate that 90 pounds K2O acre-1 would be recommended per crop year with this level of soil K (Hochmuth and Hanlon, 1995).

Table 8. Concentration of macro-nutrients in soil samples from Roma II bush bean fertilization trials with soil pH and soil texture.

Nutrient	Concentration ppm	Soil texture fractionation	
N	430	Sand	94.3 %
P	66.8	Silt	3.2 %
K	32.4	Clay	2.5 %
Soil pH	7.3	Buffered pH	7.9

Table 9. Sufficiency ranges for essential elements in the tissues of bush bean (*Phaseolus vulgaris)*. Adapted

From Mills and Jones, 1996 using data from the uppermost recently fully-developed leaves.

Element	Range
Nitrogen	3.00 - 6.00 %
Phosphorus	0.25 - 0.75 %
Potassium	1.80 - 4.00 %

Table 10. Interpretation of soil nutrient concentrations adapted from Kidder, et al., 1998; Hochmuth, and Hanlon, 1995.

Element	Very low	Low	Medium	High	Very high
			Soil concentration (ppm)		
P	<10	10-15	16-30	31-60	>60
K	<10	20-35	36-60	61-125	>125

DISCUSSION AND CONCLUSIONS

Using criteria for the growth of bush bean to interpret results, it is concluded that soil K concentrations were suboptimal for bush bean . Based on our soil test 90 pounds K2O acre-1 would have been recommended by the University of Florida Cooperative Extension Service for bush bean.

The use of ammonium nitrate as the sole fertilizer source for N application resulted in the deficiency symptoms according to the criteria of Mills and Jones (1996). These symptoms are consistent with low soil test values. Use of ammonium nitrate as the N source did not improve this condition. The use of hairy vetch mulch as a N source also provided K and thereby prevented K deficiency. A clear trend of increasing tissue K concentration with increasing vetch mulch rates was observed up to 6850 pounds of material acre-1. At N application rates with hairy vetch of 135 pounds acre-1, diagnostic leaf tissue K concentrations were within sufficiency ranges.

Although leaf N concentrations appeared to increase with N rate, this trend was not significant. This is explained by a dilution effect due to larger plant sizes under higher N nutrition. The increased pod yields indicate that greater amounts of N were being remobilized from the leaf tissue in treatments with higher N application rates.

Under vetch mulching, average leaf weight reached a maximum with a N application rate of 135 pounds acre-1 compared to maximum leaf weight with ammonium nitrate at 90 pounds N acre-1. Average leaf weight mass was greater with ammonia nitrate at all treatment levels except at 135 pounds N acre-1 where it was the same as with vetch mulch. A likely explanation for this difference is the rate of mineralization of organic N from vetch. Nitrogen from ammonium nitrate is rapidly made available to bean crops, but is also more susceptible to leaching in inorganic form. In comparison, all N applied as vetch straw does not become available immediately. Further research is required to verify whether this supposition is valid.

This study further examines bean fresh pod yield, the economic aspect of the crop. Leaf tissue dry matter appeared to provide a valid predictor of bean yields under vetch mulch to the extent that a large percentage of leaf nutrients are remobilized during pod filling in many leguminous crops. The use of vetch mulch may be a viable alternative for bush bean crops in sandy soils with pH values near 7.0. Current extension recommendations of 90 pounds N acre-1 year-1 for bean crops do not appear valid when using a vetch N source. Application rates of not less than 135 pounds N acre-1 year-1 based on vetch N concentrations are required to maximize leaf dry mass and fresh pod yield under the study conditions. The use of hairy vetch mulch has a further benefit of providing adequate K nutrition to bean crops at this application rate, indicating that it is a more complete fertilizer source for this crop.

LITERATURE CITED

Adams, F., and C. Evans. 1962. A rapid method for measuring lime requirement of red-yellow podzolic soils. Soil Sci. Soc. Amer. Proc. 26:355-357.

Badaruddin, M., and D. Meyer. 1990. Green-manure legume effects on soil nitrogen, grain yield, and
nitrogen nutrition of wheat. Crop Sci. 30:819-835.

Blaylock, A., 1995. Navy bean yield and maturity response to N and zinc. J. Plant Nutr. 18: 163-178.

Bouyoucos, G., 1936. Directions for making mechanical analysis of soils by the hydrometer method. Soil Sci. 42:

Brandsaeter, L., and J. Netland. 1999. Winter annual legumes for use as cover crops in row crops in northern regions. I. Field experiments. Crop Sci. 39:1369-1379.

Corak, S., W. Frye, and M. Smith. 1991. Legume mulch and nitrogen fertilizer effects on soil water and corn production. Soil Sci. Soc. .Amer. J. 55:1395-1400.

Freed, R., S. Eisensmith, S. Goetz, D. Reicosky, V. Smail, and P. Wolberg. 1987. User's guide to MSTAT (version 4.0). Michigan State University, East Lansing.

Futch, S., and R. N. Gallaher. 1996. A comparison of citrus leaf wash methods for the removal of zinc nutritional sprays. Proc Fla. State Hort. Soc. 109:43-46.

Gallaher, R.N., C.O. Weldon, and J.G. Futral. 1975. An aluminum block digester for plant and soil
analysis. Soil Sci. Soc. Amer. Proc. 39:803-806.

Hagendorf, B., and R.N. Gallaher. 1992. Best lupine or vetch and N fertilizer management practice for optimizing corn ear leaf area, dry weight and N concentration. Agronomy research report, AY-92-04. Agronomy Department, IFAS, University of Florida, Gainesville, Florida

Hochmuth, G., and E. Hanlon. 1995. IFAS Standardized Fertilization Recommendations for Vegetable Crops. Circular 1152, Florida Cooperative Extension Service, IFAS, University of Florida.

Kidder, G., E. Hanlon, Yeager, and G. Miller. 1998. IFAS standardized fertilization requirements for environmental horticulture crops. SL-141, Cooperative Extension Service, University of Florida, Gainesville, Florida.

Mehlich, A., 1953. Determination of P, Ca, Mg, K, Na, NH4+. North Carolina Soil Test Division (Mimeo 1953). North Carolina State University. Raleigh, N.C.

Mills, H., and J.B. Jones, Jr. 1996. Plant Analysis Handbook II. Micromacro publishing, Athens. 421 pp.

Soil Survey Staff, 1984. Official series description of the Millhopper series. United States Government Printing Office, Wash. D.C.

Teasdale, J., and A. Abdul-Baki. 1997. Growth analysis of tomatoes in black polyethylene and hairy vetch production systems. HortScience 32:659-663.

Thies, J., P. Singleton, and B. Bohlool. 1995. Phenology, growth, and yield of field grown soybean and bush bean as a function of varying modes of N nutrition. Soil Biol. Biochem. 27:575-583.

Wade, B., S. Rymph, and R.N. Gallaher. 1997. Assessment of soil incorporated crimson clover hay as an organic fertilizer source in the production of bush bean. Pp 108-116. In: Gallaher, R., and McSorley, R., (eds.). Proceeding of the 1997 Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60. Cooperative Extension Service. University of Florida, Gainesville, Florida.

Walkley, A., 1947. A critical examination of a rapid method for determining soil organic carbon in soil. Soil Sci. 65:251-264.

CORN GRAIN YIELD RESPONSE TO CROP ROTATION AND CONSERVATION TILLAGE

Ivy, R. L., Agronomist, PO Box 60, Mississippi State University, Prairie, MS 39756, Email: rli2@ra.msstate.edu, Phone: 662.369.4426, Fax: 662.369.9574, Organization: Mississippi State University,

SUMMARY

The need for an alternative crop for soybeans and an increased demand for corn as a livestock feed have caused an increase in corn acreage. The Blackland Prairie Region is an area that has seen an increase in corn production. The soil type associated with this production is a soil with a high clay content which creates special problems for crop production. The soils of the Blackland Prairie are predominately heavy expanding clays and are highly erodible when tilled. Crop rotation is a method for improved productivity and sustainability. A field study (1994-2000) was conducted to investigate the effect of selected tillage and crop rotation/tillage systems on soils in the Blackland Prairie Region. Two soil types in the Blackland Prairie Region were selected for test sites. The soil types were a Vaiden Silty Clay (very-fine, montmorillonitic, thermic, Vertic Hapladalfs) and a Houston Clay (very-fine, montmorillonitic, thermic, Typic Chromuderts).

Tillage treatments were: 1) no-tillage (NT); 2) ridge-tillage (RT) corn, planted no-till and cultivated once with a high clearance cultivator equipped with ridgers; 3) turf aerator (TA) corn, with turf aerator knives operated one month prior to planting at 10% angle from vertical and at a 6 to 8 inch depth; 4) conventional raised-bed tillage (CTB) corn chisel, disked, bedded, do-alled before planting, and cultivated once; and 5) fall para-tilled bed (FPTB) corn. Tillage/crop rotations were: 1) RT soybean fb RT corn; 2) FPTB soybean fb FPTB corn; and 3) soybean fbNT corn.

Environmental conditions during the corn production season had an influence on emergence, growth and yield. Rainfall distribution had an influence on corn yield. Summary of results being reported are for years 1994-1999 for both soil types. Results for 2000 were below normal due to extremely dry conditions. Grain yield for the Vaiden silty clay was not significantly different for three of the six years, 1994, 1996, and 1998. There was no tillage/rotation interaction for these three years. The 1995 yields were not significantly different between FPTBSbfbFPTBC, CTB and RT. NT was significantly lower but not significantly lower than RT. There was no significant difference between RTCfbRTSb, FPTB and soybean fb corn in yield for 1998. NT was not significantly lower than RT, FPTB and CTB. The 1999 yields were significantly lower for soybean fb corn and TA than for other treatments. The trend for corn is to be higher yielding in rotation with soybeans.

Grain yields for Houston clay for 1996 and 1999 were not significantly different for tillage/rotation. The 1994 grain yield for RTCfbRTSb was significantly higher than NT, although not different from other treatments. 1995 FPTB was significantly higher than other treatments, with TA yields significantly different from other treatments. 1997 corn yields RTCfbRTSb and FPTB were significantly higher than other treatments. CTB, TA and NT were not different but significantly lower than other treatments. 1998 yields were low due to extreme

dry weather. FPTB corn yields were highest but not different from other treatments. RTCfbRTSb corn yields were significantly lower than other treatments.

COMPARISON OF CONTINUOUS WHEAT TILLAGE SYSTEMS IN A GRAZED AND UNGRAZED ENVIRONMENT

Olson, Brian L.S., 11708 Highway 70 South, Texas A&M University , Vernon, TX 76385, Email: blolson@taexgw.tamu.edu, Phone: 940.552.9941, Fax: (940) 553-4657, Organization: Texas A&M University,

RATIONALE

Erosion by wind and water is a serious economic and environmental problem in the southern plains. The predominance of conventional tillage systems leaves ground exposed to the natural elements and readily available to erosion.

OBJECTIVES

A conservation-tillage field study was initiated to evaluate different tillage systems under dryland continuous wheat production which includes a grazing component on a Tillman loam.

METHODS

The effect of no-till (NT), reduced-till (RT), and conventional-till (CT) systems on continuous dryland wheat are being studied at a site near Vernon, TX. Each tillage system was either grazed or left ungrazed to determine the impact of a cattle grazing on wheat stand establishment and grain yield.

RESULTS

In 2000, wheat planting was delayed until the first week of December weather related problems. Percent residue and cone penetrometer measurements were delayed until after planting. Percent residue cover doubled from the grazed to ungrazed environment within a tillage system. Cone index values indicated more compaction was present in the first 15 cm in the NT-grazed system than in the other systems. At 15 to 30 cm, there were no differences in soil compaction across the different systems.

CONCLUSION

Compaction problems from grazing animals may limit implementation of a true no-till system in dual-purpose wheat production (grazing plus grain).

SOIL RECOMPACTION AFTER INTENSIVE DEEP TILLAGE

Busscher, Warren J., Coastal Plains Research Center, USDA-ARS, 2611 West Lucas Street, Florence, SC 29501-1242, Email: busscher@florence.ars.usda.gov, Phone: Fax: (843) 669-6970, Organization: Coastal Plains Research Center, USDA-ARS,

ABSTRACT

For many Coastal Plain soils, high soil strength within subsurface horizons requires that deep tillage be performed to provide a suitable rooting environment. Longevity of deep tillage effects have been seen for three years with older tillage equipment. Newer equipment often disrupts more of the profile; tillage effects may last longer. We used soil strength results from experiments that were deep tilled twice a year or annually to examine longevity of soil loosening from tillage. Within these experiments, tillage disruption was measured from 9 days to 6 years after tillage. Effects of disruption, as measured by a leveling off of soil strength with time, began to disappear after three years; yet strengths continued to build up for another two years. Though strengths continued to build up for five years, tillage would still be necessary annually or seasonally because yield reducing soil strengths built up after a year or less with incomplete recompaction.

INTRODUCTION

High soil strength, especially in the E horizon, impedes plant growth and reduces crop yields in many southeastern Coastal Plain soils. In these soils, high strengths are reduced and yield improved through deep tillage (Busscher et al., 2000). Though residual effects of deep tillage may be seen for years afterward, deep tillage is recommended annually, either in spring (Threadgill, 1982; Busscher et al., 1986) or fall (Porter and Khalilian, 1995) or perhaps both (Frederick et al., 1998), because soil reconsolidation between growing seasons, although incomplete, can be enough to increase soil strength to yield-reducing levels. Using slit tillage and in-row subsoiling, previous studies showed that residual deep tillage effects were often no longer seen after three years, under conditions of normal rainfall and traffic (Busscher et al., 1995).

Strength problems are compounded by low available soil water content in sandy soils. Lack of rain for a two week period causes yield-reducing crop stresses (Sadler and Camp, 1986). In the southeastern Coastal Plains, most growing seasons have two week or longer periods with no rainfall (Sheridan et al., 1979). Deep tillage helps alleviate stress by making more of the profile available for root exploration.

Tillage tools now often disrupt more of the profile than the slit-till or in-row subsoiler. They may maintain a softer profile longer than three years. In a set of experiments in the same plots, we developed a series of tillage treatments where shallow and deep tillage were linked to yield (Frederick et al., 1998; Busscher et al., 2000) and where times between tillage and measurement of soil strength ranged from 9 days to about 6 years. Because of the increase in amount of disruption, we hypothesized that soil strength would remain low in these plots for more than three years.

MATERIALS AND METHODS

In spring 1993, before plot establishment, an experimental field at the Pee Dee Research and Education Center near Florence, SC, was planted to soybean using conventional techniques of 30-in-spaced rows with in-row subsoiling. Between fall 1993 and 1996, field plots at Clemson University=s Pee Dee Research and Education Center near Florence, SC, U.S.A. were planted to wheat (Triticum aestivum L.) and soybean (Glycine max L. Merr.) double crop using deep tillage with a paratill and 7.5-in-spaced drilled rows for both crops (Frederick et al., 1998). Between 1997 and 1999, the same plots were used to grow corn (Zea mays L.). Plots were 10-ft wide and 50-ft long. Plots were located on a Goldsboro loamy sand (fine loamy, siliceous, thermic Aquic Kandiudult) that had an E horizon below the plow layer.

The day before planting, two surface tillage and four deep tillage treatments were imposed onto the plots. Two surface tillage treatments involved not disking (planting into the stubble of the previous season=s crop) or disking twice before planting. Between 1993 and 1996 the four deep tillage treatments involved deep tilling every spring, every fall, both spring and fall, and no deep tillage. Between 1997 and 1999, the four deep tillage treatments involved not deep tilling and deep tilling at least once every three years. For 1997, deep tillage treatments included no deep tillage, deep tillage 1.5 years before planting (fall 1995), deep tillage 1 year before planting (spring 1996), and deep tillage immediately before planting the corn crop. For 1998, deep tillage treatments included no deep tillage, deep tillage 2.5 years before planting (fall 1995), deep tillage 2 years before planting (spring 1996), and deep tillage immediately before planting the corn crop. For 1999, deep tillage treatments included no deep tillage, deep tillage 3 years before planting (spring 1996), deep tillage 1 year before planting (spring 1998), and deep tillage immediately before planting the corn crop. All treatments were replicated four times in a randomized complete block design.

Surface tillage, deep tillage, and planting were done in separate operations. All tillage and harvesting equipment followed the same wheel tracks as closely as possible. Surface tillage was done with a 3-m-wide Tufline2 disk (Tufline Mfg. Co., Columbus, GA) pulled by a John Deere 4230 (Deere and Co., Moline, IL) 100 hp tractor with wheels on 64-in centers. Deep tillage was done with a four-shank paratill (Tye Co., Lockney, TX). Shanks were set 26-in apart. The paratill was pulled with a Case 2670 (now Case-IH, Racine, WI) 220-hp, 4-wheel-drive tractor with dual front and rear wheels on 75-in and 122-in centers. Shanks deep-tilled soil to approximately 16 in (the bottom of the E horizon).

Between 1993 and 1996, plots were planted to soft red winter wheat cultivar >Northrup King Coker 9134= and >Hagood= soybean, a Maturity Group VII cultivar. Both wheat and soybean were drilled in 7.5-in-spaced rows with a 10-ft-wide John Deere 750 No-till Planter pulled by a Massey Ferguson 398 (Massey Ferguson, Inc., Des Moines, IA) 80-hp tractor with wheels on 75-in centers. Wheat was drilled on November 18, 1993, November 23, 1994 and November 21, 1995 at a rate of 20 seeds ft-1 and harvested on May 27, 1994, May 30, 1995, and May 24, 1996. Soybean were drilled on May 30, 1994, June 1, 1995, and June 7, 1996 at a rate of 4 seeds ft-1 and harvested on November 3, 1994, November 3, 1995, and November 8, 1996.

Between 1997 and 1999, plots were planted to corn (DeKalb 687). Corn was planted on 15-in row widths with a John Deere 750 drill in 1997 and with an 8-row Monosem planter

[2] Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture or Clemson University.

(A.T.I. Inc., Lenexa, KS) in 1998 and 1999 pulled by the Massey Ferguson 398. Corn was planted on April 1, 1997, March 31, 1998 and April 5, 1999 at a rate of 0.9 seeds ft-1 and harvested on August 28, 1997, August 18, 1998, and August 24, 1999.

To determine yield, corn grain was hand harvested from 39 ft of the middle 4 rows in each plot. Grain for the rest of the plot was harvested with a Case-IH (Case-IH, Racine, WI) 2366 combine with a 15-ft wide corn header and wheels on 10-ft centers. Since the corn header was designed for 30-in-row widths, two 15-in-row widths were harvested with each header opening.

For yield of wheat and soybean, whole plant samples were harvested from six 3-ft sections of row in each plot. When in wheat, grain for the whole plot was harvested with an Allis Chalmers (now Deutz-Allis, Norcross, GA) F3 Gleaner with a 13-ft-wide header and wheels on 7.8-ft centers. When in soybean, grain from the whole plot was harvested with an IH (now Case-IH, Racine, WI) 1420 axial flow combine with a 13-ft-wide header and wheels on 7.5-ft centers.

Cone index data were taken with a 0.5-in-diameter cone-tipped penetrometer (Carter, 1967) on June 21, 1994, June 16, 1995, and June 13, 1996 in soybean and on December 20, 1994 and December 12, 1995 in wheat and on April 22, 1997, April 29, 1998, and April 13, 1999 in corn. Cone indices were measured by pushing the penetrometer into the soil to a depth of 22-in at nine positions spaced 3.75-in apart starting at the middle of the plot and moving outward to one side of the plot into a wheel track. Cone index data were digitized into the computer at 2-in depth intervals and log transformed before analysis according to the recommendation of Cassel and Nelson (1979). Data for all positions across the plot and depth were combined to produce cross-sectional contours of soil cone indices using the method of Busscher et al. (1986). Gravimetric soil water content samples were taken along with cone indices. They were taken at the first and fifth positions of cone index readings. Water contents were measured at 4-in depth intervals to the 2-ft depth. These water contents were taken as representative of the plot. Rainfall data were collected at a weather station located approximately 2200 ft from the field plots.

Mean profile cone indices were used to compare buildup of soil strength over time after tillage. Mean profile cone indices consisted of the average of readings taken to a 22-in depth across the rows. Because different means were taken at different times, mean profile cone indices were not taken for the same environmental conditions; they were not taken at the same soil water contents. Means were corrected to a common water content based on a simplified correction (Busscher et al., 1997). Means were corrected using the equation CIc/CIo = WCo/WCc, where WCo is the original mean profile water content on a dry weight basis, WCc is the common water content to which all readings are corrected, CIo is the original mean profile cone index in atmospheres, and CIc is the mean profile cone index corrected to the common water content.

Mean profile cone index, rainfall, and time of measurement data were analyzed using regression analysis in TableCurve v3.05 (Jandel Scientific of SPSS Inc., Chicago, IL) and in GLM (SAS Institute, 1990). Data were tested for significance at the 5% level.

RESULTS AND DISCUSSION

Though complicated by rainfall at critical times during the growing season, yields within the wheat-soybean double-cropped plots and the corn plots were reduced by increases in mean profile cone indices (Frederick et al., 1998; Busscher et al., 2000).

Mean profile cone indices used to compare buildup of soil strength over time after tillage were corrected to a common water content of 13% was used. Correction to a softer, wetter soil was found to be better (Busscher et al., 1997) than correction to a dryer, harder one though correction to 11.5%, which was the mean of all the water contents, yielded results similar to those for the 13% correction.

Using GLM, the original cone index data for all readings, 1993 to 1999, were significantly correlated to both water content and time between tillage and measurement. After correction to a common water content, the correlation with water content was no longer statistically significant.

Because previous research found that soils recompact within three years, cone index data were analyzed for the first part years of the experiment, 1993 to 1996, the period when wheat and soybean were double cropped in the plots. Cone index was significantly correlated with the square root of time between tillage and measurement. Cone index data for these years (Figure 1) showed an abrupt increase appearing to level off with a maximum value of about 18.3 Atm approximately two years after tillage. The decrease in cone index seen in the last two sets of readings were probably associated with field variability and inaccuracies of the correction for water content differences. Cone index regression with time since tillage was 0.72 for 1993 to 1996.

For the later part of the experiment, 1997 to 1999, when corn was grown in the plots, cone index data for the same plots had a larger range of times between tillage and strength measurement. Times between tillage and measurement of cone index ranged from 9 days to 5.87 years. Cone indices continued to increase with time between tillage and measurement for all treatments, even those that had been tilled more than three years earlier. Cone index data (Figure 2) showed an abrupt increase with time giving readings at 17.8 Atm or less for the first three years, but continuing to increase after three years, and appearing to level off with a maximum value of about 19.4 Atm five years after tillage. It is possible that the readings continued to increase even after three years because somewhat controlled traffic limited compaction earlier in the experiment. For 1997 to 1999, cone index regression with time since tillage was 0.85.

Since plots had the same type of tillage and same traffic patterns for all years, data sets were combined. Though it should have increased precision of data analysis, combined data had a lower regression (0.79) than the latter data set, though the regression value for the combined set was between the values for the individual data sets (Figure 3). Data for the combined set showed a rapid initial build up of cone index with a continued increase lasting 5 years.

It is logical to assume that recompaction was a function of rainfall rather than time between tillage and measurement. Cumulative amounts of rainfall and time between tillage and time of measurement were highly correlated ($r2 = 0.99$) and correlations of the two with cone index were essentially the same (see for example Figure 4 where $r2 = 0.77$ for rainfall while the comparable value in Figure 3 was $r2 = 0.79$ for time).

CONCLUSIONS

In previous studies, recompaction was complete after three years, while in this study it took about five years, possibly because of limited area for traffic in the plots. In these soils that require deep tillage to provide a proper rooting environment, lower recompaction does not mean that less tillage is needed, because even after one year mean cone indices were as high as 15 to 17 Atm when corrected to 13% water content and at or above a root-limiting value of 20 Atm (Blanchar et al., 1978; Taylor and Gardner, 1963) before correction.

LITERATURE CITED

Blanchar, R.W., C.R. Edmonds, and J.M. Bradford. 1978. Root growth in cores formed from fragipan and B2 horizons of Hobson soil. Soil Sci. Soc. Am. J. 42:437-440.

Busscher, W.J., P.J. Bauer, C.R. Camp, and R.E. Sojka. 1997. Correction of cone index for soil water content differences in a Coastal Plain soil. Soil and Tillage Res. 43(3-4):205-217.

Busscher, W.J., J.H. Edwards, M.J. Vepraskas, and D.L. Karlen. 1995. Residual effects of slit tillage and subsoiling in a hardpan soil. Soil Till. Res. 35:115-123.

Busscher, W.J., J.R. Frederick, and P.J. Bauer. 2000. Timing effects of deep tillage on penetration resistance and wheat and soybean yield. Soil Sci. Soc. Am. J. 64:999-1003.

Busscher, W.J., R.E. Sojka, and C.W. Doty. 1986. Residual effects of tillage on Coastal Plain soil strength. Soil Sci. 141:144-148.

Carter, L.M. 1967. Portable penetrometer measures soil strength profiles. Agric. Eng. 48:348-349.

Cassel, D.K., and L.A. Nelson. 1979. Variability of mechanical impedence in a tilled one hectare field of Norfolk sandy loam. Soil Sci. Soc. Am. J. 43:450-455.

Frederick, J.R., P.J. Bauer, W.J. Busscher, and G.S. McCutcheon. 1998. Tillage management for doublecropped soybean grown using narrow and wide row-width culture. Crop Sci. 38:755-762.

Porter, P.M., and A. Khalilian. 1995. Wheat response to row spacing in relay intercropping systems. Agron. J. 87:999-1003.

Sadler, E.J., and C.R. Camp. 1986. Crop water use data available from the southeastern USA. Trans. ASAE 29:1070-1079.

SAS Institute Inc., 1990. SAS/STAT User's Guide, Vol. 2, SAS. Inst. Inc., Carey, NC.

Sheridan, J.M., W.G. Knisel, T.K. Woody, and L.E. Asmussen. 1979. Seasonal variation in rainfall and rainfall-deficit periods in the Southern Coastal plain and Flatwoods Regions of Georgia. Georgia Agric. Exp. Sta. Res. Bull. 243, 73 ppg.

Taylor, H.M., and H.R. Gardner. 1963. Penetration of cotton seedling taproots as influenced by bulk density, moisture content, and strength of the soil. Soil Sci. 96:153-156.

Threadgill, E.D. 1982. Residual tillage effects as determined by cone index. Trans. ASAE 25:859-863.

FIGURES

Figure 1. Mean profile cone indices plotted as a function of number of days since deep tillage with a paraplow for the wheat-soybean double cropped experiment 1993 to 1996.

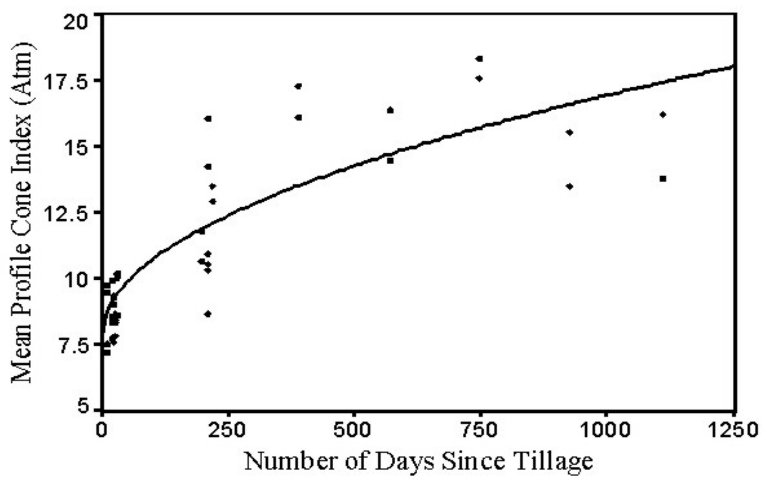


Figure 2. Mean profile cone indices plotted as a function of number of days since deep tillage with a paraplow for the corn experiment 1997 to 1999.

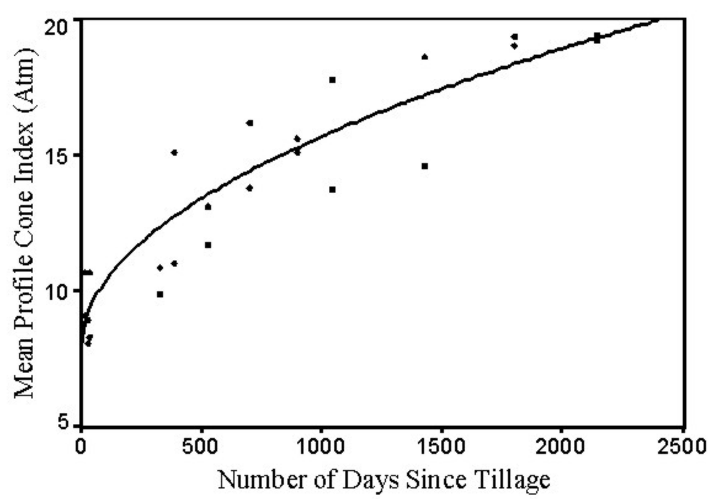


Figure 3. Mean profile cone indices plotted as a function of number of days since deep tillage with a paraplow for both experiments.

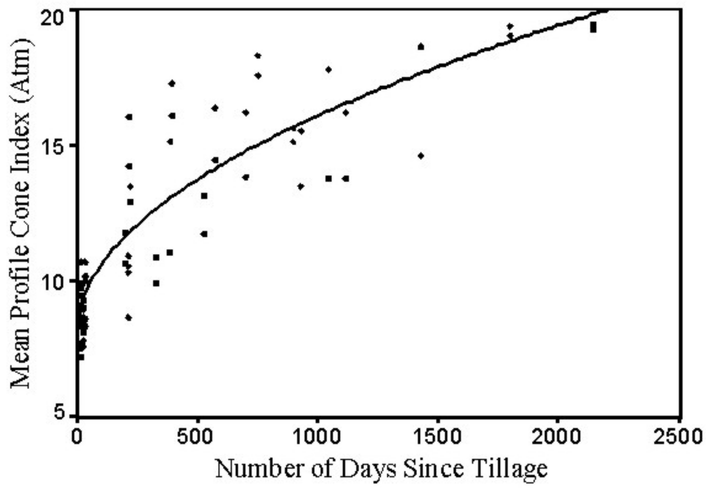
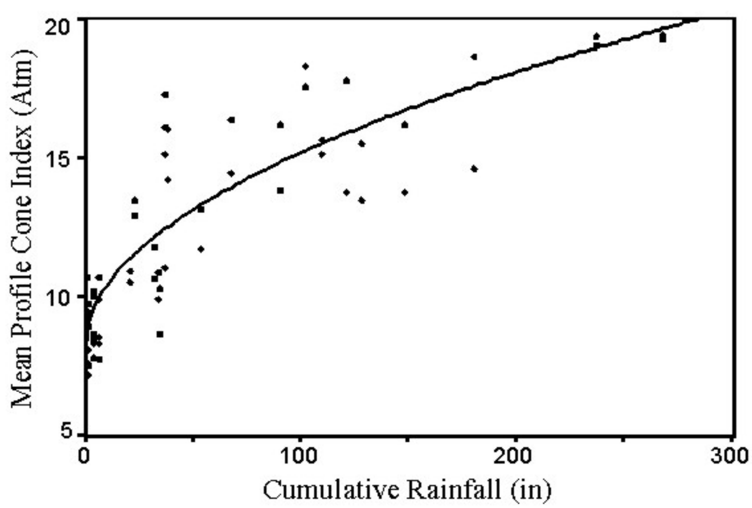


Figure 4. Mean profile cone indices plotted as a function of cumulative rainfall since deep tillage with a paraplow for both experiments.



EVALUATION OF ROW SPACING AND PLANT POPULATIONS IN UNR COTTON

Johnson, Joe, 42 MAFES Circle, Hwy 7 North, Mississippi State University, North Mississippi Branch Station, Holly Springs, MS 38635, Email: jjohnson@ra.msstate.edu, Phone: (662) 252-4321, Fax: (662) 252-5680, Organization: North Mississippi Branch Station, Mississippi State University

SUMMARY

Growing cotton in 38 and 40-inch rows with numerous spring tillage operations has been the traditional production practice in the hill section of Mississippi for a century. However, over the past decade minimum tillage practices such as no-till or other conservation-till have become accepted practices for cotton production. At the beginning of the new millennium, producers are interested in planting cotton no-till with a grain drill rather than a row planter and harvesting with a stripper rather than a spindle picker. At the present, data on row spacing and plant population for rows less than 38 inches are not available to producers of this region. This study was conducted to determine the ideal row spacing and plant populations for ultra narrow row (UNR) cotton in the Brown Loam section of Mississippi.

The experiment site was on S. H. Hurdle's farm in Benton County, Mississippi. Soils on the site were Grenada silt loam (fine silty, mixed thermic Glossic fragiudalf) with less than a 2% slope. Average depth to fragipan (a restricted layer to root penetration and downward water movement) was 26 inches. Plots were 20 feet wide and 300 feet long. Plots were planted no-till by making two passes using a 10-foot Great Plains grain drill. Row widths were accomplished by blocking metering tubes within the hopper of the grain drill. Seeding rates for the different row spacing was accomplished by adjusting the opening at the metering gate. Roundup Ready varieties were planted in 1999 and 2000.

Roundup (glyphosphate) was sprayed post emergence for weed control at three weeks after cotton emergence. Tramlines used for tractor traffic ran perpendicular to the plots thereby crossing all the plots at the same location within the plots. Insecticides were sprayed according to scouting reports and consultant's recommendations. Cotton was defoliated when boll openings reached 70 percent. A desicant was sprayed over all plots 10 days after defoliation. Harvest occurred five days after desication.

In row spacing, plant height decreased with the narrower rows. In 7.5-inch rows an increase of 50,000 plants per acre resulted in a decrease of 2 inches in plant height. Plant survival rate decreased with an increase in plant population. In 7.5-inch rows when the population exceeded 70,000 plants per acre, the increase in number of bolls per square foot failed to increase in proportion to the population increase. Barren plants increased with an increase in plant population for each row spacing. In 7.5-inch rows when plant density exceeded three plants per square foot, 30 percent of the plants were barren. Boll size was also greatly affected by row spacing and plant population. Boll size was the largest in the low population with wider rows, and smallest in the high population with narrower rows. Yields were the highest when the plants were more evenly spaced in both directions in the field. The highest yield was with a plant spacing of 1.5 plants per square foot in the 15-inch row spacing.

A REGIONAL STUDY TO EVALUATE TILLAGE, ROW PATTERNS, IN-FURROW INSECTICIDE, AND PLANTING DATE ON THE YIELD, GRADE, AND TOMATO SPOTTED WILT VIRUS INCIDENCE OF THE GEORGIA GREEN PEANUT CULTIVAR

Baldwin, John A., Professor Crop and Soil Sciences, PO Box 1209, The University of Georgia, Tifton, GA 31793, Email: jbaldwin@uga.edu, Phone: 229.386.3430, Fax: 229.386.7308, Organization: The University of Georgia,

ABSTRACT

These experiments were conducted to assess the impact of certain University of Georgia tomato spotted wilt (TSWV) Risk Assessment Index components including planting date, tillage, row patterns, and in-furrow insecticide on TSWV severity and peanut yield and grade utilizing the Georgia Green cultivar (Arachis hypogaea L.). Plots were in a Randomized Complete Block split-plot design with four replications. Planting dates were main plots with tillage, row pattern and in-furrow insecticide as split-split-split plots, respectively. The test was conducted at four locations during 1999. Plots were planted in 9.0 inch twin row patterns versus 36 inch single rows at the same seeding rate (6 seed/foot singles or 3 seed/foot twins). The peanuts were planted into a wheat cover crop by strip-tillage or conventional moldboard plow methods. Phorate (Thimet 20-G) was applied in-furrow at planting compared to no in-furrow insecticide.

There were location by tillage and location by planting date interactions so data were analyzed separately by location. Tomato spotted wilt virus incidence was significantly reduced $p \leq 0.05$ by twin row patterns, strip-tillage, and Thimet. Yields were significantly higher in twin rows. Net returns were not significantly different between tillage treatments; however twin rows and Thimet had higher net returns per acre.

INTRODUCTION

As tomato spotted wilt virus (TSWV) continues to be an economically important thrips-transmitted disease, recent research results continue to help producers deal with this problem. No single cultural practice, chemical or resistant cultivar to date has been able to eliminate the effects of the virus. Rather, several cultural practices i.e. cultivar, planting date, seeding rate, row pattern, tillage, and in-furrow insecticide have been identified that can reduce TSWV incidence, and the combination of these has lead to the University of Georgia TSWV Risk Index (Culbreath et al. 1999, Brown, et al. 2001). Several studies have shown that reduced tillage production systems in peanut have been inconsistent when compared to conventional peanuts (Cheshire et al. 1985, Colvin et al. 1988, Hartzog and Adams 1989, Wright and Porter 1995, Williams et al. 1997, Baldwin et al. 1999, Dowler et al. 1999). Other studies have shown there are fewer insect pests and less tomato spotted wilt virus (TSWV) when peanuts are planted by reduced tillage methods versus conventional planting (Brandenburg et al. 1998, Baldwin and Hook 1998).

It has been previously demonstrated that numerous peanut cultivars had improved yield, grade, and reduced TSWV when planted by twin row patterns compared to single rows under conventional or strip- tillage methods (Baldwin et al. 1997, 1998,1999, and McGriff et al. 1999).

Culbreath et al. (1999) have reported the variability of the incidence of TSWV in selected peanut cultivars.

The objective of this study was to assess the impact of certain of the University of Georgia, TSWV Risk Index components including, planting dates, twin and single rows, in-furrow insecticide and strip tillage on TSWV severity and peanut yield and grade. The economic impact of the various components and the utility of using the TSWV Risk Index was also analyzed.

MATERIALS AND METHODS

During 1999, tests were conducted at four locations; The NFREC at Marianna Florida , on a Orangeburg sandy clay loam soil, Auburn University Wiregrass Station, Headland Alabama, on a Norfolk fine sandy loam soil, RDC Pivot, Tifton Georgia, on a Tifton loamy fine sand, and at the Con-Til farm at Waynesboro, Georgia, on a Bonifay fine sand soil. Three planting dates were utilized at each location; early (April 7-8), mid (May 5-6) and late (June 2-3). Wheat was established at each location in the late fall the previous year to provide a cover crop for the strip tillage plots. The conventional areas were winter fallow and harrowed, deep turned, and beds tillovated prior to planting. Plots were replicated four times in a randomized complete block design. Tillage was the main plot with row patterns and in-furrow insecticide as sub-plots. The Georgia Green cultivar was planted by strip-till or conventional methods in either single 36 inch or twin 9.0 inch row patterns. The same seed source was used at all locations and planted at a seeding rate of 6 seed/ft. of row for singles and 3 seed/ft. of row for the twin row pattern. Phorate (Thimet 20-G) was applied in-furrow at 5.0 lb./acre on single rows and 2.5 lb./acre on each twin row compared to no insecticide. The cultural practices were kept as similar as possible i.e. the fungicide program for disease control was two chlorothalonil (Bravo Ultrex) sprays (1.37 lb./acre each) followed by four applications of Folicur (7.2 oz./acre each) to the entire plot area at each location. Spray schedules were appropriate for the three individual planting dates.

One quart/acre of glyphosate (Roundup) herbicide was sprayed prior to planting as a burndown to kill the wheat cover crop in the strip-tillage areas. Other herbicides were utilized and varied by location according to weed species. The same strip-tillage unit (KMC), planter (Monosem vacuum planter), and peanut inverter (KMC with 30 inch cut frogs and 30 inch blades) were used at each location. Some supplemental irrigation was provided at each location but only Tifton had adequate irrigation season long. Plot yields were corrected to 7% moisture and graded according to FSIS standards. The SAS System for Mixed Models (1996) was utilized for statistical analysis.

Yields, grades, and final TSWV incidence levels were collected and net returns to land, quota, and management were calculated using a budget-generator incorporating a multi-tier pricing model. Quota peanuts were priced at $610/ton and additionals were priced at $300/ton with adjustments for quality depending on grade. Any underproduction of quota poundage was considered to be fall transferred at $120/ton. Land and quota rent were not included in this model. Comparisons can be made for net returns for the various components of the TSWV Index.

RESULTS AND DISCUSSION

Several interactions occurred for combined data i.e. Location x Tillage and Location x Planting Date (Table 1). As a result, data were analyzed by Location, and means for yield and

TSWV incidence are found in Table 1. Location and treatment effects for total sound mature kernels (%TSMK) and other kernels (%OK) are in Table 2. Total sound mature kernels is the primary indicator of value of peanuts. The higher the percent meat to hull (grade) the higher the value. Other kernels are valued less as they are the kernels that fall through a 16/64 screen and are generally sold and crushed for oil. The higher the %OK the less valuable the peanut. A greater frequency of %OK also indicates a greater level of immature peanuts. These grade indicators are important in calculating net returns of the crop as affected by various cultural practices and treatments.

When yields are compared at all sites, two locations showed a positive and significant ($p<.05$) yield increase for conventional tillage over strip-tillage (Table 1). The Tifton location had a significant yield increase for strip-tillage ($p<.05$) and %TSMK (Table 2). At Waynesboro, final yields were identical for both tillage treatments when averaged across row pattern, insecticide, and planting dates (Table 1). The strip-tillage plots at the Marianna location received less than one half as much supplemental irrigation as did the conventional plots (4 vs. 9 inches). The irrigation system at Headland was not functional in August, a critical time for pod addition and pod fill and also would have resulted in a differential water pattern and amount across tillage treatments and planting dates. At Waynesboro, it was a dry season and the majority of rainfall occurred late in the season to explain the improvement in yield for the June planting.

All four locations showed significant yield increases ($p<.05$) for the twin row pattern and also significantly reduced TSWV incidence at three of the four locations. Other studies have shown significantly improved %TSMK (grade) when peanuts are planted in twin row patterns. This study showed similar results at three of the four locations (Table 2). Phorate insecticide significantly increased yield at three of the four locations and significantly reduced TSWV at two of the four locations (Table 1).

Table 4 demonstrates the effectiveness of various components of this study to reduce TSWV. Table 5 shows the improvement in yield due to various components of the University of Georgia TSWV Risk Index when applied in this study. The combined components across planting dates are found in Table 6. At three of the four Locations there was a significant reduction in yield with each corresponding percent increase in TSWV incidence. Utilizing GLM ($p<.01$) the resulting yield decreases were -25.2, -36.4, and -21.2 lb./acre for Headland, Marianna, and Tifton respectively. These results have been described in other studies and in general the greater the TSWV incidence the greater the negative effect on yield. The Waynesboro location had low levels of TSWV (Table 1) and no significant yield effects occurred.

ECONOMIC ANALYSIS

One component of the "Index" analyzed in this study was planting date. When comparing the planting dates, early (April 7-8) and mid (May 5-6), the net returns to land, quota and management across all locations and treatments were not statistically different from one another at \$387/acre and \$367/acre (Table 3). However, both planting dates were significantly different from the late planting date (June 2-3) at \$194/acre.

A second component of the "Index" that was analyzed was tillage method. Tillage was added to the 1999 TSWV Risk Index after studies have consistently shown that peanuts grown in strip-tillage systems have less thrips damage and slightly less TSWV. However, for this tillage method an inverse relationship with net returns was found due to the interaction of Location x Tillage among the locations for yield. Conventional tillage produced \$91/acre higher net returns than strip-tillage though this difference was not statistically significant (Table 3). Studies have shown that the tillage method chosen can make a difference in peanut yields. As pointed-out in the "Index", strip-tillage has been shown to have some strong advantages including reduced soil erosion and reduced time and labor required for planting, but in some situations yields have been variable. The goal is to have peanut yields in reduced tillage situations be equal to or greater than conventional tillage systems.

A third component of the index is row pattern with twin rows expected to provide lower incidence of TSWV. The average net returns for twin rows was \$375/acre compared to \$256/acre for single rows, with the difference in net returns statistically significant (Table 3).

The final component of the "Index" in this study was at-plant insecticide. The effect of phorate (Thimet 20-G) was compared to no at-plant insecticide. Phorate has demonstrated consistent, low level suppression of TSWV. The use of phorate adds cost as compared to no at-plant insecticide, but is actually less expensive than some other commonly used insecticides. Comparison of net returns across all locations and planting dates suggests that the cost incurred from phorate is justified. Net returns were \$335/acre for the treated versus \$296/acre for non-treated with the difference being statistically significant (Table 3).

The net returns associated with the interaction of row pattern and tillage method and the interaction of row pattern, tillage, and at-plant insecticide are found in Table 3. Twin, conventional and Thimet treatments had the highest average net return across planting dates and locations. Table 3 also presents the average net returns across locations by planting dates for the various treatments. The late planting date of June 2-3, 1999 consistently had the lowest average net returns. Surprisingly, the early planting date of April 7-8, 1999 had the highest average net returns across locations for some of the treatments. As mentioned earlier, the average net returns across all locations and treatments were not statistically different for the early and mid planting dates. The planting date effect on peanut TSWV incidence and yield has been one of the harder effects to quantify. However, utilizing the various components in a production system may allow a grower to have more flexibility in planting without adversely affecting net returns.

CONCLUSION

Planting date effect should be further characterized at different latitudes from the Florida Panhandle to Northeast Georgia and in combination with the strip-tillage and twin row components. Tests with these combinations serve as a part of the validation experiments needed to further refine the "Index" and to give producers the information needed to develop profitable production systems. Even within a three state area, subregional differences do occur and influence results. For instance, the optimal planting date may vary across the southeast depending on subregion. The study also shows that the index components, with the exception of tillage method, not only maximize yield but also net returns.

ACKNOWLEDGMENT

We would like to thank the Georgia Seed Development Commission, Georgia Peanut Commission, and KMC Corporation, for providing financial or technical support to this study. A special thanks goes to the field technicians at all locations for their efforts. Special recognition goes to Simmy McKeown and John Paulk, Ag Technicians with the University of Georgia, and

Richard McDaniel, CEC with the Georgia Cooperative Extension Service in Burke County, Georgia.

LITERATURE CITED

Baldwin, J.A. 1997. Yield, Grade, TSWV Incidence of Several Peanut Cultivars when Planted in win Versus Single Row Patterns. Georgia Peanut Research Extension Report No. 98-2.

Baldwin, J.A. and J. Hook. 1998. Reduced Tillage Systems for Peanut Production in Georgia. Proceedings American Peanut Research and Education Society. 30:48.

Baldwin, J. A., A. K. Culbreath, and S. Jones. 1999. Peanut cultivar response when planted in either twin or single row patterns by strip. Tillage or No-tillage Methods, Proceedings of 22nd annual Southern Conservation Tillage Conference for Sustainable Agriculture. Pg 87.

Baldwin, J.A., J. P. Beasley, Jr., A. K. Culbreath, and S. L. Brown. 1997. Twin Versus Single Row Patterns for Peanut Production. Proceedings of American Peanut Research and Education Society. San Antonio, TX. 29:20

Baldwin, J.A., J.P. Beasley, Jr., S. L. Brown, J. W. Todd and A. K. Culbreath. 1998. Yield, Grade, and Tomato Spotted Wilt Virus Incidence in Response to Twin Versus Single Row Planting Patterns. In proceedings of American Peanut Research and Education Society, Norfolk, VA. 30:51

Baldwin, J.A., J. P. Beasley, Jr., and S. L. Brown. 1999. Yield, Grade and Tomato Spotted Wilt Virus Incidence of Five Peanut Cultivars in Response to Twin Versus Single Row Planting Patterns In proceedings of American Peanut Research and Education Society, Savannah, GA. 31:72

Brandenburg, R.L., D.A. Herbert, Jr, G.A. Sullivan, G.C. Naderman, and S.F. Wright. 1998. The impact of tillage practices on thrips injury of Peanut in North Carolina and Virginia. Peanut Sci. 25: 27-31.

Brown, S. L., J. W. Todd, A. K. Culbreath, J. A. Baldwin, J. P. Beasley, Jr. R. Kemerait, and H. Pappu. 2001. Tomato spotted wilt of peanut. University of Georgia Coop Ext. Serv. Bulletin 1165R.

Cheshire, J.M., Jr., W. L. Hargrove, C.S. Rothrock, and M.E. Walker. 1985. Comparison of conventional and no-tillage peanut production practices in central Georgia, pp. 82-86. In W.L. Hargrove, F.C. Boswell, and G.W. Langdale (eds) The Rising Hope of Our Land. Proc. South. Region No-till Conf., 16-17 July, Griffin, GA.

Colvin, D.L., and B.J. Brecke. 1988. Peanut cultivar response to tillage systems. Peanut Sc. 15:21-24.

Culbreath, A.K., J.W. Todd, D.W. Gorbet, S.L. Brown, J.A. Baldwin, H.R. Pappu, C.C. Holbrook and F.M. Shokes. 1999. Response of Early, Medium, and Late Maturing Peanut Breeding Lines to Field Epidemics of Tomato Spotted Wilt. Peanut Sci. 26:100-106

Culbreath, A. K., J. W. Todd, S. L. Brown, H. R. Pappu, J. A. Baldwin, J. P. Beasley, Jr., and D. W. Gorbett. 1999. University of Georgia Peanut TSWV Website. Http:sacs.cpes.peachnet.edu/spotwilt

Hartzog, D.L. and J.E. Adams. 1989. Reduced tillage for peanut production. Soil Tillage Res. 14:85-90.

Martin, N.R., A.S. Luke, S.M. Fletcher, J.A. Baldwin, and W. D. Shurley. 1999. Twin Single row: Will the Increase in Yields Justify the Additional Costs? In proceedings of American Peanut Research and Education Society, Savannah, GA 31:31

McGriff, E. E., J. A. Baldwin, and J. E. Hudgins. 1999. Yield Response of Several Peanut Cultivars When Planted in Single and Twin Row Patterns during 1997-98 in Decatur County, GA.. In proceedings of American Peanut Research and Education Society, Savannah, GA 31:54

Littrell, R.C., G.A. Milliken, W.W. Stroup, W. Walter, and R. D. Wolfinger. 1996. SAS System for Mixed Models, SAS Institute, Inc.

Williams, E. J., J. L. Davidson, Jr., and S. Hilton. 1997. Effect of Selected Reduced Tillage Practices on Peanut Yield, Grade, and Disease Incidence. Georgia Peanut Research Extension Report No. 98-2.

Wright, F.S., and D.M. Porter. 1995. Conservational Tillage and Cultivar Influence on Peanut Production. Peanut Science. 22:120-124

Table 1. Effect of tillage, row pattern, and in-furrow insecticide on yield and final TSWV incidence at four locations during 1999.

	Headland		Marianna		Tifton		Waynesboro	
Treatment	Yield	TSWV	Yield	TSWV	Yield	TSWV	Yield	TSWV
Tillage								
Conventional	3170 a	14.1 a	3730 a	30.6 b	3945 b	20.4 b	2990 a	5.1 a
Strip Tillage	2630 b	12.3 a	2395 b	11.7 a	4400 a	15.2 a	2990 a	4.8 a
Row Spacing								
Single	2670 b	18.8 b	2860 b	25.0 b	3965 b	21.8 a	2830 b	6.6 b
Twin	3140 a	7.6 a	3260 a	17.3 a	4375 a	13.9 a	3150 a	3.3 a
Insecticide								
No	2890 a	13.3 a	2940 b	24.7 b	4050 b	19.9 a	2900 b	5.8 b
Yes	2915 a	13.0 a	3190 a	17.6 a	4290 a	15.8 a	3075 a	4.2 a
Planting Date								
April	3150 a	15.4 b	3890 a	18.4 a	4290 b	18.5 a	2740 b	2.7 a
May	3250 a	-	2830 b	16.2 a	4790 a	-	2900 b	8.0 b
June	2305 b	10.9 a	2470 b	28.9 b	3430 c	17.2 a	3325 a	4.1 a

Means in a column with a different letter are significant at $P \leq 0.05$.

Table 2. Effect of tillage, row pattern, and in-furrow insecticides on grades at four locations during 1999.

	Headland		Marianna		Tifton		Waynesboro	
Treatment	% TSMK	% OK	% TSMK	% OK	% TSMK	% OK	% TSMK	% OK
Tillage					**	**		
Conventional	71.7 a	5.4 a	72.5 a	6.3 a	73.9 b	4.2 a	70.1 a	7.0 a
Strip Tillage	72.1 a	5.6 a	72.0 a	6.1 a	76.1 a	4.9 b	70.4 a	6.7 a
Row Spacing	*	*	*		**	**		
Single	71.6 b	5.7 b	72.0 b	6.3 a	74.4 b	4.9 b	70.4 a	7.0 a
Twin	72.2 a	5.2 a	72.6 a	6.1 a	75.5 a	4.3 a	70.1 a	6.7 a
Insecticide					**			
No	71.8 a	5.5 a	72.3 a	6.1 a	74.6 b	4.6 a	70.2 a	6.8 a
Yes	71.9 a	5.4 a	73.7 a	6.4 a	75.4 a	4.5 a	70.4 a	6.8 a
Planting Date	**	*	**	**		**	**	**
April	72.2 b	5.8 b	73.7 a	5.6 a	75.1 a	5.8 b	67.3 b	7.4 b
May	73.4 a	4.4 a	73.2 a	5.8 a	74.8 a	4.0 a	69.5 b	7.4 b
June	70.1 b	6.2 b	70.1 b	7.2 b	75.1 a	3.9 a	74.0 a	5.3 a

Means in a column with a different letter are significant at $P \leq 0.05$.
* $P \leq 0.05$
** $P \leq 0.01$

Table 3. Average Net Returns for Various Treatments and Planting Dates Across Locations

Treatment	Across All Planting Dates and Locations	PD 1	PD 2	PD 3
	-- $ net return/acre ------------------------------------			
	386.55 a			
	366.71 a			
	193.71 b			

Table 4. Final TSWV Severity in Regional Planting Date Studies at 4 Locations in Georgia, Florida and Alabama. Average of 8 Tests. 1999.

Comparative Advantage in Reducing TSWV [1/]		
Twins < Singles	Strip < Conventional	Thimet < None
65 times out of 72	33 times out of 34	117 times out of 136

1/ Across 3 planting dates and 4 locations

Table 5. Peanut Yields in Regional Planting Date Studies at 4 Locations in Georgia, Florida and Alabama. Average of 8 Tests. 1999.

Comparative Advantage in Yield Levels [1/]		
Conventionally Tilled	Strip-Tilled	Insecticide
Twins > Singles	Twins > Singles	Thimet > None
12 times out of 12	11 times out of 12	37 times out of 48

1/ Across 3 planting dates and 4 locations

Table 6. Effect of Tillage, Row Pattern and Thimet Insecticide on Final TSWV Severity and Yield with 'Georgia Green' Peanuts. 1999.

Treatment		**Final TSWV** [1/]		**Yield** [1/]	
Row Pattern	**Insecticide**	**Conventional**	**Strip-Till**	**Conventional**	**Strip-Till**
Single	None	19.3	10.6	3125	2877
Single	Thimet	14.7	8.0	3336	2987
Twins	None	11.3	6.3	3521	3264
Twins	Thimet	8.0	4.3	3855	3286

1/ average of 3 planting dates and 4 locations

A REGIONAL STUDY TO EVALUATE TILLAGE, ROW PATTERNS, IN-FURROW INSECTICIDE, AND PLANTING DATE ON THE YIELD, GRADE, AND TOMATO SPOTTED WILT VIRUS INCIDENCE OF THE GEORGIA GREEN PEANUT CULTIVAR

J. A. Baldwin, J. W. Todd, J. R. Weeks, D.W. Gorbet. A. K. Culbreath, A.S. Luke-Morgan, S.M. Fletcher, and S.L. Brown [i]

INTERPRETIVE SUMMARY

As tomato spotted wilt virus (TSWV) continues to be an economically important thrips-transmitted disease, recent research results continue to help producers deal with this problem. No single cultural practice, chemical or resistant cultivar to date has been able to eliminate the effects of the virus. Rather, several cultural practices i.e. cultivar, planting date, seeding rate, row pattern, tillage, and in-furrow insecticide have been identified that can reduce TSWV incidence, and the combination of these has lead to the University of Georgia TSWV Risk Index (Culbreath et al. 1999, Brown, et al. 2001).

These experiments were conducted to assess the impact of certain University of Georgia tomato spotted wilt (TSWV) Risk Assessment Index components including planting date, tillage, row patterns, and in-furrow insecticide on TSWV severity and peanut yield and grade utilizing the Georgia Green cultivar (Arachis hypogaea L.). Plots were in a Randomized Complete Block split-plot design with four replications. Planting dates were main plots with tillage, row pattern and in-furrow insecticide as split-split-split plots, respectively. The test was conducted at four locations during 1999. Plots were planted in 9.0 inch twin row patterns versus 36 inch single rows at the same seeding rate (6 seed/foot singles or 3 seed/foot twins). The peanuts were planted into a wheat cover crop by strip-tillage or conventional moldboard plow methods. Phorate (Thimet 20-G) was applied in-furrow at planting compared to no in-furrow insecticide.

There were location by tillage and location by planting date interactions so data were analyzed separately by location. Tomato spotted wilt virus incidence was significantly reduced $p \leq 0.05$ by twin row patterns, strip-tillage, and Thimet. Yields were significantly higher in twin rows. Net returns were not significantly different between tillage treatments; however twin rows and Thimet had higher net returns per acre.

Planting date effect should be further characterized at different latitudes from the Florida Panhandle to Northeast Georgia and in combination with the strip-tillage and twin row components. Tests with these combinations serve as a part of the validation experiments needed to further refine the “Index” and to give producers the information needed to develop profitable production systems. Even within a three state area, subregional differences do occur and influence results. For instance, the optimal planting date may vary across the southeast depending on subregion. The study also shows that the index components, with the exception of tillage method, not only maximize yield but also net returns.

ROTATIONAL CROPPING SYSTEMS FOR WEED MANAGEMENT IN WHEAT

Stone, Jon C., Graduate Research Assistant, 378 Ag Hall, Oklahoma State University, Stillwater, OK 74059, Email: stonejc@okstate.edu, Phone: 405.744.9626, Fax: , Organization: Oklahoma State University,

SUMMARY

Experiments were established in cheat infested fields in north central Oklahoma to determine reductions in cheat densities in yield benefits of rotating out of wheat for one production cycle. Rotations consisted of continuous wheat; wheat, double-crop grain sorghum, early season soybeans, and double-crop wheat; and wheat, double-crop soybeans, early season soybeans, and double-crop wheat. Each rotation was implemented in no tillage and conventional tillage with eight different herbicide treatments. Crop yield and weed control data will be presented.

ENHANCEMENT OF SOIL MICROBIAL BIOMASS IN COTTON PRODUCTION SYSTEMS WITH CONSERVATION TILLAGE

Motta, Antonio C.V.[ac], D.W. Reeves[b], Y. Feng[c], C.H. Burmester[c], E.B. Schwab[b], and R.L. Raper[b]. Email: amotta@acesag.auburn.edu, Phone: 334.844.4741, Fax: 334.887.8597, Organization: [a]Universidade Federal do Parana-Brazil and CAPES, [b]USDA-ARS National Soil Dyanamics Laboratory, 411 S. Donahue Dr., Auburn, AL 36832, [c]Agronomy and Soils Department, 201 Funchess Hall, Auburn University, Auburn, AL 36849.

ABSTRACT

Microbial biomass plays a vital role in carbon and nutrient cycling and nutrient availability, and is considered a key indicator of soil quality. We measured microbial biomass in a long-term tillage experiment with cotton (Gossypium hirsutum L.) to determine changes due to soil management. The experiment was established in 1994, on a Decatur silt loam soil (clayey, kaolinitic, thermic, Rhodic Paleudult). We evaluated four conservation cotton production systems with a rye (Secale cereale L.) cover crop: strict no-tillage, shallow spring strip-tillage (6 inches deep, 12 inches wide), fall paratilling/no-tillage cotton planting, and fall in-row subsoiling/no-tillage cotton planting. A conventional tillage (fall chiseling and spring disking/cultivation) and strict no-tillage treatment, both without a cover crop, were also evaluated. Soil samples were collected during December 1999, March, June, and December 2000, at 0-1, 1-2.5, 2.5-5, and 5-10 inches increments and analyzed for microbial biomass using fumigation incubation methodology. A temporal variation in microbial biomass was detected with the highest rate observed during June. With the exception of conventional tillage, a sharp decrease in microbial biomass by depth was observed. Compared to conventional tillage, microbial biomass values for the upper layer (0-1 in), averaged over sampling dates, were 51, 94, and 135 % higher, respectively, for no-till without cover, spring strip tillage with cover, and no-tillage with cover (regardless of fall tillage). Fall deep tillage generally improved microbial biomass within 1-5 inches compared to other treatments. Microbial biomass measurement correlated well with the yield history

from these treatments. Thus, the combination of fall deep tillage, use of a rye cover crop, and no-tillage planting can improve both economic returns and soil quality in cotton production systems.

PHOSPHORUS RUNOFF FROM CONVENTIONALLY TILLED WHEAT FIELDS

Zhang, Hailin., Assistant Professor, Dept. of Plant and Soil Sciences, 051 Agricultural Hall, Stillwater, OK 74059, , Email:

haz@mail.pss.okstate.edu, Phone: 405.744.9566, Fax: 405.744.5269, Organization: Department of Plant and Soil Sciences, ,

SUMMARY

Long-term manure and fertilizer application to soils at rates in excess of crop uptake can result in elevated soil test P (STP) levels. Most runoff studies were directly related to animal manure land applications on pastures. The relationship between STP and runoff P on fields only received inorganic P fertilizers on cultivated fields, however, is not well documented and probably poorly understood. This study established the relationship between soil test P and surface runoff P on two long-term soil fertility research plots received different P rates annually for over 30 years (Stillwater and Lahoma, OK). A rainfall simulator was used to generate runoff after plots were prepared to plant winter wheat. Soil test P increased as P fertilizer rates increased. Both dissolved reactive P and total P in the runoff were highly correlated with Mehlich 3 soil test P ($r^2 > 0.98$), but slopes of the regression lines were different for different soils. Majority P in the runoff of plowed wheat fields was sediment bond (86% and 55% for Stillwater and Lahoma location, respectively). This suggests that both the source and transport factors are important in controlling P loss to water bodies. Preventing soil test P from building up and reducing runoff and erosion will minimized the impact of agriculture on the environment.

AN OVERVIEW OF RESEARCH AT THE GRAZINGLAND RESEARCH LABORATORY, EL RENO, OK

Daniel, John A., 7207 West Cheyenne Street, El Reno, OK 73036, Phone: 405.262.5291, Fax: 405.262.0133, Organization: USDA-ARS,

SUMMARY

The USDA, Agricultural Research Service has operated the Grazinglands Research Laboratory (GRL) at El Reno, Ok, since 1948. The GRL's mission is to provide technology and management strategies which increase profitability of forage and livestock production while reducing economic risk and minimizing environmental impacts. The laboratory focuses on the stocker calf component of the U.S. beef cattle industry. Five research teams reflect specialties in forage genetics and management, livestock genetics and nutrition, climate variability and seasonal forecasts, water resources and remote sensing, and small farms research. Research objectives of the 15 scientists and 35 support personnel include: developing new forage grasses and better management of existing forages; developing beef finishing systems that utilize more forage in the diet; adapting NOAA's seasonal climate forecasts into risk-based decision and management tools; utilizing long-term climatic and hydrologic data bases to assess water resources; developing new technology to monitor soil water and forage characteristics; defining and mitigating adverse effects of livestock grazing on soil and water quality, and addressing forage production problems unique to small marginal farms. The facilities at GRL include state-of-the-art livestock handling facilities, chemical laboratories, experimental herds of cattle and sheep, 200 acres of irrigated alfalfa, 900 acres of wheat, 2000 acres of improved grasses, and 3000 acres of native tallgrass prairie.

IMPACT OF CONSERVATION TILLAGE ON SURFACE WATER QUALITY

Daniel, John A., Smith, Sam J, 7207 West Cheyenne Street, El Reno, OK 73036, , Email: , Phone: 405.262.5291, Fax: 405.262.0133, Organization: USDA-ARS,

SUMMARY

Conservation tillage has several advantages, including reduction in soil movement compared to conventional tillage. Using historical data from four instrumented experimental watersheds planted in winter wheat, a comparison was made between moldboard and conservation no-till practices based on sediment and nitrate-N movement in surface runoff. Information from nearby native grasslands was included to provide baseline information. Mean annual sediment losses for no-till was 366 lbs./acre while moldboard tillage yielded a substantial 8929 lbs./acre. Sediment losses from the native grassland watershed was an order of magnitude lower than the no-till practice, at 36 lbs./acre. Annual nitrate-N loss in runoff water was below 1 lb./acre for all tillage practices and native grassland. This comparison indicates that no-till wheat can substantially reduce sediment movement in surface water.

RESPONSE OF COWPEA (*VIGNA UNGUICULATA*) TO TILLAGE AND HERBICIDE MANAGEMENT

A. Higuera[1] R.N. Gallaher[2] and G. E. MacDonald[2], , Visiting Professor, Universidad del Zulia, Facultad de Agronomía, Venezuela[1], Professor and Assistant Professor, Department of Agronomy, University of Florida, Institute of Food and Agricultural Sciences (IFAS) [2]-Putting Florida First. Corresponding Author, R.N. Gallaher, PO Box 110730, University of Florida, Gainesville, FL 32611. E-mail (rngallaher@mail.ifas.ufl.edu),

ABSTRACT

Cowpea, *Vigna unguiculata* is used both for human food and animal forage. It may become important as a fall grown forage that fits well into multiple cropping systems in the southern USA and other areas of the world with similar climate. The objectives of this study were to: 1) compare above ground plant cowpea yield, and plant N content under three tillage treatments and 2) determine potential injury and the effectiveness of five weed management programs under these tillage regimes. 'Iron Clay' cowpea was planted 24 August on Millhopper sand in 10 inch wide rows with a no-till Tye drill. Conventional tillage and no-till treatments were main plots with five herbicide combinations as split plots, replicated four times. Above ground dry matter production was determined at late bloom stage (60 days after planting) followed by Kjeldahl N analyses. Crop injury ratings and percent control of weeds were also determined at 15 and 45 days after herbicides were sprayed. This study found that best yields could be obtained with the use of glyphosate herbicide alone to provide a range of 1.27 to 1.55 ton dry matter acre^{-1}. No-till + use of broiler manure was the most consistent in providing best yield for all herbicide combinations except when using pendimethalin (Prowl) + flumioxazin (Valor) which resulted in significant cowpea plant injure (caused by the flumioxazin) for this tillage treatment. Nitrogen content (N concentration x dry matter yield acre^{-1}) mirrored dry matter yield. The use of no-till + broiler manure provided the greatest N content in the range of 75 to 79 pounds N acre^{-1} in dry matter of the above ground cowpea plant.

INTRODUCTION

Cowpea, Vigna unguiculata (L.) Walp. is grown in over two-thirds of the developing world, usually as a companion or relay crop with small grains or corn (Zea mays L.). Its major importance is a staple in the diet of many millions of people. Development of new varieties resistant to insects and pests or have shorter life cycles have contributed to increased cultivation of this crop. Cowpea is adapted to warm weather and requires less rainfall than most crops, therefore it is primarily cultivated in the semiarid regions of the lowland tropics and subtropics, where soils are poor and rainfall is limited (Mortimore et al., 1997).

The use of cowpea as fodder is attractive in mixed crop/livestock systems where both grain and fodder can be obtained from the same crop (Tarawali et al., 1997). In addition, there is increasing emphasis on integrating crop livestock production to promote more sustainable agricultural systems. Cowpea can make a very important contribution towards livestock fodder and supply N to the soil (Lat et al., 1978). Its use as a dual-purpose crop, and providing both grain and fodder is attractive where land is becoming increasingly scarce. The use of cowpea as fodder is most advanced in India, where green material is used for grazing, or cut and mixed with dry cereals for stall feeding (Tarawali et al., 1997). According to Relwani et al., (1970) the use of cowpea in combination with cereals and other crops for lactating cows in India can maintain milk yields of > 1.5 gallon cow-1 day-1. Inclusion of green cowpea pods in the fodder is considered important to raise nutritive value. Trials on fodder varieties of cowpea in India gave dry-matter yields of > 1.8 ton acre-1 and protein contents of up to 26% (Relwani et al., 1970). Cutting trials have indicated that harvesting 60 days after planting gave the best dry matter yields of highest quality (Kandaswamy et al., 1976).

Grain cowpea is planted in semiarid and arid zones of West Africa between millet rows 2 to 3 weeks after planting millet, followed by fodder cowpea 3 to 4 weeks later. Following millet harvest, the grain cowpea is harvested and the fodder cowpea is left to grow. Typical yields are 350 to 400 pounds dry cowpea fodder acre-1 (Singh 1993). Under appropriate management cowpea can provide good quality fodder for in situ grazing, silage (in combination with cereals) or hay. The management and cultivars selected will depend on the farming system requirements and the mode of use (Tarawali et al., 1997).

Farming is becoming a more labor-intensive system in many areas, driven by demographic and economic forces. Cowpea will provide a crucial role as it facilitates crop-livestock integration, which is associated with intensification and land conserving investments. In fixing N, cowpea also brings this plant nutrient into the cycle. Its economic function in the system is complementary to that of cereals (Mortimore et al., 1997).

A best management practice, which reduces soil erosion and conserves water, while at the same time increasing land productivity and conserving fuel, is conservation tillage. Any tillage and planting system that covers 30% or more of the soil surface with crop residue after planting is considered conservation tillage (Gallaher and Hawf, 1997). One tillage cycle destroyed the benefits derived from several years of no-tillage (Broome and Triplett, 1997).

Weed control is essential for no-tillage production. It is very important to carry out trials in order to study the response of cowpea to no-tillage and weed control with herbicides. Herbicides for no-tillage must 1) control vegetation present, 2) prevent growth of weeds from seed, 3) not injure the crop or succeeding crops, and 4) be economical (Triplett et al., 1964). Gutiérrez et al., (1999) carried out a no-tillage trial in Venezuela to evaluate different methods of weed control and to compare two cowpea genotypes. Glyphosate (2 lb ai acre-1) gave the best economic profit and provided >90% weed control.

The public demands that dairy and poultry farmers include manure management as a part of their business operations. The utilization of manure must be protective of the environment. Plant food nutrients in the manure can be valuable resources for production of forage crops but it is important for these systems to produce sufficient yields of high quality forages to feed the animals producing the manure (Johnson et al., 1995). A reason to apply chicken manure as an organic matter source to the soil is to improve aeration, water retention, soil structure and drainage and also to feed earthworms and microorganisms that maintain the balance and biological activity in the soil. Nitrogen, in freshly excreted chicken manure, is in the organic form, which is converted to ammonium-N during storage or after application to the soil. Since ammonium is held firmly to the surfaces of soil particles, it does not leach easily but may, under certain conditions, be converted to volatile ammonia gas (Fraser, 1985). The main value of manure is the plant nutrient content and organic matter. Animals use only about 25% of the nutrients contained in feeds, with the remaining 75% of the original content of N, P and K excreted in manure and urine (Fraser, 1985). Broiler manure, like any fertilizer, should be applied to soil only at rates required to meet crop nutrient needs.

The objectives of this study were to: 1) compare above ground plant cowpea yield, and plant N content under three tillage treatments and 2) determine potential injury and the effectiveness of five herbicide weed management programs under these tillage regimes.

MATERIALS AND METHODS

'Iron Clay' cowpea was planted 24 August at the Agronomy Departments Field Teaching Laboratories, University of Florida. Soil at this site is classified as Millhopper sand (sandy siliceous hyperthermic grossarenic paleudult) (Soil Survey Staff, 1984). The field had been planted in the spring with corn and ears were removed near the end of July. Stalks were chopped and spread evenly over the field on 31 July 2000. Soil fertility test was obtained from samples collected on 1 August 2000. Conventional tillage treatments were tilled on 1 August 2000. Plots were sprayed with a uniform rate of 2 quarts (2 lb ai) roundup (Glyphosate) acre-1 five days prior to planting. 'Iron Clay' cowpea was planted with a Tye no-till drill on 31 August in 10 inch wide rows. Lannate (1 pint acre-1) was applied to control leafhoppers and leaf miners three weeks after planting.

A split-plot experimental design with tillage treatments as main effects in a randomized complete block and 4 replications was used. Tillage treatments included: 1.Conventional tillage, 2. No-till directly into chopped cornstalks-residue from previous crop, and 3. No-till directly into chopped cornstalks-residue from previous crop + broiler manure application to provide the equivalent of 120 pounds N acre-1. Conventional tillage plots were harrowed and tilled following chopped cornstalks. Initial tillage was done on 1 August 2000. The assumption was that N from the broiler manure would be 50% as efficient as if using ammonium nitrate as the N source. This assumption would result in fulfilling the Florida Cooperative Extension recommendation of 60 lb N acre-1 for cowpea.

The sub-effects were the herbicide treatments: 1. untreated check; 2. pendimethalin (Prowl)-0.75 lb ai acre-1, pre-emergence treatment (PRE), 3. pendimethalin-0.75 lb ai/acre PRE + flumioxazin (Valor)-0.078 lb ai acre-1 PRE; 3. Pendimethalin-0.75 lb ai acre-1 PRE + flumioxazin (experimental, not registered for use on cowpea); 4. pendimethalin-0.75 lb ai acre-1 PRE + prometryn (experimental, not registered for use on cowpea)-1.25 lb ai acre-1 PRE; and 5. metalachlor (Dual Magnum) at 0.40-lb ai acre-1 PRE + imazethapyr (Pursuit)-0.032 lb ai acre-1 post-emergence (POST).

Based on soil test all plots were fertilized with 80 lb K20 acre-1 using muriate of potash. Irrigation was applied as needed using overhead sprinklers. Black-eye Cowpea Mosaic Virus (BCMV) was identified on a few plants and destroyed (Plant Disease Diagnostic Clinic, University of Florida).

Three rows per plot were harvested at the late bloom stage, 60 days after planting for this variety, to determine above ground plant yield. Sub-samples were taken to obtain dry matter percent by drying at 70 °C in a forced air oven. Dry plant samples were chopped in a hammer mill, ground using a Wiley mill with a 2.0 mm stainless steel screen and stored in air tight plastic bags.

For N analysis a mixture of 0.100 g (100 mg) of dried plant tissue, 3.2 g of salt-catalyst (9:1 K2SO4:CuSO4), 2 Pyrex beads and 10 ml of H2SO4 was vortexed in a 100 ml Pyrex test-tube under a hood. To reduce frothing, 2 ml 30% H2O2 was added in small increments and tubes were digested in an aluminum block digester at 370 °C for 210 minutes (Gallaher et al., 1975). Tubes were capped with small funnels that allowed for evolving gasses to escape while preserving refluxing action. Cool digested solutions were vortexed with approximately 50 ml of deionized water, allowed to cool to room temperature, brought to 75 ml volume, transferred to square Nalgene storage bottles (Pyrex beads were filtered out), sealed, mixed and stored. Nitrogen trapped as (NH4)2SO4 was analyzed on an automatic Technicon Sampler IV (solution sampler) and an Alpkem Corporation proportioning Pump III.

Cowpea injury (%) and weed control of purple nutsedge (Cyperus rotundus) and Florida pusley (Richardia scabra) were evaluated 15 and 45 days after herbicides were sprayed. Pre-emergence treatments were sprayed on 25 August 2000 at 2:30 pm, 95 °F (air temperature), 100 °F (soil temperature) and 60% relative humidity. The POST treatment (Pursuit + non-ionic surfactant, 0.25% v/v) was sprayed on 8 September 2000 at 10:00 am, 85 °F (air temperature), 80 °F (soil temperature) when the second trifoliate leaf appeared in cowpea and purple nutsedge plants were about 3 inches tall.

Data were placed in a Quatro-Pro (1987) spreadsheet for transformations and preparation of Ascii files. Data were analyzed using MSAT (1985). Analysis of variance was calculated to determine statistical significance. Means were compared using Fisher's Protected LSD test at p = 0.05 and p = 0.10.

RESULTS AND DISCUSSION

Plant Yield

Above ground dry plant yield showed an interaction between tillage and herbicides (Table 1). No differences in yield occurred between the conventional tillage and no-till treatments among the weed control treatments. Yield among these treatments ranged from 1.01 to 1.38 ton dry matter acre-1. The no-till + broiler manure treatment was the most consistent in providing the best yield. This was especially true when using pendimethalin + prometryn or metalachlor + imazethapyr. However, yield for these two treatments were no different from the untreated check. Yield was lowest from the use of pendimethalin + flumioxazin in the no-till + broiler manure treatment (Table 1) and was positively related to cowpea crop injury (Table 3). Based on these data, the narrow row planting of cowpea resulted in quick canopy closure for excellent competition against weeds. This study suggests that best yield could be obtained with the use of glyphosate as a pre-plant burn-down treatment to provide a range of 1.27 to 1.55 ton dry matter acre-1.

Table 1. Dry plant yield of 'Iron Clay' cowpea from tillage and herbicide treatments, fall 2000, Gainesville, Florida.

Herbicide Treatment	Tillage: Conventional	No-till	No-till+BM	Average
----- lb ai acre^{-1} ------	----- Dry plant yield, ton acre^{-1} -----			
Untreated Check	1.27 A b W	1.29 a w	1.55 a w	1.37
Pendimethalin (0.75 PRE)	1.20 A b W	1.38 a w	1.50 a w	1.36
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	1.37 A W	1.23 a Wx	1.02 b x	1.21
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	1.10 A b X	1.30 a b Wx	1.54 a w	1.31
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	1.07 b X	1.01 b x	1.58 a w	1.22
Average	1.20	1.24	1.44	

Tillage=NS; Herbicides=NS; Interaction=*; CV Herbicides=17.7%
Comparison of tillage means within a herbicide treatment: LSD@0.05 p=0.40; @0.10 p=0.33
Comparison of herbicide means within a tillage treatment: LSD@0.05 p=0.29; @0.10 p=0.24
BM=Broiler Manure; ai=active ingredient in lb acre^{-1}; PRE=pre emergence, POST=post emergence

PLANT N CONTENT (YIELD)

Nitrogen content (N concentration x dry matter yield acre-1) mirrored dry matter yield. Therefore, there was a significant interaction between tillage and herbicide treatments (Table 2). The low yield from use of pendimethalin + flumioxazin for the no-till + broiler manure (Table 1) resulted in the lowest N content. The use of no-till + broiler manure provided the greatest N content in the range of 75 to 79 pounds N acre-1. As was the case for dry matter production (Table 1) the use of glyphosate as a pre-plant burn-down treatment could provide the highest N content (Table 2).

Table 2. Nitrogen content for cowpea from tillage and herbicide treatments, Gainesville, Florida, Fall 2000.

Herbicide Treatment	Tillage: Conventional			No-till			No-till+BM			Average
----- lb ai acre^{-1} ------	----------------------------------- Plant N, lbs acre^{-1} -----------------------------------									
Untreated Check	65.5	a	W	66.6	A	w	75.7	a	W	69.2
Pendimethalin (0.75 PRE)	60.8	a	W	67.8	A	w	76.3	a	W	68.3
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	65.7	a	W	66.0	A	w	49.0	b	X	60.3
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	57.1	a	X	63.6	A	X	79.4	a	W	66.8
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	57.8	a	X	54.4	A	X	74.9	a	W	62.4
Average	61.4			63.7			71.0			

Tillage=NS; Herbicides=NS; Interaction* =NS; CV herbicides = 16.6%
Mean separation for tillage within a herbicide: LSD @ 0.05 p = 16.1
Mean separation for herbicides within a tillage: LSD @ 0.05 p = 15.6
BM=Broiler Manure; ai=active ingredient in lb acre^{-1}; PRE=pre emergence, POST=post emergence

COWPEA INJURY (%) BY HERBICIDE TREATMENTS

Cowpea injury was not significant among tillage treatments (Table 3). However, injury was observed for three of the five herbicide treatments at the first sampling date. Pendimethalin + flumioxazin and metalachlor + imazethapyr both showed slight early season crop injury but symptoms had diminished by mid-season. Pendimethalin alone did not cause significant injury, therefore the treatment of pendimethalin + flumioxazin can be attributed to flumioxazin.

Table 3. Percent crop injury in a crop of Iron Clay cowpea from tillage and herbicide treatments, fall 2000, Gainesville, Florida.

Herbicide Treatment	Tillage: Conventional	No-till	No-till+BM	Average
----- lb ai $acre^{-1}$ ------	------------------------------ Cowpea injury, % (09/18/00)--------------------------			
Untreated Check	0.0	0.0	0.0	0.0 c
Pendimethalin (0.75 PRE)	0.0	0.0	0.0	0.0 c
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	27.5	21.3	26.3	25.0 a
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	12.5	3.8	3.8	6.7 b
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	16.3	11.3	5.0	10.8 b
Average	11.3	7.3	7.0 NS	@ 0.05

Tillage =NS; Herbicides = **; Interaction = NS; CV Herbicides = 90.0%
Comparison of herbicide means: LSD @ 0.05 p = 6.3; @0.10 p= 5.3

Herbicide Treatment	Tillage: Conventional	No-till	No-till+BM	Average
	------------------------------- Cowpea injury, % (10/18/00)--------------------------			
Untreated Check	6.3	1.3	7.5	5.0 b
Pendimethalin (0.75 PRE)	6.3	2.5	22.5	10.4 b
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	13.8	11.3	50.0	25.0 a
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	11.3	0.0	0.0	3.8 b
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	5.0	1.3	0.0	2.1 b
Average	8.5	3.3	16.0 NS	@ 0.05

Tillage=NS; Herbicides=**; Interaction = +; CV Herbicides = 156.8%
Comparison of herbicide means: LSD @ 0.05 p=8.5; @0.10 p =6.9
BM=Broiler Manure; ai=active ingredient in lb $acre^{-1}$; PRE=pre emergence, POST=post emergence

PURPLE NUTSEDGE (CYPERUS ROTUNDUS) CONTROL (%)

Purple nutsedge was not affected by tillage (Table 4). Metalachlor + imazethapyr provided best early season control at 80%. By the second rating date even the control plots showed 55% control of purple nutsedge, which illustrates the importance of crop canopy shading. All other treatments were essentially equal and provided excellent purple nutsedge control by the time of the second rating time (90%).

Table 4. Control of purple nutsedge in a crop of Iron Clay cowpea from tillage and herbicide treatments, fall 2000, Gainesville, Florida.

Herbicide Treatment	Tillage: Conventional	No-till	No-till+BM	Average	
----- lb ai acre^{-1} ------	----------------------- Purple Nutsedge control, % (09/18/00) ---------------------				
Untreated Check	47.5	52.5	12.4	37.5	c
Pendimethalin (0.75 PRE)	62.5	60.0	29.9	50.8	b
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	83.8	60.0	40.1	61.3	b
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	50.0	67.5	32.5	50.0	b
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	79.8	80.0	79.0	79.6	A
Average	64.5 W	64.0 W	39.0 X @ 0.05		@ 0.05

Tillage=**; Herbicides=**; Interaction=NS; CV herbicides=31.8%
Comparison of tillage means: LSD @ 0.05 p = 9.1; @0.10 p = 8.7
Comparison of herbicide means: LSD @ 0.05 p = 14.7; @ 0.10 p = 12.2

Herbicide Treatment	Conventional	No-till	No-till+BM	Average	
	------------------------ Purple Nutsedge control, % (10/18/00) --------------------				
Untreated Check	47.5	62.5	55.0	55.0	c
Pendimethalin (0.75 PRE)	90.0	87.5	91.3	89.6	b
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	91.3	87.5	91.2	90.0	b
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	91.3	90.0	91.1	90.8	A
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	88.8	90.0	91.2	90.0	b
Average	81.8	83.5	84.0 NS		@ 0.05

Tillage = NS; Herbicides =**; Interaction =NS; CV herbicides=9.48%
Comparison of herbicide means: LSD @ 0.05 p = 64; @ 0.10 p = 0.7
BM=Broiler Manure; ai=active ingredient in lb acre^{-1}; PRE=pre emergence, POST=post emergence

FLORIDA PUSLEY (RICHARDIA SCABRA) CONTROL (%)

Florida pusley was not affected by tillage (Table 5). All herbicide treatments provided 66 to 90% control. Chemical weed control was rather effective in control during the early cowpea growth period compared to the untreated control. However, by the time of the second weed rating most herbicide treatments were no better in their control of Florida pusley then the control treatment. Pendimethalin + flumioxazin was the most consistent in control (Table 5), but this treatment caused the greatest crop injury (Table 3) and the lowest dry matter yield (Table 1) and N content (Table 2).

Table 5. Control of Florida pusley in a crop of Iron Clay cowpea from tillage and herbicide treatments, fall 2000, Gainesville, Florida.

Herbicide Treatment	Tillage: Conventional	Tillage: No-till	Tillage: No-till+BM		Average	
----- lb ai acre^{-1} ------	------------------------ Florida pusley control, % (09/18/00) -----------------------					
Untreated Check	0.0	0.0	0.0		0.0	c
Pendimethalin (0.75 PRE)	70.0	66.3	88.8		75.0	b
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	88.8	90.0	91.3		90.0	A
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	88.8	91.3	91.3		90.4	A
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	72.5	91.3	90.0		84.6	A b
Average	64.0	67.8	72.3	NS		@ 0.05

Tillage = NS; Herbicides =**; Interaction = NS; CV herbicides = 23.7%
Comparison of herbicide means: LSD @ 0.05 p = 13.4; @ 0.10 p = 11.1

Herbicide Treatment	Conventional	No-till	No-till+BM		Average	
	------------------------ Florida pusley Control, % (10/18/00) ----------------------					
Untreated Check	6.3	1.3	7.5		5.0	B
Pendimethalin (0.75 PRE)	6.3	2.5	22.4		10.4	AB
Pendimethalin (0.75 PRE) +flumioxazin (0.078 PRE)	13.8	11.3	26.3		17.1	A
Pendimethalin (0.75 PRE) + prometryn (1.25 PRE)	11.3	0.0	3.8		5.0	B
Metalachlor (0.40 PRE) + imazethapyr (0.032 POST)	5.0	1.3	5.0		3.8	b
Average	8.5	3.3	13.0	NS		@ .05

Tillage = NS; Herbicides =**; Interaction =NS; CV Herbicides = 156.8 %
Comparison of herbicide means: LSD @ 0.05 p = 8.5; @ 0.10 p = 6.9
BM=Broiler Manure; ai=active ingredient in lb acre^{-1}; PRE=pre emergence, POST=post emergence

ACKNOWLEDGMENTS

Appreciation is extended to Jim Chichester, Howard Palmer, and Walter Davis for technical assistance.

LITERATURE CITED

Broome, M.L., and G.B. Triplett. 1997. Weed control for corn planted into Sod. . P 245-247. In R.N. Gallaher and R. McSorley (eds.). Proceedings 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60. University of Florida Cooperative Extension Service, Gainesville, Florida.

Fraser, H. 1985. Manure characteristics. Resources management branch. Ministry of Agriculture, Food and rural Affairs. In Ontario Web site. Government of Ontario, Canada. 5 pp.

Gallaher, R.N., C.O. Weldon, and J.C. Futral. 1975. An Aluminum block digester for plant and soil analysis. Soil Sci. Soc. Amer. Proc. 39(4):803-806.

Gallaher, R. N., and L. Hawf. 1997. Roles of conservation tillage in production of a wholesome food Supply. P 23-27. In R.N. Gallaher and R. McSorley (eds.). Proceedings 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60. University of Florida Cooperative Extension Service, Gainesville, Florida.

Gutiérrez, W. C. Medrano, A. Gómez, E. Urrutia, M. Urdaneta, E. Esparza, J. Báez, Y. Villalobos, and B. Medina. 1999. Rev. Fac. Agron. (LUZ). 16:597-609.

Johnson, J.C., Jr., G.L. Newton, J.G. Davis, and P.R. Utley. 1995. Forage production from two minimum-till cropping systems utilizing liquid dairy manure. Animal & Dairy Science. CAES/UGA. Annual Report. P 199-202.

Lat, R.B., D. Rajat, and D.J. Minson. 1978. Legume contribution to the fertilizer economy in legume-cereal rotations. Indian Journal of Agricultural Science 48(7):419-424.

Mortimore, M.J., B.B. Singh, F. Harris, and S.F. Blade. 1997. Cowpea in traditional cropping systems. In advances in cowpea research. Copublication of International Institute of tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS). Chapter 9. Sayce Publishing. Devon, UK. pp. 99-113.

MSTAT 4.0. 1985. Users Guide to MSAT, Version 4.0 Michigan State University, Lansing, U.S.A.

Kandaswamy, P., P. Muthuswamy, and K.K. Krishnamoorthy. 1976. Effect of stage of cutting on the crude protein, phosphorus content and yield of cowpea (Vigna sinensis L.) The Madras Agricultural Journal 63(3):178-180.

QUATTRO PRO 4.0. 1987. Manual for QUATTRO PRO 4.0, Getting Started. Borland International, Inc., 1800 Green Hills Road, P.O. Box 660001, Scotts Valley, CA 95067-0001.

Relwani, L.L., C.K. Kurar, and R.K. Bagga. 1970. Varietal trial on cowpea (Vigna sinensis) for fodder production. Indian Journal of Agriculture 15(2):166-168.

Singh, B.B. 1993. Cowpea breeding: Archival report (1988-1992). Crop Improvement Division, IITA, Ibadan, Nigeria.

Soil Survey Staff. 1984. Official series description of the Millhopper series. United States Government Printing Office, Wash. D.C.

Tarawali S.A., B.B. Singh, M. Peters, and S.F. Blade. 1997. Cowpea haulms fodder. In Advances in Cowpea Research. Copublication of International Institute of Tropical

Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS). Chapter 27. Sayce Publishing. Devon, UK. P 313-325.

APPENDIX A

Past Conferences and Contact Persons

Year	Location	Contact
1978	Griffin, GA	W.L. Hargrove Agronomy Department Georgia Station 1109 Experiment Street Griffin, GA 30223-1797 (404) 228-7330
1979	Lexington, KY	W.W. Frye Agronomy Department University of Kentucky Lexington, KY 40546 (606) 257-1628
1980	Gainesville, FL	David Wright N. Florida Res. & Educ. Ctr. Route 3 Box 4370 Quincy, FL 32351 (904) 627-9236
1981	Raleigh, NC	M.G. Wagger Soil Science Department North Carolina State Univ. Raleigh, NC 27650 (919) 737-3285
1982	Florence, SC	Jim Palmer Agronomy Department Clemson University Clemson, SC 29634 (803) 656-3519
1983	Milan, TN	Don Tyler West Tennessee Ag. Exp. Stn. Jackson, TN (901) 425-4747
1984	Dothan, AL	Joe Touchton Agronomy Department Auburn University Auburn, AL 38301 (205) 844-4100
1985	Griffin, GA	W.L. Hargrove Agronomy Department Georgia Station 1109 Experiment Street Griffin, GA 30223-1797 (404) 228-7330

Year	Location	Contact
1986	Lexington, KY	W.W. Frye Agronomy Department University of Kentucky Lexington, KY 40546 (606) 257-1628
1987	College Station, TX	Tom Gerik Blackland Research Center Temple, TX 76501 (817) 770-6603
1988	Tupelo, MS	Normie Buehring Northeast Ms. Branch Stn. Verona, MS 38879 (601) 566-2201
1989	Tallahassee, FL	David Wright N. Florida Res. & Educ. Ctr. Route 3 Box 4370 Quincy, FL 32351 (904) 627-9236
1990	Raleigh, NC	M.G. Wagger Soil Science Department North Carolina State Univ. Raleigh, NC 27650 (919) 737-3285
1991	N. Little Rock, AR	Terry C. Keisling Soil Testing & Research Lab. P. O. Drawer 767 Marianna, AR 72360 (501) 295-2851
1992	Jackson, TN	Paul Denton University of Tennessee P. O. Box 1071 Knoxville, TN 37901 (615) 974-7208
1993	Monroe, LA	Bob Hutchinson Northeast Research Station LSU AgCenter P.O. Box 438 St. Joseph, LA 71366 (318) 766-3769

1994	Columbia, SC	Jim Palmer Agronomy Department Clemson University Clemson, SC 29634 (803) 656-3519
1995	Jackson, MS	Normie Buehring Mississippi State University P.0. Box456 Verona, MS 38879 (601)566-2201
1996	Jackson, TN	Paul Denton Don Tyler University of Tennessee 605 Airways Blvd. Jackson, TN 38301-3201
1997	Gainesville, FL	Ray Gallaher University of Florida 631 Wallace Bldg. Gainesville, FL 32611
1998	N. Little Rock, AR	Stan L. Chapman Terry C. Keisling Arkansas Agri. Exp. Stn. Univ. of Arkansas Division of Agriculture Fayetteville, AR 72701
1999	Tifton, GA	Jim Hook University of Georgia Crop & Soil Science Dept. P.O. Box 748 Tifton, GA 31793-0748
2000	Monroe, LA	Pat Bollich Rice Research Station LSU AgCenter P.O. Box 1429 Crowley, LA 70527-1429 (337) 778-7531
2001	Oklahoma City, OK	Jim Stiegler Oklahoma State University Plant and Soil Sciences Dept. 369 Agricultural Hall Stillwater, OK 74075 (405) 744-6422

APPENDIX B

Southern Conservation Tillage Conference for Sustainable Agriculture

Award Recipients

Year	Recipient	Affiliation
1998	Dr. Raymond Gallaher	University of Florida, Gainesville, FL
1999	Dr. George Langdale	USDA-ARS, Watkinsville, GA
2000	Dr. Stan Chapman	University of Arkansas
2000	Dr. Don Howard	University of Arkansas
2001	Dr. Normie Buehring	Mississippi State University
	Dr. Terry Keisling	University of Arkansas

i