PROCEEDINGS OF THE THIRD ANNUAL NO-TILLAGE SYSTEMS CONFERENCE

THEME:

ENERGY RELATIONSHIPS IN MINIMUM TILLAGE SYSTEMS

Sponsored by
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June 19, 1980

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PREFACE

Climatic conditions in Florida and the Southeast are such that multicropping should be fully utilized to harvest the ENERGY FROM THE SUN and to meet the demand for agricultural products. Food and fiber production must increase to satisfy the needs of a rapidly growing population in Florida and the Southeast and to help meet the needs created from national and world competition. Producers must make better utilization of their farmland on a year-round production basis to offset increased costs of ENERGY inputs from fuel, machinery, chemicals, and fertilizer as well as increased cost due to inflation, land prices, taxes, labor, and interest.

Many multicropping systems can be more efficiently managed by utilizing no-tillage operations in crop production. The no-tillage method of producing crops consists of planting directly into an unprepared seedbed and the elimination of tillage operations through harvest. No-tillage offers producers an opportunity to reduce erosion, conserve water, reduce labor, be timely in planting, reduce production cost, increase the probability of growing two or more crops per year on the same land (Multiple Cropping), and reduce FUEL use in crop production. The no-tillage practice has become more popular during recent years because of (a) the availability of planting equipment designed to operate under unplowed stubble and/or mulched conditions, (b) the development of improved herbicide to control grass and broadleaf weeds, (c) the quality research conducted in recent years by agricultural scientists, (d) the educational efforts with field days, demonstrations, conferences, and shortcourses conducted by scientists in our state University Cooperative Extension Services, and (e) of late, the spiraling cost of ENERGY is causing producers to take a closer look at the use of excess tillage.

We initiated a coordinated program on Multicropping Minimum Tillage Systems in Florida, beginning in 1976. Numerous faculty of the Institute of Food and Agricultural Sciences at various Agricultural Research Centers and the University of Florida at Gainesville, initiated multicropping and/or minimum tillage research studies and demonstrations. We are presently completing three and four years old studies and results are beginning to become available for Florida farmers to use. Scientists located throughout the Southeast are also involved in various aspects of no-tillage. Cooperative efforts among Universities and other Federal and state agencies are increasing so that “know-how” is more readily accessible to our farmers.

This conference has been planned for extensive show-and-tell activities by scientists, governmental agencies, seed companies, fertilizer industries, chemical industries, equipment companies, other companies and dealers and by farmers. The main objective is to transfer information available on no-tillage management to farmers and those who serve farmers with particular emphasis on energy conservation.

Preparation for the "Third Annual Southeastern No-Tillage Systems Conference" has been a difficult task and several people and organizations deserve acknowledgement. I personally wish to extend special recognition to Mr. Rolland Weeks and his assistants Mr. J. David Massey, Mr. Joseph K. McCoy and Ms. Suzanne Dyal for Mr. Week's leadership and the hard work and talent they all have provided to make the conference a success.

Miss Marilyn L. Copeland is appreciated for her time devoted particularly to the typing, telephone calls and headaches associated with these proceedings. I also wish to express appreciation to Mr. Bruce A. Fritz, Ms. Edwina L. Williams and Ms. A.D. Staples for their assistance with messages and various other problems.
The Robinson Family of Williston, Mr. J. Raymond and his father Mr. R.S. Robinson deserve special recognition for aiding in carrying out this conference on their farm. Mr. Danny Stephens is acknowledged for furnishing equipment and other help in making this conference a success.

Acknowledgements are extended to all faculty, administrators, students, technical assistants, industry personnel, governmental agencies, and farmers who have supported our efforts. Listed below are other who have provided extensive support for us to carry out this conference:

Chevron Chemical Corporation
CIBA – Geigy Corporation
BASF Wyandotte Corporation
Brown Manufacturing Co.
DeKalb Agresearch, Inc.
Florida Feed and Seed Company
FMC Corporation
Gold Kist Inc.
International Minerals and Chemical Co.
Mr. Mont Brook – Morriston, FL.
Kaiser Agricultural Chemical Co.
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NO-TILLAGE SYSTEMS FOR THE THIRD ANNUAL SOUTHEASTERN NO-TILLAGE SYSTEMS CONFERENCE

The economic strength of our nation has depended heavily upon a cheap and readily available energy supply. The agricultural sector has, over the last fifty years, also become heavily energy dependent. The short supply and high cost of energy can have a devastating effect on our ability to continue producing the safe, nutritious and reasonably priced food supply needed by our citizens and for export. The escalating cost of production inputs and high interest rates are causing many farmers today to consider whether to continue farming or not.

We at the University of Florida's Institute of Food and Agricultural Sciences (IFAS) are addressing energy problems through extensive "low-energy technology' research, extension and education programs. Florida is taking a leadership role nationally in the development of low-energy technology, and IFAS is heavily committed to this effort.

New technology usually takes time to develop. However, our multi-cropping minimum tillage program is one example where we have low-energy technology ready for the farmer's use. This "No-Tillage Systems Conference" is designed to show the technology available to our farmers and the management practices that will work today. On behalf of IFAS, I welcome you to this "Third Annual Southeastern No-Tillage Systems Conference". We trust that you will gain information that will aid you in lowering energy inputs while maintaining your production needs and goals. Best wishes.

K. R. Tefertiller
Vice President for
Agricultural Affairs

FLORIDA COOPERATIVE EXTENSION SERVICE
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COOPERATIVE EXTENSION SERVICE AGRICULTURAL EXPERIMENT STATIONS
SCHOOL OF FOREST RESOURCES AND CONSERVATION COLLEGE OF AGRICULTURE

REPLY TO

STATEMENT ON NO-TILLAGE SYSTEMS FOR THE THIRD ANNUAL SOUTHEASTERN NO-TILLAGE SYSTEMS CONFERENCE

No-tillage systems, like many of the practices developed and demonstrated by IFAS, are part of our effort to insure that Florida Agriculture remains a competitive and compatible industry. No-tillage systems are a good example of technology being applied to reduce cost of production, conserve energy inputs and enhance our national drive toward greater energy independence and reduce both topsoil and water losses.

The success of our farmers in squeezing out production costs is the major reason the American public has paid so little for their food supply. Advancement of no-tillape technology should help to insure continued increases in productivity on our farms as well as the unequal contribution of the farmer to the overall productivity in our country and the world.

We believe that hiqhly reliable no-tillage systems will be essential to Florida Agriculture. Florida's dependence on petroleum energy under current technology demands our unconditional commitment to both immediate advances in productivity and material reductions in our reliance on petroleum energy.

John T. Woeste
Dean for Extension

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STATEMENT OF NO-TILLAGE SYSTEMS FOR THE THIRD ANNUAL SOUTHEASTERN NO-TILLAGE SYSTEMS CONFERENCE

Multiple cropping and minimum tillage are different but important approaches to increasing the productivity per unit of land and at the same time minimizing the amount of energy required per unit of productivity. Neither approach to production is new, but each has assumed significantly greater importance in view of the energy environment in which we live and the need to conserve energy wherever possible. The integration of multiple cropping and minimum tillage practices has even greater potential for increased production and improved efficiency in the utilization of energy. Consequently, the Institute of Food and Agricultural Sciences of the University of Florida has made significant increases in research programs in these two important areas.

IFAS' multiple cropping/minimum tillage research program is statewide with emphasis on vegetable and agronomic succession cropping systems and sod seeding interpldnt systems. Variables in this array of studies include tillage practices, weed control techniques, pest management techniques and strategies, irrigation, fertility, and various crop sequences. The results of such investigations are made available to agricultural industries in the state through a series of field demonstrations and research and extension publications.

Multiple cropping/minimum tillage research is truly a multidisciplinary research effort and as a consequence involves scientists from the commodity and discipline departments within IFAS. In addition, it does and will continue to involve very close cooperation between and among scientists located in Gainesville with scientists located at out-state research centers; our system of out-state research centers provides an ideal setting for the development and evaluation of multicropping/minimum tillage management systems. I am pleased with the research program that has been developed in this important area and am confident that with results of these and other related research programs, Florida's agriculture will continue to be competitive.

It is a pleasure to have you join us in the Third Annual Southeastern No-Tillage Systems Conference and to have the opportunity to provide to you first-hand some of the significant results of our research in this area.

F. Aloysius Wood
Dean for Research

PEST MANAGEMENT DECISIONS IN NO-TILLAGE AGRICULTURE

J. N. ALL

No-tillage (NT) systems involving corn are becoming increasingly popular in the South because of the advantages apparent with these operations. NT is especially useful in various types of multi-crop systems that take advantage of the Southern resource of a long growing season. Non-continuous types of NT in which some form of tillage is utilized in a multi-crop sequence are most prevalent. Since corn often is planted later than normal in these systems, it may be subjected to greater infestations by pests. Continuous NT procedures are not as common in the South and usually are associated with sloping terrain with high erosion potential. It is important to distinguish between the two types of NT in a discussion of pest potential because the ecosystems undoubtedly differ greatly. Thus, unless otherwise specified the present discussion is concerned with non-continuous types of NT.

The insect complex attacking corn in the South causes millions of dollars in damage annually. For example, during 1976 in Georgia insect losses and cost of control in conventionally tilled (T) corn exceeded $14 million, while losses associated with virus diseases transmitted by insects was ca. $0.2 million (Suber and Todd 1980). Economic impact of pests in NT are not available, but research indicates that most problems are comparable to T systems (All and Gallaher, 1976).

Much of the present discussion is based on research conducted over the past 6 years in over 50 experiments in Georgia in which various NT systems were compared directly with T cropping. The experiments were located in 6 areas representing the major edaphic and climatic areas of Georgia. In the tests all cropping practices (e.g. irrigation, planting date, subsoiling, insecticide, hybrids, herbicides, cropping sequence) were the same in either tillage system and the only difference was the tillage operation in T plots. Insect populations were quantified using standard sampling procedures. Also observations of pest problems were made in farmers' fields and a survey was conducted of extension personnel, commercial pest managers, pesticide and agricultural equipment distributors, and seed company representatives to assess their views on pest potential in Southern NT systems.

Soil Insects - Ecosystems are undoubtedly greatly different in NT and T systems, and the variation is probably highest near the soil surface due to the presence of debris from former crops in NT. These conditions can have variable effects on soil insects.

The lesser cornstalk borer (**LCB**), Elasmopalpus lignosellus (Zeller), is a polyphagous insect whose outbreaks in T corn are usually associated with droughty soil conditions (Dupree **1965**). **LCB** infestations are substantially

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reduced in NT systems as compared to T systems (All and Gallaher 1977). This has been observed in over 30 experiments over a 6 year period and has been observed in growers' fields. All and Gallaher 1977 pointed out that higher soil moisture occurred in NT than T systems and proposed this as a factor inhibiting survival of LCB in NT. Later research indicated that a behavioral response of LCB is involved. Movement of radiolabeled larvae in relation to corn seedlings was distinctly different in NT than in T. Larvae released 20 cm from corn seedlings quickly located the plants in the T system; seedlings in WT systems were not located for up to 7 days after release (Cheshire et al. 1977, Cheshire and All 1978).

The billbug, Spenophorus callosus Oliver, feeds on various weeds, especially nutgrass, Cyperus rotundus L., in the larval stage and attacks corn only as adults. Overwintering adults migrate into corn fields from weeded areas and may cause extensive damage, especially in fields planted early in the season (Morgan and Beckham 1960). S. callosus produces damaging infestations in NT corn, and research indicates that problems can be greater than in T systems. In a recent experiment near Midville, Ga., S. callosus damage was 32.1 infested plants/100 m row in NT as compared to 19.0 infested plants in the T plots. The field had a moderate infestation of nutgrass that was poorly controlled with planting time applications of herbicides and the higher billbug populations were associated with the weed. Insecticide applications at planting time (Durant 1975, All and Jellum 1977) and after plants emerge (All and Jellum 1977) control S. callosus infestations in T systems; these methods also are effective in NT systems (J. All unpublished data).

Other soil insects such as the Southern corn rootworm Diabrotica undecimpunctata howardi Barber, seedcorn maggot Hylemya platura (Meigen), wireworms Melanotus spp., white fringed beetle Graphognathus spp., cutworms Agrotis spp. larvae have not developed quantifiable populations in experimental plots to assess their biopotential in NT systems. Also no reports of major infestations of these insects were expressed by the persons surveyed. However, damage to corn by these insects must be of concern to entomologists, especially in continuous NT systems where soil habitats are not periodically disturbed by tillage operations.

Whorl Feeding Insects - Important insects that infest the seedling stage of corn (not discussed as soil insects) in the South include the fall armyworm Spodoptera frugiperda (J. E. Smith, armyworm Pseudaletia unipuncta (Haworth), corn earworm Heliothis zea (Boddie), European corn borer Ostrinia nubialis (Hubner), and the Southwestern corn borer Diatraea grandiosella Dyar). Observations of all these insects in Georgia indicate that greatest damage can be anticipated in late corn plantings such as certain multi-crop systems involving NT (All and Gallaher 1976).

Infestations of fall armyworms are a major threat to corn in NT multi-crop systems and are a factor that may limit the potential of certain of these systems in the South. Research indicates that tillage systems have little impact on development of fall armyworm infestations (All and Gallaher 1976). Close inspection of corn in experiments comparing NT and T systems at various planting dates demonstrated that heavy infestations often occur in both cropping systems planted after mid-May. Oviposition and larval populations on 2-4 leaf stage seedlings developed more rapidly in T plots,, but populations and damage were similar in 5-leaf stage plants. Yield losses were comparable in either system. Efficacy of foliar insecticides was similar in either tillage system (J. All unpublished data).

Severe armyworm damage has been reported in late planted NT systems (Wrenn 1975) and damage from the other whorl feeders should be of concern in certain cases. However, our research indicates that the damage potential of these insects is not enhanced in NT as compared to T.

Stalk and Ear Feeding Insects - Many insects that attack these growth stages in the South are also major pests in Northern states. However, their reproductive potential often is enhanced in the warmer Southern climate. For example, first generation European corn borer damage early planted corn while second and third generation larvae infest corn of later planting dates. Our research indicates that European corn borer infestations are similar in NT and T systems. However, infestations were increased in late plantings and these often are associated with NT practices in multi-cropping sequences. We also noted a reduction in the number of infested and lodged plants in irrigated plantings (both NT and T) as compared to nonirrigated plants (All and Gallaher 1976). Low infestations of South-western cornstalk borers were observed in Northwest Georgia during 1976-1979. Whorl feeding and stalk borer damage were similar in either tillage system (J. All unpublished data).

We have observed corn leaf aphid, Rhopalosiphum maidis (Fitch), infestation of corn tassels in NT and T plots. In two experiments, extensive sampling in fields with moderate johnsongrass populations (significantly higher in NT than T) revealed that aphid colonization of corn tassels was higher in T (4.0 x 10 colonies/ha) than NT (2.7 X 10 colonies/ha) plots. However, many johnsongrass plants had colonies and if these are coupled with the aphid populations on corn, the overall number of colonies in NT was 3.5 x 10 colonies/ha as compared to 4.5 X 10 /ha in T. Thus in this case, the increased plant diversity of NT had a dilution effect on an insect population infesting corn. In certain experiments substantially higher populations of a spittle bug, Prosapia sp., have been observed in NT as compared to T plots. However, the numphai feeding on brace roots caused no apparent damage to plants.

Corn earworm and fall armyworm infestations in corn ears in NT parallels damage in T systems. Populations of both species were greater in plantings associated with multi-cropping and delayed corn planting dates. Damage by fall armyworm is especially severe in late planted corn with as many as 6 larvae causing complete destruction of some ears. Sampling indicated that damage was reduced in irrigated as compared to non-irrigated plots in both NT and T (All and Gallaher 1976).

Other insects associated with corn ears prior to harvest include sap beetles (Nitidulidae), maize weevil complex (Sitophilus spp.), Tenebrionidae, and Angoumois grain moth (Sitotroga cerealella Oliver)), and these are serious problems in the South. Infestations initiated in the field by these species increase in stored grain (Floyd 1971). Also, these pests may be implicated in distributing grain-infesting fungi such as Aspergillus flavus that produce mycotoxins in stored grain. Field infestations of certain of the stored grain insects may be increased in certain NT systems where corn is grown in the stubble of small grains. These insects are found in unharvested grain and data suggests that populations move into corn prior to harvest (J. All unpublished data).

Heavy populations of the ring-legged earwig, Euborellia anntrlipes (Lucas), were observed in NT corn ears; significantly more infested ears were sampled in NT plots (All and Gallaher 1976). These insects are not normally considered pests of corn, but they can produce damage to grain. Feeding near the tip of ears on the basal portion of the pericarp of kernels loosens the grain so that it is easily detached. All life stages were observed and as many as 10 individuals were counted in ears.

Epidemiology of Corn Virus Diseases - Research indicates that two virus diseases, maize chlorotic dwarf (MCD) and maize dwarf mosaic (MDM), are greater in certain NT systems (All et al. 1977, 1980). Leafhoppers transmit MCD in corn; the blackfaced leafhopper, Graminella nigrifrons (Forbes), is a major vector (Nault et al. 1973). Several aphid species transmit MDM, including the corn leaf aphid (Williams and Alexander 1965).

The epidemiology of the diseases is complicated by the fact that both viruses infect a variety of grasses including weeds (e.g. large crabgrass, Digitaria sanguinalis (L). Scop., and johnsongrass, Sorghum halepense (L.) Pers.) and small grains (e.g. winter wheat, Triticum aestivum L.) (Nault et al. 1976). Johnsongrass is the only known perennial host of the pathogens and in many areas it is an important factor in the spread of disease by acting as a reservoir of inoculum for vector transmission to corn (Damsteegt 1976).

We found that MCD and MDM were enhanced in NT as compared to T when johnsongrass was poorly controlled by the herbicides paraquat and atrazine (All et al. 1976). Data from these and other studies suggests that early season control of johnsongrass is very important in reducing disease in corn. Severity of the diseases is greater to young plants (Scheifele 1969), and thus the presence of even low populations of johnsongrass in fields when corn germinates greatly increases early season transmission by vectors. Recent tests showed that the herbicide glyphosate effectively controls johnsongrass in CT with corresponding reduction in disease (J. All unpublished data).

Optimum pest management of MCD and MDM involves integration of several control strategies to suppress the various factors involved in spread of the diseases (All et al. 1980). Vectors of MCD are susceptible to systemic insecticides (e.g. carbofuran) and hybrids are available that have disease resistance (Kuhn and Jellum 1975, Pitre 1968, Kuhn et al. 1975, All et al. 1976). Use of a resistant hybrid with a systemic insecticide was effective in controlling leafhoppers and decreasing MCD in NT. Grain yield was increased by up to 2333 kg/ha (All et al. 1977). Recent research in NT systems showed that an integrated chemical control approach using a systemic herbicide (glyphosate) to control johnsongrass plus a systemic insecticide (carbofuran) was highly effective (J. All unpublished data).

In summary, insect potential in NT systems in the South varies with the species involved and the type NT method. In general, non-continuous NT systems that have some form of tillage operation within a 1 or 2 year cropping sequence do not appear to develop greater insect infestations than T systems planted at the same time. However, certain insects such as billbugs produce greater damage in NT and concern must be shown for corn virus disease problems in NT systems where johnsongrass populations exist. Conversely, NT has control potential for lesser cornstalk borer. Obviously the environment that develops in NT systems differs greatly from T cropping, and the influence of these ecosystems on the biology of pest insects must be studied on an individual basis. Research indicates that standard control methods can be used in NT systems, but increased effort is needed in refining chemical application methodology for NT. Also, efforts in developing integrated pest management systems need to be expanded for NT.

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MINIMUM TILLAGE - ONE COUNTY AGENT'S VIEWPOINT

JOHN A. Baldwin[1]

Each year in Levy County, numerous acres planted to corn and other crops are damaged or destroyed by high winds and blowing soil traveling across young stands of agronomic and vegetable crops. In some years, soil erosion due to wind not only damages crops by "sand blasting" but at times even reduces herbicidal activity by disturbing treated pre-emergence areas.

Our deep sandy soils also lend themselves to leaching of nutrients as well as compaction problems which potentially restrict root growth. Continous tillage of row crop land by discing, harrowing and plowing have created serious compaction problems in some of our deep sandy soils at depths of six to twelve inches. Evidence of this has been demonstrated by subsoiling two to three inches below this compacted zone and comparing plant growth and yield to conventionally tilled land.

In essence, as a County Agricultural Agent, it is important to keep abreast of the latest technology and innovations in cropping systems and tillage equipment. Inflationary times and increasing fuel costs have increased the unit cost of production. Methods are needed to reduce unit costs while maintaining or increasing current production to make row crop production economical. Over production may create marketing problems by reducing prices paid to growers, but it will be up to producers to limit or restrict the acreage planted in order to influence supply and demand. Economical and efficient production practices are needed to maintain an economically sound agriculture for Florida.

To utilize minimum tillage, a producer must evaluate his own set of conditions on his farm. Soil types, crop rotations, managerial abilities and other resources must all be evaluated.

The major advantages of minimum or reduced tillage have been demonstrated to be; reduction of soil erosion, energy conservation, less soil compaction, improved timing of crop establishment and planting and in some instances, reduced machinery investment.

Some major disadvantages have also been observed. When corn is planted in February or possibly Early March, soil temperatures may remain lower during extended periods when a mulch system of minimum tillage is used. Cold, wet soils may inhibit germination or early season root growth. Insects, particularly soil insects such as cutworms, may be more prevalent when heavy mulches of winter cover crops are used. Also, producers will need to put their best managerial ability together because there is less room for error under minimum tillage systems, particularly under mulch systems of minimum tillage. More reliance is

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needed on herbicides for weed control programs. Proper liming of soils for optimum herbicide activity, timing of spray applications, proper calibration of equipment and the potential use of directed sprays need to be included in the management plan.

Producers should be cautioned to start on a small scale until sufficient experience is gained. They should also attend shortcourses, seminars, demonstrations and field days to see and learn of multi-cropping, minimum tillage systems.

It is a package approach. We do not want to plant into a weed field. Plan through your County Extension Agent before implementing mimimum tillage practices. A management plan to fit your particular farm and resources will be needed. Planning before implementation of new farming methods reduces chances of failure and insures proper scheduling of production activities. Calling your County Agent when problems occur because of poor planning often results in no recourse for a solution. The cropping system and method of tillage should be well planned and fit to the individual farm and management regime. The planting and management of the succeeding or previous crop may be just as much or more important than the current crop being grown under minimum tillage methods. Subsoiling may not be needed in all instances, and fields should be inspected as to need for subsoiling prior to planting. The subsoiling will require more fuel and horsepower than doing strictly no-till plantings. Proper weed identification and mapping of fields are extremely important in the selection of proper herbicides for a given situation. A working knowledge of minimum tillage practices is needed by County Agents. It is essential that the agent make available to the producer the most current information on minimum tillage.

Weather conditions affect our yields regardless of the cropping system being used. The weather causes our greatest risk in row-cropping today. We cannot control weather patterns but the use of minimum tillage in many situations may help insure better growing conditions and reduce adverse effects such as soil erosion, leaching of nutrients, inadequate moisture at planting time, drought stress of crops, labor problems and time.

As multiple cropping systems are put into practice by producers, more intense use of available land will occur.'. As energy costs increase, minimum tillage systems will fit more and more into the picture of modern day agriculture.

Minimum Tillage acreage has increases since 1978, in Levy County. Corn, Soybeans and Grain Sorghum have been planted following winter rye and the prior years' crop residues by minimum tillage methods. Several thousand acres of pines have been clear cut in the past three years. This will increase the potential of crop damage by wind erosion. Also, energy costs are affecting our ability to irrigate economically. Minimum tillage practices should help to reduce both wind erosion and soil moisture losses. Again, we must learn to fit this system of cropping to our land and management, keep current on production practices, and remember that a total management plan is needed to insure the best use of capital and other resources.

BREEDING SMALL GRAINS: MINIMUM TILLAGE AND ENERGY IMPLICATIONS

R. D. BARNETT, P. L. PFAHLER, AND H. H. LUKE

Wheat, oats, and rye along with the clovers and ryegrass are used as the winter annual components of many multiple cropping systems commonly used in the southeastern United States. They can be used as forage or grain crops, green manure, and cover crops, or as a weed suppressing and moisture holding mulch for summer row crops. Small grains require relatively low levels of input in the way of energy requiring fertilizers and pesticides. They are able to utilize much of the nitrogen fixed by leguminous summer annuals, such as soybeans and peanuts, that might be lost by leaching during the winter months. They also are very efficient in the utilization of residual fertilizers which have been applied to row crops. Small grains do require fertilization but not nearly as much as most summer annual grass or vegetable crops.

Small grains do not require nematicides or insecticides because these pests are relatively inactive during the growing season of the small grains. Also, they do not require herbicides because very few winter weeds are able to compete with them.

There are three methods of establishing a small grain crop: 1) prepared seedbed, 2) sod seeding into permanent pasture, and 3) aerial seeding into standing crops. The prepared seedbed method is the best and most widely used, though more costly. The major problem in sod seeding small grains into summer grasses is that the summer grass is vigorously growing at the ideal planting time for small grains. The summer grass must be grazed very closely in order to obtain an acceptable stand of small grains. Sod seeding is usually more successful with ryegrass or clover since their growing season does not overlap that of the perennial grass.

Aerial seeding is growing in popularity because it is cheaper, easier, and faster than conventional methods and can be done into a number of crops but works best in soybeans. The seed are disseminated from the air just as the soybean leaves start to turn yellow, then the leaves fall covering the seed. This works very well with adequate moisture but does not work well during dry falls. It works best with the later-maturing soybeans since their leaf fall comes at the optimum time to seed small grains. This system is used quite extensively in the southeast for seeding rye and ryegrass for winter-grazing.

Diseases are a major limiting factor to small grain production in Florida because the mild winters are extremely favorable for the maximum development of plant diseases. Minimizing the losses to disease requires an integrated approach that includes crop rotation, deep plowing, timely planting, variety selection, and fungicides. Crop rotation is especially important

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in the case of wheat because several serious diseases build up if wheat is grown on the same area year after year. Turning the soil, although rather expensive and requiring high energy, would help reduce the initial inoculum of several wheat diseases if wheat had recently been grown on the same area. This practice reduces weed problems for the following summer crop since many of the weed seed are buried. Also, any potential problem that might be caused from a herbicide used on the previous summer crop would be reduced since the herbicide residue would be diluted into a larger volume of soil.

Fungicide seed treatments are a cheap way to avoid potential germination problems. If the seed are not of top quality, seed treatment will often improve germination and insure a better stand. Seed treatments are especially useful when planting in early fall when temperatures are high and seedling diseases are active. Seed treatments are helpful late in the season when the temperatures are rather low and germination is slow. When the seedlings are below the soil surface over a long time period, they are more susceptible to attack by seedling diseases.

Wheat is the most versatile of the small grains. It can be used as a grazing, silage, hay, greenchop, green manure, or mulch crop. It can also be used as a feed grain and most importantly as a food crop. The type of wheat grown in the southeast is soft red winter wheat. The flour from this type of wheat is not used in bread but is used in cakes, cookies, donuts, crackers, etc. High quality soft red winter wheat should be low in protein and have a high test weight. Excess nitrogen fertilization will cause the protein content to be too high and results in poor quality wheat.

Diseases are one of the major limiting factors in wheat production. Leaf rust, septoria glume blotch, and powdery mildew are all capable of causing substantial yield losses and must be controlled either by the use of resistant cultivars or fungicides. It is important in wheat production to adopt new cultivars as soon as they become available because after a few years new races of disease organisms develop and cause severe damage to the new cultivars.

Increased wheat acreage in the southeastern United States has resulted in sharp yield reductions caused by lack of rotation and seedborne infestation by Septoria nodorum **(13).** Our observations and those of others indicate that infested seeds are a major source of inoculum (10, 13) that might be reduced by foliar fungicide applications (9) and by seed treatments. Other work with fungicides has shown that yield increases may be obtained when fungicides are used properly (3, 4, 8).

Planting late in the season reduces the damage caused by several important pest of wheat, septoria, powdery mildew, and hessian fly. Some of the new early-maturing cultivars of wheat perform well from later planting and they fit into the multiple cropping systems better than the later-maturing cultivars.

All small grains provide excellent winter pasture but there are marked differences among species and cultivars in their forage production. Under a monthly clipping schedule, rye yields considerably more forage than the other small grains (11). When used as a silage or hay crop, oats perform better than the other small grains (2). Rye produces more forage early in the season, whereas oats and wheat produce most of their forage later in the season.

There are also differences between cultivars in their season of forage production. For example, Florida 501 oats produces significantly more forage than Coker 227 in the fall but the reverse is true for spring forage production. Oats can be planted about one month earlier in the fall than rye or wheat because oats have more resistance to seedling diseases, and are more tolerant of heat stress.

Rye is well suited to many multiple-cropping systems involving corn, peanuts, and vegetables and especially those that require the small grain be removed early as forage. Rye is better adapted than the other small grains to infertile, sandy, acid soils and will produce a good crop with less fertilizer. Rye grows at lower winter temperatures than the other small grains. It makes an excellent mulch for no-till corn and is easily killed by herbicides.

The breeding program on rye is centered on leaf rust resistance and forage production. Attempts to select types that have resistance to seedling disease are being made. Hopefully these types can be planted earlier in the fall. Tetraploid ryes that should do the same for rye production as tetraploid ryegrass has the ryegrass production are being developed. The tetraploids have larger seed and normally grow more vigorously than the diploid cultivars. The tetraploids develop early and remain vegetative longer in the spring than the diploid, and therefore, increase the length of the forage production season.

A screening program for rye is in progress to develop types that can be planted earlier for forage production. This has been done by planting the rye one month before the earliest recommended date, mowing the plots regularly during the winter, and then bulk harvesting the surviving plants. A number of single plant selections were made in 1979 after 5 cycles had been made. These will be increased and tested to determine if progress has been made in the development rye that can be planted earlier.

Triticale, a synthetic crop derived from wheat x rye hybrids shows promise for forage and feed grain production. Most of the research done with this crop has been done during the last ten years. In clipping trials, triticale produced less forage than rye but more than wheat in Florida (1). It is equal to rye and wheat as a spring silage crop but is inferior to oats (2). and is equal to or better than rye and wheat as a grazing crop (6). In Georgia, triticale has been found lacking in winter-hardiness and forage production (7). Progress has been made in improving grain quality and in developing shorter, earlier maturing, higher yielding types. New cultivars recently tested in Georgia (12), Alabama (14), and Florida (5) had higher grain yields than the best cultivars of the other small grains. The first cultivar developed in the southeast was released during 1979 by Alabama A & M University (15). A number of cultivars have been released in Texas. Only a limited amount of triticale has been grown in the southeast.

Triticale produces vigorous, robust plants that are impressive in appearance and yield better than the other small grains under stress conditions of limited moisture or high temperatures. It has large seed which are less dense than wheat. Slightly higher seeding rates may be required for triticale. Triticale seems to have fewer disease problems than wheat and is somewhat difficult to thresh. It appears to have some potential in minimum tillage, low energy applications but has a marketing problem since there are no regular marketing channels for triticale. Initial use will probably be restricted to the farms where it is produced.

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CONSERVATION OF ENERGY IN NO-TILLAGE SYSTEMS BY MANAGEMENT OF NITROGEN

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Energy conservation is a major concern and priority in agriculture today. The inputs of fertilizers, pesticides, and fuels in crop production have increased rapidly in recent years and farming is now a very energy dependent industry. About 80 percent of the energy used by agriculture is from liquid petroleum fuels and natural gas, which makes efficient use of energy in agricultural production even more important. No-tillage systems of crop production are one alternative for conserving energy. Conventional tillage of corn and soybeans requires large amounts of fuel in plowing and disking operations. Part of the fuel saved in no-tillage due to fewer trips across the field is offset by slightly higher amounts of herbicides and, in some cases, higher rates of N fertilizer used for no-tillage corn production.

The greatest single energy input into corn production is nitrogen fertilizer, representing almost one-half of the total energy input for no-tillage corn. Conclusions from earlier work in Kentucky (Thomas et al., 1973; Blevins et al., 1977; M. S. Smith, Univ. of Ky., personal communication) which are pertinent to the N status under no-tillage compared to conventional tillage include the following associated with no-tillage:

- ---Higher soil water content at the beginning of any particular rainfall event
- ---Greater preservation of large soil pores by lack of tillage
- ---Slower rate of organic matter decomposition
- ---Less mineralization of N
- ---Higher immobilization of N.

These factors resulted in lower plant available N under no-tillage during the growing season due to higher leaching loss of NO_3^-, slower N release from organic matter and greater immobilization. These results led to recommendation of higher rates of N fertilizer for no-tillage corn production than for conventional tillage. But, more recent comparisons of yields of no-tillage and conventional tillage corn (Frye et al., 1978) showed a greater response to N fertilizer, higher yields at higher N rates, more efficient use of N fertilizer, and a lower input:output ratio of energy with no-tillage.

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The investigation reported in this paper (No. 80-3-86) is in connection with a project of the Kentucky Agricultural Experiment Station and is published with approval of the Director.

In this paper, we discuss the response of no-tillage corn to N fertilizer, compare the N efficiency in no-tillage and conventional tillage systems, and suggest better ways to manage nitrogen in no-tillage corn production. By improved management of nitrogen, energy is conserved or used more efficiently.

Response to Nitrogen Fertilizer

A summary of corn yields from a long-term no-tillage and conventional tillage experiment is presented in Table 1. On plots where no nitrogen was applied the 10-year average corn yield was 76 bu/acre for no-tillage and 95 bu/acre for the conventional tillage treatments. We conclude that a combination of greater leaching losses, a slower rate of mineralization and more immobilization of N resulted in lower yields and plants showing more severe N stress during the growing season in no-tillage. Nitrogen rates above 75 lb/acre resulted in slightly higher grain yield for no-tillage compared with conventional tillage. The lower yields with no-tillage at low levels of N fertilizer and higher yields at higher rates of N fertilizer are similar to results reported by Bandel et al., 1975 in Maryland and Moschler et al., 1974 in Virginia.

In our experiments (Table 1), highest yields were obtained during the second and third years (1971 and 1972). Both of these years had a very favorable distribution of rainfall for corn, whereas the first year (1970) had low rainfall during the growing season. The high yield with no nitrogen fertilizer is evidence that the soil initially had a high potential for soil nitrogen mineralization. Yields produced in the tenth year (1979) were comparable to the 10-year average, except for the observed yield decrease in the zero nitrogen treatment of conventional tillage. This suggests that corn yields can be maintained over a long period of time in no-tillage as well as conventional tillage.

A comparison of yields on the Maury soil *to* yields on other well-drained soils in Kentucky is shown in Table 2. Yields from no-tillage and conventional tillage receiving 150 lb N/acre showed the highest yield increase for no-tillage on the Crider silt loam soil. The Crider is a deep, well-drained soil developed in residuum of limestone with a thin layer of loess at the surface. The well-drained to moderately well-drained sloping soils with moderate porosity seem best suited for no-tillage systems in Kentucky. No-tillage on soils with high water table or slow internal drainage often results in lower yields of corn than conventional tillage. This is related to increased wetness due to the surface mulch and cooler temperatures at planting time, which contribute to lower plant stands, the development of stress conditions during early stages of growth and, perhaps, denitrification loss of N.

Table 1. Summary of corn yields from limed plots on a Maury silt loam soil at Lexington, Ky. with different levels of nitrogen and no-tillage and conventional tillage systems. (Yields from unlimed plots omitted for brevity.)

Year	Tillage system	Nitrogen applied as NH_4NO_3 (lb/acre) 0	75	150	300
		bu/acre			
1970	NT[†]	90	99	99	105
	CT[†]	91	90	90	90
1971	NT	99	166	170	173
	CT	151	180	159	162
1972	NT	118	153	149	155
	CT	130	161	159	165
1973	NT	66	119	126	121
	CT	66	123	129	135
1974	NT	89	154	165	167
	CT	129	162	163	162
1975	NT	60	97	100	106
	CT	78	80	82	96
1976	NT	69	144	156	170
	CT	85	129	141	141
1977	NT	58	106	109	115
	CT	88	123	127	132
1978	NT	33	78	85	99
	CT	67	100	97	100
1979	NT	73	118	123	121
	CT	68	130	124	123
10-year Ave.	NT	76	123	128	133
	CT	95	128	125	131

[†]NT = No-Tillage; CT = Conventional Tillage.

Table 2. Average corn grain yields produced on well-drained soils in Kentucky by no-tillage and conventional tillage systems with 150 lb/acre N.

	Number of year tested	Grain yields No-tillage	Conventional tillage
		bu/acre	
Maury silt loam	10	128	125
Crider silt loam	5	158	133
Allegheny loam	3	175	174

Nitrogen Efficiency

Table 3 shows the N fertilizer efficiency[1/] values for the yield responses to each 75-lb increment of the 75- and 150-lb rates of N fertiliz'er for no-tillage and conventional tillage corn on the Maury soil at Lexington which was shown in Table 1. Grain yields from each pound of N fertilizer of both increments were greater for no-tillage than conventional tillage, This may be somewhat misleading with regard to the first increment, since the average yields with both the 0 and 75 lb/acre N treatments were lower for no-tillage plots than for conventional tillage (Table 1). But the efficiency values in Table 3 are based on increases in yield resulting from the added nitrogen fertilizer. If one looks at the yield response in Table 1 together with the N fertilizer efficiency values in Table 3, the results suggest the need for slightly more N fertilizer to obtain maximum yields in no-tillage; however, the nitrogen fertilizer is used more efficiently. The more efficient use of nitrogen in no-tillage corn is probably due to the soil moisture conserved by no-tillage.

Table 3. Efficiency of nitrogen fertilizer in no-tillage and conventional tillage corn grown on Maury soil at Lexington, Ky. (Based on 10-year average yields.)

N fertilizer applied	lb grain/lb N[†]		BTU in grain/BTU in N[‡]	
	No-till	Conventional	No-till	Conventional
1st 75 lb/acre	35.1	24.6	9.5:l	6.7:l
2nd 75 lb/acre	3.7	-3.7	1.0:l	-1.0:l

'Calculated by subtracting yield without N fertilizer from yield with N fertilizer and dividing by incremental amount of N fertilizer applied, in this case, 75.

'6,800 BTU/lb corn grain; 25,000 BTU/lb N.

Using a value of 25,000 BTU/lb of N, each lb is equivalent to less than one quart of gasoline (145,000 BTU/gal) or about one pint of diesel fuel (207,000 BTU/gal). Therefore, to realize the full effects of no-tillage on energy conservation, it must be viewed in terms of improved energy input:output ratio associated with higher crop yield or greater N efficiency. Table 3 shows the N fertilizer efficiency values converted to energy input:output ratios. They do not represent direct energy savings but represent more efficient use of energy in no-tillage crop production. No-tillage itself results in direct energy conservation through less fuel consumption than conventional tillage. These data point out that the energy saved with reducing tillage operations is not lost in additional N fertilizer that may be recommended for no-tillage corn.

[1/] N fertilizer efficiency as used in this paper is grain yield with N fertilizer minus grain yield without N fertilizer.

Effect of N Fertilizer Management Practices

Certain N fertilizer management practices may result in direct energy savings or more efficient use of energy in no-tillage systems. These practices may provide the N efficiency necessary to allow the farmer to use no-tillage and obtain the energy conservation benefits associated with it without requiring more N fertilizer to maintain yields equal to or greater than conventional tillage.

As pointed out previously, loss of NO_3^- by leaching during the growing season was greater under no-tillage than under conventional tillage (Thomas et al., 1973). N may be lost also by denitrification when soil moisture remains above field capacity for periods of several days where easily oxidized organic matter is present. These conditions often occur under no-tillage on soils with sticky clay subsoils or on soils with fragipans that retard internal water movement. To avoid these losses, a split application or delayed application of N fertilizer 4 to 6 weeks after planting has become an accepted and useful management practice in Kentucky. Table 4 shows the results from a study of the optimum application of N fertilizer for corn on a well-to moderately well-drained, slowly permeable Hampshire silt loam soil. The delayed application of 150 lb/acre N as ammonium nitrate gave significantly higher yields. Yields, N fertilizer efficiency, and energy efficiency are favored by delaying the N fertilizer on soils with slow permeability.

Table 4. Effect of time of nitrogen application as ammonium nitrate on no-tillage corn production on a Hampshire silt loam soil in Franklin County, Ky.

		Efficiency of N fertilizer	
N applied (lb/acre)	Yield (bu/acre)	lb grain/ lb N added†	BTU in grain/ BTU in N‡
0	75	-	-
150 at planting	104	10.4	2.8:1
150 delayed 5 weeks	131	20.5	5.6:1
75 at planting + 75 delayed	135	22.0	6.0:1

†Calculated by subtracting yield without N fertilizer from yield with N fertilizer and dividing by the amount of N fertilizer applied (150).

‡6,800 BTU/lb corn grain; 25,000 BTU/lb N.

Losses of N by leaching and denitrification are likely to be greater early in the cropping season in Kentucky, accounting for the beneficial effects of delaying application of N fertilizer. Fertilizer recommendations in Kentucky state that rates of N fertilizer can be decreased by 35 lb/acre N, if as much as two-thirds of the N is delayed 4 to 6 weeks for no-tillage corn on moderately well-drained soils and for conventional tillage corn on moderately well and poorly drained soils. The N saved by this practice represents about 875,000 BTU of energy or about 6 gal of gasoline per acre. It should be pointed out, however, that the N recommendation on soils with impaired drainage is 50 lb/acre more than on well-drained soils if the N fertilizer is all applied at planting. Thus, even with delayed application, at least 15 lb/acre more N is recommended for soils with impaired drainage as a safe-guard against the greater potential N loss.

An additional management practice recommended for no-tillage corn production on wet soils is delaying planting for 2 to 3 weeks later than the recommended planting date for conventional tillage corn. This practice usually results in a better stand of plants and allows application of N fertilizer after the soil has dried out but before N demand is high in the crop.

A nitrification inhibitor, nitrapyrin,[2/] sprayed onto granules of ammonium nitrate fertilizer which was broadcast on the soil surface substantially increased yields of no-tillage corn in experiments over several years at several locations in Kentucky (manuscript in review). Yield increases ranged up to 46%, depending on soil and weather conditions. The increased N fertilizer efficiency achieved by inhibiting nitrification also would represent considerable energy efficiency.

Another approach to energy conservation through N fertilization is to provide N to the no-tillage corn crop by growing winter-annual legumes as cover crops. Winter cover crops included in this research in Kentucky are hairy vetch, bigflower vetch, crimson clover and rye. Preliminary results show that the legumes can provide substantial amounts of nitrogen for no-tillage corn, with hairy vetch being more effective than the others. In 1979, grain yields on plots with hairy vetch but with no N fertilizer were statistically equal to yields on other plots with 88 lb/acre N fertilizer added, N fertilizer conservation of such a magnitude would represent considerable conservation of energy.

Summary

No-tillage production of corn requires considerably less tractor fuel than conventional tillage, but N management is more critical due to slower mineralization, higher immobilization and potentially greater losses by leaching and denitrification of NO_3^-. More N fertilizer may be recommended for no-tillage corn, but the N is usually more efficient, producing more grain/lb of N than under conventional tillage. Several N management practices have been shown to improve N efficiency in no-tillage experiments in Kentucky, thus contributing to energy conservation. These practices include delaying N fertilizer application for 4 to 6 weeks after planting corn, growing winter-annual legumes as cover crops for no-tillage corn, spraying a nitrification inhibitor (nitrapyrin) onto N fertilizer granules, and delaying planting on wet soil until it has dried out and the potential for denitrification has diminished.

[1/] Nitrapyrin, 2-chloro-6(trichloromethyl) pyridine, is manufactured by Dow Chemical U.S.A., Midland, Mich.

These management practices along with the generally more efficient use of N fertilizer in no-tillage allow farmers to obtain the energy conservation associated with fuel savings in no-tillage due to fewer trips across the field without having this advantage negated by application of higher rates of N fertilizer. Through efficient N management no-tillage can be both a direct and indirect energy conserving practice, and yields equal to or greater than conventional tillage can be maintained.

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DOUBLE CROPPING SOYBEANS SUCCEEDING SOYBEANS IN FLORIDA

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INTRODUCTION

Growing two crops during the warm season is possible in much of Florida where soil temperature is adequate and the frost-free period exceeds 240 days. Soybean (Glycine max L. Merr,), because of its photoperiodic sensitivity, is usually planted as the second crop, either after a cool season cereal or after a warm season crop such as vegetables, melons, or early maturing corn (Zea mays L.) in Florida (Guilarte et al., 1975; Prine et al., 1978; Gallaher et al., 1979). However, experiments in Florida by Boote (1977, 1980) demonstrated that early maturing soybean cultivars can be planted in March for maturity in late June, with sufficient time to plant a second warm season crop, such as adapted late-maturing soybeans (Guilarte et al., 1975; Prine et al., 1978; Akhanda et al., 1976).

In order to produce two soybean crops per year, the first crop must be planted early to a cultivar from early maturity groups (less than group V) so the crop will progress rapidly into seed growth and mature by late June (Boote 1977, 1980). The optimum Maturity Group (MG) for the first crop was Group III, although Groups II and IV were acceptable. When planted in March, cultivars of MG V through VIII were induced to flower by the initially short days, but the accelerating daylengths delayed subsequent reproductive development and delayed maturity until September-October (Boote, 1977, 1980). Thus planting a second soybean crop was not feasible after MG V, VI, VII, VIII and later cultivars. Long photoperiods after flowering have been shown to prolong post-flowering development and reduce partitioning of dry matter to seeds (Johnson et al., 1960; Lawn and Byth, 1973; Raper and Thomas, 1978; Thomas and Raper, 1976). Hartwig (1954) observed flowering at 49 and 41 days after emergence for MG VI and VII cultivars planted April 10 at Stoneville, MS (latitude 33^0 20' N), but reported that the plants aborted nearly all early flowers and matured in October.

In addition to cultivar selection, March-planted early maturing soybeans may encounter several other problems including the hazard of late frosts and cool soil temperature which causes slow emergence and reduced early growth (Hartwig, 1954). When planted in lower latitudes including Florida, early maturity groups flower early, are short, and set their pods lower (Whigham and Minor, 1978; Boote, 1977). Incomplete canopy cover can be overcome by planting in narrow rows, but low pod set remains a more challenging problem.

This paper addresses the feasibility of double cropping soybeans succeeding soybean. Specific objectives were to evaluate soybean cultivars in a range of Maturity Groups for yield, reproductive development, and suitability as the first crop in double cropping systems or as the second crop in double

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cropping systems in Florida, and to evaluate row spacing, planting methods, and other cultural practices needed to grow two soybean crops per year in Florida.

MATERIALS AND METHODS

First Crops: Soybeans were grown during the spring seasons (1976–1979) at the University of Florida Agronomy Farm, Gainesville, FL (Latitude 29° 40' N). The soybean cultivars and planting dates are listed in the Tables. The soil type in the experimental areas was Kendrick sand, a loamy, siliceous, hyperthermic Arenic Paleudult in 1976, 1978, and 1979; and a Eainesville sand, a hyperthermic, coated Typic Quartzipsamment in 1979. Soil pH was at recommended levels or corrected by preplant dolomite addition. Fertilizer (40 kg N, 35 kg P, and 133 kg K) was incorporated before planting the first crop. The fields were plowed and disked prior to planting. Agricultural chemicals are given as active ingredients per hectare. Nematode control was furnished in 1976 and 1977 by injecting 26 kg/ha of 1,2-dibromo-1-3-chloropropane. In 1978, fenamiphos (ethyl-3-methyl-4-(methylthio)phenyl (1-methylethy1)phosphoramidate) was disked in at 7.5 kg/ha. No nematocide was used in 1979. Weeds were controlled with pre-emergence herbicides: in 1976, 2.2 kg/ha alachlor (2-chloro-2', 6'-diethyl-N-(methoxymethy1) acetanilide) and 2.5 kg/ha dinoseb (2-sec-butyl-4,6-dinitrophenol, in 1977, 1.3 kg/ha benefin (N-butyl-N-ethyl-*a*, a,a-trifluoro-2,6-dinitro-p-toluidine), 2.6 kg/ha vernolate (S-propyl dipropyl thiocarbamate), 2.2 kg/ha alachlor, and 2.8 kg/ha dinoseb; in 1978, 1.3 kg/ha benefin; in 1979, 1.3 kg/ha benefin, 2.2 kg/ha alachlor, 2.2 kg/ha naptalam (N-1-naphthylphthalamic acid), and 1.1 kg/ha dinoseb. Moderate herbicide injury, probably from vernolate, was observed in 1977. Foliar feeding insects were not a problem; however, 0.5 kg/ha of methomyl (S-methyl-N-((methylcarbamoy1)oxy) thioacetimidate) was applied 25 May 1976 for an infestation of southern green stinkbug (Nezara viridula L.). Plots were irrigated to supplement rainfall during the season.

The experimental design was a randomized complete block. Replications numbered three, six, four, and four in 1976 through 1979, respectively. Seeds were planted in 31-cm rows in 1976 and 1977, 25-cm rows In 1978, and 35-cm rows in 1979. Seeding density ranged from 56 to 64 seeds/m^2. Each plot consisted of five or six rows 5 m long of which the center three or four rows were harvested for yield.

Reproductive development of cultivars was observed as days from emergence to R1 (50% of plants having one flower), R4 (50% having a 2.0 cm long pod anywhere on the plant), R5 (50% having detectable bean swelling in any pod), and R8 (95% of the pods at mature color). The reproductive stages differ slightly from those of Fehr et al (1971) and Fehr and Caviness (1977) in that R3, R4, and R5 stages pertain to pods at any node on the plant rather than at the top four nodes having fully-expanded leaves.

The soybeans were hand-harvested a few days after reaching R8 maturity, warm air-dried, and threshed. Yield of clean seed per plot was based on harvested areas (bordered middle rows) of 4.46 m^2 in 1976 and 1977, 4.34 m^2 in 1978, and 5.12 m^2 in 1979. Average height to tip of main stem was measured at maturity. Seed quality was rated on a scale of 1 (very good) to 5 (very poor). Weight per 100 seeds was determined. To estimate combine harvestability, at least 50 cm of bordered row was cut into two segments; soil line to 8 cm, and above 8 cm. Individual segments were threshed separately and percent seed weight below 8 cm height was determined. All data on reproductive development and yield characteristics were subjected to analysis of variance. Cultivar means were compared by the new Duncan's Multiple Range test. The error term was the cultivar by replication mean square.

Second Crop: The second crop 'Cobb' soybeans were planted 30 June 1977, 29 June 1978, and 27 June 1979 in 92, 46, and 35-cm rows,respectively. Tillage prior to the second crop consisted of disking in 1977, plowing and disking in 1976, and no-tillage in 1979. No nematocide or additional fertilizer was applied. Alachlor, at 2.2 kg/ha was used all three years for weed control with addition of 2.2 kg/ha of glyphosate (N(phosphonemethy1)glycine) on no-tillage plots in 1979. Cultivation was done in 1977 and 1978. The second crops were irrigated in 1978 and 1979. Insecticides were needed in 1978 and 1979. Four yield replicates were harvested each year from bordered rows similar in area to the first crop. Yield and maturity characteristics were handled similarly to the first crop. To convert kg/ha to lb/ac, multiply by 0.892. Divide lb/ac by 60 to obtain bu/ac.

RESULTS AND DISCUSSION

Cultivars with Suitable Reproductive Development for First Crop: Maturity data from 1976 and 1979 (Table 1) shows cultivars from a range of Maturity Groups (MG). Maturity data from 1977 and 1978 were intermediate to those in 1976 and 1979. Reproductive development and maturity was prolonged in 1976, partially due to season and partially due to southern green stinkbug damage. In 1979, the only year nematocide was not applied, nematode injury may have hastened reproductive development and senescence, especially for the first three cultivars listed.

Cultivars in MG 00 through I including 'Corsoy' (MG 11) flowered early (29 days after emergence) and did not differ significantly in days from emergence to R1, R4, and R5. However, they differed up to 6 days in time to maturity. Maturity Group 11, 111, and IV cultivars flowered 1 to 2 days later; thereafter, each respective MG was progressively somewhat slower in reaching each successive reproductive stage. The largest difference among MG 00 to IV cultivars occurred in days from RS (bean swell) to R8 (95% pod maturity). The slightly slower reproductive development of MG II, III, and IV cultivars contributed to taller plants with 1 to 2 more nodes, but the significantly longer pod fill period (R5 to R8) gave these cultivars a considerable yield advantage over MG 00, 0, and I (Table 2).

The MG V, VI, and VII cultivars were delayed in flowering and slower in reproductive development than MG IV and earlier cultivars. They flowered at least 10 days later than MG IV cultivars. The substantial shift in reproductive behavior from MG IV to MG V is noteworthy. Reproductive behavior of 'Essex', typical of MG V, was more comparable to that of MG VI and VII than to that of MG IV. 'Hill' does not exhibit flowering behavior typical of MG V (K. Hinson, personal communication). Cultivars later than MG IV required 3 to 20 more days from R1 to R4 than did earlier MG's. Most of this delay was lag time before any active pod elongation. Subsequent reproductive development (R5 to R8) was also prolonged for MG V to VII cultivars. Essex and Hill set a reasonable pod load, but later cultivars such as 'Bragg' (MG VII) remained green and set pods at a very slow rate and did not mature until the normal time in October. Essex and Hill had 80 to 90% mature pods by 25 July and 31 July, respectively, but the remainder of the pods stayed green, and the plants retained one-third of their green leaf area at that time.

Table 1. Reproductive development of soybean cultivars planted in March of 1976 and 1979 at Gainesville, FL.

Cultivar	Maturity Group	Nodes at Maturity	Reproductive Development Stage R1	R4	R5	R8
			-------days after emergence--------			
March 1976†						
Fiskeby V	000		30ef *	38f	45f	77f
Altona	00		29f	38f	46ef	81e
Portage	00		29f	38f	46ef	82e
Clay	0		29f	38f	46ef	82e
Evans	0		30ef	38f	47ef	86d
Hodgson	I		29f	38f	47def	87d
Steele	I		30ef	39f	47def	85d
Corsoy	II		29f	39f	47def	93c
Amsoy 71	II		31d	41e	48cde	94c
Williams	III		32cd	42d	49cd	99b
Calland	III		31de	42d	49c	109a
Cutler 71	IV		33c	44c	52b	109a
Bonus	IV		33c	44c	50bc	108a
Hood	VI		52a	71a	76a	-
Bragg	VII		45b	68b	75a	-
15 March 1979						
Maple Arrow	00	6.4e*	28e	37g	40f	76h
Amsoy 71	II	8.1d	29de	39fg	43e	79g
Woodworth	III	8.6d	29de	39fg	42e	82f
Williams	III	9.7c	30cd	40ef	43de	88e
Union	IV	10.Ibc	31cd	41cd	46c	90d
Franklin	IV	9.8c	30cd	41de	44d	89de
Cutler 71	V	10.9a	32c	42c	46c	93c
Essex	V	10.7ab	42b	56b	61b	124b
Hill	V	11.3a	52a	64a	69a	131a

* Means in a column within a given year not followed by the same letter are significantly different at the 0.05 level according to Duncans New Multiple Range test.

† Results for 1976 averaged over three planting dates: 8, 18, and 29 March, and three replications per planting date.

The cause for this abnormal reproductive behavior is the sensitivity of each particular genotype to photoperiod. The later the MG of a cultivar, the shorter days it requires to successfully complete reproductive development. When planted in March, the days were short enough to induce flowering and pod set of these later cultivars. But the subsequently lengthening days of May, June and July affected reproductive development even though flowering had been initiated. The later the MG, the more sensitive it is to the effect of a given lengthening photoperiod on reproductive development (Major et al., 1975). This means that only certain combinations of cultivars and planting dates will fit for an early soybean crop at a given temperature-and-increasing-daylength location. For Gainesville, MG V and later cultivars planted in March were adversely affected by daylength and matured too late to allow a second crop. In fact, they produced less and poorer quality seed than if planted at recommended dates (May-June). MG II, III, and IV cultivars were early enough to allow a second crop.

Yield Characteristics of First Crop Soybean Cultivars: Good yield levels were achieved in all four years under conditions of narrow rows, irrigation, and good weed control. A comparison of yield characteristics to maturity group indicates MG 000 to I cultivars were uniformly early, short and low yielding, with low pod set (Table 2). Their low yield potential can be attributed to a short filling period (days from R5 to R8). Successively later maturity groups were later maturing, taller, had poorer quality seed, and set fewer seeds below 8 cm. Potentially economical yield levels were generally achieved with MG III and IV cultivars which matured between June 20 and 30 at Gainesville if planted March 14. 'Amsoy 71' of MG II also yielded well, except in 1979 when no nematocide was used. 'Williams' (MG 111) was probably the most consistently good performer over the years. This agrees with Williams' unusually good adaptation in INTSOY's tropical-subtropical trials in spite of being in MG III (Whigham, 1975; Whigham and Minor, 1978). Certain other MG III and IV cultivars: 'Woodworth', 'Bonus', and 'Franklin' yielded significantly less than Williams. 'Union', being of Williams parentage, appeared similar to Williams. While 'Calland' (MG 111) and 'Cutler 71' (MG IV) were tall and yielded well, they had some negative attributes: poorer seed quality, later maturity, and a tendency to maintain green stems and a few green leaves at maturity, possibly in response to lengthening days. This "staygreen" trait was even more pronounced on MG V cultivars which "matured" with poor quality seed in late July, but retained about one-third green leaves and about 10-20% green pods. While the plant and pod height of MG IV cultivars is desirable, their poorer seed quality and later maturity conflict with prompt early harvest in the warm humid rainy season in Florida which arrives in late June. Delayed maturity and harvest delays planting and reduces the growth period of the second soybean crop.

Second crop soybeans and total seed yield from two crops. Second crop 'Cobb' soybeans were planted June 30, June 29, and June 27 after harvesting early soybean crops in 1977, 1978, and 1979, respectively. First crop 'Williams' yield, second crop 'Cobb' yield, and combined yield of two crops is shown in Table 3. The yield potential of the second crop in 1977 was limited by incomplete canopy cover in 92 cm rows and growth under rainfed conditions. The

Table 2. Yield characteristics of soybean cultivars planted in March of 1976, 1977, 1978, and 1979 at Gainesville, FL.

Cultivar	Maturity Group	Maturity Date†	Height at Harvest	Seed Yield	Yield below 8 cm	Seed Quality††
			cm	kg/ha	%	1-5
			March 1976†			
Fiskeby V	000	6-5f	33g	1890d	24a	1.6e
Altona	00	6-9e	53e	2600b	12def	1.8de
Portage	00	6-10e	51e	2610b	9efg	2.0cd
Clay	0	6-10e	45f	2150c	17abcd	1.7de
Evans	0	6-14d	47f	2590b	12cdef	1.8de
Hodgson	I	6-15d	47f	2330c	14bcde	2.0cd
Steele	I	6-13d	48f	2660b	17abcd	1.7de
Corsoy	II	6-21c	52e	2910a	18ab	2.3bc
Amsoy 71	II	6-22c	59d	3110a	11def	2.4bc
Williams	III	6-27b	66c	3000a	10efg	2.4b
Calland	III	7-7a	75b	3010a	7fg	3.4a
Cutler 71	IV	7-7a	83a	2920a	5g	3.4a
Bonus	IV	7-6a	78b	2650b	9efg	3.2a
			14 March 1977			
M65-217	00	6-8e	36d	2130bcd	22abc	1.3f
Altona	00	6-3f	39d	1940cd	20bc	1.5def
Portage	00	6-4f	37d	1800d	12c	1.8bc
Maple Arrow	00	6-9d	40d	1990cd	21bc	1.4ef
Evans	0	6-9d	36d	2280bc	28ab	1.8bcd
Corsoy	II	6-14c	45c	2390b	31a	2.0ab
Amsoy 71	II	6-16b	55b	2990a	19bc	2.2a
Williams	III	6-20a	60a	3200a	17c	1.7cde
			14 March 1978			
M65-217	00	6-12c	41c	1800b	27b	1.9b
Prize	II	6-12c	36c	1540b	41a	2.4a
Amsoy 71	II	6-19b	52b	2630a	22bc	2.0b
Williams	III	6-22a	54b	2760a	12c	2.0b
Franklin	IV	6-24a	60a	2320a	13c	2.2ab
			15 March 1979			
Maple Arrow	00	6-7h	28h	1580d	12a	1.4f
Amsoy 71	II	6-10g	40g	1830d	10ab	1.7def
Woodworth	III	6-13g	45f	1980cd	9abc	1.6ef
Williams	III	6-19e	51e	2800b	4cd	1.7def
Union	IV	6-21d	55d	2900ab	6bcd	2.0de
Franklin	IV	6-20de	60c	2370c	1d	2.0d
Cutler 71	IV	6-24c	65b	2840ab	1d	2.7c
Essex	V	7-25b	55d	3280a	#	3.2b
Hill	V	8-1a	72a	1880d	#	4.3a

* Means in a column within a given year not followed by the same letter are significantly different at the 0.05 level.

† Results for 1976 averaged over three planting dates: 8, 18, and 29 March. Maturity dates for 1976 adjusted to a hypothetical 14 March planting date to allow comparison to the other three years.

†† 1 = Very Good; 5 = Very Poor.

Not measured, but was less than 3%.

yield potential of both the first and second crop in 1978 were limited by insufficient irrigation frequency in a dry season coupled with a sting nematode infestation in one-third of the cxperimcnt. In 1979 the two crops received nearly optimum irrigation and rainfall frequency, hut received no nematocide. The excellent weather is reflected in the high yields for 1979. The 1979 yields were 2800 kg/ha (42 bu/ac) plus 3410 kg/ha (51 bu/ac) for a total of 6210 kg/ha (93 bu/ac) per season. Even under the adverse conditions of 1978, total yield was 4400 kg/ha (65 bu/ac), a yield more than twice the state average. The second crop responded well to narrow row spacing with a 30% increase in 1978 from 46 versus 92 cm rows and a 9% increase in 1979 from 35 versus 105 cm rows. The cultivar Bragg yielded as well as Cobb in the two years it was planted.

Table 3. 'Total yield of 'Cobb' soybeans succeding 'Williams' soybeans during 1977, 1978, and 1979 at Gainesville, FL.

Year	Crop	Cultivar	Row Spacing	Planting Date	Maturity Date	Seed Yield	Total Yield
			cm			kg/ha	kg/ha
1977	First	Williams	31	3/14	6/20	3200	
	Second	Cobb	92	6/30	10/30	2070	5270
1978	First	Williams	25	3/14	6/22	2760	
	Second	Cobb	46	6/29	10/29	1640	4400
1979	First	Williams	35	3/15	6/18	2800	
	Second	Cobb	35	6/27	11/1	3410	6210

Tillage conditions differed for the second crops in each year. Disking in 1977 was not satisfactory, because it provided a good seed depth in which first crop soybeans volunteered in the second crop. This was not desirable, because volunteers from first crop seed were short, matured early, and had poor seed quality by the time the full season crop was mature. In other words, first crop volunteer soybeans acted like 'weeds'. Morever, the low pod set of the first crop is likely to result in sufficient cutter bar loss to give a volunteer soybean problem. After the 1978 early crop, the field was plowed with a moldboard plow to bury the seed lost during harvest. This worked, but the second crop was planted in dry soil and irrigated too heavily. Emergence and stand was reduced by soil compaction and weed pressure increased. In 1979, the second crop was seeded no-till into the residue left from the first soybean crop. Lasso-Roundup (2.2 kg/ha alachlor and 2.2 kg/ha glyphosate) were applied to control future weeds as well as weed escapes from the first crop. The second crop in 35 cm rows covered the ground quickly and weeds were not a problem. This no-tillage method effectively solved the volunteer soybean problem, controlled weeds, maintained soil moisture for germination, and speeded replanting with lower energy input.

Conclusions and Recommended Cultivars and Practices for Growing Soybeans Succeeding Soybeans in Florida: March-planting of soybean cultivars in MG 000 to VIII during four years indicated that the cultivar for the first crop should be from MG II, III, or IV for best yield potential, seed quality, sufficient pod and plant height, and sufficiently early maturity to allow a second crop. Williams was the best performing cultivar, but Union, Cutler 71, and Amsoy 71 were also good within MG II to IV. Cultivars from MG V, VI. VII, VIII, and IX, when planted in March, were adversely affected by the lengthening days. As a result their reproductive development was slow and they matured too late to allow planting a second crop.

Growing two soybean crops per year will require careful management. The first crop must be planted no later than the end of March on well-drained, productive soils that have previously produced good soybean yields. Irrigation and good weed control are absolutely essential. Plant in narrow rows at populations near 60 plants per m^2 (Table 4). This will give a closed canopy and reduce weed competition. Yield was increased 21% by planting in 25cm as compared to 102 cm row spacing. Yield was not increased by doubling seeding rate to 112 seeds/m^2. The fraction of seed yield below 8 cm was reduced by either greater in-row plant competition (fewer rows at the same area planting density) or by greater overall planting density at the same in-row competition. Because pods are set low, careful combine harvest and low cutter bar height are needed. Harvesting at the earliest possible time is essential to prevent loss of seed quality in the warm humid summer and to give maximum growing time for the second crop planted. Spraying a harvest aid desicant such as paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) may be desirahle if the last few leaves fail to die as pods begin to mature. Seed drying may be needed.

The second crop should be a full-season adapted cultivar. Bragg (MG VII) and Cobb IMG VIII) have performed better than the few MG IX experimental lines tried. Best yield performance of the second crop occurred in years when no-till planting methods, narrow rows, optimum irrigation was practiced. The

Table 4. Effect of row spacing and population on yield characteristics of 'Amsoy 71' and 'Williams' soybean planted 14 March 1978 at Gainesville, FL.

Cultivar	Row Spacing	Harvest Plant Density	Height at Harvest	Seed Yield	Yield below 8 cm	Weight of 100 Seed	Seed Quality††
	cm	no/m^2	cm	kg/ha	%	g	1-5
Amsoy 71	25	47	52a*	2630a	22a	17.9abc	2.0a
	51	51	53a	2400a	15b	17.6bc	2.2a
	51†	99†	53a	2370a	2c	16.9c	2.2a
	76	50	55a	2130a	11b	18.8ab	2.2a
	102	50	59a	2280a	4c	19.4a	2.4a
Williams	25	47	54a	2760a	12a	19.8a	2.0a
	51	50	55a	2610ab	6b	19.6a	1.9a
	51†	98†	53a	2520ab	1c	18.9a	1.9a
	76	49	57a	2330ab	2c	20.1a	1.9a
	102	48	58a	2190b	3c	19.9a	2.03

* Means in a column within a given cultivar not followed by the same letter are significantly different at the 0.05 level according to Duncans New Multiple Range test.

† This row spacing treatment seeded at 112 seeds/m^2; all other treatments seeded at 56 seeds/m^2.

††1 = Very Good; 5 = Very Poor.

combined total yields of two soyhean crops per season were 5270, 4400. and 6210 kg/ha in 1977, 1978, and 1979. In spite of the apparent success of these experiments, further experimental and farm level evaluation is needed before the practice is recommended to Florida producers. Careful management is the key.

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WEED CONTROL PROGRAMS FOR NO-TILLAGE SOYBEANS

B. J. BRECKE

Interest among growers in raising two or more crops per year on the same land area (multicropping) is increasing. One of the most successful such production systems in the southeastern United States has been double cropping soybeans after small grain (2). This system is suited to a wide area of the southeast where fall seeded small grains are harvested early enough for soybeans to be planted.

No-tillage planting of the soybeans has contributed to the success of double cropping because it allows establishment of the soybean crop with the least delay. This often results in more favorable soil moisture at planting and allows more time for the soybean crop to mature. Another important advantage in this time of rapidly rising fuel costs is the lower per-acre energy requirement for no-till compared to conventional planting. No-till also requires less labor and decreases soil erosion (1).

Weed Control Programs

In no-till cropping, as with conventional tillage systems, weeds must be controlled to obtain maximum crop yields. When soybeans are planted into the residue of a previously well managed small grain crop, there are some advantages from a weed control standpoint. First, any weeds present are usually small and therefore can be controlled easily with a foliar applied herbicide. Second, the small grain residue will act as a mulch for the soybeans and aid in preventing weed emergence.

Regardless of mulch effectiveness, however, herbicides are essential for weed control in no-till soybeans since cultivation is not possible. A contact-active herbicide will be needed to control any vegetation present at the time of planting while herbicides with residual (preemergence) activity will he needed to prevent further weed infestation. A postemergence treatment may also he required to control escapes from the preemergence application.

Weed control programs for no-till soybeans have been studied at the Agricultural Research Center, Jay, Florida for the past 4 years. The results of these studies indicate that, as in conventional tillage systems, a complete herbicide program is required to control the more troublesome weeds (trade and common herbicide names are listed in Table 1). The results summarized in Table 2 show that neither preemergence treatments nor directed postemergence applications alone provide complete weed control in no-till soybeans. The directed treatments did provide somewhat better control than the preemergence treatments hut control was still less than desired.

The results from a 1979 test (Table 3) again show that preemergence applications were not as effective as desired. However, when a program including both a preemergence and directed postemergence application was used, excellent control of both grass and broadleaf weeds was obtained. Examples of such pro-

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grams include Paraquat + Surflan + Lexone preemergence plus either Lexone + Butyrac, Lorox + Butyrac, or Paraquat directed postemergence. To obtain the beat results the directed postemergence applications should be made to soybeans at least 12 inches tall and to weeds less than 3 inches tall. The spray should not contact more than the lower one-third of the soybean plant. The addition of a surfactant will improve control.

Conclusions

Though the mulch provided by residue from a small grain crop will aid in controlling weeds, herbicides are an essential part of a no-till cropping system. A good herbicide program includes a contact-active material to control any vegetation present at the time of planting in combination with herbicides which provide residual control of both grass and broadleaf weeds. A directed postemergence application may be required in instances where preemergence materials do not provide the desired weed control.

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Table 1. List of common and trade names of herbicides described in this paper.

Common name	Trade name
Paraquat	Paraquat
Metribuzin	Sencor or Lexone
Linuron	Lorox
Oryzalin	Surflan
2,4-DB	Butyrac or Butoxone

Table 2. Weed control in no-till soybeans at ARC, Jay, 1976.

Treatment	Rate lbs/A a.i.	When applied[1]	% Control[2] CB	TM
Paraquat + Sencor + X77	.5 + .5 + .25%	PRE + PRE + PRE	69	69
Paraquat + Lasso + Lorox + X77	.5 + 2 + 1 + .25%	PRE + PRE + PRE	54	70
Paraquat + X77 + Sencor + 2,4-DB	.5 + .25% + .38 + .25	PRE + PRE + DP + DP	84	88
Paraquat + X77 + Lorox + Butyrac	.5 + .25% + .5 + .25	PRE + PRE + DP + DP	74	84

[1]PRE = Preemergence in the soybeans; DP = directed postemergence.
[2]CB = Cocklebur; TM = tall morningglory.

Table 3. Weed control programs for no-till soybeans at ARC, Jay, 1979.

Treatment	Rate lbs/A a.i.	When applied[1]	% Weed Control[2] CG	TM	BW
Paraquat + Dual + Lexone + X77	.25 + 1.5 + .5 + .25%	PRE + PRE + PRE + PRE	53	80	83
Paraquat + Lasso + Lexone + X77	.25 + 2 + .5 + .25%	PRE + PRE + PRE + PRE	83	80	73
Paraquat + Surflan + Lexone + X77	.25 + 1 + .5 + .25%	PRE + PRE + PRE + PRE	80	53	90
Paraquat + Surflan + Lexone + X77 + Lexone + Butyrac + x77	.25 + 1 + .5 + .25% + .5 + .25 + .25%	PRE + PRE + PRE + PRE + DP + DP + DP	91	100	100
Paraquat + Surflan + Lexone + X77 + Paraquat + X77	.25 + 1 + .5 + .25% + .25 + .25%	PRE + PRE + PKE + PRE + DP + DP	95	100	100
Paraquat + Surflan + Lexone + X77 + Lorox + Butyrac + X77	.25 + 1 + .5 + .25% + .5 + .25 + .25%	PRE + PRE + PRE + PRE + DP + D? + DP	83	95	98

[1]PRE = Preemergence to the soybeans; DP = directed postemergence.
[2]CG = Crabgrass; TM = tall morningglory; BW = Florida beggarweed.

DEEPER ROOTING IN MINIMUM TILLAGE TO CONSERVE ENERGY

Robert B. Campbell

Conserving energy in the 1980's is more than just reducing fuel or "petrol" use. We would like to believe a little energy conservation is essential, preferably by someone else or by some governmental action that will provide us with labor saving productivity improvements to maintain the comforts we have become accustomed to. Scientific reality, however, dictates that quick easy solutions will not be developed without careful planning for the efficient use of our energy resources and without strong efforts to find and develop new sources of energy. Because agriculture is the primary source of our food supply, energy must be considered in relation to the total crop production potential, i.e. production per petrol dollar spent or production per unit of energy input.

Reduced tillage defined

No-till farming in concept is directed to lower use of energy for crop production. Unfortunately the word no-till is misleading, in fact, no-till is not no till at all. The term has been coined to refer to a system of residue management. In this system, seeds are drilled into soil with live or dead plant materials still remaining on the soil surface. Weeds are mostly controlled by the application of constant or residual grass and broad leaf herbicides. However, mechanical weed control is possible under some circumstances. This concept of residue management has been referred to as eco-fallow (2), minimum till (5), or conservation tillage (3). These systems require higher levels of soil and crop management than conventional clean till farming methods.

Advantages and problems in minimum tillage

Often claimed advantages of minimum tillage over conventional tillage include: lower erosion, water conservation, ability to plant earlier, planting on steeper less fertile slopes, lower fuel costs, and lower compaction (5). Minimum tillage methods can be used in multiple cropping systems (4). Even though these appear to be distinct advantages, there are disadvantages or special challenges that must be addressed to make minimum tillage successful. Because minimum tilled land is not 'smooth and open, stands of crops are difficult to establish. Birds, and rodents are more active because the residue provides protective cover. Fungi and insects infestations are more common when residues remain on the surface. The real question is how can these problems be solved. Most certainly they can be solved, but only with greater scientific input.

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The soil physical system and minimum tillage

Recognizing soil physical and chemical conditions is an essential part of residue management in different parts of the country. Minimum till farming in the Southeast has to be accomplished in deep sandy soils or in sandy loam or loamy sand soils with genetically compact or mechanically compacted layers (1). These soils also have low water retentivity, consequently it is just as important to consider deep rooting and ways of achieving deeper rooting in minimum tillage as in conventional tillage. Without giving proper attention to these soil physical conditions, minimum tillage practices would eventually reduce the production base and actually increase energy use per unit of crop production.

In view of the limitations that soil physical conditions may have on residue management and energy use, corn rooting patterns were studied in relation to soil strength and soil water availability to corn in a Norfolk loamy sand soil with a compact A^2 horizon. Large acreages of these soils occur in the Southeast. For example, in Florence County, South Carolina alone, 58% of the tilled soils have an A layer (1). Although these layers vary in compactness, they are easily compacted by tillage tools and wheel traffic.

Describing soil physical parameters

Soils are never uniform in texture, structure and bulk density. Roots are not symetrically distributed in soil, therefore, water withdrawal can not be uniform. Consequently, a mean value and frequency distribution of certain properties such as bulk density are frequently used to describe soil conditions shown in Table 1.

Table 1. Bulk density and related frequency distribution for a Norfolk soil at Florence, SC

Bulk Density	Relative Frequency - %		
g/cm^3	Ap	A_2	B
1.25-1.29			10.0
1.30-1.34	4.3		5.0
1.35-1.39	2.1		5.0
1.40-1.44	2.1		5.0
1.45-1.49	8.7		20.0
1.50-1.54	26.1		30.0
1.55-1.59	17.5		20.0
1.60-1.64	8.7	2.9	5.0
1.65-1.69	8.7	7.7	
1.70-1.74	17.4	15.4	
1.75-1.79	2.2	32.7	
1.80-1.84	2.2	38.5	
1.85-1.89		1.9	
1.90-1.94		0.9	
Mean g/cm^3	1.57	1.78	1.48
Std. deviation	0.155	0.049	0.099
Schewness	-0.0107	-0.2283	-0.7704

The mean bulk density values for the Ap, A_2 , and B horizons are 1.57, 1.75, and 1.48 g/cm^3, respectively. The wide distribution of the Ap layer is a result of subsoiling in a minimum tillage experiment in which corn was planted into a standing rye cover crop. The subsoil tool[1] produced a narrow slot 10-15-cm wide in the A_2 layer that penetrated 47 cm, about 5 cm into the B horizon. The Ap bulk denaity measurements were more normally distributed about the mean value than the A_2 or B horizons.

Rooting and soil strength

Increasing bulk density increases resistance to rooting but bulk density is not the only factor that affects rooting because decreasing soil water content also increases the strength of soil. Therefore, root penetration is a function of bulk density, water content, and texture. We have determined that soil probes give a reliable index of rootability in soil, and that a penetrometer index of 20 kg/cm^2 represents a value beyond which few roots penetrate. In the Ap horizon at the mean bufk density of 1.57 root penetration is severely restricted at a matric potential of a little over -1000 mb. One could anticipate that roots would be well distributed throughout the A_2 horizon because of the wide range in the bulk density frequency distribution (see Table 1). In the A_2 horizon however, the matric potential at which roots were redtricted was -220 mb at a mean bulk density of 1.78 g/cm^3. Root development observations in a corn field showed that rooting in the A_2 horizon occurred only in the subsoiled portion of the A_2. Rooting in the B horizon was restricted to those roots that extended down the A_2 subsoiled soil. The B horizon had the lowest bulk density of all layers studied, 1.48 g/cm^3. Rooting observations demonstrated that once a root grew through the disturbed A_2 horizon, root growth into the B horizon was only slightly impeded. Because soil strength restricted rooting, soil strength affects water availability. By taking *-50* mb as the upper limit of water availability and the water content corresponding to 20 kg/cm^2 as the lower limit of water availability to the plant, the amount of water storage for each layer to the 75-cm depth can be calculated. These calculated water storage values are given in Table 2.

Table 2. Water storage in a 75-cm profile based on -50 mb and the matric potential water content at 20 kg/cm^2 as the upper and lower availability water limits, respectively. (only the subsoiled portion of the A_2 was considered)

Layer	Depth (cm)	Storage (cm)
Ap	0-17	2.37
A_2	17-35	0.30
B	35-75	2.91
Total		5.58

1/ Brown-Harden Superseeder with an attached subsoil tool. Mention of tradenames is for reference and does not constitute endorsement by USDA or its cooperators.

Various assumptions were made for calculating effective soil water storage. Four examples taking various limiting factors into consideration are presented in Table 3.

Table 3. Calculated available water storage in a Norfolk loamy sand profile to depth of 75 cm.

Limiting Condition for Estimating Available Water	Soil Water Storage (cm)
(1) -50 mb and -1000 mb upper and lower limits	7.1
(2) -50 mb to 20 kg/cm^2 strength (all layers)	6.0
(3) -50 mb to 20 kg/cm^2 in (subsoiled in A_2 only)	5.6
(4) -50 mb and -1000 mb in actual observed rooting volume	4.0

These data show the importance of having roots uniformly distributed throughout the soil profile and further the necessity of expanding the volume of rooting in the B horizon. If roots were restricted only to the A horizon, the effective water availability to the plants would have been about 43% of that of the subsoiled soil - 2.37 vs. 5.58 cm.

These soil water storage calculations do not take into account the amount of water that would have been provided to the plant by unsaturated flow for most regions in the soil to the root surfaces.

These data indicate efficient energy use in minimum tillage agriculture when depth of rooting and methods of offsetting the effects of drought are taken into account. High crop production insures efficient use of fuel that has been expended in establishing the crop which is an important aspect of the energetics of residue management.

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FUEL CONSUMPTION AND POWER REQUIREMENTS FOR TILLAGE OPERATIONS

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It is estimated that well over half of the engine horsepower-used on American farms is for tillage operations. Many of the implements used, and much of the need for tillage operations have long been taken for granted. Reducing tillage operations was of considerable. interest before the advent of high priced energy, but interest increased **sharply** when the price per gallon of fuel jumped to three digits.

Diesel tractors are more efficient than gasoline tractors (a diesel uses about 70% as much fuel for a given job than a gasoline tractor). Tractors used to perform tillage operations were some of the first to use diesel engines because they were relatively high horsepower units that offered the greatest opportunity to recapture the diesel's higher initial cost. The transition to diesel is virtually complete today. Diesel engines are found in the large multi–hundred horsepower land preparation tractors down to sub–20 horsepower imported tractors. Many manufacturers of water cooled tractors either do not offer a gasoline engines powered unit or only prepare one on special order. Therefore, fuel consumption figures reported in this paper are considering diesel tractors exclusively.

Most of the published information used for determining farm implement energy rcquirements were derived from data gathered in the Midwest. This data would probably be appropriate for many farm implements, but energy requirements for tillage implements could be appreciably different because of soil type.

Determining Implement Energy Use

Reasonably accurate energy use data can be determined by simply filling the tank to the top, using the machine over a measured area, and determining the fuel used by accurately measuring the fuel needed to restore the leve1 in the tank, if a relatively large area is being worked, the tractor is on level ground, and the tracbbr is shook vigorously to expel air bubbles from the tank.

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In order to increase the accuracy of energy use values when working smaller areas, and, to speed up the operation by eliminating the need for burping air bubbles from the tank, a plexiglass tube was mounted on the fuel tank of a tractor as shown in Figure 1 below. This arrangement makes it possible to get a relatively large fuel level change in the tube when working smaller areas than would be feasible with the "Tank Refill" method.

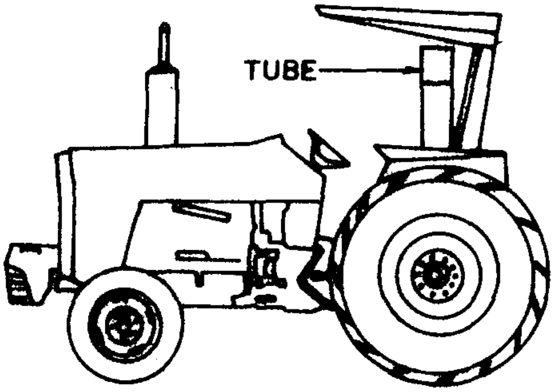

FIGURE 1

The first tube that was mounted on the tractor had a 2 inch inside diameter and would give a large, easily measured fuel level change when the tractor was used for a short time. However, a small change in the temperature of the tractor fuel caused a significant change in the fuel level in the tube. The tube was changed to a 4 inch inside diameter tube in order to reduce the error induced by fuel volume change.

Results of Implement Energy Requirement Trials

Corn-was planted at three different locations in the Gainesville area beginning in February, 1980. The soil preparation and planting treatments were as shown below

1) Disk, moldboard plow, disk, subsoil, plant
2) Disk, moldboard plow, disk, plant
3) Subsoil, plant
4) plant

The energy requirements for these operations were determined using the "Tank Refill" method. Even though the plot areas were only 0.3 acres to 0.9 acres, which is probably small for determining fuel requirements by tank refilling, the results given in Table 1 fall in a rather narrow band. A great amount of credit for this uniformity of results is attributed to the amount of tractor shaking done to expel air bubbles.

Table 1 - Corn Planting Energy Requirements

Location	Plot Number	First Disking	Plowing	Second Disking	Subsoil and Plant	Plant
		Energy Used Per Operation (Gallons/Acre)				
Gainesville	1	0.54	1.63	0.75	1.53	-
	2	-	-	-	-	0.64
	3	0.41	1.40	0.65	-	0.83
	4	-	-	-	1.39	-
	5	0.53	1.43	0.61	-	0.77
	6	0.53	1.50	0.50	1.31	-
	7	-	-	-	1.23	-
	a	-	-	-	-	0.64
Newberry	1	0.56	1.27	0.63	1.19	-
	2	-	-	-	-	0.74
	3	0.51	1.47	0.53	-	0.86
	4	-	-	-	1.24	-
	5	0.51	1.42	0.60	-	0.85
	6	0.51	1.36	0.60	1.31	-
	7	-	-	-	1.27	-
	8	-	-	-	-	0.76
Chiefland	1	0.58	1.40	0.67	1.32	-
	2	-	-	-	-	0.73
	3	0.51	1.35	0.62	-	0.87
	4	-	-	-	1.44	-
	5	0.49	1.34	0.57	-	0.87
	6	0.49	1.33	0.60	1.32	-
	7	-	-	-	1.44	
	8	-	-	-		0.73

The equipment used to perform the soil preparation and planting operations were: an eight foot wide tandem disk, a 3 bottom plow that cut approximately a 4 foot-6 inch slice, a two row Brown-Harden no-till planter with subsoiling shanks, a two row Brown-Harden no-till planter without subsoiling shanks, two sets of unit planters for mounting on the two no-till units, a 52 horsepower tractor, and a 58 horsepower tractor.

The data indicates that at all locations the initial disking required approximately 0.5 gallons per acre. The moldboard plowing required approximately 1.40 gallons per acre. The second disking required approximately 9.6 gallons per acre of 0.1 gallons per acre more than the initial disking because of more slippage. The no-till planter equipped with the subsoiler shanks required about 1.30 gallons per acre. When the no-till planter did not have subsoiling shanks approximately 0.75 gallons per acre was used for planting. Subtracting the no subsoiling from the subsoiling figures indicates that approximately 0.55 gallons per acre were required for the subsoiling operation.

Tests were also conducted at the Agricultural Experiment Station in Quincy, Florida to determine the energy requirements for some tillage operations in heavier soil than those found in the Gainesville area. The results are shown in Table 2.

Table 2 - Tillage Energy Requirements, Quincy

Operation	Depth of Cut (inches)	Gallons/Acre
Tandem disk	5	0.66
Offset disk	6 - 7	0.96
Rolling cultivator	shallow	0.36

The tandem disking operation was performed by a 12 foot wide unit with 20 inch scalloped disks drawn by an 85 horsepower tractor. The offset disk was a 7 foot wide unit with 20 inch scalloped disks drawn by a 52 horsepower tractor. The rolling cultivator was a 4 row unit drawn by a 150 horsepower tractor.

Comparison with Other Published Data

The following is a comparison of the tillage energy requirements published by Iowa State University and those recently determined in Florida.

Field Operation	Gallons/Acre	
	Iowa	Florida
Moldboard plow	1.90	1.40
Offset disk	0.95	0.96
Tandem disk	0.45	0.50
Rolling cultivate	0.40	0.36

How Might Energy Requirements Be Reduced

Farmers cannot use tractor engine efficiency as the sole guide for determing what tractor to buy because of practical considerations like dealer location and dealer's ability to provide parts and service. However, it is felt that more thought should be given to engine efficiency in order to reduce energy requirements. The results of the Nebraska Tractor Tests conducted over the last 10 years reveal that the 24 most efficient tractors delivered 13.91 horsepower hours per gallon while the 24 least efficient tractors delivered 11.16 horsepower hours per gallon. This is a difference of 24.6% and farmers must be made more aware of how to use Nebraska Test Data.

HERBICIDE TOLERANCE AND WILD RADISH CONTROL IN LUPINE AND VETCH

G.R. England, W.L. Currey, and R.N. Gallaher

INTRODUCTION

Wild radish (Raphanus raphanistrum Crantz) is a common weed in grain crops throughout the world. Wild radish is a self pollinated annual found mainly in cereals, fallows, and non-crop areas. In Florida it grows as a winter annual in these sites. It is a moderate to vigorous competitor for space.

Extensive work in the control of this weed has been done in Germany, the Soviet Union, and Great Britan. Research has been carried out world wide on the control of wild radish in numerous crops, using many herbicides. In Brazil, wild radish was controlled with 2, 4-D applied by air (Guibert, 1972). Merich et al. (1972) found BAS 3580H (bentazon 26% and dichloroprop 34%) and BAS 3960H (bentazon 25% and mecoprop 37.5%) controlled wild radish, Chrysanthamum segetum, Cusicim spp., Galum aparine, Matricaria spp., and Sinapsis arvensis. Hahn (1973) controlled wild radish in grasses with SYS 67ME (MCPA 86% free acid) at 1.5 kg/ha and SYS 67 Prop (dichloroprop potassium 64% acid). Koboreva (1971) controlled wild radish in buckwheat (Fagopyrum tataricum) with 1-2 kg/ha 2, 4-D amine. Treating with MCPA (1-2 kg/ha) or norea (0.5 kg/ha) increased yields of buckwheat by 1000 kg/ha. Osususka et al. (1973) gained twice the control of wild radish compared to the check with 0.25 kg/ha of atrazine. Cochet et al. (1973) obtained control with Phyt 3425 (chlormtofen 20% + linuron 5%) at 1.85-5.0 kg/ha. Huggenburger et al. (1974) obtained control of wild radish, Digitaria singuevalis, Amaranthus spp., Polygonium spp., and Sinapsis arvensis with oryzalin 1.0-1.4 kg/ha + linuron (1.0-1.4 kg/ha) applied surface preemergence with 12.5 mm precipitation or shallow incorporation. Hermant et al. (1973) treated 4 cm flax (Linum usitatissimum and R. (raphanistrum) in an early stage with bentazon and achieved good weed control with no injury to the flax. Detrernix et al. (1973) achieved control of Raphanus with alachlor (1.7-2.0 kg/ha) or propachlor (0.5 kg/ha) applied preemergence. Leiderman et al. (1972) controlled wild radish with oxadiazon (1.5-2.0 kg/ha). Amaranthus vidis, Galingosa parviflora, and Digitaria sanguinalis were also controlled.

Wild radish is a problem in winter forage crops at the Robinson Farm in Williston, Florida. Since this problem weed existed in land already utilized for research, the following experiment was established to determine possible control measures that could be utilized to control wild radish in lupine, Lupinus angustifolia, and vetch (Vicia villosa).

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MATERIALS AND METHODS

The experiment was conducted at the Robinson Farm in Williston, Florida during the winter of 1979–1980. Wild radish control was evaluated in lupine and vetch which were planted behind several no-tillage operations. The land was harrowed three times and then "Hairy vetch" (33.6 kg/ha) and "Frost lupine" (89.6 kg/ha) were properly inoculated and drilled on November 1, 1979. Lupine was irrigated (3.2 cm) on November 9, 1979 and vetch was irrigated on November 10. A portion of both lupine and vetch received an application of bentazon (1.12 kg/ha) on January 3, 1980. The bentazon was applied in a 280 l/ha spray at 2.8 kg/cm^2.

On January 15, 1980, three chemicals, acifluorfen (Blazer), bentazon (Basagran), and 2, 4-DB (Butyrac) were applied postemergence to vetch and lupine.

Herbicides	Rate
acifluorfen	0.28, 0.43, 0.56
bentazon	0.84, 1.12
2, 4-DB	0.28, 0.56

AG98 at 0.25% v/v was added to acifluorfen. Two applications of each chemical were made to lupine and vetch which had been previously treated with 1.12 kg/ha bentazon and to plots not previously treated. The major weed to be studied was wild radish.

The herbicides were applied with a C02 backpack plot sprayer in 187 l/ha spray at 3.36 kg/cm^2 on January 15, 1980. The second application of acifluorfen and bentazon was made on January 28, 1980 to wild radish plants that were 61 cm high. The second application of 2, 4-DB was made on February 3, 1980. The same method of application was used.

Each experiment was set up in a randomized complete black design and 4 replications were used. The treatments were rated by 4 visual observations for crop tolerance and wild radish control. A rating of 0 equals no affect on the crop or the weed, while a rating of 10 equals complete control of either the crop or the weed.

RESULTS AND DISCUSSION

In the four visual ratings there were significant differences between both weed control and crop tolerance (Tables 1. 2. 3, 4). By the fourth rating, acifluorfen and bentazon had provided almost complete wild radish control at all rates. Acifluorfen had caused from moderate to severe crop injury in vetch and severe crop injury in lupine. Bentazon caused no crop injury in vetch but almost completely removed the lupine.

Bentazon provided good wild radish control in both crops. There was excellent crop tolerance in vetch, but no crop tolerance of bentazon in lupine. Acifluorfen provided comparable weed control to bentazon. There was some tolerance of vetch at the low rate.

2, 4-DB, due to the advanced stage of growth of WR at application, provided no wild radish control. It caused slight crop injury in both vetch and lupine. In vetch it caused leaf curl and in lupine it caused the stem to curl.

The timing of application was not optimum for control with selective herbicides. It is significant that good control of the weed by bentazon and acifluorfen was obtained in this stage of growth.

There seemed to be an interaction with bentazon and temperature. Control of wild radish appeared to be enhanced by hard freezes after application. This was observed at Williston and in wild radish treated with 0.84 kg/ha basagran at the Green Acres research farm.

Bentazon has been shown to be affected by environmental factors (BASF Tech. Info., Bull. No 7804). An optimum temperature for bentazon would be over 18 C (Ellison, 1980). This temperature relationship would have to be considered when determining a control program for a winter weed, since winter temperatures in Florida vary so much.

This experiment should be repeated to observe the activity of these chemicals on the crop and weed, in an earlier growth stage. The affects of temperature on bentazon need to be evaluated further.

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TABLE 1. Control of Wild Radish and Vetch Tolerance From the Use of Herbicides Following an Application of 1.12 kg/ha Bentazon.

Treatment	Date: 1-26-80	2-3-80	2-7-80	2-14-80
	Wild Radish Control			
acifluorfen	6.0 a	8.5 a	9.9 a	9.9 a
bentazon	4.5 a	8.0 a	9.5 b	9.7 a
2,4-DB	1.0 b	1.0 b	1.0 c	1.0 *b*
check	1.0 b	0.0 *b*	1.0 c	1.0 b
	Crop Tolerance			
acifluorfen	2.5 a	5.5 a	6.5 a	6.5 a
bentazon	0.0 a	0.5 c	2.0 b	0.0 c
2,4-DB	0.0 a	2.0 *b*	0.0 b	3.0 b
check	0.0 a	0.5 c	0.0 b	0.0 c

A rating of 0 equals no affect on the crop or weed, while a rating of 10 equals complete control of either the crop or the weed.

Values among treatments within each date followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's new multiple range test.

TABLE 2. Control of Wild Radish and Vetch Tolerance From the Use of Herbicides With No Previous Herbicide Application.

Treatment	Date 1-26-80	2-3-80	2-7-80	2-14-80
	Wild Radish Control			
acifluorfen	3.5 a	4.5 b	6.5 a	7.0 b
bentazon	1.5 b	6.0 a	8.5 a	8.25 a
2,4-DB	0.0 b	0.0 c	0.5 b	0.0 c
check	0.0 b	0.0 c	0.0 b	0.0 c
	Crop Tolerance			
acifluorfen	3.0 a	4.0 a	5.5 a	4.5 a
bentazon	0.0 b	0.5 b	0.0 b	0.0 c
2,4-DB	0.0 b	2.5 ab	2.0 b	2.0 b
check	0.0 b	0.0 b	0.0 b	0.0 c

A rating of 0 equals no affect on the crop or weed, while a rating of 10 equals complete control of either the crop or the weed.

Values among treatments within each date followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's new multiple range test.

TABLE 3. Control of Wild Radish and Lupine Tolerance from the Use of Herbicides Following an Application of 1.12 kg/ha Bentazon.

Treatment	Date 1-26-80	2-3-80	2-7-80	2-14-80
	Wild Radish Control			
acifluorfen	4.0 a	7.5 a	9.25 a	9.7 a
bentazon	2.0 b	8.0 a	9.25 a	9.5 a
2,4-DB	1.0 bc	1.0 b	1.0 b	1.5 b
check	0.5 c	1.0 b	1.0 b	1.0 b
	Crop Tolerance			
acifluorfen	8.0 a	9.45 a	9.9 a	9.9 a
bentazon	10.0 a	9.95 a	9.9 a	9.9 a
2,4-DB	2.0 b	5.0 b	4.0 b	2.5 b
check	0.0 b	0.5 c	2.0 b	2.0 b

A rating of 0 equals no affect on the crop or weed, while a rating of 10 equals complete control of either the crop or the weed.

Values among treatments within each date followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's new multiple range test.

TABLE 4. Control of Wild Radish and Lupine Tolerance From the Use of Herbicides Following No Previous Herbicide Application.

Treatment	Date: 1-26-80	2-3-80	2-7-80	2-14-80
	Wild Radish Control			
acifluorfen	3.0 a	4.5 a	6.5 b	8.25 a
bentazon	1.0 b	6.0 a	8.0 a	8.75 a
2,4-DB	0.56 b	0.0 b	0.0 c	0.0 b
check	0.0 b	0.0 b	0.0 c	0.0 b
	Crop Tolerance			
acifluorfen	5.0 a	9.0 a	8.5 b	7.5 a
bentazon	3.5 ab	9.9 a	9.9 a	9.9 a
2,4-DB	0.5 b	3.5 b	2.0 c	2.5 b
check	0.5 b	0.5 b	0.0 d	0.0 b

A rating of 0 equals no affect on the crop or weed, while a rating of 10 equals complete control of either the crop or the weed.

Values among treatments within each date followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's new multiple range test.

WEED CONTROL FOR NO-TILLAGE SOYBEANS IN RYE STRAW

RAYMOND N. GALLAHER AND WAYNE L. CURREY

INTRODUCTION

Soybean (Glycine max L. Merr.) is an important cash crop to Florida agriculture. In recent years acreage has steadily increased and is expected to be over 500,000 acres by 1985, This crop has a potential gross value of over 100 million dollars annually, adding significantly to Florida's economy. Most of Florida's soybean crop is planted succeeding other crops such as small grains, vegetables, and corn in multiple cropping systems.

Significant acreage of small grains grown for grain is produced in Florida. Soybeans–is an ideal crop to succeed small grain in a succession double cropping system. Past experience shows that no-tillage planting of soybeans into small grain straw can have advantages as compared to conventional tillage management. Some of these advantages include: 1) Elimination of tillage for seedbed preparation, thus conserving time, fuel cost, and equipment, and (2) Conservation of soil and water due to ground cover from the straw.

Weed control in no-tillage soybeans planted into small grain straw can often get out of hand if proper herbicides and timing of herbicide application are not managed properly. Weeds probably cause the greatest yield loss and .is the most devistating pest encountered in soybean farming irrespective of tillage regeime. The objective of this study was to investigate herbicides and no-tillage management variables for control of weeds and treatment influence on yield of soybeans planted in rye straw.

MATERIALS AND METHODS

This study was conducted from 1977 through 1979 at the Green Acres Agronomy farm near Gainesville, Florida. Cobb soybeans were planted into rye straw in late May using a Brown Harden Superseeder minimum tillage planter. Soybeans were seeded in 30 inch rows at 12 seed per foot. Main treatments were no-tillage in-row subsoil versus no-tillage coulter slot-planting. Four sub-treatments were herbicide combinations as shown under Tables 1 and 2. The test was replicated three times. All plots received .25 pounds a.i. paraquat plus 1 pint Ortho x 77 per 100 gallons of water applied post directed when the crop was 14 to 18 inches in height.

Weed populations were estimated at harvest each year and are reported as percentage of the ground covered by weeds. No ground cover of weeds would represent 0% while complete ground cover would represent 100%.

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RESULTS AND DISCUSSION

Yield

Soybean yield was considerably higher than the Florida state average (Table 1). No-tillage coulter slot-planting gave the highest yield in 1977 as compared to no-tillage in-row subsoil. Weather conditions in 1977 were such that severe moisture stress occurred all over Florida. Several sources indicated that sufficient rainfall did not occur to seal up the subsoil slots in 1977 and instead of obtaining better soil moisture utilization, the reverse occurred. No data is available to substantiate this hypothesis: however, the open slot may have caused soil moisture to evaporate and be lost more easily. Main plot treatments had no affect on yield in 1978 or 1979.

Herbicide treatments had no effect on yield of soybeans in 1977. The area was in bahiagrass *(Paspalum Notatum* Flugge) Var.) sod and was destroyed by tillage in 1976. Weeds were not a big problem in 1977 as in subsequent years, Also bahiagrass reestablishment and competition did not become significant until after the first year. These combined factors are thought to be the reasons for all herbicides resulting in similar yield of soybeans in 1977.

A definite trend emerged among herbicide variables in 1978 and 1979. The best treatment (alachlor + metribuzin + glyphosate) gave a three-year average of 37 bu/A. This was a six bu/A advantage over using glyphosate alone, which resulted in the lowest yield. Applications of oryzalin + metribuzin + paraquat and prodiamine + metribuzin + paraquat were not statistically different in yield from alachlor + metribuzin + glyphosate.

Ground Cover of Weeds

The percentage ground cover of weeds at harvest time (Table 2) shows a strong relationship with yield. As yield increased weed cover decreased. Note that weed pressure was much greater where glyphosate was used alone. All other treatments had the same ground cover of weeds at harvest. This difference was due. to residual herbicides used in the first three treatments but not in treatment four.

If the three year average yield in Table 1 is plotted against the three year average percentage ground cover of weeds in Table 2 then we obtain a simple change relationship given by the following equation: yield = 38 bushels - .23(x change in percent ground cover of weeds). This means that soybean yield was reduced by 0.23 bu/A as the percent ground cover of weeds increased by 1%. If there had been no weeds, yield should have been 38 bu/A. If there had been 30% round cover of weeds, yield prediction would be 38 bushels - .23(30%) or 31 bu/A.

Summary

With proper management, no-tillage soybeans in rye straw can be grown successfully. Proper selections and timing of herbicides are critical for successful weed control in no-tillage soybeans. This study shows that alachlor + metribuzin + glyphosate provided good overall yield and the least competing weeds. Other treatments, using residual herbicides and the contact herbicide paraquat were statistically equal in yield and in weed control to the above treatment. Soybean yield was reduced by almost 1/4 bu/A for each percentage increase in ground cover of weeds.

Table 1. Yield as affected by subsoiling and chemical weed control for minimum tillage soybeans.

Treatment	1977			1978			1979			3-Year Average		
	Sub-Soil	Coul.	$\bar{X}$	Sub-Soil	Coul.	$\bar{X}$	Sub-Soil	Coul.	$\bar{X}$	Sub-Soil	Coul.	$\bar{X}$
	Percent											
1[†]	41	46	40a[§]	34	32	33a	38	31	35a	37	36	37a
2	33	47	44a	32	28	30ab	31	31	31ab	32	35	34ab
3	37	43	40a	30	28	29ab	31	31	31ab	32	34	33ab
4	37	41	39a	29	27	28 b	26	29	28 b	30	32	31 b
$\bar{X}$	37	44[‡]		31	29NS		32	31NS		33	34NS	

[†]1. Alachlor (Lasso) 3 lb. a.i./A + Metribuzin (Sencor 50WP) 0.38 lb a.i./A + glyphosate (Roundup) 2 lb a.i./A.
2. Oryzalin (Surflan 75W) 1 lb. a.i./A + Metribuzin (Sencor 50WP) 0.38 lb/A a.i. + paraquat (Ortho Paraquat CL) .5 lb a.i./A + Ortho X-77 added at 1 pt/100 gal. spray.
3. Prodiamine (Rydex) 0.33 lb a.i./A + Metribuzin (Sencor 50WP) .38 lb a.i./A + paraquat (Ortho Paraquat CL) .5 lb a.i./A + Ortho X-77 added at 1 pt/100 gal. spray.
4. Glyphosate (Roundup) 2 lb a.i./A.

[‡]Significant difference between tillage means at 0.05 level of probability.

[§]Means followed by common letters in the same column are non significant at the 0.05 level of probability.

NS = Non-significant

Alachlor - 2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide
Metribuzin - 4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)one
Glyphosate - N(phosphonemethyl)glycine
Oryzalin - 3,5-dinitro-N^4,N^4-dipropylsulfanilamide
Paraquat - 1,1'-dimethyl-4,4'-bipyridinium ion
Prodiamine - 2,4-dinitro-N3,N3-dipropyl-6-(trifluoromethyl)-1,3-benzenediamine

Table 2. Percent ground cover of weeds at harvest of minimum tillage as affected by tillage and chemical weed control.

Treatment	1977 Sub-Soil	1977 Coul.	1977 $\bar{X}$	1978 Sub-Soil	1978 Coul.	1978 $\bar{X}$	1979 Sub-Soil	1979 Coul.	1979 $\bar{X}$	3-Year Average Sub-soil	3-Year Average Coul.	3-Year Average $\bar{X}$
	percent											
1.[†]	21.3	11.3	16.3 b[§]	12.0	14.0	13.0 b	6.8	12.5	9.7a	13.5	13.8	13.21
2.	25.8	17.0	21.4 b	15.3	13.0	14.2 b	16.0	18.8	17.4a	19.3	16.3	17.8'
3.	22.5	23.8	23.2 b	22.0	12.0	17.0 b	11.3	18.8	15.1a	18.8	18.3	18.61
4.	41.3	26.3	33.8a	61.3	43.8	52.6a	14.5	22.5	18.5a	39.0	28.3	33.7a
$\bar{X}$	27.8	19.6NS		27.7	29.7NS		12.2	18.2NS		22.7	18.9NS	

[†] 1. Alachlor (Lasso) 3 lb. a.i./A + Metribuzin (Sencor 50WP) .38 lb a.i./A + glyphosate (Roundup) 2 lb a.i./A.
2. Oryzalin (Surflan 75W) 1 lb a.i./A + Metribuzin (Sencor 50WP) .38 lb a.i./A + paraquat (Ortho Paraquat CL) .5 a.i./A + Ortho X-77 added at 1 pt/100 gal. spray.
3. Prodiamine (Rydex) .33 lb a.i./A + Metribuzin (Sencor 50WP) .38 lb a.i./A + paraquat (Ortho Paraquat CL) .5 a.i./A + Ortho X-77 added at 1 pt/100 gal. spray.
4. Glyphosate (Roundup) 2 lb a.i./A.

[§] Means followed by common letters in the same column are non significant at the 0.05 level of probability.

NS = Non Significant

SUBSOILING AND MINIMUM TILLAGE OF CORN ON FLORIDA FLATWOOD SOIL

R.N. Gallaher and W.R. Ocumpaugh

INTRODUCTION

Establishing corn (Zea mays L.) in unprepared seedbeds is becoming a widely practiced management procedure. Minimum or no-tillage planting of corn can significantly reduce fuel use and the time required to plant when compared to conventional tillage management. Florida has a widely diverse number of soil types, some of which have produced greater corn yield after in-row subsoiling when compared to a check. Florida flatwood soils are extensive and data on subsoiling and minimum tillage on these soils are lacking. This paper provides and discusses corn data as influenced by tillage on three Florida flatwood sites in 1979. The soil at all locations was a Pomona sand (sandy, siliceous, hyperthermic Ultic Haplaquods) having less than one percent slope.

EXPERIMENTAL PROCEDURE

Three experiments were established in 1979 on soils classified as Pomona sand. These studies were either on or adjacent to the Beef Research Unit of the Institute of Food and Agricultural Sciences, University of Florida, located about 19 km (12 miles) North of Gainesville. All experiments had two corn hybrids ('DeKalb XL78' and 'Asgrow RX114') as whole plots and in-row subsoiling versus no subsoiling as sub plots. Each was replicated three times. Tillage and planting operations were accomplished with 4600 and 5600 Ford tractors. Brown-Harden two row Superseeder frames were used for planting, one with and one without in-row subsoilers attached. Individual planters were John Deere Flexi 71 units attached to the frame.

In a single pass, corn was seeded in 76.2 cm (30 inches) wide rows at 74,130 seed/ha (30,000 seed/A) with 2.24 kg/ha (2 pound/A) active ingredient (a.i.) alachlor (Lasso) (2-chloro-2', 6'-diethyl-N-(methoxymethyl) acentanilide), 2.24 kg/ha (2 pounds/A) a.i. atrazine (2-chloro-4-ethylamino-6-isopropyl-amino-1,3, 5-triazine) and 2.24 kg/ha (2 pounds/A) a.i. carbofuran (Furadan) (2, 3-Dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate). Corn on minimum tillage experiments also received in the herbicide tank mix 0.56 kg/ha (0.50 pounds/A) a.i. paraquat plus 0.47 L (1 pint) Ortho X77 surfactant per 378.4 L (100 gallons) of water applied. The herbicides were applied using 8004 tips spaced 50.8 cm (20 inches) apart at 2.812 kg/cm^2 (40 psi) pressure in a liquid solution of 113.52 L/ha (30 gallons/A) using water as a carrier.

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Experiment one

Land preparation for experiment one included a harrow (2.44 meter 8 foot bushog) operation followed by a moldboard plow (Ford with three 40.6 cm (16 inch) plows) operation on recently cleared land. We then broadcast 56-43.4-232.6-33.6-28 kg/ha (50–38.7–207.5–30–25 pounds/A) of N(nitrogen), P(phosphorous), K(potassium), Frit 503 trace elements and Mg(magnesium), respectively and harrowed once more on March 16 prior to planting on March 17. Plot size consisted of eight rows 76.2 meters (250 feet) long. A 23.2 sq meter (250 sq feet) area was sampled from each plot for yield determination on July 6, 1979.

Experiment two

This area had been in corn production in 1977 but was not farmed in 1978. In November of 1978 a light harrow was run over the test site but young blackberry (Rubus sp.) and other weeds were extensive when corn was planted by the minimum tillage procedures on March 17, 1979. Fertilizer was applied at planting in a 20 cm (8 inch) band over the top of the corn row at a rate of 31.4–27–78.2 kg/ha (28–24–69.7 pounds/A) N, P, and K, respectively. The plots were 6 rows wide and 30.48 meters (100 feet) in length. A 9.29 sq meter (100 sq feet) area was sampled from each plot for yield determination on July 6, 1979.

Experiment three

This area was adjacent to experiment two and had the same cropping history. This area was undisturbed, in that it had not been harrowed the previous fall as was the case in experiment two. It was covered with large fruit bearing blackberry briars and covered uniformly with other broadleaf and grassy weeds. Treatment and sampling was the same as for experiment two, however, plot length was 15.24 meters (50 feet) instead of 30.48 meters (100 feet) as for experiment two. Plots were sampled for yield determination on July 9, 1979.

Common practices

Procedures common to all studies included the sidedress application of 168 kg N/ha (150 pounds/A) when corn was 50 cm (20 inches) in height. Near the same time a post direct application of 0.28 kg/ha a.i. paraquat plus 1.121 kg/ha a.i. linuron (Lorox) (3-(3, 4-Dichlorophenyl)-l-methoxy 1–methyl–urea) and 0.47 L (1 pint) Ortho X77 surfactant per 378.4 L (100 gallons of water was made on minimum tillage experiments. Post direct herbicide treatments were not needed on experiment one because of low weed populations associated with the recently cleared land.

Plot weights of whole plants and ears were taken for dry matter, moisture and shelling percent using routine procedures. Forage yields are reported at zero moisture on a dry matter basis and grain adjusted to 15.5%.

Statistical analyses were made using taped programs for a split plot on a programmable calculator. Means were evaluated by F test.

RESULTS AND DISCUSSION

Data are given in tables 1 through *3* for yield and other variables. We have indicated treatment differences at the *80%* level of probability and above. The *80%* level was chosen due to the difficulty of measuring treatment difference with a small number of replications and treatments.

Both hybrids responded to subsoiling for forage yield in all experiments. This was not the case for grain yield. DeKalb *XL78* did not respond in experiment two and neither hybrid responded to subsoiling in experiment three. Grain yield was positively related to ear weight and ear weight was larger in the two minimum tillage experiments, (Tables *2* and ***3)*** as compared to the conventional tillage test (Table 1). This was as expected since it has been shown that more soil moisture is available to corn if grown under minimum tillage as compared to conventional tillage. Since subsoiling also resulted in higher yield it can be assumed that this also was beneficial in moisture conservation and possibly better plant root distribution into the subsoil layers.

Subsoiling had the greatest benefit for corn in the conventional tillage study (Table 1). More soil moisture would be lost as a result of extra soil exposure for evaporation and lack of ground cover to reduce runoff and infiltration in the conventional tillage area. The greater response to subsoiling in experiment one indicated a greater need for subsoil water as compared to the no-tillage studies.

Yields in the no-tillage experiments were equal to or greater than in the conventional tillage test. Most inputs were equal except for the extra fertilizer used and extra fuel consumption, and time required to prepare the land €or planting in experiment one. Specific fuel consumption and time measurements for various operations have not been made for a Pomona sand but have been measured for other Florida soils. Using average values for fuel consumption and time measures for Florida sandy soils show that the various tillage regimes used in these studies vary widely as follows: (1) Conventional tillage soil preparation and planting would use an average of 34.78 L/ha (3.72 gallons/A) of diesel fuel and would take 241.91 min/ha (97.9 min/A) to perform. (2) Planting with in-row subsoiling into the conventional tillage seedbed would add 5.05 L/ha (.54 gallons/A) fuel used and would require additional time of 12.36 min/ha (5.0 min/A). (3) No-tillage would reduce fuel and time requirements tremendously. No-tillage without subsoiling required an average of 6.55 L/ha (.70 gallons/A) diesel fuel and 77.59 min/ha (31.4 min/A) to plant. (4) No-tillage with in-row subsoiling would add 6.45 L/ha (.69 gallons/A) diesel fuel used and 9.43 min/ha (41 min/A) time to plant corn.

From the fuel and time data given we can note the following: (1) To grow corn as in experiment one (non-subsoiled) it would require five times more fuel than no-tillage (non-subsoiled) as in experiments two and three, (2) it would take over three times more time to establish the crop in the conventional versus no-tillage system, and (3) it would take twice the fuel of that required for no-tillage to plant with in-row subsoiling, but would require only slightly more time to subsoil.

If farmers can obtain yields from no-tillage on flatwood soils as we obtained in these studies, significant savings in energy, equipment, and labor will result in Florida agriculture. At the same time profits would be higher because of these reduced input costs as well as 'the extra returns generated from higher yields that would likely occhr.

An additional factor that needs to be considered on flatwood soils is that if heavy rains come after the soil has been cultivated (harrowed and/or moldboard plowed) it can become so wet during the planting season that it may delay planting. The cultivated soil when wet will not support machinery. This is not a serious problem in minimum tillage situations. Thus in wet years planting time could be delayed from a few days to a few weeks under convenfional tillage. Delayed planting often results in reduced yields. Worse still would be to have the soil tilled and the fertilizer cultivated in, ready to plant then get heavy rain that delayed planting two weeks or more as happened at the Beef Research Unit in 1980. No measurements were made, but undoubtedly, considerable N and K fertilizer was lost due to leaching.

Table 1. Corn Variables as influenced by subsoiling and corn hybrids grown on a flatwood soil in a conventional tillage seedbed, Gainesville, Florida, 1979. (Exp. 1).

	Subsoil			Subsoil		
Variety	Yes	No	Mean	Yes	No	Mean
	Dry forage yield kg/ha			Grain yield kg/ha		
DeKalb XL78	18,699	15,993	17,346a	7,044a	6,755a+	6,900
Asgrow RX114	18,650	15,890	17,270a	6,077a	4,708a+	5,393
Mean	18,675	15,942*		6,561	5,732**	
	Percentage grain in forage			Ear weight in grams		
DeKalb XL78	31.8a	32.1aNS	32.0	134	103	119a
Asgrow RX114	30.6a	25.0b*	27.8	130	87	109a
Mean	31.2	28.6		132	95**	
	Number plants/ha			Number ears/ha		
DeKalb XL78	57,564	56,531	57,048b	52,828	58,856	55,842a
Asgrow RX114	59,717	65,314	62,516a	52,225	54,378	53,381a
Mean	58,641	60,923NS		52,527	56,617*	
	Plant height in cm			Ear node height in cm		
DeKalb XL78	251a	259aNS	255	81	86	84b
Asgrow RX114	265a	239b++	252	91	98	95a
Mean	258	249		86	92NS	

NS=Non significant
+ = Significant interaction at the 80% level of probability.
++ = Significant interaction at the 90% level of probability.
* = Significant interaction at the 95% level of probability or between the tillage treatment.
** = Significant differences at the 99% level between tillage treatments.
letters = Values between hybrids followed by different letters are significantly different at the 95% level of probability.

Multiply kg/ha by 0.89 to get pounds/A.
Multiply number/ha by 0.405 to get numbers/A.
Divide grams by 454 to get pounds.
Divide cm by 2.54 to get inches.

Table 2. Corn variables as influenced by subsoiling and corn Hybrids on a flatwood soil in a non-tilled seedbed, Gainesville, Florida, 1979. (Exp. 2).

Variety	Subsoil Yes	Subsoil No	Mean	Subsoil Yes	Subsoil No	Mean
	Dry forage yield kg/ha			Grain yield kg/ha		
DeKalb XL78	22,221	20,822	21,522a	9,209	9,121	9,165a
ksgrow RX114	18,613	17,668	18,14lb+	7,734	7,539	7,637b++
Mean	20,417	19,245+		8.472	8.330NS	
	Percentage grain in forage			Ear weight in grams		
DeKalb XL78	35.0	37.0	36.0a	153	154	154a+
Asgrow RX114	35.1	36.1	35.6a	145	137	141b
Mean	35.1	36.6NS		149	146NS	
	Number plants/ha			Number ears/ha		
DeKalb XL78	60,600	61,676	61,138a	60,600	59,200	59,900a
Asgrow RX114	55,971	51,666	53,819a	54,895	55,218	55,057a
Mean	58,286	56,671NS		57,748	57,209NS	
	Plant height in cm			Ear node height in cm		
DeKalb XL78	272	266	269a	97	96	97a
Asgrow RX114	268	252	260a	97	102	lOOa
Mean	270	259NS		97	99NS	

NS = Non significant.
\+ = Significant interaction at the 80% level of probability.
++ = Significant interaction at the 90% level of probability.
* = Significant interaction at the 95% level of probability or between the tillage treatment.
** = Significant differences at the 99% level between tillage treatments.
letters = Values between hybrids followed by different letters are significantly different at the 95% level of probability.

Multiply kg/ha by 0.89 to get pounds/A.
Multiply number/ha by 0.405 to get numbers/A.
Divide grams by 454 to get pounds.
Divide cm by 2.54 to get inches.

Table 3. Corn variables as influenced by subsoiling and corn hybrids on a flatwood soil in a non-tilled seedbed, Gainesville, Florida, 1979. (Exp. 3).

Variety	Subsoil Yes	Subsoil No	Mean	Subsoil Yes	Subsoil No	Mean
	Dry forage yield kg/ha			Grain yield kg/ha		
DeKalb XL78	15,542	14,629	15,086a	7,144a	7,232a NS	7,188
Asgrow RX114	16,793	14,751	15,772a	7,389a	6,089a+	6,739
Mean	16.168	14.690++		7,267	6,661	
	Percentage grain in forage			Ear weight in grams		
DeKalb XL78	38.8	41.8a++	40.3	154a	150a NS	152
Asgrow RX114	37.2	34.96++	36.1	162a	130b++	146
Mean	38.0	38.4		158	140	
	Number plants/ha			Number ears/ha		
DeKalb XL78	42,732	46,284	44,508a	47,360	47,683	47,522a
Asgrow RX114	40,364	48,437	44,401a	45,530	46,607	46,069a
Mean	41,548	47,361 NS		46.445	47,145 NS	
	Plant height in cm			Ear node height in cm		
DeKalb XL78	256	252	254a	85	76	81a
Asgrow RX114	255	246	251a	99	86	93a
Mean	256	249 NS		92	81 NS	

NS = Non significant.
\+ = Significant interaction at the 80% level of probability.
++ = Significant interaction at the 90% level of probability.
* = Significant interaction at the 95% level of probability or between the tillage treatment.
** = Significant differences at the 99% level between tillage treatments.
letters = Values between hybrids followed by different letters are significantly different at the 95% level of probability.

Multiply kg/ha by 0.89 to get pounds/A.
Multiply number/ha by 0.405 to get numbers/A.
Divide grams by 454 to get pounds.
Divide cm by 2.54 to get inches.

COMPARISONS OF ENERGY REQUIREMENTS FOR WEED CONTROL IN CONVENTIONAL AND NO-TILLAGE SOYBEANS

J. M. GOETTE, W. L. CURREY, B. J. BRECKE,
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ABSTRACT

Comparisons of energy efficiency were made between weed control programs in conventional and no tillage soybean (Glycine max (L.) Merr.) production. Two weed control systems of each of conventional and no tillage soybean production were compared. Calculated energy inputs and measured yields were used to determine the specific energy productivity for each weed control program. Both no tillage operations showed the highest overall energy efficiency with paraquat + oryzalin + metribuzin at planting and metribuzin + 2,4-DB directed post exhibiting the greatest energy productivity.

INTRODUCTION

The weed control programs in this study were selected to compare the energy efficiences of preemergence and directed post herbicides in no-till soybean production to that of preplant incorporated herbicides in combination with directed post herbicides or cultivation in conventional production.

Energy is an important factor in determining the efficiency of production. The importance of energy will increase in the future due to rising fuel costs and exhaustion of non-renewable resources. Energy conservation is a major reason for the increasing adoption of no tillage production systems.

There are many different energy units used throughout the world. One of the more common units is the joule which is of the metric (**SI**) system. This report will commonly refer to these energy units as megajoules (MJ) or 10^6 joules.

Fluck (1979) proposed that a new measure of productivity, the quantity *of* product per unit of input energy, be designated and that **it** be termed energy productdvity. In the **SI** system of units, a convenient measure of energy productivity is kilogrammes per megajoule (kg/MJ).

Energy productivity is specific for each agricultural product, location and time. That is, energy productivity can be used only to compare alternative production systems and energy conservation practices which result in the same product, at the same place, at the same time. By calculating the energy productivity of various production systems, the most energy efficient system may be determined.

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RESULTS AND DISCUSSION

Results from these four weed control programs indicated that the no-tillage operations produced larger yields and required less energy input than the conventional operations. Therefore, the no-till production systems showed greater efficiency from an energy point of view due to larger values of energy productivity.

Many explanations exist for no-tillage efficiency. Robertson and Prine (1976) and Triplett and Van Doren (1977) listed numerous advantages:

(1) Less fuel is required due to fewer and less energy-intensive field operations.

(2) Higher yields often result, particularly in dry land farming and on well-drained land. Evidence of this report supports the above statement.

(3) Less time and labor are required.

(4) Land use may be intensified.

(5) It is possible to farm lower quality land.

(6) Less erosion occurs.

(7) Moisture is conserved.

(8) Soil structure may be improved.

(9) There is lower investment for machinery.

The no-till weed control program that exhibited the greatest energy productivity was the combination of paraquat + oryzalin + metribuzin at planting with metribuzin + 2,4-DB directed post. This herbicide program produced an efficiency rating 21.7% greater than that of the highest yielding conventional program and 27.3% greater than that of the lowest yielding conventional program.

The no-till preemergence application of paraquat, alachlor, and metribuzin contributed the second highest energy productivity. This weed control program was found to be 17.8% greater than that of the highest yielding conventional program and 23.7% greater than that of the lowest yielding conventional program which contained two cultivations.

Green and McCulloch (1976) stated that, in general, at least two mechanical weeding operations are required to achieve the effect of one chemical treatment. This statment is supported by the poor performance of the conventional program which contained two cultivations. It produced the lowest yield while requiring the greatest total energy input. When compared to the directed post-treatments in conventional production, the mechanical weeding again proved to be the least efficient. This comparison supports the statement that chemicals are an efficient use of fossil fuel.

The purpose of this research was to determine the energy requirements of various weed control programs in no-tillage and conventional production of soybeans and to compare their energy efficiencies.

MATERIALS AND METHODS

Field experiments to evaluate the energy productivity of weed control programs in no-till and conventional soybean production were initiated in June of 1979 at the Agricultural Research Center located in Jay, Florida. The soil type was a Tifton fine sandy loam. Preplant incorporated and preemergence herbicides were applied during the first week in June with the directed-post treatments applied August 1. Soybeans yields for these four weed control programs were obtained in the fall.

The energy inputs for manufacturing soybean herbicides are given in Table 1. This energy input is the product of the energy requirement for manufacturing times the application rate. The weed control programs in no-tillage and conventional soybean production are listed in Table 2. The no-till programs consist of preemergence applications with one program having additional directed-post treatments. The conventional programs include preplant incorporated treatments with the first program containing two cultivations and the second having directed-post treatments. The itemized energy inputs include the energy required for herbicide production, incorporation, cultivation, and application of directed-post treatments. The energy inputs for preplant and preemergence application are included with the incorporation and planting operations.

When examining energy productivity, all inputs of production must be considered. For conventional soybean production, the total energy input less the energy required for herbicide production, application, incorporation and cultivation equals a base energy input of 15,164 MJ/ha. The base energy input includes energy for fertilizer, fungicides, insecticides, labor, and machinery. This value must be added with the individual weed control inputs to give an accurate estimate of the total energy input.

No-till production systems require less energy inputs of production. Fluck and Baird (1980) state that fuel reductions result in an average saving of 1170 MJ/ha. Lower labor requirements also result in a decrease in energy consumption. Elimination of two field operations might reduce labor inputs by one hour per hectare or labor energy requirements by about 75 MJ/ha. Lower energy requirements for less machinery will be in the order of 100-200 MJ/ha. Total energy reductions for limited tillage as compared to conventional cultivation may be in the order of 1395 MJ/ha for the base energy input. This reduction of energy consumption in no-till production results in a base energy input of 13,769 MJ/ha as compared to 15,164 MJ/ha for conventional production systems.

The energy productivity (Table 3) is calculated by dividing the yield (kg/ha) by the total energy input (MJ/ha). Fluck and Baird (1980) state that energy productivity is intended to and can serve as an evaluator of how efficiently energy is utilized in production systems yielding a particular product. This value illustrates the quantity of soybeans produced per megajoule of input energy.

The findings of this study strongly support the advancement of herbicide weed control programs in no-tillage soybeans over that of conventional tillage practices. The higher energy productivity of weed control in no-till soybeans illustrates the effectiveness of no-tillage in combination with proper weed control programs.

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Table 1. ENERGY INPUT FOR SOYBEAN HERBICIDE PRODUCTION

Herbicide	Rate lb/A	Rate kg/ha	Energy Requirements MJ/kg	Herbicide[1] Energy Input MJ/ha
Paraquat	.25	.28	460	129
Trifluralin	.50	.56	150	84
Alachlor	2.0	2.24	280	627
Oryzalin	1.0	1.12	150	168
Metribuzin	.50	.56	410	230
2,4-DB	.25	.28	87	24

[1] Produat of energy requirement times rate of application.

Table 2. ENERGY INPUTS FOR WEED CONTROL PROGRAMS IN NO TILLAGE AND CONVENTIONAL SOYBEANS

Cultivation (one) - 390 MJ/ha
Application (one) - 73 MJ/ha
Incorporation (2-disc) - 750 MJ/ha

Weed Control Programs	Itemized Energy Inputs MJ/ha	Subtotal Energy Inputs MJ/ha
A. No Tillage		
(1) Paraquat pre +	129	
Alachlor pre +	627	
Metribuzin pre	230	986
(2) Paraquat pre +	129	
Oryzalin pre +	168	
Metribuzin pre +	230	
Metribuzin DP +	230	
2,4-DB DP	24	
Application (DP)	73	854
B. Conventional Tillage		
(3) Trifluralin ppi +	84	
Metribuzin ppi +	230	
Incorporation +	750	
Cultivations (2)	780	1844
(4) Trifluralin ppi +	84	
Metribuzin ppi +	230	
Incorporation +	750	
Metribuzin DP +	230	
2,4-DB DP +	24	
Application (DP)	73	1391

Table 3. ENERGY PRODUCTIVITY OF WEED CONTROL PROGRAMS IN NO-TILLAGE AND CONVENTIONAL SOYBEAN PRODUCTION.

Weed Control Program	Yield kg/ha	Total Energy[1] Input MJ/ha	Energy[2] Productivity kg/MJ
(1) Paraquat + Alachlor + Metribuzin	2345	14755	.1589
(2) Paraquat + Oryzalin + Metribuzin + Metribuzin + 2,4-DB	2439	14623	.1668
(3) Trifluralin + Metribuzin + Cultivations (2)	2063	17008	.1213
(4) Trifluralin + Metribuzin + Metribuein + 2,4-DB	2164	16555	.1307

[1]Conventional Tillage - 15,164 MJ/ha + Weed Control Input.
No Tillage - 13,769 MJ/ha + Weed Control Input.

[2]Energy Productivity $= \dfrac{\text{Yield kg/ha}}{\text{Total Energy Inputs MJ/ha}}$

= Quantity of soybeans produced per megajoule of input energy.

ARE NO-TILL MULTICROPPING PRODUCTION METHODS PROFITABLE FOR FLORIDA FARMERS?

DAN L. GUNTER, NANCY MCCABE AND RAY GALLAHER

Increasing costs of agricultural inputs, especially energy and credit, are forcing farmers to evaluate their conventional production methods to determine if lower cost practices can be identified. No-till and multicropping are two practices being given increasing consideration.

Benefits of these practices have been extolled in many of the agriculture publications. The benefits often mentioned include:

1. better utilization of land,
2. reduced fuel and labor costs,
3. spreading of fixed costs of machinery over more annual hours of use, and
4. possible increased yields.

New planting equipment designed to operate in unplowed stubble or mulch and improved herbicides to control weeds and grasses reduce the problems farmers have found to be associated with no-till production practices.

Scientists working for the Institute of Food and Agricultural Sciences (IFAS) at the University of Florida have been conducting research on no-till and multi-cropping methods for some of the more important Florida field crops.

The purpose of this paper is to report an evaluation of the profitability of producing corn and soybeans using no-till, multicropping practices. A profit-ability comparison is also made to conventional corn and soybean production.

PROCEDURE

We used data collected from IFAS experiments which were first conducted during 1973 at the University farm near Williston. Multicropping was used in both the no-till and conventionally produced crops. Rye was harvested as hay and/or grain and followed by either corn or soybeans planted with conventional or no-till methods.

Corn and soybeans were no-till planted in a single operation using a two row Brown-Harden Super Seeder with a subsoiler. Conventionally planted corn and soybeans required harrowing, plowing, harrowing and then planting.

To compare the profitability of these enterprises we developed budgets which are a systematic listing of income and expenses for a production period. The

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budgets show income, variable costs, harvest costs, fixed costs and net returns. The budgeted costs are based on 1980 input price levels and the annual ownership and operation costs of the following set of machinery and equipment:

Machinery and Equipment

	USED IN NO-TILL PRODUCTION	USED IN CONV. PRODUCTION
Tractor, 55 hp	X	X
Truck, 2 ton	X	X
Grain Combine	X	X
Sprayer	X	X
Planter		X
Super Seeder 2 row	X	X
MB Plow (4)		X
Harrow		X
Fertilizer Spreader	X	X

ESTIMATED COSTS FOR SOYBEANS

The budget for conventionally tilled soybeans is shown in Figure 1. Yield from the experiment was 20 bushels per acre, variable costs are $78.87 and harvest costs, which include labor and operating expenses associated with the machinery, are $7.81 per acre. The total variable costs which can be thought of as "out –of-pocket" expenses totaled $86.68. The fixed costs are $21.52 and include the normal "DIRTI" five expenses associated with ownership of machinery and equipment. The DIRTI five are: Depreciation, Interest, Repairs, Taxes, and Insurance. Total per acre costs are $108.20, which subtracted from grow receipts leaves a net return to land and management of $65.80 per acre.

ESTIMATED COSTS FOR CORN

Budgets for no-till and conventionally produced corn are shown in Figures 3 and 4. The revenue and costs for alternative corn production methods are:

	NO-TILL	CONVENTIONAL
	---------------- Dollars	----------------
Revenue	263.25	256.50
Total Costs	156.77	166.04
Returns to Land and Management	106.48	90.46

CONVENTIONAL TILL SOYBEANS IN RYE STUBBLE
YELL DRAINED ACIDIC SANDY LOAM
LEVY COUNTY. 1980 PRICES

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION				$
	BU.	6.00	29.00	174.00
TOTAL				$ 174.00
2. VARIABLE COSTS				
PREHARVEST				$
SOYBEAN SEED	BU.	13.00	1.00	13.00
TOXAPHENE	LBS.	0.77	4.00	3.08
PARAQUAT	PT.	5.30	2.50	13.25
LASSO	LBS.	4.50	2.00	9.00
LEXONE	LBS.	8.75	0.38	3.32
BASAGRAN	QT.	7.75	2.25	17.44
ORTHO X 77	PT.	1.75	0.67	1.17
INNOCULANT	BU.	1.70	1.00	1.70
MACHINERY	ACRE	2.46	1.00	2.46
TRACTORS	ACRE	5.11	1.00	5.11
LABOR(TRACTOR & MACHINERY)	HOUR	3.50	1.65	5079
INTEREST ON OP. CAP.	DOL.	0.14	25.32	3.54
SUBTOTAL, PRE-HARVEST				$ 78.87
HARVEST COSTS				$
MACHINERY	ACRE	5.47	1.00	5.47
LABOR(TRACTOR & MACHINERY)	HOUR	3.50	0.67	2.34
SUBTOTAL, HARVEST				$ 7.80
TOTAL VARIABLE COST				$ 86.68
3. INCOME ABOVE VARIABLE COSTS				$ 87.32
4. FIXED COSTS				$
MACHINERY	ACRE	17.21	1.00	17.21
TRACTORS	ACRE	4.31	1.00	4.31
TOTAL FIXED COSTS				$ 21.52
5. TOTAL COSTS				$ 108.20
6. NET RETURNS				$ 65.80

BROWN-HARDEN SUPER SEEDER
COBB SOYBEANS, SUBSOILED
NANCY MCCABE - RAY GALLAHER 3/10/80

BUDGET IDENTIFICATION NUMBER--- 124438040 10118
ANNUAL CAPITAL MONTH 11

PROCESSED BY FARM SYSTEMS LAB - FOOD & RESOURCE ECON. DEPT., U. OF FLORIDA
PROGRAM DEVELOPED BY DEPT. OF AG. ECON. , OKLAHOMA STATE UNIVERSITY
DATE PRINTED: 30 APRIL 1980

Figure 1.

NO-TILL SOYBEANS IN RYE STUBBLE
WELL DRAINED ACIDIC SANDY LOAM
LEVY COUNTY, 1980 PRICES

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION				$
	BU.	6.00	39.00	234.00
TOTAL				$ 234.00
2. VARIABLE COSTS				
PREHARVEST				$
SOYBEAN SEED	BU.	13.00	1.00	13.00
TOXAPHENE	LBS.	0.77	4.00	3.08
PARAQUAT	PT.	5.30	2.50	13.25
LASS	LBS.	4.50	2.00	9.00
LEXONE	LBS.	8.75	0.38	3.32
BASAGRAN	QT.	7.75	2.25	17.44
ORTHO X 77	PT.	1.75	0.67	1.17
INNOCULANT	BU.	1.70	1.00	1.70
FURADAN	LBS.	0.72	10.00	7.20
MACHINERY	ACRE	2.01	1.00	2.01
TRACTORS	ACRE	2.66	1.00	2.66
LABOR(TRACTOR & MACHINERY)	HOUR	3.50	0.986	3.02
INTEREST ON OP. CAP.	DOL.	0.14	27.11	3.79
SUBTOTAL, PRE-HARVEST				$ 80.64
HARVEST COSTS				$
MACHINERY	ACRE	5.47	1.00	5.47
LABOR(TRACTOR & MACHINERY)	HOUR	3.50	0.67	2.34
SUBTOTAL, HARVEST				$ 7.80
TOTAL VARIABLE COST				$ 88.45
3. INCOME ABOVE VARIABLE COSTS				$ 145.55
4. FIXED COSTS				$
MACHINERY	ACRE	15.86	1.00	15.86
TRACTORS	ACRE	2.25	1.00	2.25
TOTAL FIXED COSTS				$ 18.10
5. TOTAL COSTS				$ 106.55
6. NET RETURNS				$ 127.45

BROWN-HARDEN SUPERSEEDER
COBB SOYBEANS. SUBSOILED, WITH FURADAN
NANCY MCCABE - RAY GALLAHER 3/10/80

BUDGET IDENTIFICATION NUMBER--- 124438040 10118
ANNUAL CAPITAL MONTH 11

PROCESSED BY FARM SYSTEMS LAB - FOOD & RESOURCE ECON. DEPT., U. OF FLORIDA
PROGRAM DEVELOPED BY DEPT. OF AG. ECON., OKLAHOMA STATE UNIVERSITY
DATE PRINTED: 30 APRIL 1980

Figure 2.

NO- TILL CORN GRAIN IN RYE HAY STUBBLE
WELL DRAINED ACIDIC SANDY LOAM
LEVY COUNTY, 1980 PRICES

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION				$
CORN	BU.	2.25	117.00	263.25
TOTAL				$ 263.25
2. VARIABLE COSTS				
PREHARVEST				$
CORN SEED	LBS.	0.85	19.00	16.15
NLPEK	CWT.	6.00	6.00	36.00
NITROGEN	LBS.	0.24	120.00	28.80
FURADAN	LBS.	0.72	20.00	14.40
ATRAZINE	LBS.	1.83	2.00	3.66
PARAQUAT	PT.	5.30	1.50	7.95
ORTHO X 77	PT.	1.75	0.66	1.15
LOROX	LBS.	4.50	1.00	4.50
MACHINERY	ACRE	2.06	1.00	2.06
TRACTORS	ACRE	3.36	1.00	3.36
LABOR(TRACTOR & MACHINERY)	HOUR	3.50	1.09	3.80
INTEREST ON OP. CAP.	DOL.	0.14	41.78	5.85
SUBTOTAL, PRE-HARVEST				$ 127.68
HARVEST COSTS				$
YACHINERY	ACRE	6.45	1.00	6.45
LABOR(TRACTOR b UACHINERYI	HOUR	3.50	0.85	
SUBTOTAL. HARVEST				$ 9.42
TOTAL VARIABLE COST				$ 137.10
3. INCOME ABOVE VARIABLE COSTS				$ 126.15
4. FIXED COSTS				$
WACHINERY	ACRE	16.84	1.00	16.84
TRACTORS	ACRE	2.83	1.00	2.83
TJTAL FIXED COSTS				$ 19.67
5. TOTAL COSTS				$ 156.77
6. NET RETURNS				$ 106.48

BROWN-HARDEN SUPERSEEDER
FUNKS G-4507 CORN, SUBSOILED, 5-10-5
NANCY MCCABE - RAY GALLAHER 3/10/80

BUDGET IDENTIFICATION NUMBER--- 104438040 10118
ANNUAL CAPITAL UONTH 7

PROCESSED BY FARM SYSTEMS LAB - FOOD E RESOURCE ECON. DEPT.,U. OF FLORIDA
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Figure 3.

CONVENTIONAL TILL CORN IN RYE HAY STUBBLE
YELL DRAINED ACIDIC SANDY LOAM
LEVY COUNTY. 1980 PRICES

	UNIT	PRICE Of? COST/UNIT	QUANTITY	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION				$
CORN	BU	2.25	114000	256.50
TOTAL				$ 256.50
2. VARIABLE COSTS				
PREHARVEST				$
CORN SEED	LBS.	0.85	19.00	16.15
N&P&K	CWT.	6.00	60 00	36.00
NITROCEN	LBS.	0.24	120.00	28.80
FURADAN	LBS.	0072	20.00	14.40
ATRAZINE	LBS.	1.83	2.00	3.66
PARAQUAT	PT.	5.30	1.50	7.95
ORTHO X 77	PT.	I. 75	0.66	1.15
LOROX	LBS.	4.50	1.00	4.50
MACHINERY	ACRE	2.52	1.00	2.52
TRACTORS	ACRE	5.81	1.00	5.81
LABOR(TRACTOR & MACHINERY)	HOUR	3.50	1.88	6.58
INTEREST ON OP. CAP.	DOL.	0.14	42.99	6.02
SUBTOTAL. PRE-HARVEST				$ 133.53
HARVEST COSTS				$
MACHINERY	ACRE	6.45	1.00	6.45
LABORETRACTOR & MACHINERY)	HOUR	3.50	0.85	2.97
SUBTOTAL. HARVEST				$ 9.42
TOTAL VARIABLE COST				$ 142.95
30 INCOME ABOVE VARIABLE COST5				$ 113.55
4. FIXED COSTS				$
MACHINERY	ACRE	18.19	1.00	18.19
TRACTORS	ACRE	4.90	1.00	4.90
TOTAL FIXED COSTS				$ 23.09
5. TOTAL COSTS				$ 166.04
6. NET RETURNS				$ 90.46

BROWN-HARDEN SUPERSEEDER
FUNKS G-4507 CORN. SUBSOILED, 5-10-5
NANCY MCCABE - RAY GALLAHER 3/10/80

BUDGET IDENTIFICATION NUMBER--- 104438040 10118
ANNUAL CAPITAL MONTH 7

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Figure 4.

Yields observed were three bushels per acre higher in the no-till field while the machinery operating costs were lower accountinq for the $76.02 difference in net revenue.

FUEL AND LABOR COSTS COMPARISONS

With increased interest in energy conservation, producers can compare fuel use for the alternative production methods. Figure 5 shows the gallons per acre of gasoline and diesel fuel. The no-till practices require almost three gallons less fuel than the conventional practices. This translates into more than a $3 per acre cost savings at 1980 fuel price levels. However, fuel savings alone may not provide enough incentive for farmers to adopt a new set of cultural practices.

In addition to the fuel savings, labor and machinery requirements are reduced with no-till practices. Figure 6 shows a labor savinas of almost 0.8 of an hour/acre for both corn and soybeans produced using no-till production methods. Likewise, machinery hours required are lower using no-till. For example, the variable costs per acre for the tractor is $5.11 for conventionally planted soybeans and $2.66 for no-till (Figure 7). The variable costs for the tractor for no-till corn production is $3.36 per acre as compared with $5.81 if produced conventional ly.

PROFITABILITY OF MULTICROPPING

Other fixed or variable cost comparisons can be made, but the real test is whether or not net returns are higher? If we compare net returns per acre where corn and soybeans are multicropped with hay, yieldinq both rye grain and hay, the total net returns are as follows:

	NO-TILL CORN	CONV. TILL CORN	NO-TILL SOYBEANS	CONV. TILL SOYBEANS
Single crop	$106.48	$ 90.46	$127.45	$65.80
Rye grain and hay	14.29	14.29	14.29	14.29
Total returns/acre	$120.77	$104.75	$141.74	$80.09

CONCLUSIONS

The results of the experiments and budget analysis show that no-till and multi-cropping are more profitable than conventional cultural practices to produce the same crops. Differences in profits are due to reduced costs and higher yields using no-till production.

These results stem from one year's experiment. Further experimental work needs to be undertaken to evaluate the effectiveness of no-till practices under farm conditions. Farmers considering no-till practices should do some careful feasibility analyses before they trade their mold board plow and disk for one-pass planting equipment.

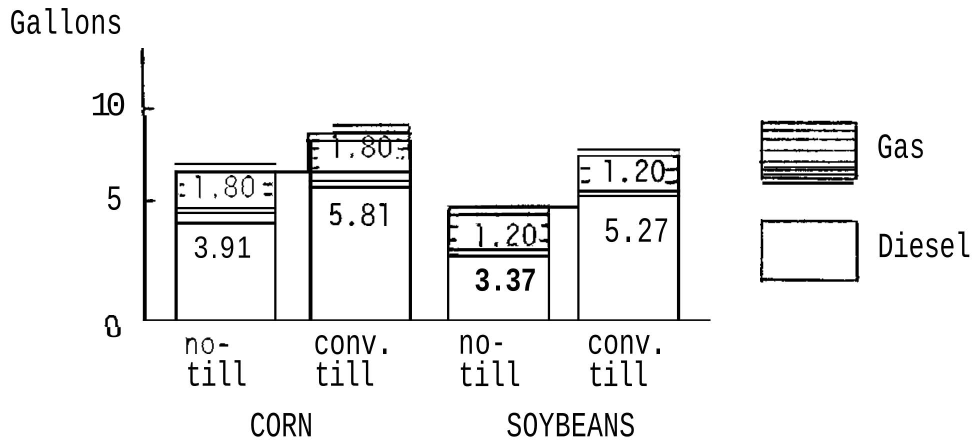

Figure 5. Fuel Used Per Acre.

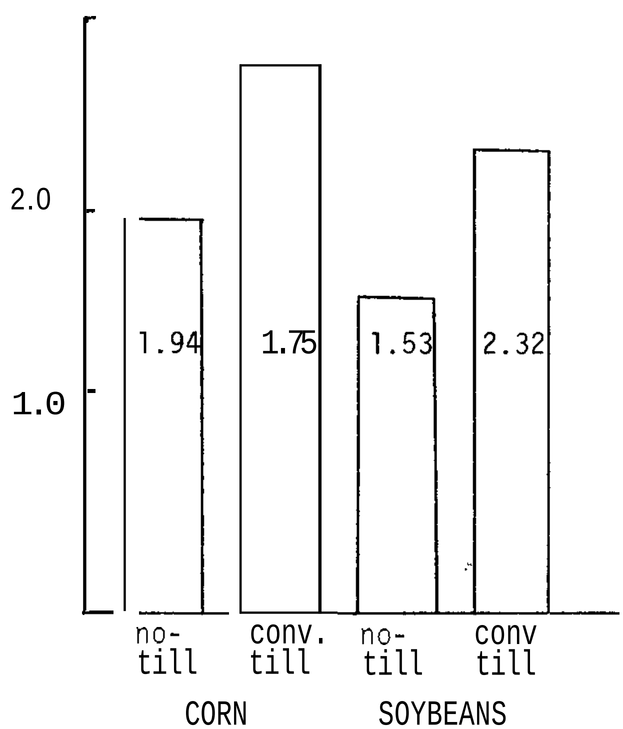

Figure 6. Labor Requirements For Conventional and No-Till Corn and Soybeans.

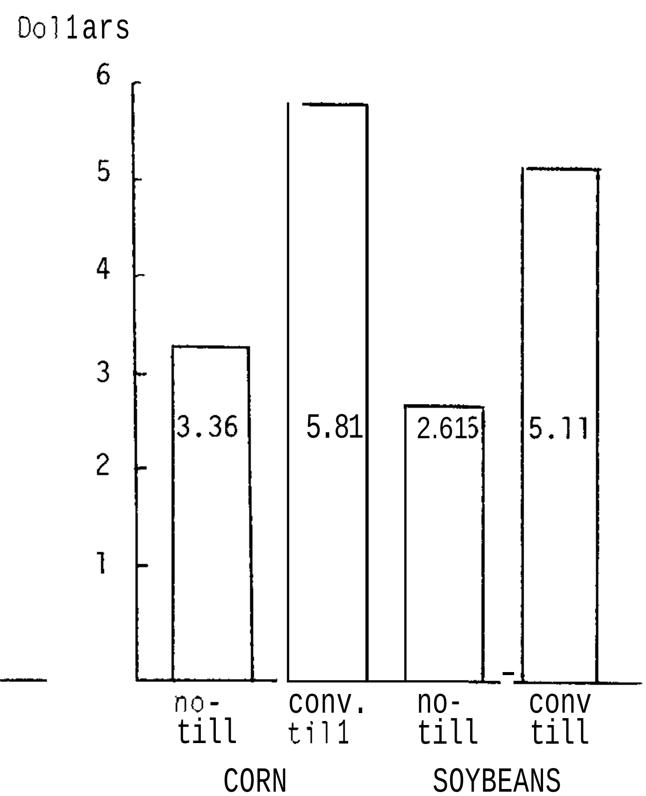

Figure 7. Variable Costs of Tractor Per Acre.

ALTERNATIVE TILLAGE IN JEFFERSON COUNTY, FLORIDA

Larry A. Halsey and Phil Worley

Pine Seedling - No Til Site Preparation Demonstration

A significant portion of the pine timber and pulpwood industry in North Florida is on farm land. Private landowners receive technical assistance from the Florida Department of Agriculture, Division of Forestry, as well as the County Cooperative Extension Service.

It is estimated that in Jefferson County 20% of the acreage planted in relatively small blocks by private landowners is on abandoned sod or pasture. Various methods of conventional site preparations are employed, including plowing and discing, roto-tilling, or bedding. All constitute a significant portion of the total cost of planting pines. Seedlings occasionally are planted in sods with no mechanical preparation. Pines planted directly in sod or in poorly prepared sites must compete with extensive grass root systems for moisture and nutrients during establishment and early growth years.

The Forester and the County Extension Director initiated a demonstration "no-till" pine seedling block to determine if chemical site preparation would eliminate a number of the production problems associated with conventional methods.

Together with Kent Frost, Product Development Specialist of Monsanto, and landowner Ferd Naughton, a 1.25 acre site was selected for the demonstration. The site was an abandoned Pensacola Bahiagrass pasture. Roundup (glysophate) herbicide was applied at *3* pounds active ingredient per acre (broadcast basis) over 4 foot strips on 12 foot middles on October 22, 1979. Seedlings were transplanted in the herbicide treated strips on 12' x 5' spacings on January 29, 1980. Spring regrowth of the sod was uniform in the untreated middles between treated strips. Perennial grass control under the treatment approached 100%, with virtually no regrowth. Germination of spring annual weeds in the strip was observed. As of the middle of April, following the January planting, a preliminary estimate of seedling survival was 97%.

The site was established on small acreage for observation only. On the basis of the apparent effectiveness of this chemical site preparation methods, a follow-up trial on 8-10 acres is anticipated in fall and winter of 1980-81. Side-by-side plantings under conventional site preparation and Roundup treatment will be conducted. The following data will be compiled in the experiment: 1) Comparative fuel consumptions of the various techniques; and equipment, material, labor, and other costs for accurate budget comparisons. 2) Penitrometer comparisons

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of the various site preparations methods, as an index of the ease of entry of the coulter of the seedling planter unit. 3) Growth characteristics at various intervals following planting, as well as survival and mortality counts. 4) Observations of root systems of sample seedlings under each of the various preparation methods.

Assumed advantages of the "no-til" or chemically prepared site include reduction of cost of site preparation, better survival and early growth due to reduced competition for nutrients and moisture, and reduced erosion and pollution from runoff due to the mulch cover. It should be noted that the Roundup label for use does not include this specific application. The trial is being conducted in cooperation with Monsanto Company representatives for experimental use only.

Minimum Tillage in Row Crops

During 1978, 135,163 acres of cropland on 2,135 farms in the United States were assisted through cost share practices involving conservation tillage systems (SL9) under the Agricultural Stabilization and Conservation Service (USDA-ASCS). In Florida, 1978 acreage totaled 535 acres on three farms. In 1979, 37 farms received cost-share assistance under Agricultural Conservation Program (ACP) totalling 2,182 acres to demonstrate minimum or reduced tillage systems in farming. Jefferson County growers are receiving cost-share on 5 farms with over 320 acres in 1980, for minimum tillage demonstrations, with total acreage in non-conventional planting or tillage at 3-4,000 acres,,

Jefferson County is located along the Florida-Georgia border. Farm land is gently sloping to hilly, with predominate soil type of Ultisols, with sandy to loamy sand textures of 6.5-8% clay fraction and 2-4% organic matter. Corn, soybeans, peanuts, tobacco and small grains for seed and forage are the main agronomic crops. Up to 25,000 acres of small grains or small grains with clover are planted annually for winter and spring grazing. Corn and soybean crops often are planted behind winter annual pastures. Corn under better than average high yield management yields 80-85 bu/A; soybean yields of 30-33 bu/A are normal. Both crops are planted under minimum tillage; however, a yield history using reduced tillage is unavailable.

Various alternative planting and tillage systems are currently being employed, from strict "no-til" planting in rye or oats in an absolute "once over" operation to discing once or twice prior to planting with no-ti1 equipment. Reduction of erosion, reduction of time spent in planting, reduction in fuel consumption and increased moisture availability during droughty periods around corn tassle and silking stage are most often referenced by farmers using reduced tillage methods as justification for employing the systems. Farmers are assisted in alternative tillage techniques by the ASCS, the Soil Conservation Service, and equipment and chemical suppliers.

MINIMUM TILLAGE DEMONSTRATION PROJECT
AGRICULTURAL CONSERVATION PROGRAM (ACP)

BY

Betty P. Jones, County Executive Director, Alachua County ASCS Office

ACP Program Objectives

The Agricultural Conservation Program (ACP) provides cost-sharing as an incentive to encourage farmers and ranchers to carry out conservation measures that:

1. control erosion and sedimentation from agricultural land and conserve the water resources on such land;
2. control pollution from animal wastes;
3. conserve wildlife habitat;
4. facilitate sound resource management systems through soil and water conservation;
5. contribute to the national objectives of assuring a continuous supply of food and fiber necessary for the maintenance of a strong and healthy people and economy; and
6. assures performance of the type conservation measures needed to improve water quality in rural America.

ACP is a joint effort by agricultural producers and Government to restore and preserve the environment and basic land resources. Cost-share assistance is available under annual or long-term agreements.

Program Administration

The ACP is administered by Agricultural Stabilization and Conservation (ASC) State, county and community committees, working under the general direction of the Agricultural Stabilization and Conservation Service (ASCS) of the U.S. Department of Agriculture. County and community committee members are elected by farmers within the local county. Funds for cost-sharing are appropriated annually by the Congress In recent years, the appropriation has been about $190,000,000.

The ASCS county committee in the local county approves cost-sharing on the basis of requests filed by individual producers. After receiving the official practice approval, performance is done according to specifications developed for the specific practice. All expenses incurred during performance are paid by the farmer. Later, after the practice has been certified as being performed according to practice specifications, the farmer is reimbursed on an average of from SO to 75 percent of the out-of-pocket cost of performing the practice.

Technical Assistance for Farmers

Farmers are provided necessary technical assistance to perform engineering type practices by the Soil Conservation Service (SCS). Forestry practices are performed under the supervision of the Florida division of Forestry personnel located in the county where the participating farm is located.

Demonstration Project Concept

Demonstration type special projects are authorized under the ACP. The purpose of such projects is to help achieve enduring soil and water conservation and environmental benefits through the use of innovative, up-to-date methods for treating conservation problems. Cost-share assistance is provided under approved projects as an incentive to encourage farmer participation.

Alachua County Demonstration Project

Based on past experience, farmers generally consider minimum tillage farming ineffective and conducive to crop failure. With the availability of existing herbicides, insecticides, and pesticides, and improved planting equipment, the Alachua County ASC Committee recognized the potential and the advantages of conservation tillage farming. The Committee, working closely with the Alachua County ACP Development Group, recommended the special project to the Florida State ASC Committee for approval and funding. The project was designed to demonstrate on a community-wide basis the techniques to be followed when using a minimum tillage operation to grow corn and soybeans.

Cost-share assistance was provided under the project for farmers to utilize ACP practice SL9 – Conservation Tillage Systems. (See Exhibit 1 for practice specifications.) A 70 percent cost-share rate was approved which reimbursed the participating farmer for most of the out-of-pocket expense incurred above those expenses normally associated with “standard” row-cropping methods.

In order for farmers to become familiar with and to utilize the most recent developments in multi-cropping minimum tillage and no-tillage, a farm visit was made to each participating farm to inspect the fields and to develop a plan of operation. The plans were developed in consultation with Dr. Raymond Gallaher, Associate Professor of Agronomy, Institute of Food and Agricultural Services, University of Florida; the Cooperative Extension Agent; and the SCS District Conservationist, and included specific recommendations for farmers to follow in planting and providing necessary weed control (see Exhibit 2). A follow-up inspection was made by ASCS to check compliance.

Farm tours were held in connection with the project to demonstrate planting techniques, and to evaluate plant growth and weed control during the growing season.

Farmer Participation

A total of 20 farmers participated in the demonstration project. These producers grew 940 acres of corn and grain sorghum and 412 acres of soybeans. Yields were comparable to those for crops grown using the "standard" row-cropping system.

Summary

Participating farmers were generally successful in carrying out their first-year minimum tillage operation. Yields were satisfactory. Most farmers reported a reduction in fuel cost. However, several farmers indicated that fuel savings were offset by the increased expense incurred for weed control. Overall, most participating farmers believe crops can be grown with less expense using multi-cropping minimum or no-tillage systems than with the "standard" row-cropping system.

Additional experience is needed, however, for producers to realize the maximum benefits. They believe that the system should be tested over a period of years -- i.e. three to five years -- in order for them to assess benefits. Some farmers are concerned about the impact that a wet growing season or an unusual dry growing season would have on yields. Most participants believe that weed control would be a serious problem during wet years.

The SL9 - Conservation Tillage System ACP practice specifications have been changed to permit farmers to receive cost-sharing for three consecutive years. This change will permit farmers to do demonstration planting to help them further evaluate minimum tillage operations, to gain the necessary experience, and to develop techniques that will be most effective under the system.

Acknowledgments: The author and the Alachua County ASC Committee wish to express their appreciation to Dr. Raymond N. Gallaher, Coordinator, Agronomy Research Support Laboratory, University of Florida; Mr. A. T. Andrews, Alachua County Agent; and Norman Porter, SCS District Conservationist for their technical assistance; and to those participating farmers who were willing to expend their resources at considerable risk to demonstrate conservation tillage systems during the 1979 crop year. We learn by doing. Thank you for sharing your experience with Alachua County farmers.

EXHIBIT 1

SL9 CONSERVATION TILLAGE SYSTEMS

A Purpose. To demonstrate a method of installing tillage systems and residue management systems of farming that will:

1 Protect soil from wind and water erosion and improve soil permeability.

2 Prevent or reduce pollution from sediment and chemically contaminated runoff from agricultural non-point sources.

B Applicability. To cropland needing erosion or sediment control while being devoted to the production of intertilled or small grain crops.

C Policies.

1 Cost-sharing is not authorized where the farmer has already adopted a satisfactory conservation tillage system of farming.

2 Cost-sharing for this practice may be approved for no more than 3 years with the same person.

3 The land involved must be protected by crop residue, temporary cover, or other permitted management methods from harvest until the next planting.

4 Eligible tillage operations may consist of:

a Chisel plowing with other limited operations, or

b Plow-plant, or

c Light tillage without plowing, or

d Approved slot or strip tillage operations ahead of planting, or

e Planting on chemically killed sods, or

f Other similar methods.

5 All tillage operations must he performed as nearly as practicable on the contour or parallel to terraces, except where the committee determines that this is not necessary.

EXHIBIT 1

6 Chemicals used in performing this practice must be Federally, State and locally registered and must be applied strictly in accordance with authorized uses, directions on the label, and other Federal or State policies and requirements.

7 Cost-sharing is not authorized for designated set-aside acreage.

8 Cost-sharing is not authorized for acreages where the crop is cultivated unless prior approval of the method of cultivation is approved in advance by the county committee.

D Specifications.

1 Performance of this practice shall be carried out according to the plan developed in consultation with the Cooperative Extension Agent, a representative of the Institute of Food and Agricultural Sciences, Department of Agronomy, University of Florida, and the SCS District Conservationist.

2 Cost-sharing is authorized on a per-acre basis for the following:

a Planter and related equipment. (Excludes tractor).

b Planting operation. (Includes tractor and labor).

c Applying herbicide. (Includes material).

d Insecticide -- material only.

e Applying post directed application of herbicide. (Includes material).

3 Performance shall be verified by a representative of the county committee before approval of cost-share payment.

E Maximum Cost-share Rates.

1 Regular Rates

a $ 3.50 per acre €or planter and related equipment.

b $ 4.20 per acre for planting.

c $12.25 per acre to apply herbicide.

d $ 8.40 per acre for the insecticide.

e $ 7.70 per acre to apply post directed application of herbicide.

2 Rates for Low-income Farmers

a $ 4.00 per acre for planter and related equipment.

b $ 4.80 per acre for planting.

c $14.00 per acre to apply herbicide.

d $ 9.60 per acre for the insecticide.

e $ 8.80 per acre to apply post directed application of herbicide.

EXHIBIT 2

CONSERVATION TILLAGE SYSTEMS

NAME____________________________ FSN________________

Performance of practice SL9 must be carried out according to a plan developed by ASCS in consultation with the Extension Agent; Department of Agronomy, University of Florida; and the SCS District Conservationist. The following recommendations are to be used as a guide, If for any reason they cannot be followed, contact the County Executive Director for other recommendations.

Crop: ____________________________________

Acreage: __________________ Photograph Number: ____________

Irrigated: ☐

Non-irrigated: ☐

Succeeding Crop or Land Use: ____________________________

____

Contour Planting: ☐

Conventional Planting: ☐

Apply Herbicide: ☐

Suggested Material: 1/ ________________________

Apply Insecticide: ☐

Suggested Material: 1/ ________________________

Apply Postemergency Herbicides: ☐

Suggested Material: 1/ ________________________

1/ Identify material that should be used for the crop to be planted. Attach any pamphlet, written guidelines, etc., applicable to the use of the material to the farmer's copy of the plan before delivery to the farmer.

EXHIBIT 2

Equipment to be Used:____

____

____

____

Land Preparation Authorized: ____________________________________

____

____

____

____

General Comments and Additional Guidelines:_______________________

____

____

____

ESTABLISHMENT OF LEGUMES IN BAHIAGRASS SOD

R. S. KALMBACHER*

Bahiagrass (Paspalum notatum) is widely grown from Texas through the Carolinas, and in Florida is a major pasture grass. It is a tough competitor which forms an extremely dense sod crowded with stubby stolons. Bahiagrass is popular because it resists encroachment from weeds, has few disease and insect problems, withstands close grazing, establishes from seed, and does not require high soil fertility. However, grazing studies indicate that bahiagrass is lower in nutritional value when compared with bermudagrass or digitgrass. By midsummer protein and digestibility are low, suggesting that animal intake and performance are adversely affected. In addition bahiagrass is a warm season species that produces 85% of its annual dry matter from May to October. In spite of the valuable attributes of bahiagrass its forage quality is low, and it produces little winter forage.

An ideal method of overcoming these deficiencies is to manage bahiagrass with legumes that provide needed quality and biological nitrogen. At present there are no comnercially available perennial legumes adapted to south Florida, but ranchers can use a combination of winter and summer annual species. Florida's summer annual legumes are jointvetch or aeschynomene (Aeschynomene americana), hairy indigo (Indigofera hirsuta), and alyce clover (Alysicarpus vaginalis), and the winter species (which act as annuals in south Florida) are alfalfa (Medicago sativa), red clover (Trifolium pratense) and white clover (T. repens).

Since natural reseeding is not always reliable with summer annuals or impossible with most winter annuals (except Dutch clover), reseeding is a frequent practice. Establishment by conventional tillage, which involves chopping or disking, is expensive and energy intensive. An alternative is sod-seeding, which Kentucky workers have shown to use only 20% of the energy input of conventional (prepared seedbed) tillage. However, widespread use of sod-seeding in Florida has been limited by a low probability of success in establishment. At the University of Florida's Ona Agricultural Research Center in south Florida considerable research effort has been devoted to sod-seeding in the past 4 years. We have identified several reasons why legume stands often fail even when water and fertility are adequate.

Forage legumes are slow to establish, and it is extremely important to control bahiagrass competition. A grass competes with a developing legume seedling for light, water, and nutrients: in this order of importance. Although little is known about the competitive effects for water and nutrients, we have found that having sufficient light available to legume

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seedlings when they emerge is quite important. Twenty five percent shade did not inhibit aeschynomene seedling growth, and seedling weight was equal to that of plants grown in full sunlight, but when 90% of the light was shaded from aeschynomene seedlings, there was: a 94% reduction in seedling weight; a 45% reduction in weight from seedlings grown under 73% light reduction; and a 19% reduction in seedling weight was found when plants were grown under 55% light reduction.

There are two forms of competition from bahiagrass: 1) competition from previous grass growth present at the time of seedling emergence; and 2) competition resulting from new grass growth during seedling development. Sod management for these forms of competition is different for winter and summer annual legumes.

Controlling competition before seeding.

Removal of sod cover can be accomplished in several ways, and the choice may be dictated by economics. Some alternatives are disking, mowing, grazing, and fire.

When bahiagrass sod was heavily disked and seeded in early December to red or white clover as compared to drilling seed directly into a thick, untreated sod, the average dry matter yield of the legumes after 2 years was 27% lower in the drilled plots as compared to disk and broadcast seeded plots (Table 1). The number of legume seedlings was 52% higher in the disk and broadcast plots. In another study aeschynomene yields were also much greater where bahiagrass was heavily disked as compared to drilling in untreated grass (1300 vs 600 kg/ha). The reason for the difference was the removal of the bahiagrass canopy by disking. Since most sod-seeding drills simply cut a slot in the sod and deposit the seed with a minimum of disturbance, they do not remove the grass canopy. If a drill is used or if there is too much cover *to* allow for a good disking, then some other sod canopy elimination practices must be used.

Table 1. Comparison of method of seeding on dry matter yield of red and white clover in bahiagrass sod. Ona ARC. 1977-78.

Year	Zip(R) Sod Seeded	Disk and Broadcast
	kg/ha	
1977	3500	6230
1978	5500	6030
Average	4500	6130

Harvesting excess forage as hay is best, as this justifies cost of mowing and eliminates the cover. Mowing seems to defeat the purpose of sod-seeding as it requires more time and energy, and the thatch can result in as much competition as uncut grass.

Grazing is an excellent alternative, and research has shown that yields of red and white clover seeded in bahiagrass that had been grazed to a 5 cm (2 inch) stubble were equal to the yield of legumes seeded in a bahiagrass sod which had been burned. Burning has most often resulted in the best legume stands in our research. Grazing is probably a more useful tool for removing sod cover before seeding winter legumes because after weaning calves in the fall, cows can be concentrated on bahiagrass until the canopy is removed. In June when summer annuals are seeded, the nutritional requirement of cows with calves is probably too high to allow the kind of prolonged bahiagrass grazing which promotes good summer annual legume growth. When compared with burning prior to seeding, grazing as a method of canopy elimination resulted in aeschynomene stands and yields that were comparable. Grazing or disking, followed by broadcasting seed resulted in 1500 and 1300 kg/ha, respectively, vs 600 kg/ha for untreated bahiagrass.

Fire is an excellent way to prepare bahiagrass for inter seeding of legumes. Often a dense bahiagrass canopy can be burned after a frost in December, but sometimes chemical desiccation is necessary. The herbicide Paraquat(R) has been applied at 0.56 kg/ha (0.5 lb/A) to kill and dry out the canopy in order to allow burning. The result was excellent stands of both winter and summer annual legumes (Table 2).

Table 2. Dry matter yield of winter or summer legumes seeded with a Zip(R) sod seeder in bahiagrass treated with various herbicides. Ona ARC. 1977-78.

Canopy control: Before seeding	Canopy control: After seeding	Herbicide treatment	Legume yield: Winter annual†	Legume yield: Summer annual‡
			------------kg/ha-	-------
yes	no	Paraquat(R) + bum	6640§	2970
no	yes	Dowpon(R) M	3840	2810
no	no	no herbicide	1310	260

† Red and white clover.

‡ Aeschynomene, hairy indigo, alyce clover.

§ Divide kg/ha by 1.121 to get Ib/A.

Burning 12 to 14 cm tall (4.7 to 5.5 inch) bahiagrass resulted in temperatures that reached 83 C (182 F) at the soil surface. The value of this heat is demonstrated in the control of insects and other pests that eat legume seedlings. At the Ona ARC a small land snail (Polygyra cereolus) has been found to be responsible for decimating stands of sod-seeded clovers. Burning resulted in 98% mortality of this pest, resulting in successful legume establishment.

Controlling competition after seeding.

Control of sod growth after legume emergence can be accomplished with grazing or herbicides. Herbicides are valuable for controlling competition after seeding because thcy can stop grass growth. When herbicides were applied to 7 to 10 cm tall (2.8 to 4 inch) bahiagrass in late June, better yields of summer legumes were. obtained as compared to untreated grass (Table 3). Successful stands of legumes resulted when canopy cover was slight at seeding and sod control was employed during legume development.

Table 3. Dry matter yield of summer legumes sod-seeded in bahiagrass treated with various herbicides Ona ARC. 1977-78.

Herbicide	Sod control	Legume yield* Aeschynomene	Alyce clover	Hairy indigo
		kg/ha		
Round-up(R)	Excellent	4950	5030	1900
Dowpon(R)	Good	2920	4130	1380
Paraquat(R)	Poor	100	970	140
No herbicide	Poor	210	450	120

* Divide kg/ha by 1.121 to get lb/A.

Using herbicides to control competition after seeding winter legumes has questionable value. Delaying seeding date in south Florida until after November 15 usually assures that bahiagrass growth will be slowed by cool temperatures. When night temperatures fall below 15 C (59 F) bahiagrass growth almost stops, If competition at seeding time has been removed, little growth wiil develop after seeding. Hence, with winter annuals it is much more important to remove competition at seeding than to control competition after seeding.

To demonstrate this point, the canopy was removed at seeding by paraquat and burning, arid the grass canopy regrew slowly, but was unchecked through the late fall and winter. (Table 2). Excellent yields were obtained from red and white clover (6640 kg/ha) in this burn treatment but poorer yields (3840 kg/ha) resulted in a Dowpon M treatment where the grass canopy remained at seeding, but all new growth was stopped. Similar summer annual yields resulted with a burn vs Dowpon M treatment (2970 vs 2810 kg/ha) but yields produced from untreated grass were poor (260 kg/ha). Both types of competition control are necessary when sod seeding summer legumes in bahiagrass, but removing sod cover prior to seeding is most important for winter legumes.

Sod-seeding machines.

If a good job is done controlling grass competition and adequate fertility and water are supplied (for winter legumes), the type of sod-seeding drill that you use makes little difference in the legume establishment. We have used very simple, relatively inexpensive machines, such as the Zip(R) seeder; intermediately priced machines, such as the John Deere Powr-till(R) and Tye(R) seeder; or very expensive, sophisticated machines like the Bettison 3-D seeder and have had success with all of these. If the practices for successful establishment are followed, then machine preference is a personal and economic matter. As pointed out earlier, disking sod and broadcasting seed can result in good establishment.

The following are steps recommended for establishing winter or summer annuals in bahiagrass in south Florida.

Winter annuals (alfalfa, red and white clover).

1. Limit the use of nitrugen on bahiagrass after September 15. Raise the soil pH to 6.0 for clover and 6.5 for alfalfa,

2. Before seeding graze, remove as hay, or burn off all excess bahiagrass leaving a maximum of 7.6 cm (3 inches).

3. Inoculate seed with proper strain of fresh Rhizobium and seed legumes after November is to take advantage of cool temperatures which limit bahiagrass growth. Waiting until November 15 also increases the chances of rain from cold fronts.

4. Fertilize legumes at seeding with 340 to 450 kg/ha (300 to 400 lbs/A) of 0-10-20 and after the first cutting (about March 15) apply another 340 to 450 kg/ha of 0-10-20. Apply micronutrients if none were applied in the past 4 years.

5. Irrigate if necessary. irrigation may be more important with disk and broadcast methods of seeding than sod drill methods because of poorer seed-to-soil contact with the former.

6. Bahiagrass growth may be grazed or mowed during legume establishment, provided seedlings are not clipped.

Surnner annuals (aeschynomene. -alyce clover, hairy indigo).

1. Limit the use of nitrogen fertilizer on bahiagrass after April 15 Raise soil pH to 5.5 to 6.0.

2. Before seeding, graze, remove as hay, or burn (after desiccation with paraquat) all excess bahiagrass, leaving a maximum of 7.6 cm (3 inch).

3. If herbicides are used to control sod growth after seeding, best results will result if the chemicals are applied 2 to 3 weeks before seeding so that sod-control is in effect. Dowpon M, especially if part of a smutgrass control program, is recommended at 2.5 kg/ha active (3.0 lb/A).

4. Inoculate seed with proper strain of fresh Rhizobium and seed legumes after June 15 to increase the probability of favorable moisture conditions. Seed naked aeschynomene (de-hulled), and for all legumes it is desirable to use seed rates that are 20 to 25% higher than used

in prepared seed beds.

5. Fertilize legumes at seeding with 560 kg/ha (500 lb/A) of 0-10-20. Use micronutrients if none have been applied in the past 4 years.

6. If no herbicides were used to control grass growth, then graze or mow to remove competition. Do not allow legume seedlings to be grazed. When legumes are 7 to 10 cm tall (3 to 4 inches) remove cattle and allow the legumes to reach 60 cm (24 inches) before grazing.

Quality legumes can be established in bahiagrass, provided these steps are followed. Seek advice from county extension or extension forage specialist about varieties, seeding rates, soil testing, etc. With costly nitrogen fertilizer and expensive feed costs, legumes are too good to do without.

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CONSERVATION TILLAGE SYSTEMS IN FLORIDA -- SCS VIEWPOINT[1]

JOHN D. LAWRENCE[2]

Introduction

The U.S. Department of Agriculture, Soil Conservation Service (SCS) provides technical assistance to land users through soil and water conservation districts. This assistance involves help in installing conservation practices and resource management systems needed to maintain or improve the resource base, improve quality in the environment and improve the standard of living. In order to achieve the above objectives, SCS develops and evaluates'with land users alternatives for land use and treatment through conservation planning.

Soil erosion is a serious problem in Florida. The 1977 SCS National Resources Inventory (3) estimates that each year approximately 13,298,000 tons of soil are being eroded by sheet and rill erosion from cropland in Florida. Studies by Griffin (1) show that row crop erosion rates often exceed the rate of erosion acceptable for maintaining long-term productivity of the soil. Soil erosion also caused a reduction in crop yields and an increase in nutrient loss. Sediment from erosion is also the nation's largest nonpoint source of water pollution. Most of the nutrients and some pesticides become attached to sediment particles and may move into nearby water courses (2).

The Soil and Water Resources Conservation Act, passed by Congress in 1977, involves the public in developing a national program for the conservation of soil, water, and related natural resources. It sets a reduction of energy use in agriculture and reduction of soil erosion on agricultural land as major objectives.

The Universal Soil Loss Equation (USLE) is widely used by SCS as a means of estimating or predicting soil loss. SCS is working with land users in developing cropping systems that will reduce soil erosion to below the soil loss tolerance level. For most Florida soils, this level is an average of 5 tons per acre per year. The proper use of crop residues is one of the best tools available for reducing erosion and is the basis for conservation cropping systems.

[1]For presentation at the Third Annual Southeastern No-Tillage Systems Conference, June 19. 1980. Billiston, Florida.

[2]Conservation Agronomist, U.S. Department of Agriculture, Soil Conservation Service, Gainesville, Florida 32602.

Cropping Systems in Conservation Tillage

On a field of Orangeburg loam tilled by conventional methods, a cropping system of continuous corn has an annual estimated soil loss of 11.8 tons/acre. Corn silage and soybeans double-cropped with conventional tillage have an annual estimated soil loss of 19.8 tons/acre. Conventional tilled corn harvested for grain and the crop residue left on the surface has an annual estimated soil loss of 11.0 tons/acre. With a cropping system of soybeans, small grain, and soybeans using no-tillage, the annual estimated soil loss is only 3.7 tons/acre (1,4). The importance of good conservation planning is evident when considering that only one of the above four cropping systems reduces soil loss to below the tolerance level of 5 tons/acre/year.

In SCS, cropping systems that reduce soil loss to the tolerable level are called conservation tillage systems. These systems include no-tillage farming which is the system most adapted to Florida conditions.

In no-tillage farming, the crop is planted directly in chemically treated sod stubble or crop residue and other residues without mechanical seedbed preparation. No-till planting has become a common practice in many areas of the country but only a small percentage of Florida cropland is planted by no-tillage methods. In 1979, approximately 156,536 acres of no-tillage and similar tillage systems was done in Florida. It has been estimated that the figure will increase to 188.420 acres in 1980.

The reduction in machinery and power cost may be offset by additional herbicide requirements. Labor requirements for no-tillage systems are about one-third those of conventionally planted corn.

Tables 1 and 2 (5) indicate that labor and horsepower-hour per acre are considerably less for no-tillage than for conventional tillage.

Table 1. Labor and Power (Horsepower-hours per acre)

	Conventional Corn		No-Till Corn	
	Operator	Power	Operator	Power
Disking	0.7	0.7	---	---
Breaking	1.1	1.1		---
Disking	0.7	0.7	---	---
Harrowing	0.4	0.4	---	---
Planting	1.1	0.6	1.1	0.6
Weed Control	0.4	0.3	0.4	0.3
Cultivating	0.9	0.7		---
Picking	0.8	0.8	0.8	0.8
	6.1	5.3	2.3	1.7

Table 2. Nebraska Study - Energy Requirements (Horsepower-Hour Per Acre)

Operation	Conventional	No-Till
Chop stalks	9.9	---
Disk	5.5	---
Plow	19.0	---
Disk	5.5	---
Harrow	5.5	---
Plant	4.0	2.0
Spray	1.0	1.0
Cultivate	3.3	---
Cutlivate	3.3	---
Combine	8.2	8.2
	65.2	11.2

The water erosion problem on conventional tillage systems has been studied in northwest Florida (1). By using the Universal Soil Loss Equation, SCS estimated in 1977 that soil loss from water erosion on Dothan, Greenville, Orangeburg, Red Bay, and Tifton soils (5-7% slope) planted to row crops was 14 to 18 tons/acre. On moderately sloping (2-5%) soils, such as Fuquay, Lucy, Troup, and Wagram, estimated erosion loss exceeded 9 tons/acre. On nearly level (0 to 2%) soils, estimated soil loss was 8 tons/acre on soils such as Greenville, Orangeburg, Red Bay, and Tifton (1,4).

On a conventionally tilled field of Orangeburg sandy loam soil (3% slope), two high residue producing crops and two low residue producing crops in a 3-year rotation of peanuts, small grain (grain), soybeans, and corn, estimated annual soil loss was 13.9 tons/acre. Under a grass-crop rotation of pasture (3 years), small grain, tobacco, and corn, estimated annual soil loss was 4.8 tons/acre. With a no-tillage cropping system, however, of soybeans, corn, small grain, and soybeans, soil loss on the same Orangeburg soil averaged only 2.4 tons/acre/year. These examples and Table 3 show the value and practicality of using residues in reducing soil loss on cropland (1,4).

Table 3. Average Annual Soil Loss on Orangeburg Sandy Loam Soils with Different Cropping and Tillage Systems

Slope	Cropping System	Tillage	Average Annual Soil Loss Tons/Acre
5-7%	Small grain-soybean-corn	Conventional	13.9
2-5%	Grass-small grain-tobacco-corn	Conventional	4.8
0-2%	Soybean-corn-small grain	No-Till	2.4

Summary

Well planned and applied conservation tillage systems are one of the best conservation practices to reduce soil erosion, thereby protecting our resource base. They can also reduce labor, fuel, and power requirements.

Almost 1 million acres of corn, soybean, and cotton crops in Florida are adapted to minimum or no-tillage cropping systems. These crops are grown mainly in north-northwestern and north-central Florida.

SCS encourages land users to leave residue on the surface in conservation tillage systems to break the splash effect of falling raindrops and reduce transport of soil particles by flowing water.

Several conservation tillage demonstrations have been held in Florida in cooperation with soil and water conservation districts, agricultural agencies, and equipment and chemical companies. SCS works with these agencies as well as with individual land users.

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PEST INSECTS AS AFFECTED BY TILLAGE METHODS IN SOYBEANS, CORN AND SORGHUM

Ki-Munseki Lema, R.N. Gallaher, and S.L. Poe

INTRODUCTION

The no-tillage method of crop production has become more popular in Florida during recent years because of (a) the availability of planting equipment designed to operate under unplowed stubble and/or mulched conditions. (b) development of improved herbicides to control grass and broadleaf weeds, (c) our extension IFAS research efforts on no-tillage systems, and (d) our educational efforts with field days, demonstrations, conferences, and shortcourses through the IFAS Cooperative Extension Service. The double cropping succession of soybeans following small grain is probably the most practiced agronomic double cropping system all over the world. Soybeans succeeding corn in the warm season is another multicropping system that is also enjoying increased acreage in Florida and other parts of the southeastern United States.

Plant residues and the lack of soil disturbance associated with no-tillage systems provide favorable conditions for the build-up of pest populations. The multicropping practice that continueously provides food and/or suitable habitat for various pest organisms, also creates conditions that are conducive to pest activity. Our knowledge of insect biology and behavior as they are affected by the no-tillage practice is limited in spite of the increasing adoption of this practice for crop production. The objective of this study was to collect data on insect pests in multicropping, no-tillage soybean, corn and sorghum .systems.

EXPERIMENTAL PROCEDURE

Soybean systems

Observations on the effects of soil tillage methods on insect pest populations were made on the Robinson farm in Williston, and at Green Acres Agaonomy Farm, Gainesville. The following six tillage treatments were compared in two separate experiments in rye stubble and corn stalk at Williston: (1) no-tillage into rye stubble, (2) no-tillage plus in-row subsoil into rye stubble, (3) no-tillage into rye mulch, (4) no-tillage plus in-row subsoil into rye mulch, (5) conventional tillage into rye stubble, and (6) conventional tillage plus in-row subsoil into rye stubble.

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"Cobb" soybeans were planted in the rye stubble experiment on March 21, 1978 with a 2-row Brown-Harden Superseeder mounted on a 5600 Ford tractor. The entire field was fertilized with 600 pounds per acre 5-4.4-12.5 (N-P-K) applied at planting along with 1 pint (0.25 pound a.i. per acre) of paraquat plus 0.33 pint of Ortho XJ77 surfactant and 1 pound a.i. per acre of alachlor. A second crop of soybeans was grown at Williston from August to November, 1978. The same tillage treatments as above were evaluated in corn stalk. The agronomic practices were the same as in the rye stubble study above.

The Green Acres experiment was conducted in "Florida 501" oat stubble in which four tillage treatments, no-tillage and conventional tillage plus in-row subsoil for each, were compared. "Cobb" soybeans were planted on June 3, 1978. During the planting operation, 400 pounds per acre 5-4.4-12.5 (N-P-K) were applied along with 0.25 pound a.i. per acre metribuzin, 1 pound a.i. per acre linuron and 1.5 pints (0.375 pound a.i.) per acre of paraquat plus 0.33 pint Ortho X-77 surfactant. This study was repeated in 1979; soybeans were planted on June 12, 1979.

corn systems

No-tillage and conventional tillage treatments with in-row subsoil for each were compared in the vetch and wheat stubble. "DeKalb XL78A" corn was planted in both conventiona tillage and no-tillage plots on April 19, 1978 in the "Hairy" vetch stubble. In the "Holly" wheat stubble experiment, corn was planted on June 3, 1978. Planting was conducted with the same equipment as that used in the soybean systems.

All the plots in the vetch stubble experiment were fertilized at planting with 400 pounds per acre 0-7.92-29.88 (N-P-K), and additional applications of N (25 pounds per acre) were made on April 22, and June 10, 1978. The wheat stubble field was fertilized with 600 pounds per acre 5-4.4-12.5 (N-P-K) on June 3, 1978, with an additional application of 50 pounds per acre of N made on June 12. In both experiments, paraquat (0.38 pound a.i. per acre), plus Ortho X-77 surfactant (0.33 pint per acre), was used at planting, and 2, 4-D (.25 pounds a.i. per acre) and atrazine (2 pounds a.i. per acre) after emergence, for weed control. All the plots in the vetch stubble study and half of the rows in each replication in the wheat experiment were treated with carbofuran at the rate of 2 pounds a.i. per acre during the planting operation.

The two experiments were repeated in 1979 with the same cultural practices, except that no insecticide was used in the 1979 season. "DeKalb XL78A" corn was planted on April 6 in the vetch study and June 12 in the wheat stubble experiment.

Sorghum systems

One experiment was conducted at Green Acres to determine the influence of no-tillage cropping and nitrogen fertilizer on time of grain sorghum flowering and sorghum midge infestation. The experimental site was in untilled and bahiagrass sod for five years before plowing and planting rye and lupine. The following treatments were compared in a latin plot layout: (1) no-tillage into rye mulch, (2) no-tillage into rye stubble, (3) no-tillage into lupine mulch, (4) no-tillage into lupine stubble, and (5) no winter crop conventional tillage for a check. Four levels (0, 50, 100, and 200 pounds per acre) af nitrogen fertilizer were tested as subtreatments.

Growers ML-135 grain sorghum hybrid was planted on April 17, 1978 in rows 30 inches apart using the Brown-Harden Superseeder. When sorghum was about 39 inches high, atrazine (2 pounds a.i. per acre) and paraquat (0.25 pounds a.i. per acre) plus Ortho X-77 surfactant were applied on the entire area as post application for weed suppression.

Estimation of insect populations and damage

Damage due to the lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller), and cutworms was assessed weekly by recording the number of damaged plants in two rows randomly selected in each replication. Fall armyworms, *Spodoptera Frudiperda* (J.E. Smith), and corn earworm, *Heliothis* zea (Boddie), damage levels were determined in corn by counting the number of plants with damaged foliage and the number of damaged ears in two rows and among 30 consecutive plants per replication. To assess stink bug damage to soybeans, pods were collected from 20 plants per treatment and the number of damaged seeds were recorded.

Populations of above-ground pest insects were monitored in soybeans using the plant shaking and sweep net methods. Non-baited pitfall traps (one trap/replication) were used to monitor populations of cutworms, *Feltia subterranea* (Fab.), and wireworms, *Conoderus amplicollis* (Gyll.) and *C. falli* Lane. The traps consisted of cottage cheese cups about one-third filled with ethylene glycol that killed and preserved the catches.

In the sorghum study, midge infestations were determined by counting adults of the sorghum midge, *Contarinia sorghicola* (Coquillett), that emerged from caged sorghum head samples. Twenty-five sorghum heads per replication were removed at random from the two middle rows of each plot at the milky stage of development and placed into 10 inch X 13.5 inch X 20 inch cardboard midge emergence cages. Emerging sorghum midges were collected in plastic vials inserted into the sides of each cage.

Ten sorghum heads per replication were examined and rated for grain damage on a scale of 0-10. Zero indicated no midge damage, and 1-10 indicated 10-100% grain loss. Days taken by the grain sorghum to reach mid-bloom (50% of the plants in each plot with 90-100% of the head emerged from the boot) were monitored 30-40 days after sorghum planting.

Yield determination

Dry matter yield of corn and soybeans was determined by harvesting two 20 foot rows in the middle of each plot. These samples were weighed and subsamples taken to determine dry matter. Soybean and corn yields are reported at 13% and 15.5% dry matter, respectively.

Sorghum yield was evaluated by hand harvesting sorghum from 16.4 feet/row in the two middle rows of each plot. Sorghum heads were dried in a greenhouse at 95–104 F €or about seven days to reduce grain moisture content to 10%. The heads were threshed in a Vogel[R] single head-thresher and the grain weighed.

RESULTS

Soybean systems

Two insects, the velvetbean caterpillar, Anticarsia gemmatilis Hubner, and the southern green stink bug, Nezara viridula (L.), were the most important pests observed during the two years. Early planted soybeans in the rye stubble study were not infested by the velvet-bean caterpillars. Populations of the southern green stink bug were significantly (P=0.05) higher in the no-tillage into rye mulch than in the conventional tillage (Table 1). The no-tillage into rye stubble was not significantly different from the conventional tillage for stink bug infestations.

Stink bugs were in trace numbers in the corn stalk (late planted soybeans) experiment at Williston, but velvetbean caterpillars populations reached such a high level that an application of Lannate[R] was made on September 27, 1978. However, the differences between treatments for the caterpillar populations were not significant (P=0.05). An average of 10.00, 10.13, and 10.79 velvetbean caterpillars per shake was recorded in the no-tillage into corn stalk in rye stubble, no-tillage into corn stalk in rye mulch and the conventional tillage into corn stalk, respectively. In-row subsoil did not affect significantly caterpillar populations in either main tillage treatments.

Damage to soybean seedlings caused by the lesser conrstalk borer at Williston was generally low and was not affected significantly by the tillage methods. On the average, 1.92, 1.92, and 2.04 damaged plants per row were observed respectively in no-tillage into corn stalk in rye stubble, rye mulch, and conventional tillage.

Tables two and three show data collected on stink bug infestations and damage in the oat stubble at Green Acres. Stink bug populations in 1979 were about double those in the 1978 season, but the statistical analysis of the data failed to reveal any significant (P=0.05) differences between the tillage methods for stink bug populations and damage to seeds in either year.

In 1978, numbers of velvetbean caterpillars collected from no-tillage were statistically the same as those collected from the conventional tillage soybeans (Table 4). The 1979 results indicated that significant differences were found between treatments only for small (up to 0.59 inch) larvae; populations of small larvae were significantly higher in no-tillage than in all other treatments (Table 4). Medium (0.62–0.98 inch) and larger (over 0.98 inch) larvae were not affected.

The lesser corn stalk borer caused significantly more damage to no-tillage soybeans than to conventionally tilled soybeans in 1979 (Table 5). Other insects observed on soybeans in more or less high populations included the three-cornered alfalfa hopper, Spissistilus festinus (Say), and the soybean looper, Pseudoplusia includens (Walker). No significant differences were found in numbers of these insects between the untilled and conventionally tilled soybeans.

Table 6 contains yield data collected from 1977 to 1979. During the first year, soybean yields were significantly higher under no-tillage as compared to the conventional tillage systems. No significant differences were detected among treatments the second year, but the no-tillage non-subsoiled treatment was lower than yield for other treatments in 1970.

The trend for yield of no-tillage soybeans to go down after the second year is apparent. In-row subsoiling may prolong this trend as reflected by the yield for this treatment being the same as for con? ventional tillage soybeans. The yield response to no-tillage in 1977 is likely due to extra soil moisture and the extreme droughty conditions experienced that year.

Corn systems

Tables 7-15 show the results obtained on insect pests from both the vetch stubble and the wheat stubble experiments. Infestations due to the fall armyworms and corn earworms were more severe in the late plant ed (wheat stubble) than in the early planted field corn, but were not affected by the tillage methods (Tables 7-10). These pests did not, according to the results, cause more damage in no-tillage corn than in conventionally tilled corn.

Wireworm populations were not affected by the no-tillage practice as compared to the conventional tillage (Table 11). Although no-tillage greatly increased cutworm populations (Table 12), no apparent damage was done to corn seedlings by these insects. Cutworms, however, may be expected to cause more damage to non tilled than to conventionally tilled corn because of their higher population levels in no-tillage corn systems. Therefore, a good program for weed control and insecticidal treatments of the soil must be an important part of the cropping procedure when no-tillage is adopted for corn production.

No-tillage significantly reduced lesser cornstalk borer damage to corn (Tables 13-15). This practice may be used in an integrated control program along with early planting, irrigation (lesser cornstalk borer damage is more severe on late planted and waterstressed crops) and applications of a good soil insecticide in order to regulate lesser cornstalk borer infestations.

Yield data are shown in Tables 16 and 17, respectively for the vetch and wheat experiments. Yield of corn was either not affected by tillage method or tended to be greater in no-tillage treatments. The mulching benefits of vetch are reflected in the higher yields under no-tillage.

Sorghum systems

The results of the study are shown in Table 18. Sorghum planted in lupine stubble and lupine mulch plots attained mid-bloom earlier than that planted in the conventional tillage and rye mulchfstubble treatments. Percent grain loss was lowest in the lupine plots and highest in the conventional tillage plots. Yield of the grain sorghum was higher in no-tillage into lupine mulch than in all other treatments.

Since lupine is a legume and therefore fixes nitrogen in the soil, it can be argued that sorghum grown after the lupine benefited from the "fixed nitrogen". Accelerated growth resulted in early sorghum flowering; thus facilitating escape of the crop from damaging midge populations.

Table 1. Effect of tillage on southern green stink bug populations estimated by the shake cloth method in "Cobb" soybeans at Williston, FL., 1978.

Treatment	Stink bug population[1] Total Number	Average/Shake*
No-tillage into rye stubble	74	1.3ab
No-tillage plus in-row subsoil into rye stubble	86	1.5b
No-tillage into rye mulch	97	1.7b
No-tillage plus in-row subsoil into rye mulch	106	1.9b
Conventional tillage into rye stubble	54	1.0a
Conventional tillage plus in-row subsoil into rye stubble	61	1.1ab

[1]Numbers are totals and averages of eight weekly shakes/treatment for seven weeks.
*Values followed by the same letter are not significantly different at 0.05 level by Duncan's new multiple range test.

Table 2. Number of southern green stink bugs collected from "Cobb" soybeans by the plant shaking method[1] at Green Acres, Gainesville, FL.

Treatment	Average/Shake* Nymph 1978	Nymph 1979	Adult 1978	Adult 1979
No-tillage into oat stubble	1.2	2.3	2.1	4.9
No-tillage plus in-row subsoil into oat stubble	0.6	1.3	1.6	4.7
Conventional tillage	0.8	1.3	1.8	4.9
Conventional tillage plus in-row subsoil	0.5	1.9	2.1	3.9

1/Eight weekly shakes per treatment for nine weeks for 1978 and four shakes for four weeks for 1979.
*In the analysis of variance, no significant differences were detected among the means. Therefore, Duncan's comparisons were not made.

Table 3. Stink bug damaged to seeds in no-tillage and conventional tillage "Cobb" soybeans at Green Acres, Gainesville, FL.

Treatment	1978 Percent Damage*	1979 Percent Damage*	1979 Percent Small Seeds*
No-tillage into oat stubble	7.5	16.3	38.9
No-tillage plus in-row subsoil into oat stubble	3.9	14.3	28.9
Conventional tillage	8.4	15.0	19.3
Conventional tillage plus in-row subsoil	7.5	17.0	20.7

1/ Damage: seeds with at least one feeding puncture.
Small seeds: small, wrinkled and fungus infected seeds.
*In the analysis of variance, no significant differences were detected among the means. Therefore, Duncan's comparisons were not made.

Table 4. Number of Velvetbean caterpillars collected from no-tillage and conventional tillage soybeans at Green Acres, Gainesville, FL.

Treatment	Average No. Larvae/Shake1				
	1978*		1979**		
	Small	Large	Small	Med.	Large
No-tillage into oat stubble	7.9	2.9	11.4	1.9e	1.8x
No-tillage pus in-row subsoil into oat stubble	8.4	2.2	16.lb	2.8e	2.1x
Conventional tillage into oat stubble	8.6	1.8	17.1b	2.7e	1.1x
Conventional tillage plus in-row subsoil	8.5	3.5	16.4b	2.9e	1.7x

1/ 1978, Small: up to 0.98 in.; Large: over 0.98 in.
1979, Small: up to 0.59 in.; Medium: 0.62-0.98 in.; Large: over 0.98 in.
*In the analysis of variance no significant differences were detected among the means. Therefore, Duncan's comparisons were not made.
**Means in each column not followed by the same letters are significantly different at the 0.05 level by Duncan's new multiple range test.

Table 5. Lesser cornstalk borer infestations in no-tillage and conventional tillage "Cobb" soybeans at Green Acres, Gainesville, FL., 1979.

Treatment	Infested Plants[1]	
	Total number	Average/row*
No-tillage into oat stubble	103	4.3a
No-tillage plus in-row subsoil into oat stubble	46	1.9b
Conventional tillage into oat stubble	34	1.4b
Conventional tillage plus in-row subsoil into oat stubble	20	0.8c

1/ Estimations based on two different rows/replications observed weekly for three weeks.
*Values not followed by the same letter are significantly different at the 0.05 level by Duncan's new multiple range test.

Table 6. Yield of soybeans from conventional and no-tillage systems in oat stubble at Green Acres, Gainesville, Florida.

Treatment	1977	Average yield* 1978	1979	Average
		bu/A		
No-tillage into oat stubble	36.0a	29.0a	15.0b	26.6
No-tillage plus in-row subsoil into oat stubble	36.0a	34.0a	21.0ab	30.3
Conventional tillage	21.0b	34.0a	26.0a	27.0
Conventional tillage plus in-row subsoil	21.0b	30.0a	24.0a	25.0
Average	28.5	31.7	**21.5**	

*Data among tillage treatments followed by the same letter within each year are not significantly different at the 0.05 level of probability. Data among years with a common underline within each tillage treatment are not significantly different at the 0.05 level of probability, by Duncan's new multiple range test.

Table 7. Foliage ear damage caused by the fall armyworm, and the corn earworm, in no-tillage and conventional tillage corn at Green Acres, Gainesville, FL., 1978[1].

Treatment	% infestation* Foliage	Ears
No-tillage into vetch stubble	24.6	44.3
No-tillage plus in-row subsoil into vetch stubble	37.5	38.4
Conventional tillage	30.8	43.2
Conventional tillage plus in-row subsoil	22.7	50.8

laumbers are averages of 120 plants per treatment (each week) for four weeks for foliage and three weeks for ears.
*In the analysis of variance, no significant differences were detected among the means. Therefore, Duncan's comparisons were not made.

Table 8. Damage caused by the fall armyworm, and corn earworm, to no-tillage and conventional tillage field corn at Green Acres, Gainesville, FL., 1979[1].

Treatment	Corn infestation* Avg. No./row plants	ears	%infestation plants	ears
No-tillage into vetch stubble	0.4	2.8	1.5	10.6
No-tillage plus in-row subsoil into vetch stubble	0.5	3.6	2.0	14.6
Conventional tillage	0.6	2.0	1.5	5.4
Conventional tillage plus in-row subsoil	0.4	3.4	0.8	9.9

[1]Numbers are averages of 120 plants per treatment (each week) for five weeks for foliage and four weeks for ears.
*In the analysis of variance, no significant differences were detected among the means. Therefore, Duncan's comparisons were not made.

Table 9. Infestations of the fall armyworm, and corn earworm, in no-tillage and oonventional tillage field corn at Green Acres, Gainesville, FL., 1978[1].

Treatment	% infestation* plants	Plants with destroyed whorl	tassel	ears
No-tillage into wheat stubble	77.5	94.6	74.2	86.9
No-tillage plus in-row subsoil into wheat stubble	77.8	90.8	70.9	78.5
Conventional tillage	74.8	93.3	84.3	82.3
Conventional tillage plus in-row subsoil	76.2	94.6	83.2	72.1

[1]Average based on 120 plants per treatment per week.
*In the analysis of variance, no significant differences were detected among the means. Therefore, Duncan's comparisons were not made.

Table 10. Infestations of the fall armyworm, and corn earworm, in no-tillage and conventional tillage field corn at Green Acres, Gainesville, FL., 1979.

Treatment	Infested plants* Average No./row	% (on row basis)	% (on 120 plant basis)
No-tillage into wheat stubble	31.4	68.9	91.7
No-tillage plus in-row subsoil	35.2	71.8	92.1
Conventional tillage	27.0	60.3	87.5
Conventional tillage plus in-row subsoil	30.7	64.5	88.7

*In the analysis of variance, no significant differences were detected among the means. Therefore, Duncan's comparisons were not made.

Table 11. Number of wireworms, collected in pitfall traps from con- vent'onal tillage and no-tillage corn at Green Acres, Gainesville, FL., 1979[1].

Treatment	Total Number Vetch stubble	Total Number Wheat stubble	Average/Trap* Vetch stubble	Average/Trap* Wheat stubble
No-tillage	466	150	12.94	6.25
No-tillage plus in-row subsoil	368	207	10.22	8.62
Conventional tillage	389	265	10.80	11.04
Conventional tillage plus in-row subsoil	280	173	7.78	7.21

[1]Numbers are totals and averages of nine weeks for vetch and six weeks for wheat with four traps per treatment.
*In the analysis of variance, no significant differences were detected among the means. Therefore, Duncan's comparisons were not made.

Table 12. Activity of the granulated cutworm, monitored by nonbaited pitfall traps in no-tillage and conventional tillage corn at Green Acres, Gainesville, FL., 1979[1].

Treatment	Cutworm population Total No.	Avg. /Trap
No-tillage into vetch stubble	160	10.0a*
No-tillage plus in-row subsoil	345	21.6a
Conventional tillage	34	2.1b
Conventional tillage plus in-row subsoil	5	0.3b

[1]Numbers are totals and averages of four traps per treatment for four weeks.
*Values not followed by the same letter are significantly different by Duncan's new multiple range test at the 0.05 level.

Table 13. Lesser cornstalk borer, infestations in no-tillage and conventional tillage field corn at Green Acres, Gainesville, FL., 1978-1979.

Treatment	Damaged Plants[1] Total No. 1978	1979	Average No./row* 1978	1979
No-tillage into vetch stubble	3	15	0.1a	0.9c
No-tillage plus in-row subsoil into vetch stubble	2	13	0.1a	0.8c
Conventional tillage	32	3	1.3b	0.2c
Conventional tillage plus in-row subsoil	32	2	1.3b	0.1c

[1]Estimation is based on eight rows per treatment examined each week for three weeks.
*Means in each column not followed by the same letter are significantly different at the 0.05 level by Duncan's new mutiple range test.

Table 14. Infestations of the lesser cornstalk borer, in no-tillage and conventional tillage field corn at Green Acres, Gainesville, FL., 1978.

Treatment	No. plants observed	infested	Infestations* %	Infestations* Plants/row
No-tillage into wheat stubble	1987	31	1.6a	100c
No-tillage plus in-row subsoil into wheat stubble	2751	104	3.8b	3.2d
Conventional tillage	2507	88	3.5b	2.7d
Conventional tillage plus in-row subsoil	2966	80	2.7b	2.5d

*Values in each column not followed by the same letter are significantly different at the 0.05 level by Duncan's new multiple range test.

Table 15. Infestations of the lesser cornstalk borer, in no-tillage and conventional tillage field corn at Green Acres, Gainesville, FL., 1979.

Treatment	No. Plants Total observed	No. Plants Number infested	Infestation* %	Infestation* Avg./row
No-tillage into wheat stubble	1138	90	7.9	3.7
No-tillage plus in-row subsoil into wheat stubble	1171	89	7.6	3.7
Conventional tillage	1160	109	9.4	4.5
Conventional tillage plus in-row subsoil	1140	90	7.9	3.7

*In the analysis of variance, no significant differences were detected among the means. Therefore, Duncan's comparisons were not made.

Table 16. Yield of corn from Conventional tillage and no-tillage in vetch stubble at Green Acres, Gainesville. FL.,

Treatment	Average Yield* (Ton/A-Dry Matter) 1978	1979	2-year average
No-tillage into vetch stubble	3.8a	3.6ab	3.7a
No-tillage plus in-row subsoil into vetch stubble	3.7a	3.9a	3.8a
Conventional tillage	2.7b	2.3b	2.5c
Conventional tillage plus in-row subsoil	3.2ab	2.6ab	2.9b

*Values in each column not followed by the same letter are significantly different at the 0.05 level by Duncan's new multiple range test.

Table 17. Yield of Corn from conventional tillage and no-tillage in wheat stubble at Green Acres, Gainesville, FL.

Treatment	1978	Average Yield* (Ton/A Dry Matter) 1979	2-year average
No-tillage into wheat stubble	3.lb	3.2ab	3.la
No-tillage plus in-row subsoil into wheat stubble	3.3ab	3.5a	3.4a
Conventional tillage into wheat stubble	3.3ab	2.7b	3.0s
Conventional tillage plus in-row subsoil into wheat stubble	3.6a	3.0ab	3.3a

*Values in each column not followed by the same letter are significantly different at the 0.05 level by Duncan's new multiple range teat.

Table 18. Days to mid-bloom, percent grain loss and yield of the grain sorghum at Gainesville, FL., 1978.

Treatment	Days to mid-bloom $\bar{X} \pm SD$	%grain loss $\bar{X} \pm SD$	Yield (Ton/A)
No-tillage into rye mulch	70.2±5.7	9.4±12.7	3.6
No-tillage into rye stubble	71.0±5.3	10.0±13.3	3.3
No-tillage into lupine mulch	65.3±7.2	4.8±4.0	4.1
No-tillage into lupine stubble	64.5±5.1	4.3±3.4	3.5
Conventional tillage	68.3±6.9	12.1±19.2	3.3

NO-TILLAGE IN NORTH CAROLINA

W. M. LEWIS, A. D. WORSHAM, GEORGE C. NADERMAN AND EUGENE G. KRENZER

In this report we are presenting somewhat of an overview of our current research and extension activities in North Carolina. Many represent our concerns on which we are placing emphasis.

For a number of years our no-tillage acreage varied from 8 to 10% of the corn, soybean, and grain sorghum acreages. However, most of the soybeans were no-till double cropped after small grain harvest. In the last three years we have witnessed an increased interest in no-tillage and other reduced tillage systems. This has been influenced, in part, by increasing costs of fuel, labor and equipment and by implementation of the Water Quality Act.

We have continued to place emphasis on no-tillage in our corn, soybean, soils, and weed management extension programs. This past year we conducted six training sessions throughout North Carolina in cooperation with Soil Conservation personnel. These sessions were aimed at growers, chemical and equipment dealers, SCS personnel and agricultural extension agents.

This report is divided according to our varied interests: Corn Extension Program, Soils Extension Program, Weed Science Research, and Weed Science Extension.

Corn Extension Program

The emphasis on no-tillage corn in our corn extension program in North Carolina has expanded in the last three years. We are attempting to determine why there has not been more acceptance of no-till corn production. Our approach has been to conduct on-farm tests comparing conventional tillage with no-tillage to demonstrate to farmers these practices side by side and at the same time collect information on these two tillage systems. It also gives us a chance to learn what are some of the problems facing the farmer. Our no-tillage plantings have been into a rye cover crop.

The results from tests conducted on Piedmont clay soils have been quite strongly in favor of no-till planting corn into rye. However, in the sandy Coastal Plain locations our results have been mixed.

Table 1: Corn Yields (Bu/A) in Piedmont Tillage Tests

	COUNTY			
Tillage Method	Caswell	Stokes	Granville	Guilford
Conventional	71	141	58	96
No-till into Rye	94	155	68	99

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Table 2: Corn Yields (Bu/A) in Sandy Coastal Plain Soils Tillage Tests

	COUNTY				
Tillage Method	Johnston	Wilson	Robeson	Chowan	Northampton
Conventional	109	108	I53	114	116
No-till into Rye	87	115	122	105	118

We feel that the effect of the rye mulch on moisture infiltration rate is the most important factor contributing to increased yeilds in the Piedmont locations. Though there is some no-tillage corn in the Piedmont, johnsongrass is a major limiting factor toward expansion of no-tillage production in this area.

In the sandy soils we have become concerned that even though nitrogen has been applied in split applications (a small amount at planting plus the remainder 4 to 6 weeks later), lack of nitrogen may be limiting yields where corn has been no-till planted into a rye cover crop causing some of the yield reductions noted in Table 2. We believe several things could cause this: 1) more nitrogen may be leaching in the no-tillage plots; 2) more denitrification or 3) the nitrogen may become tied up in the rye residue.

In 1980 we are continuing these studies but have expanded them to look more closely at nigrogen rates in conventional versus no-till planting into soybean residue, rye, or vetch. We would like to learn more about our thoughts on the fate of applied nitrogen in the rye residue plots. We also want to evaluate the usefulness of vetch as a cover crop and source of nitrogen especially when overseeded in soybeans. Will this be an economically attractive practice?

Soils Extension Program

In our Soils Extension Program, we have evaluated various tillage methods for corn and soybeans in on-farm tests since 1977. Although the program has emphasized the comparison of in-row subsoiling, chisel plowing and conventional tillage, the following no-tillage treatments have been included: 1) No-tillage planted corn into residue of in-row subsoiled soybean crop as compared with repeated subsoiling and conventional tillage. This was intended to evaluate the possible carryover effect of subsoiling, 2) Same as above with soybeans planted into corn residue, and 3) No-tillage corn into conventionally seeded small grain residue (rye, wheat or oats).

In October, 1979 we reviewed costs of the various tillage methods in a 300-acre operation. This indicated a $7/A cost savings for no-tillage corn into soybean residue compared with chisel plowing and discing. However, the cost of establishing a rye residue crop for no-tillage corn made this system more expensive than chiseling and discing. This emphasizes the importance of determining the yield and conservation benefits of these two no-tillage methods and special management considerations of them, including nitrogen requirement, weed, nematode and disease management. This comparison is included in several locations in our 1980 program.

Weed Science Research

We have evaluated and helped obtain registration for all the herbicides currently labelled for use in the no-tillage crop production. The only herbicides showing any promise for vegetation kill, other than paraquat or glyphosate, is a combination of acifluorfen and diclofop in soybeans.

Over the years, glyphosate treatments have produced higher yields of no-till corn and soybean compared to paraquat. Better late grass control from glyphosate was found not to be entirely responsible for increased yields, therefore a growth regulator affect was suspected. Growth-chamber and greenhouse studies showed that glyphosate was exuded from the roots of treated plants (such as a cover crop) and could cause stimulatory or inhibitory effects on adjacent plants in the soil, depending on the concentrations of glyphosate applied to the treated plants. In field experiments the increased yields of glyphosate treated plots made glyphosate more economical to use than paraquat where green cover was present at planting.

Several successions of weed complexes have been noted in continuous no-till plots in a high organic soil but no predominant species. Corn yield in continuous no-till plots has decreased by about 20% over a four-year period.

Our first attempt in 1978 to grow no-till flue-cured tobacco was not too successful. No-till tobacco in 1979, planted into a good stand of rye on ridged rows, yielded the same as conventional planted tobacco. The grade index, a measure of quality, was much higher for the no-till tobacco as compared to conventional, especially for the earlier primings. Weed control, except for nutsedge, was satisfactory with paraquat or glyphosate applied prior to transplanting and diphenamid or napropamide applied over-top after transplanting. This method offers the potential for soil erosion control, moisture conservation, less sand damage to small seedlings and less sand on the tobacco leaves. Work in 1980 has expanded to four locations.

In preliminary studies in 1979, corn stands and yields and soil insects were correlated with time of killing the small grain cover crop. Corn yielded **107** Bu/A when the small grain cover crop was killed 5 weeks before planting compared to 61 Bu/A when the cover crop was killed at planting. Wireworm damage at planting was five times higher at one location, but four times less at the other location when the cover was killed early compared to at planting. There appeared to be no appreciable difference in foliar insect feeders among treatments. Studies will be continued for at least two more years before definite conclusions can be drawn on the influence of these factors on no-till corn.

Weed Science Extension

Our primary objective through our on-farm testing program has been to demonstrate herbicide programs for no-tillage corn and soybeans. We have also found greater corn and soybean yields where glyphosate was used to control the small grain cover crop rather than paraquat. The use of oryzalin in standing wheat or barley for no-till doublecropped soybeans has been a successful practice providing linuron or metribuzin is also applied at planting. We have initiated three tests this year to evaluate johnsongrass control programs in conventional vs no-tillage planted corn. Glyphosate was applied in the fall to certain plots and glyphosate applied in row wick applicators will be used during the growing season.

THE INFLUENCE OF MINIMUM TILLAGE ON POPULATIONS OF SOILBORNE FUNGI, ENDOMYCORRHIZAL FUNGI, AND NEMATODES IN OATS AND VETCH

D. J. MITCHELL, N. C. SCHENCK, D. W. DICKSON, AND R. N. GALLAHER

Advantages of minimum tillage over conventional tillage, which may include improved soil and water conservation, increased yields, more efficient time and labor utilization, and reduced energy input, may be augmented or compromised by the effects of tillage operations on the development of plant diseases. Few detailed studies have been conducted on the influences of minimum tillage on populations of plant pathogens or on diseases caused by viruses, fungi, and nematodes (1,2,4,5,6,8, 12,14).

Stalk rot of grain sorghum caused by _Fusarium_ spp. was reduced and grain yield was increased under minimum tillage as compared to conventional tillage in each of 3 years of a study by Doupnik et al. (6). The incidences in wheat take-all, caused by _Gaeumannomyces graminis_, and of eyespot or footrot, caused by _Cercosporella herpotrichoides_, were lower after several years under minimum tillage as compared to conventional tillage (2,4). Although differences were not statistically significant, there were trends of higher incidences of maize chlorotic dwarf and maize dwarf mosaic viruses, greater disease severity, and lower yield in minimum tillage than in conventional tillage plots (1). Examples of diseases that have been observed to be problems in minimum tillage, include gray leaf spot of corn, caused by _Cercospora zeae-maydis_, and anthracnose of corn, caused by _Colletotrichum graminicola_ (8). Information is not available on the effects of minimum tillage on the development of plant diseases caused by nematodes; however, great differences in populations of plant pathogenic nematodes have not been associated with tillage practices (1,5,12,14). With one exception (1), these studies have only considered an individual or closely related plant pathogens.

Since populations of microorganisms interact in soil and tillage practices will have direct and indirect effects on any given plant pathogenic microorganism, it is important to monitor as many of these interactants as possible and to determine their influences on each other and on crop production. This study was initiated to evaluate the effects of minimum tillage on populations of fungi and nematodes in vetch, which was grown after sorghum, and oats, which were grown after soybeans. It is intended to provide background information for more detailed studies on the effects of multicropping and minimum tillage on plant pathogenic fungi and nematodes as well as on beneficial organisms such as endomycorrhizal fungi (11), actinomycetes, and bacteria.

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METHODS AND MATERIALS

The fields assayed in this study were maintained on the Green Acres

Gainesville. Populations of the microorganisms were followed in vetch (*Vicia villosa*) in the fourth year of a vetch-grain sorghum (*Sorghum bicolor* "DeKalb BR64") rotation and in oats (*Avena sativa* "Florida 501") in the fourth year of an oats-soybean (*Glycine max* "Cobb") rotation. Plots consisted of four repetitionsof minimum or conventional tillage of each crop in randomized complete block designs.

In studies on vetch, grain sorghum residue was harrowed three times and 30 pounds/acre of hairy vetch were planted with a drill in rows spaced 7 inches apart on 7 November 1979. Conventional tillage for the preceeding grain sorghum consisted of two rototill passes before planting in April 1979; grain sorghum was planted directly in the vetch stubble in the minimum tillage treatments. The vetch was topdressed with 18-14-85-4-2 pounds/acre of N-P-K-Mg-S plus 30 pounds/ton of Frit 503 trace elements on 28 December 1979. Vetch dry matter yield was determined on 3 April 1980 by collecting growth on a 25 ft^2 area at random near the center of each 1125 ft^2 plot.

In the studies on oats, soybean residue was left undisturbed on minimum-tillage oat-soybean sucession plots; conventional tillage plots were prepared by two passes with a harrow on 7 November 1979. Oats were planted in all plots with a drill in rows spaced 7 inches apart at 144 pounds/acre on 7 November 1979. One pint of 2-4 D/acre was broadcast over the oats on 27 December 1979 to control winter annual broadleaf weeds. The oats received the same fertilization as the vetch in December but an additional application of 66 pounds of N/acre was made on 28 January 1980. Oat grain yield was determined by harvesting a 300 ft^2 area from the center of each 1125 ft^2 plot in mid May 1980.

Forty random soil samples from each plot were bulked to provide approximately 2 kg of soil. After thorough mixing, portions of each sample were assayed for various microorganisms. For soilborne fungi, dilutions of soil in water of 1:5,000 (wt:vol) were dilution-plated in potato dextrose agar containing 1 ml of Turgitol NPX, 100 mg of streptomycin sulfate and 40 mg of chlortetracycline HC1 per liter of medium (13). *Pythium* spp. from 1:25 dilutions of soil in water were isolated on Difco cornmeal agar containing 10 mg pimaricin, 250 mg ampicillin, 10 mg rifampicin, and 100 mg pentachloronitrobenzene per liter of medium (9). Bacteria and actinomycetes were isolated from 1:1,000,000 dilutions of soil in water dilution-plated in 0.3% tryptic-soy agar (10). Endomycorrhizal fungi were assayed by wet-sieving 40g subsamples of soil to collect spores and debris as described by Gerdemann and Nicolson (7); the sievings were then centrifuged in a 0.5 M sucrose solution and the supernatant was poured over a 230 mesh sieve (63% opening) to further free spores from soil debris. Spores were then washed onto a 15-cm Petri plate in 10-15 ml of water and examined under a dissecting microscope (20 to 70X) to count and identify spore numbers for each species of mycorrhizal fungus present. Nematodes were counted after extraction from soil by the centrifugal-flotation method of Caveness and Jensen (3).

RESULTS AND DISCUSSION

Although populations of soil fungi, bacteria, and actinomycetes were higher at harvest than at planting and also, except with Pythium spp. or actinomycetes, were higher in vetch than in oats, no significant differences appeared between populations in soils under minimum or conventional tillage (Table 1). Information is not available on the influence of minimum tillage on populations of bacteria and actinomycetes in soil, but they generally are of benefit to crop plants and it is significant in this study that they were not depressed by minimum tillage practices. Of the 1,658 soilborne fungi isolated and identified in a comparison of the mycoflora of soils under minimum or conventional tillage, Wacha and Tiffany (15) found only two species, Penicillium velutinum and Rhizopus oligosporus, that varied significantly with tillage treatments following the second year of soybeans in a corn-soybean rotation. The predominant fungi reported in their study were similar to those observed in this study. It is of significance that Trichoderma spp., which are considered beneficial because of their role in the decomposition of organic matter and possible biological control of plant pathogens, maintained higher populations under minimum than conventional tillage in this study.

There were qualitative and quantitative differences in species of mycorrhizal fungi present on each sample date for the various crop and tillage treatments (Tab1e 2). There were consistently higher spore numbers associated with oats after soybeans than with vetch after sorghum. Immediately after crop harvest (November sample), spore numbers were higher in conventional than in minimum tillage plots, but these differences did not persist in later samples. Most spores recovered were from species in the genus Gigaspora; oats had three times as many Gigaspora spores as did vetch (Table 3). However, spores from species in the genus Acaulospora were more abundant from vetch than oat samples. Generally there were more spores from each genus in the conventional tillage than in the minimum tillage treatments. However, there was consistently higher root infection in the minimum tillage than the conventional tillage plots (Table 3). This would indicate that factors favoring root infection occur more with minimum than the conventional tillage practices. The importance of the positive effects of minimum tillage on beneficial organisms such as endomycorrhizal fungi and organisms antagonistic to plant pathogens is obvious. Research is needed on artificial infestation of plant debris under minimal tillage systems with organisms that will protect the host plants.

Populations of most of the five nematodes examined in this study behaved similarly under minimum tillage and conventional tillage (Table 4). Because of extreme variations in numbers of nematodes within replicate samples, statistical differences were not observed. Ring nematodes appeared to occur in lower numbers in vetch under minimum tillage than under conventional tillage, but populations appeared to be slightly higher in oats under minimum as compared to conventional tillage. Root lesion nematodes also generally were slightly more numerous in oats under minimum as compared to conventional tillage. The total numbers of nematodes were influenced by the high populations of ring nematodes in vetch and of ring plus lesion nematodes in oats. Populations of lesion nematodes, Pratylenchus zeae and of spiral nematodes, *Helicotylenchus* spp., in corn were not influenced by methods of tillage (1), but Corbett and Webb (5) found that populations of Pratylenchus minyus and other migratory plant parasitic nematodes were reduced in wheat under minimum tillage when compared to conventional tillage. Southards (12) and Thomas (14) have demonstrated the significance of multiple seasons of study and variation of tillage treatments, respectively, in the evaluation of the effects of tillage on nematode populations. Direct plant damage by nematodes, as well as indirect damage due to interactions with other microorganisms, will be important factors in the future development of minimum tillage; it is important that disease and not just population dynamics be evaluated critically over multiple seasons in diversified soils and climates.

No significant differences were observed in the frequency of isolation of fungi from roots of vetch or oats grown under minimum or conventional tillage (Table 5). Plant disease symptoms were not apparent under either tillage system. No significant differences occurred in yields of vetch from minimum tillage (1975 pounds/acre) and conventional tillage (2095 pounds/acre) plots. Although data for the yield of oats were not available at the time of writing, yields were significantly greater (P=0.05) in 1979 under minimum tillage (62 bushels/acre) than under conventional tillage (53 bushels/acre).

The results of this preliminary investigation indicate that after 3 years of multicropping vetch-grain sorghum and oats-soybeans, plant diseases did not become serious hindrances to vetch or oat production under minimum tillage in north Florida. Future studies must develop a comprehensive understanding of the interactions of various organisms in crop development under minimum tillage.

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TABLE 1. Populations of soilborne fungi in soil planted with vetch or oats under minimum or conventional tillage.[z/]

Organism	Propagules of Microorganism/g of soil							
	Vetch				Oats			
	Oct. 1979		April 1980		Oct. 1979		April 1980	
	Min.	Con.	Min.	Con.	Min.	Con.	Min.	Con.
Pythium spp.	104	105	116	140	56	59	160	159
Fusarium spp. x 10^3	3.9	3.2	17.8	14.3	1.9	1.6	2.3	3.1
Trichoderma spp. x 10^3	1.7	1.0	9.0	6.1	0.8	1.3	3.3	1.7
Penicillium spp. x 10^3	3.2	4.1	6.3	4.0	1.4	0.7	3.3	4.1
Other fungi x 10^3	16.8	17.4	4.8	20.0	11.8	13.3	1.6	1.7
Total fungi x 10^3	26.3	26.8	83.4	81.0	16.3	17.1	74.0	80.0
Total bacteria x 10^6	13.1	8.7	32.8	32.1	7.3	9.2	15.0	16.4
Total Actinomycetes x 10^6	0.7	0.8	1.5	1.6	1.9	1.2	2.8	2.9

[z/] Minimum and conventional tillage plots were maintained for 3 years of multicropping; vetch followed grain sorghum and oats followed soybeans.

Table 2. Effect of minimum and conventional tillage practices on the spore numbers of vesicular–arbuscular mycorrhizal fungi per gram of soil at five month sample dates.

Crop and Tillage[y]	Spores/g of soil at sample date					
	1979		1980			
	November	December	January	February	March	Mean
Oats–soybean						
Minimum	2.36[z]	2.98	4.01	3.72	2.24	3.06
Conventional	4.48	2.53	3.69	3.02	3.31	3.49
Vetch–sorghum						
Minimum	1.52	1.38	1.55	1.75	1.29	1.50
Conventional	2.21	0.99	1.12	1.65	1.25	1.44
Mean	2.64	1.97	2.59	2.54	2.02	

[y] Minimum and conventional tillage plots were maintained for 3 years of multicropping; vetch followed grain sorghum and oats followed soybeans.
[z] Mean numbers of spores per gram of soil from four replicate samples.

Table 3. Effect of minimum and conventional tillage practices on the incidence of vesicular–arbuscular mycorrhizal fungi in soil and in roots of vetch and oats.

Crop and Tillage[y]	Mean numbers of spores/kg of soil of four genera of mycorrhizal fungi				Root colonization by mycorrhizal fungi
	Gigaspora	Acaulospora	Glomus	Sclerocystis	
Oats					(%)
Minimum	388[z]	35	53	7	9
Conventional	480	88	27	8	2
Vetch					
Minimum	104	129	20	2	38
Conventional	91	124	26	3	18

[y] Minimum and conventional tillage plots were maintained for 3 years of multicropping; vetch followed grain sorghum and oats followed soybeans.
[z] Mean numbers of spores from five monthly samples of 4 replicates per treatment.

TABLE 4. Populations of plant pathogenic nematodes in soil planted with vetch or oats under minimal or conventional tillage in north Florida.

			Number of Nematodes Y//250 cm^3 of Soil											
			Root lesion		Stubby Root		Root knot		Ring		Dagger		Total	
Sampling Date		Crop	Min. z/	Con.	Min.	Con.	Min.	Con.	Min.	Con.	Min.	Con.	Min.	Con.
October	1979	Vetch	12	3	9	9	4	4	9	6	3	3	37	25
November	1979	Vetch	8	9	20	21	1	17	144	297	30	16	173	360
January	1980	Vetch	11	11	4	9	9	6	60	107	4	11	88	144
February	1980	Vetch	3	2	2	3	0	0	59	86	0	0	64	91
March	1980	Vetch	2	0	18	12	0	0	30	132	3	8	53	152
October	1979	Oats	74	36	10	6	3	0	0	2	1	4	88	48
November	1979	Oats	44	28	24	11	3	1	64	17	7	4	142	61
January	1980	Oats	47	25	18	16	0	0	40	27	10	10	115	78
February	1980	Oats	2	9	1	1	0	0	11	9	2	0	16	19
March	1980	Oats	16	9	5	10	0	0	26	9	6	2	53	30

Y/ Root lesion nematode = Pratylenchus brachyurus, stubby root nematode = Paratrichodorus christiei, root knot nematodes = Meloidogyne spp., ring nematode = Macroposthonia ornata, dagger nematode = Xiphinema spp.

z/ Minimum and conventional tillage plots were maintained for 3 years of multicropping; vetch followed grain sorghum and oats followed soybeans.

Table 5. Frequency of isolation of fungi from roots of vetch or oats grown under minimum or conventional tillage.

	Frequency of isolation (% of plants)z/			
	Vetch		Oats	
Fungus	Minimum Tillage	Conventional Tillage	Minimum Tillage	Conventional Tillage
Pythium spp.	100	100	100	100
Pusarium spp.	85	74	aa	90
Trichoderma spp.	65	63	63	60
Penicillum spp.	68	50	60	55
Aspergillus spp.	3	3	5	5
Curvularia spp.	5	10	0	3
Rhizopus sp.	3	15	5	0

z/Surface disinfested roots were plated on potato dextrose agar containing 200 mg of streptomycin/liter of medium; data presented as % of plants with roots infected (20 root systems/plot collected).

Seeding and Reseeding of Cool-Season Forages in North Florida

G. M. Prine[1]

Introduction

Cool-season forages are seeded on temporary pastures or perennial summer grass sods during the fall in North Florida. Growing of cool-season legumes in temporary or sod pastures became a lost art during the period of low-priced nitrogen during the 50's, 60's and early 70's. The purpose of this paper is to establish some of the fundamental rules for successful seeding and reseeding of small-seeded, cool-season grasses and legumes.

Seeding on Temporary Pastures

The earliest and most growth from a temporary cool-season pasture occurs when the crops are planted on a well-prepared seedbed. If the soil is turned and harrowed and good rainfall occurs it is possible to plant in early October in North Florida. The best mixtures are small grains, rye grass and one of the clovers either arrowleaf, crimson, sub, red or white. Steps for successful planting of cool-season temporary pastures are:

1. Do not plant until soil surface is moist and soil reservoir is filled with water. Seeding when soil is only wet to shallow depths can lead to disaster if drought follows seeding. If irrigation is available it is usually best to irrigate before seeding because this decreases the chance of damping off disease. Irrigation or rainfall prior to seeding also prevents the loss of legume inoculation, a problem when planting into hot, dry soil.

2. Lime and fertilize prior to seeding or band fertilizer at planting.

3. Seed should be planted at proper depth according to their size.

4. Firm soil around planted seeds. Good contact between soil and seed is essential to insure proper germination.

5. Check planting often for insect damage particularly from mole crickets and fall armyworm. It will be necessary to apply insecticides in some seasons.

6. Apply up to 60 pounds of N per acre to small grains-ryegrass-legume mixtures at seeding or when legume seedlings are out of the cotyledon

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stage. Apply no N to pure legume plantings. If growth of grasses falters in December, apply 300 pounds/acre of 15-0-15 fertilizer. The potash helps the legumes as well as the grasses.

7. Graze the new planting lightly if weeds or small grains are shading out clover and ryegrass. Do not let livestock stay on the new planting for more than a few hours at a time. Refrain from grazing as soon as the taller shading plants are eaten off.

8. Do not overgraze the cool-season pasture. This is probably the greatest fault in the management of cool-season pastures. Temperatures are cold, days are short, and light intensities are low during winter; so growth rates are low. Feed is scarce and the manager grazes his cool-season forage too closely, lowering the pasture productivity and often creating a longer forage deficit period than is necessary. Supplemental feed is necessary during the winter months to help prevent the need for overgrazing of cool season pastures.

Seeding of Legumes on Pasture Sod

When planting small-seeded legumes on pasture sod which has never been planted in legumes, it is desirable that all precautions are taken to insure a good stand of inoculated seedlings. The following steps are suggested:

1. Wait to plant until summer perennial grass is dormant frost or minimum temperatures of 50° F or lower can be expected on most days. This usually occurs about November 1 in North Florida. The summer grass top growth can also be killed by herbicides if earlier plantings are desired. Early plantings are preferable for successful forage production, but hazards are high for early planting in North Florida.

2. There should not be a large quantity of summer grass topgrowth available. This should be grazed or cut before seeding the winter crop. Burning this top growth before seeding is excellent if practiced.

3. Apply the needed dolomite lime several months prior to seeding legumes.

4. Fertilize with 300 to 500 pounds/acre of 0-10-20 (N-P_2O_5-K_2O) fertilizer just prior to seeding legume. Also apply sulfur and minor elements if needed.

5. Some scarification of soil surface is necessary when seeding legumes. In broadcast plantings this may be disc harrowing but the sod seeders which till soil, place seed and pack are desirable. Banding fertilizer and seed is excellent. Some damage to the summer grass is usually necessary in seeding operation but drastic damage should be avoided or recovery will be poor the following spring.

6. Seed should be inoculated with two or more times the amount of specific inoculant for the particular legume planted and a sticker-coating system is recommended. We have had excellent results with the PELINOC coating system. Inoculation is the most important planting step. All precautions to prevent death of the inoculant bacteria should be taken.

7, Plant the highest recommended seeding levels for each crop alone or in mixture. The legume should be seeded at least 60% of the pure stand seed recommendation when planted in a mixture with grasses). The small grain and/or ryegrass in legume mixtures should be planted at 50% or less of the pure stand planting rate.

8. Plant in moist soil following rainfall which saturates the soil over 6 inches deep. This promotes both rapid seed germination and protects the inoculant bacteria which often die in dry sand. Neither clover or ryegrass do well on droughty, excessively-drained sandy soils, unless irrigated.

9. Do not apply N to any grasses planted with legumes until a killing frost or until legume seedlings have passed the cotyledon stage. Do not apply N unless cool-season grasses are present.

10. Light grazing of the new plantings is helpful if warm season perennial grass is shading out legumes. Only allow livestock to graze new plantings a few hours each time. Do not let livestock stay on new planting continuously or they will pull up and trample too many young seedlings.

Reseeding Annual Forage Crops on Pastures

The most efficient method of seeding many cool-season, small seeded annual legumes is not to seed them but to let them reseed or volunteer. The annual legumes; arrowleaf, rose, crimson, subterranean, and Persian clovers, big-flowered vetch, and serradella; contain cultivars capable of reseeding. White and red clovers act as annuals in the south and many cultivars will reseed. 'Florida Reseeding' ryegrass also has the ability to volunteer if managed properly. Seeds of all the above crops have some protective mechanism which allows them to lie dormant during the summer months and germinate in the fall. By taking advantage of the seeds' ability to survive the summer, we could grow these valuable legumes on many millions of acres which now have no crops during the winter and spring.

There are three rules for successful reseeding of these cool-season crops.

1. The first rule is to make an excellent supply of seed every season, particularly the seeding season. It may take a seed crop of 200 pounds of seed to be the equivalent of 10 pounds of seed planted in the normal manner. Some seed will be eaten by various animals, or be

attacked by various micro-organisms, others will not germinate because of various dormancies, and some may be washed away by heavy rains. So only a low percentage of seed will survive and germinate.

2. The second rule is to graze, mow or otherwise maintain a short perennial warm-season grass sod during the fall months when seedlings are germinating. In many cases some scarification of soil surfaces such as light harrowing is helpful. Close grazing by livestock is the best way to maintain this short sod.

3. The third rule is to apply fertilizer and lime to provide maximum benefit to the cool-season crop. This often means all the fertilizer is applied in fall of year. No nitrogen is needed unless the cool-season crop contains a cool-season grass in addition to legumes. Nitrogenous fertilizer, up to 60 pounds/acre N, may be applied in fall to boost growth of grasses such as ryegrass.

Reseeding Ryegrass. Most cultivars of Italian ryegrass (*Lolium multiflorum*) reseed to some degree. The release of "Florida Reseeding" ryegrass in 1978 gives a ryegrass cultivar with a higher percentage of summer-dormant seed and better volunteering than other adapted cultivars. This greatly increases the potential of having both a volunteering annual grass and legume on perennial grass pasture sods. Grazing must be deferred on ryegrass during seeding if it is to make a satisfactory seed crop for successful reseeding. The reseeding ryegrass should be grown in mixture with a reseeding legume such as arrowleaf, crimson, subterranean, rose, white and red clover, vetches, and serradella. The deferred grazing often enhances the seed reproduction of the legume as well as the ryegrass.

The approximate time of flowering and periods when grazing should be deferred on Florida Reseeding ryegrass and a number of reseeding legumes is shown in Figure 1. By planting several legume-ryegrass mixtures in different pastures it is possible to maintain a high level of seed production and still have grazing at the same time. For example, crimson and sub clovers, and Florida Reseeding ryegrass will start seed production if grazing is deferred about April 10. Seed will be approaching maturity in these crops in early May. Arrowleaf, southern red and white clovers make excellent growth during month of April and many cultivars begin flowering profusely in early May. Florida Reseeding ryegrass will still reseed satisfactorily if grazing is deferred by the end of first week in May. If reseeding crimson and/or sub clovers-ryegrass mixtures are planted on about 1/2 of the pasture acreage and grazing deferred from about April 10 to May 7, this part of pasture should successfully reseed. The livestock can be heavily stocked on the arrowleaf and/or red and/or white clover-ryegrass mixtures during the April 10 to May 7 period when they are most productive. The livestock can be returned to crimson and/or sub clover-ryegrass pastures about May 7. The clover and ryegrass stubble and young growth of the perennial grass have produced a lot of forage during deferred grazing which can carry the live·tock while the grazing is deferred on the arrowleaf, red, or white clover pastures. When the ryegrass seeds begin to shatter, then grazing can be resumed on these pastures also. In some seasons drought may tend to reduce forage supply and the deferred grazing scheme often becomes untenable. It may be necessary to scarifice the seed crop on part of the pasturage because all growth is needed for grazing. In this case, try to make a seed crop with the legume since the ryegrass seed is usually relatively cheap. If both legume and ryegrass seed crops are lost it may be necessary to replant. However, if the legumes have reseeded on the area for several prior years, scarification of the soil surface by harrowing or some other means will often bring enough seed to surface for a satisfactory volunteer crop. The scarification can take place at time of planting for the ryegrass which must be replanted if little or no seed is produced.

At Pine Acres Research Ranch near Citra, FL we have had 80 acres of rye-ryegrass-legume mixtures on Suwanee bermudagrass sod for several seasons. The rye and ryegrass are topseeded on short sod in October with a grain drill with small seed attachment following a disc harrow. A cultipacker follows the grain drill. Grazing is deferred a short time in April on sub clover and crimson clovers mixtures planted on one half the pasture acreage. The rye has already been grazed out. The ryegrass seed heads grow up during the short deferred grazing period (10 days to 2 weeks). When the cattle are returned they eat the ryegrass seed heads and leave most of the crimson clover seed heads which are relatively unpalatable. Sub clover can be grazed during seed production since seed production is not damaged by moderate grazing. Grazing continues on arrowleaf clover pastures in the other half of the acreage until late June. Because arrowleaf clover is the only winter plant still surviving in June, this clover is grazed so closely by cattle that seed production has usually not been as high as desired. When inadequate seed of a legume is produced in spring, we add some seed of that legume in the fall. By applying 60 pounds/acre of nitrogen fertilizer to the rye and ryegrass in fall and irrigating to insure early establishment in October we have been successful in having cool-season pastures from mid-December until mid-June.

SEEDING PERIOD

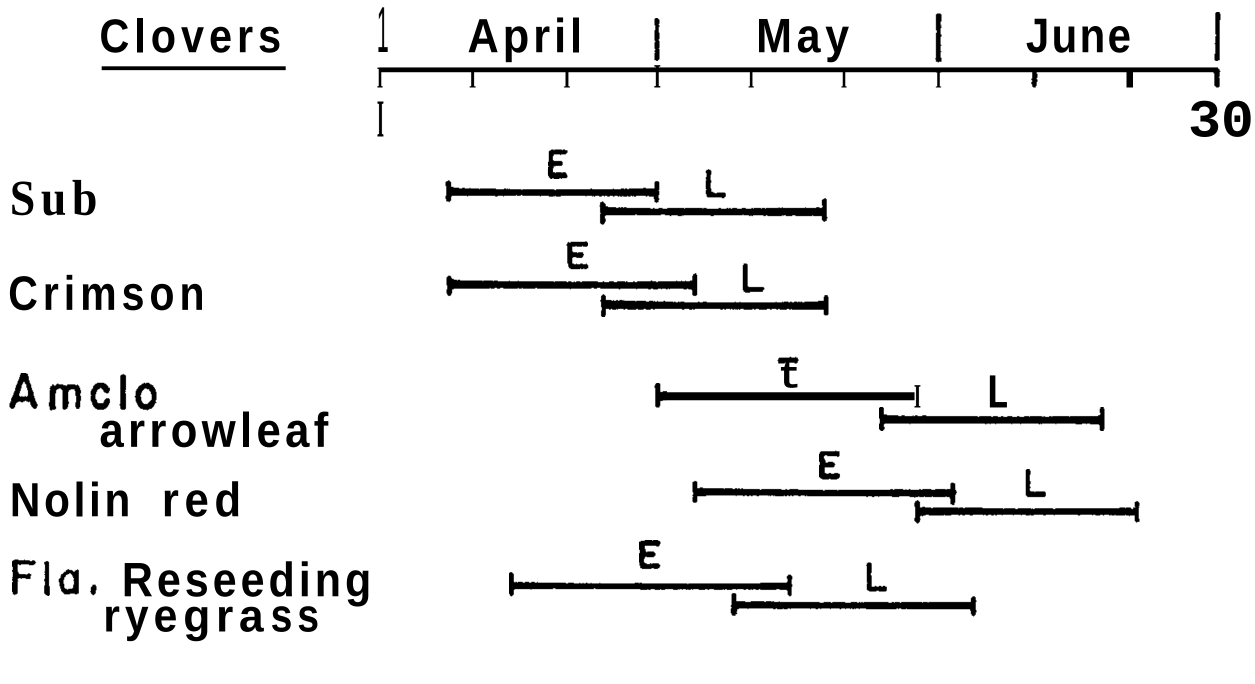

Fig. 1 Seed production periods of various cool-season forage crops. E marks the earliest period and L the latest period that grazing can be deferred on the crop and a good seed crop obtained.

SUBSOILING: TILLAGE AND ENERGY IMPLICATIONS

F. M. RHOADS AND D. L. WRIGHT[1]

Tillage pans were identified and characterized in four Coastal Plain soil series occurring throughout the Southeastern United States (5). Depth to the pan was 11 to 15 cm, pan thickness was 13 to 14 cm, and root growth within the pan was severely restricted.

Deep tillage and deep placement of lime, fertilizer, and nematicides have been tested on various crops at several locations with inconsistent results (1, 2, 3, 6, 9, 10, 11, 12). Subsoiling under the row increased seed cotton yields 41% but bedding, deep placement of lime, and addition on a nematicide had no influence on yield (1). Subsoiling increased soybean yields in 7 of 16 experiments, whereas, a nematicide increased yields in 10 of 16 tests (6). However, the combined treatment of subsoiling, plus a nematicide, increased yields significantly in 13 of 16 experiments (6). Subsoiling, in New Jersey, with and without deep placement of lime and fertilizer on a Collington sandy loam soil, did not produce significant yield increases of several vegetables (2). However, residual effects of subsoiling significantly increased water movement into this soil for 3 years after the last deep tillage operation.

In-row subsoiling before planting produced highest soybean yields in North Florida (7). Depth of rooting of corn was increased with subsoiling (8). Response to subsoiling on sandy soils appears to be related more to increased nutrient availability than to availability of water. Yield response to subsoiling has been most consistent where under-the-row subsoiling was practiced.

Energy requirements for subsoiling are quite high and considerable savings could be achieved if the subsoiling operation was not necessary every growing season. However, under normal tillage operations the soil is recompacted each year and subsoiling is required on an annual basis for maximum crop yields. There is a possibility that recompaction of the soil following subsoiling could be minimized under minimum tillage production of crops. Avoiding travel over crop rows from the previous season with tillage implements and tractor wheels should reduce soil compaction. This can be accomplished with minimum tillage operations where succeeding crops are planted directly in stubble rows of the previous crop.

This report contains test results from experiments designed to measure the effect of soil-moisture content on resistance to soil penetration and the effects of a disc-harrow and a tractor wheel on soil compaction. Power requirements for subsoiling at different levels of soil penetrometer resistance were also estimated.

METHODS

Eight tillage and compaction treatments were applied to three soil types during the winter of 1979-80. The soils were Orangeburg loamy fine sand, Norfolk loamy

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fine sand, and Troup sand. All treatments were harrowed with an offset disc-harrow before tillage and compaction treatments were applied. Treatments were as follows: 1) no treatment, 2) subsoiled only, 3) subsoiled followed by one trip with the offset harrow, 4) subsoiled followed by two trips with the harrow, 5) subsoiled followed by four trips with the harrow, 6) subsoiled followed by one trip with the tractor tire directly over the subsoiled furrow, 7) subsoiled followed by two trips with the tractor tire as in no. 6, and 8) subsoiled followed by four trips with the tractor tire as in no. 6.

Resistance to penetration was measured with a recording penetrometer to a depth of two feet (60 cm). Four measurements were taken each time per treatment and averaged. Soil-moisture content was measured with a neutron moisture probe when penetrometer measurements were made.

Penetrometer measurements were taken to correspond to different levels of soil-moisture content.

Power requirements were estimated from the following equation:

$$HP = PR \times 14.5 \times A \times 3 \text{ mph} \times \frac{5280}{3600} \times \frac{1}{550}$$

where HP = horsepower
PR = penetrometer resistance in bars
A = area of chisel point in square inches
mph = miles per hour

These estimates may be slightly high since the angle of the chisel point with respect to direction of travel was not considered.

RESULTS AND DISCUSSION

Soil moisture content has a significant effect on resistance to penetration of the soil profile. The traffic pan is located in the top foot (30 cm) in most coastal plain soils with a long history of cultivation. Therefore, the moisture content in the upper part of the soil profile will have a pronounced effect on penetrometer resistance. Penetrometer resistance (PR) was reduced from 36 to 18 bars in the top 30 cm of a Norfolk soil when the moisture content increased from 17.4% to 20.6% (Fig. 1). This corresponds to a power requirement change of 25 HP per chisel or 100 HP for a four row subsoiler (Table 1). The change in moisture content corresponds to 0.18% per bar of chanqe in PR. Similar results were observed in the Trour, soil except the moisture change was much less, corresponding to .09% per bar change' in PR (Fig. 2).

From an energy viewpoint the most desirable moisture content for subsoiling is at field capacity or when the soil first becomes dry enough for tillage following rainfall. It may be desirable to subsoil when the soil *is* dry in order to shatter the tillage pan as much as possible but the increased yield response may not offset the added cost of energy. A decrease in moisture content in the Norfolk soil of 3% below field capacity would about double the power requirement for subsoiling. A decrease of only 1% moisture below field capacity would double the power requirement for subsoiling in the Troup soil. Furthermore, substantial yield increases have been observed in corn and soybeans as a result of subsoiling when soil moisture content was near field capacity (7, 8).

Soil compaction has been attributed mainly to the use of a disc-harrow, by many people. However, four trips over a subsoil crevice with an offset disc-harrow recompacted the soil to a PR value of less than 5 bars (Fig. 3). The graph shows the depth of subsoiling at about 14 inches (35 cm) and the depth of the harrow at about 6 inches (15 cm). One trip over a subsoiled crevice with a tractor tire caused greater recompaction of the soil than 4 trips with a harrow (Fig. 4). Four trips over the crevice with a tractor tire recompacted the soil to resistance levels of over 15 bars as measured with the recording penetrometer. There is a high probability that tractor tires will pass over the subsoil crevice three or four times during a single year where conventional tillage is used. This is why most growers have planters attached directly behind the subsoiler chisel in order to avoid recompaction of the soil between the subsoiling and planting operation. Minimum tillage provides a way to avoid recompaction of soil in the subsoil slit between crops since the ,location of the rows from the previous crop are visible during the planting operation. Therefore, the tractor operator can run the tractor wheels between rows and plant directly over the subsoiler slit made for the previous crop. Perhaps as a result of this practice the subsoiling operation would only be necessary every other year. Thus, a significant savings of energy would be accomplished.

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Figure Captions

Figure 1. Effect of soil moisture content on penetrometer resistance in a Norfolk soil. Average per cent moisture by volume is shown for 0 to 30 cm and 30 to 60 cm for two separate observations.

Figure 2. Effect of soil moisture content on penetrometer resistance in a Troup soil. Average per cent moisture by volume is shown for 0 to 30 cm and 30 to 60 cm for two separate observations.

Figure 3. Penetrometer resistance before subsoiling and in the subsoiler crevice before and after four trips with a disc harrow.

Figure 4. Effect of a tractor tire on recompaction of soil in the subsoiler crevice.

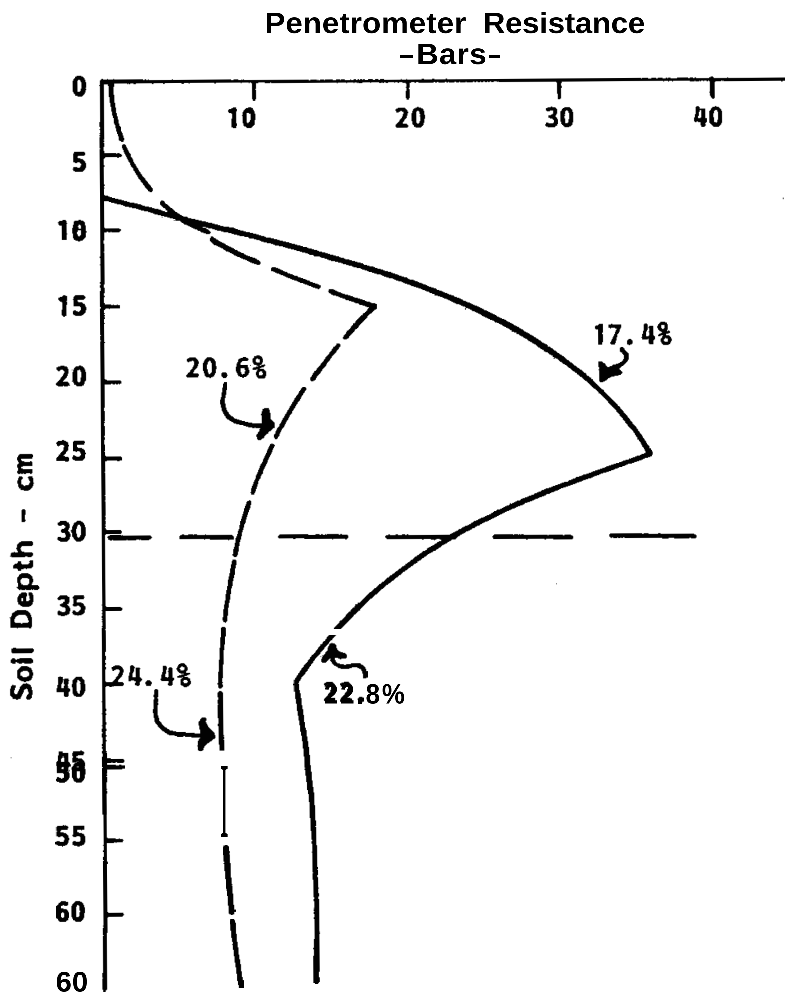

Figure 1. Effect of soil moisture content on penetrometer resistance in a Norfolk soil. Average per cent moisture by volume is shown for 0 tp 30 cm and 30 to 60 cm for two separate observations.

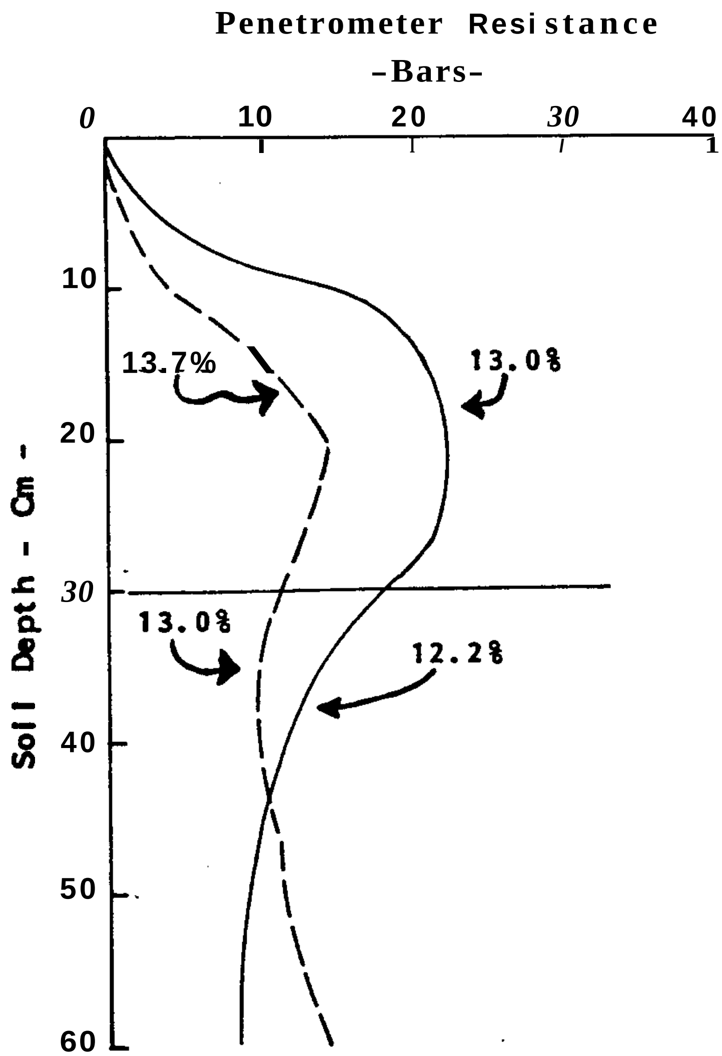

Figure 2. Effect of soil moisture content on penetrometer resistance in a Troup soil. Average per cent moisture by volume is shown for 0 to 30 cm and 30 to 60 cm for two separate observations.

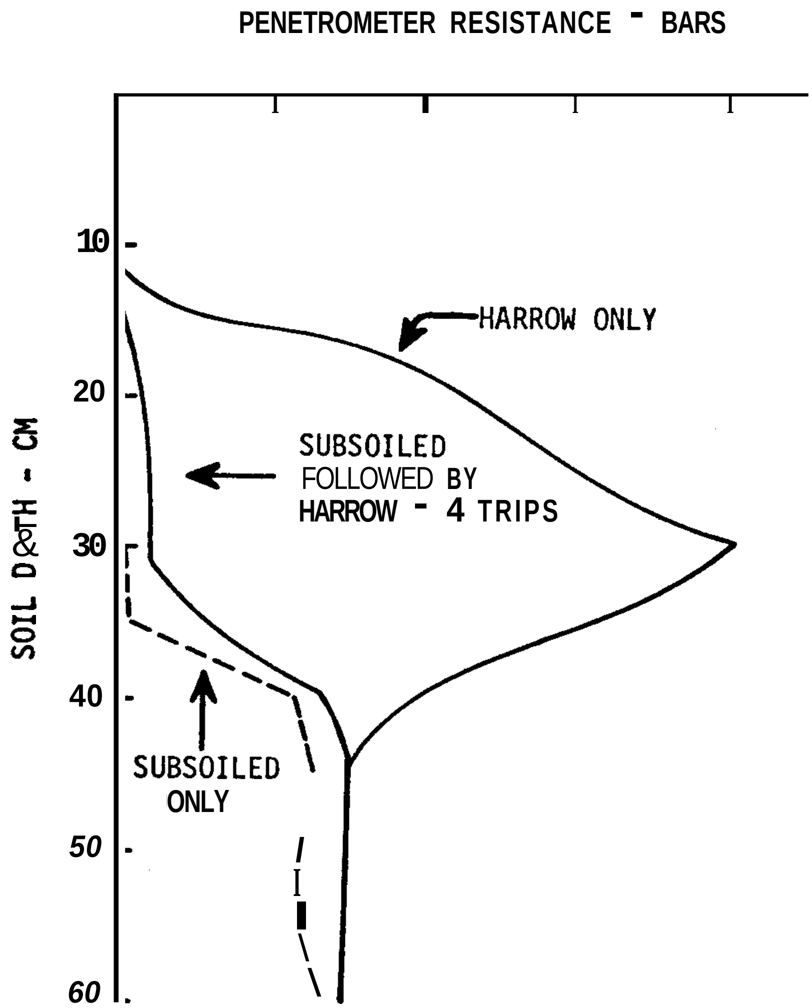

Figure 3. Penetrometer resistance before subsoiling and in the subsoiler crevice before and after four trips with a disc harrow.

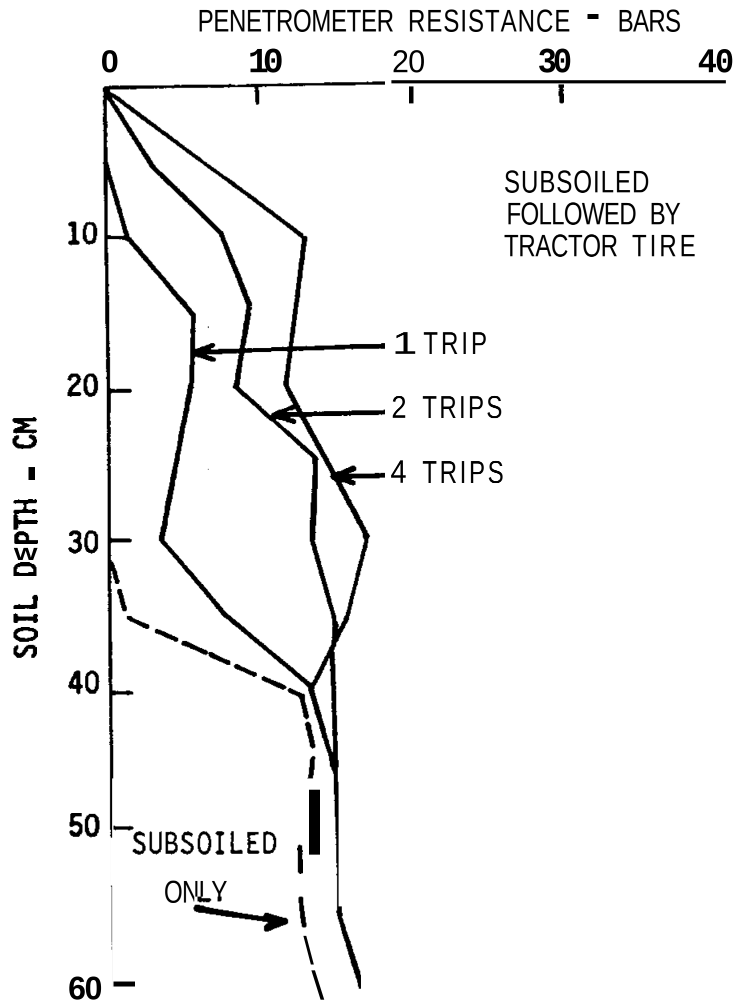

Figure 4. Effect of a tractor tire on recompaction of soil in the subsoiler crevice.

Table 1. Power required to pull a single subsoil chisel through the soil with various levels of resistance to penetration at a speed of 3 miles per hour. Chisel point dimensions 2 inches by 6 inches.

Penetrometer Resistance (bars)	Horsepower per chisel
5	7
10	14
20	28
30	42
40	56

Minimum Tillage of Corn in Perennial Sod:[1] A Three-year Study with Energy Implications

W. K. Robertson, R. N. Gallaher, and G. M. Prine[2]

Minimum tillage (often termed no-tillage since only a small fraction of the soil is tilled) for corn *(Zea mays* L.) was compared with conventional tillage (plowing, harrowing, and planting) in Pensacola bahiagrass *(Paspalum notatum* Flugge) sod for 3 years on Scranton fs, a siliceous, thermic Humaqueptic Psammaquent. If yield returns were equivalent, energy savings would be important (2).

In 1976, there were no differences in corn yields for conventional versus no-tillage when rows were 45 cm apart. When rows were 90 cm apart, yields were higher for the conventional method but not at the 5% level of probability. Responses were the same for Funks G-4708 and Pioneer 3369A cultivars.

In 1978, conventional tillage was compared with no-tillage with and without subsoiling for four corn cultivars. With subsoiling there were no yield differences between no-tillage and conventional but methods of tillage interacted with subsoiling. There was a large response to subsoiling for both the no-tillage method and the conventional method of tillage, but greater for no-tillage. As a result, the no-tillage method gave higher yields than the conventional method under subsoiling.

The yield responses, over tillage methods, for subsoiling were related to stand. Stands (plants/ha) were improved by subsoiling but more so for no-tillage. Forage yields correlated with grain yields but bahiagrass regrowth yields at harvest were better when corn yields were low. This suggests that the better groundcover of the higher yielding treatments shaded out undergrowth.

Tillage methods did not affect yields in 1979 although subsoiling improved the plant population.

For the three years of the experiments, grain yields for no-tillage were superior or as good as the conventional method when narrow rows were used and the soil was subsoiled beneath the row to 35 cm. The need for subsoiling interacted with season; in 1978 there was a benefit but in 1979 there was no effect.

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The no-tillage method of planting row crops has been widely adopted in many states. An exception is Florida. Yet research has shown that in most instances yields could be comparable to conventional methods if the best stand and row widths are adopted (3,4,5,6,7). Comparable yields would make the no-tillage method preferable because the method offers additional flexibility in planting and savings in time, machinery, and energy over-the conventional method. The no-tillage practice has been evaluated by Gallaher (1) and Robertson and Prine (8).

METHODS

In 1976, the experiment was a factorial of two cultivars: Funks G-4708 and Pioneer 3369A; two methods of planting: conventional, which included rotatilling, harrowing, and planting with the no-till planter and no-till which had once-over with the no-till planter; and two row widths: 90 and 45 cm. Treatments were replicated four times. The no-till planter was made by Allis Chalmers and had the serrated coulters. It had attachments to apply fertilizer: 880 kg/ha of 4-3.4-6.6 (N-P-K); carbofuran 2,3-Dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate; and liquid herbicides: 2-ch1oro-4-ethy1amino-6-isopropy1-amino-1,3, 5-triazine (atrazine) and N (Phosphonomethyl) glycine (glyphosate or roundup). Plots consisted of 6 rows, 90 cm apart, and 12.3 meters long. The 45 cm row width was obtained by doubling back between the 90 cm rows.

In 1978 and 1979, the experiments were factorials of two subsoil treatments: subsoiled to 36 cm depth beneath row and a check; and 4 cultivars: Funks G-4507, DeKalb XL18, DeKalb XL12, and Pioneer 3958, replicated 4 times. Plots consisted of 6 rows spaced 76 cm apart. At maturity, grain yields were calculated at 15% moisture and stover (stalks, less ears) and undergrowth yields on an oven-dry basis.

In 1978, corn received 900 kg/ha 4-3.4-13.3 (N-P-K) at planting. Carbofuran was applied at the rate of 22 kg/ha beside the row and to control weeds glyphosate and atrazine werebroadcast over the soil surface at the rate of 4 liters and 3 kg/ha (actual), respectively. About 30 days after planting, 420 kg/ha of NH_4NO_3 was applied as a sidedressing. Following harvest in middle August, 3 soybean *[Glycine max* (L.) Merr.] cultivars, 'Jupiter,' 'UF V-1,' and 'Cobb,' and sunflowers *(Helianthus* sp 'Sungrow 380A') were planted with the no-till planter following the corn cultivars to study residual effects of tillage and subsoiling.

On March 27, 1979, corn received 350 kg/ha of 4-3-17.5 (N-P-K) beside the row and 3 kg/ha (actual) of atrazine and of 2-chloro-2', 6'-diethyl-N-(Methoxymethyl) acetanilide (Alachlor) and 4 liters/ha glyphosate broadcast during the planting once-over operation. Bahiagrass frosted just before treatment and since there was a possibility glyphosate might not work, we post directed 1, l'-dimethyl-4, 4'-bipyridinium ion (paraquat) at the rate of 1 liter/ha on April 28. On May 11, the corn was sidedressed with a mixture of 15-0-12.5 (N-P-K) and NH_4NO_3 at the rate of 350 and 420 kg/ha, respectively.

RESULTS AND DISCUSSION

Corn grain yields were not significantly different at the 5% level of probability in 1976 for planting treatments, cultivars, or row width (Table 1). Conventional planting was somewhat better than no-till at the 90-cm row width for both cultivars but the difference was reduced considerably at the 45-cm row width. Probably the closer rows shaded out undergrowth and reduced competition for nutrients and water. In succeeding years, 75-cm rows were planted.

The best response in 1978 was for subsoiling. Both corn grain and forage yields were increased (Table 2). The higher forage under subsoiling crowded out undergrowth so that weed and bahiagrass growth following subsoiling was lower than the check. The effects of tillage methods over subsoiling and cultivars were not different. Grain and forage yield for Funks G-4507 and grain yield for Pioneer 3958 were significantly higher than DeKalb XL18 and XL12. Cultivars did not affect undergrowth.

Although the overall effectsof tillage methods were not different, they did interact with subsoiling. The interaction for corn grain yields is shown in Table 3. Without subsoiling, no-till corn grain yield was significantly lower than conventionally-planted corn. However, with subsoiling no-till corn grain yields were higher than the check. Probably subsoiling increased root depth and access to water and the advantage was enhanced under no-till planting since evaporation from the residue covered surface was reduced so that moisture supplies down the profile were greater. Additional benefit for subsoiling was evident in stands (Table 4). Stands were significantly higher for subsoiled corn compared to check but methods of tillage had little effect on stand. Ears per plant were not affected by subsoiling or planting methods.

Nutrient composition of the corn stover was not affected greatly by subsoiling (Table 5). The differences in uptake that occurred (Table 6) were essentially related to yield differences (Table 2). Subsoiling reduced the uptake of nutrients in the undergrowth because corn grew better and competed with the undergrowth for nutrients and water. For methods of planting, uptake of nutrients in the undergrowth was better from the conventional treatment possible because of the composition of the undergrowth. There were more weeds and less bahiagrass for conventional compared to no-till and since undergrowth contained more nutrients following conventional planting, the weeds must have been higher in nutrients than bahiagrass.

Soybeans were planted late (August 15) and yields were low, averaging 980 and 880 kg/ha for 'Jupiter' and 'UF V-1' cultivars, respectively. 'Cobb' soybeans and sunflowers gave no consistent yields. There was no residual effects due to tillage and subsoiling on the 'Jupiter' and 'UF V-1' soybean yields.

In 1979, low rainfall in the latter stages of growth reduced grain yields. Subsoiling and tillage had no effect on yield or ears per plant. However, subsoiling again improved the stand. There were almost 52,000 plants/ha for the subsoiled beans compared to 46,400 plants/ha on the check. Funks G–4507 had the highest yield similarly to the 1978 results, but Pioneer 3958 yielded significantly less than Funks G–4507 as compared to 1978 where yields were about the same. Yields and uptake of N for the stover corresponded to grain yields. The overall stover/grain yield ratio in 1978 and 1979 was 1.84 and 1.58, respectively.

SUMMARY

In 1976 and 1979, the conventional practice of planting corn gave yields no different from the no–tillage method. Since costs of planting by the no–tillage method are definitely lower (2), it follows that it would be more economical to plant corn by the no–tillage practice.

In 1978, corn yields obtained from the conventional practice was more than by no–tillage; 4470 vs 3370 kg/ha, respectively (Table 3). The value of the yield difference (1100 kg/ha) would probably more than make up for the savings in using the no–tillage compared to the conventional method (2). However, when both methods had the added practice of subsoiling, there was increased yields far both methods of planting and the increase was enough greater for no–tillage that it was superior to the conventional method; 5643 vs 5258 kg/ha, respectively (a 385 kg/ha yield difference).

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Table 1. 1976 corn grain yield data testing row width and no-tillage on two cultivars.

Treatments	N[‡]	Cultivars[†] Funks G-4708	 Pioneer 3369A	Average over cultivars
		Bows spaced 90 cm, kg/ha		
Conventional	4	5240	5130	5180
No-till	4	4880	4360	4620
		Rows spaced 45 cm, kg/ha		
Conventional	4	4730	5330	5030
No-till	4	4800	5400	5100
		Average over spacing, kg/ha		
Conventional	4	4980	5240	5110
No-till	4	4840	4880	4860
	8	4910	5060	

'Funks G-4708 is an early-maturing cultivar and Pioneer 33698 is a medium maturing cultivar.

[‡]Number of observations.

Table 2. 1978 yield data in no-tillage experiment on corn on Scranton fs.

Treatments	N[†]	Yields		
		Corn grain	Forage	Undergrowth
		---------------kg/ha---------------		
Subsoiling				
No	32	3920b[‡]	6760b	2770a
Yes	32	5450a	10460a	2240b
Tillage				
Conventional	32	4860	9090	2531
No-till	32	4510	8130	2480
Cultivars				
Funks G-4507	16	5100a	10740a	2620
DeKalb XL18	16	4030b	7870b	2780
DeKalb XL12	16	4190b	7280b	2410
Pioneer 3958	16	5150a	8540b	2200

'Number of observations.

'Values followed by different letters are different at the 5% level of probability.

Table 3. 1978 corn grain yields showing interaction between subsoiling and no-tillage treatments.

Subsoiling treatment	Planting method	
	Conventional	No-tillage
	--------------kg/ha--------------	
NO	4470A†	3370bB
Yes	5260	5640a

†Values followed by different small letters in between columns and different capital letters in rows are different at the 5% level of probability. Data are averages over four replications and four cultivars.

Table 4. 1978 corn plant population and ears per plant as affected by no-tillage and subsoiling.

Treatments	N[†]	Plants/ha	Ears/plant
Subsoiling			
No	32	46,600b[‡]	0.91
Yes	32	60,200a	0.92
Planting method			
Conventional	32	53,000	0.92
No-tillage	32	53,800	0.91

[†]Number of observations.

[‡]Values followed by different letters are different at the 5% level of probability.

Table 5. Nutrient composition of corn stover and undergrowth in 1978 as affected by subsoiling and methods of planting.

		Stover				Undergrowth			
		Subsoiling		Methods of planting		Subsoiling		Methods of planting	
Nutrient	N[†]	No	Yes	Conventional	No-till	No	Yes	Conventional	No-till
		%							
N	32	0.88	0.88	0.95	0.82	1.19	1.15	1.26	1.08
P	32	0.23a[‡]	0.22b	0.23	0.22	0.20	0.21	0.24a	0.18b
K	32	0.59	0.60	0.56	0.63	1.81	1.80	2.00a	1.61b
Ca	32	0.10	0.11	0.10	0.11	0.95	0.89	1.48	0.36
Mg	32	0.09	0.08	0.09	0.08	0.23	0.22	0.28a	0.17b
		ppm							
Cu	32	17	21	18	19	21	17	22a	16b
Fe	32	20	17	19	19	48	48	52a	43b
Mn	32	25	22	23	24	119	118	126	111

[†] Number of observations.

[‡] Values followed by different letters in horizontal rows testing subsoiling and methods of planting for stover and undergrowth, respectively, are significantly different at the 5% level of probability.

Table 6. Uptake of nutrients in corn stover and undergrowth in 1978 as affected by subsoiling and methods of planting.

		Stover				Undergrowth			
		Subsoiling		Method of planting		Subsoiling		Method of planting	
Nutrient	N[†]	No	Yes	Conventional	No-till	No	Yes	Conventional	No-till
		kg/ha							
N	32	60b[‡]	90a	85a	66b	33a	26b	33a	26b
P	32	16b	23a	21a	18b	6a	5b	6a	4b
K	32	39b	62a	51	50	40b	41a	52a	40b
Ca	32	7	12	9	9	26	22	39a	9b
Mg	32	6b	9a	9a	7b	6a	56	7a	4b
cu	32	0.12b	0.22a	0.17	0.17	0.06a	0.04b	0.06a	0.04b
Fe	32	0.14	0.18	0.17	0.15	0.13a	0.10b	0.13a	0.10b
Mn	32	0.16b	0.23a	0.20	0.18	0.34	0.27	0.33	0.28

'Number of observations.

‡Values followed by different letters in horizontal rows testing subsoiling and methods of planting for stover and undergrowth are significantly different at 5% level of probability.

Table 7. 1979 yield data in no-tillage corn experiment on Scranton fs.

Treatments	N[†]	Grain yield	Plants/ha	Ears/plant	Stover Yield	Stover N uptake
		kg/ha			-------kg/ha-------	
Subsoiling						
No	32	3200	46,400b	0.91	4610	49
Yes	32	3250	51,980a[‡]	0.91	5610	56
Tillage						
Conventional	32	3230	49,050	0.92	5060	51
No-till	32	3220	49,340	0.90	5160	54
Cultivars						
Funks G-4507	16	4190a	47,200	0.87	8490a	74a
DeKalb XL18	16	3120b	48,850	0.89	5160b	52b
DeKalb XL12	16	3560b	47,550	0.93	3170b	30c
Pioneer 3958	16	3040b	53,190	0.94	3600b	44bc

†Number of observations.

‡Values followed by different letters are different at the 5% level of probability.

NO-TILLAGE VERSUS CONVENTIONAL TILLAGE CORN IN BAHIAGRASS SOD WITH SOYBEANS FOLLOWING

R. L. STANLEY, JR. AND R. N. GALLAHER

Perennial grasslands occupy several million acres in the southeastern USA and also occur on vast acreages in the tropics. With proper management techniques that are efficient and at the same time conserve the land and other natural resources, much of this area could be used for grain production. Research was initiated at AREC Quincy with 3 objectives: (1) compare conventional methods of soil preparation and cultivation with no-tillage methods for producing corn in Bahiagrass sod, (2) determine the influence of the two practices on soybean production following the corn, and (3) identify limiting factors in no-tillage corn production.

Six early corn hybrids were planted in a bahiagrass sod on 22 March, 1978. Seeding directly into the sod (no-tillage planting) with a Brown-Harden Super Seeder was compared to planting on a prepared seedbed that included turning with a moldboard bottom plow and one disking. The Super Seeder was used to plant both treatments. Rows were 30 inches wide and the subsoiler feet ahead of the planters were set at 14 inches deep. In a single pass over the plots application of an insecticide, herbicide, and fertilizer was made while subsoiling and planting. "Roundup" herbicide was broadcast at 1/2 gallon of comnercial products per acre. Furadan was banded over the row at 20 pounds comercial product per acre. Fertilizer applied at planting was 1000 lb/A of 5-10-15 ($N-P_2O_5-K_2O$) with ammonium nitrate applied at 450 lb/A when the corn was 24 inches tall. Conventional tillage plots were cultivated once. Irrigation water was applied two times, but facilities were not adequate to irrigate for maximum yield potential. Sample rows were hand harvested on 19 July. At this time moisture in the grain was in a range of 26 to 30%.

Grain yields are shown in Table 1 as bushels/A at 15.5% moisture. The highest yielding hybrid for both planting methods was Funk's G-4507. With this hybrid the prepared seedbed resulted in a yield increase of 16 bushels/A over the no-tillage treatment. All hybrids responded in a similar manner with yield differences up to 44 bu/A. The average increase of all varieties was 24 bushels/A in favor of conventional land preparation.

Cobb soybeans were planted behind the corn on 26 July with the Super Seeder. Two quarts Lasso plus 1 pint Lexone and 10 pounds 10G Furadan (not labelled) were applied during the planting operation. Roundup at 1 gallon/A was applied in a second trip over the field. All soybeans were planted without any tillage into the conventional and no-tillage corn residue. Soybean yields were low due to the late planting date, stink bug damage, and shattering losses caused by excessive rainfall at harvest time. Average yield from no-tillage beans behind conventional tillage corn was 15 bushels/A compared to 9 bushels/A behind the no-tillage corn.

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The experiment was repeated in 1979 with 7 corn hybrids planted on 14 March. Aatrex-Lasso-Paraquat (1-2.5-0.5 a.i./A) was broadcast at planting with Furadan banded at 20 pounds per acre. At planting, 800 lb/A of 7-14-21 ($N-P_2O_5-K_2O$) was applied with 300 lb/A ammonium nitrate applied on 20 April. Conventional tillage plots were cultivated once. On 16 May Paraquat + Lorox (0.5 + 1.0 a.i./A) was applied post directed to all plots. Supplemental irrigation was used to maintain a favorable moisture regime. Corn was harvested on 18-20 July with grain moisture content 24 to 30%.

Corn grain yields for 1979 are shown in Table 2. Funk's 6-4507 was again the highest producer. Whereas in 1978 the conventional method resulted in a 16 bu/A increase over no-till (Table 1), in 1979 the no-till method resulted in a 7 bu/A advantage with this hybrid (Table 2). DeKalb XL-12 also produced a slightly higher yield under no-till. The other hybrids showed a slight yield advantage for the conventional method in 1979. The average yield difference in 1978 (Table 1) was 24 bushels per acre for conventional versus no-till, while in 1979 (Table 2) the average difference was only 6 bushels per acre.

Cobb soybeans were planted following corn harvest on 26 July. Half the area was planted in rows and half was drilled using a grain drill. Lasso-Sencor-Paraquat (1.5-0.5-0.5 a.i./A) was applied to row planted beans with Paraquat omitted from the drilled beans which were planted on a disked seedbed. On 11 September, Paraquat at 0.5 a.i./A was post-directed to soybeans in rows. The drilled beans held the weed competition to a desirable level. Soybeans were irrigated once on 17 December. A plot combine was used to harvest the soybeans. Moisture content was 15 to 18% at harvest.

Soybean yields following conventional corn was 17 bushels per acre, while yields behind no-till corn was 18 bushels per acre. Yields of drilled beans were no different from those in rows.

Results from these 2 years of research show that corn yields of up to 150 bushels per acre can be realized with no-till practices on Bahiagrass sod. Higher yields might be achieved by increasing plant populations. In 1979, plant populations were in the range of 18,000 to 23,000 plants per acre. Current recommendations are for 30,000 plants per acre for irrigated corn. Obtaining a uniform and consistent stand has been a problem, and if this can be solved to give higher populations, yields of up to 200 bu/A might be realized. Research is being continued with this objective in mind.

Soybean yields following corn in these experiments have been low enough that this practice would probably not be profitable.

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Table 1. Grain Yields of 6 Corn Hybrids Seeded in a Bahiagrass Sod. AREC, Quincy - 1978.

Hybrid	Conv. [1]	No-Till [2]	Diff. [3]
Funk's 6-4507	150	134	16
Northrup King PX 20	131	87	44
DeKalb XL 12	124	108	16
Pioneer 3958	124	104	20
DeKalb XL 18	116	91	25
Pioneer 3965	114	88	26
Avg.	126	102	24

1/ Conventional Tillage. Turned with bottom plow and disked once before planting with Brown-Harden Super Seeder.

2/ No-Till. Planted directly into sod with Brown-Harden Super Seeder.

3/ Advantage (+ or -) of conventional over no-till.

Table 2. Grain Yield of 7 Corn Hybrids Seeded in A Bahiagrass Sod. AREC, Quincy - 1979.

Hybrid	Conv.[1]	No-Till[2]	Diff.[3]
		Bu/A Grain	
funk's G-4507	150	157	- 7
DeKalb XL-726	132	129	+ 3
Pioneer 3958	125	111	+14
Northrup King PX 20	118	114	+ 4
DeKalb XL 18	111	96	+15
Pioneer 3965	110	91	+19
DeKalb XL 12	102	107	- 5
Avg.	121	115	6

[1] Conventional Tillage. Turned with moldboard plow and disked once. Seeded with Brown-Harden Super Seeder.

[2] No-Till. Planted directly into sod with Brown-Harden Super Seeder.

[3] Advantage (+ or -) of conventional over no-till.

NO-TILLAGE IN FLORIDA FROM A FARMERS VIEWPOINT

Danny Stephens

INTRODUCTION

I have been asked by Dr. Raymond Gallaher to give my views concerning minimum tillage farming. As you read this please understand that these are my views for our situation at this present time. I do not intend for you to accept statements written in this article as absolute fact of receive the impression that I am making the statements I make as absolutes nor to be taken as specific guidelines upon which to base your program. Read these thoughts of mine wisely as you would those of others. By this I mean, use what I say only to influence your thinking as you consider if this different method of farming might fit in your program. Again remember as you read, the statements I make are simply my opinions now, some of which may have changed by the time you read them.

CONSIDERATIONS

I have been attempting to use a method of minimum tillage for seven years During that time I have made many mistakes most of which were very costly. I would advise anyone considering minimum tillage to be very careful in their consideration. This is not a new wrinkle you can add to your conventional method. It is an <u>entirely different approach</u> to farming and should be delt with as such. I do not intend to influence anyone against minimum tillage, the opposite is actually true. It is my opinion that within the next decade most farming operations that survive will be centered around some form of minimum tillage multicropping system. My reasons for making this statement are many, I will list a few. One-- economically there is no doubt that a well planned, well executed minimum tillage system will produce more dollars for less dollars invested. This will be recognized in the form of less equipment needs, fewer man power hours per acre, fewer acres needed to produce needed income because of higher production per acre, less energy input, and quality land gained that would be lost from erosion.

Two - from a management standpoint I do not think that there is any comparison. Any system with the advantages possible from minimum tillage over the conventional methods must be considered by the farm managers in business in the future.

Danny Stephens, Farmer, Williston, Florida.

Three - morally I believe it to simply be closer to the right way to farm. The more you study this system the more it appears to be the way updisturbed nature maintains and reproduces itself. Also we have the moral obligation to conserve and wisely use our resources. With well planned systems of minimum tillage and multicropping we make use of and conserve all resources.

Four - when we consider soil erosion from wind or water, minimum tillage can cut soil loss to almost zero. This loss of available soil for the production of food and fiber and in the future fuel, must be stopped. We lose much more productive soil to erosion and uoban development in our country every year than we gain.

Five - I believe this system has more to offer in the Southeast than any other area of our country, though I do believe some customized form can be used anywhere. Because of climate we can produce usable plant energy year round. We can do this much more efficiently thnough minimum tillage multicropping than through our conventional methods. One day I believe we as farmers will be growing much of the fuel to run our country. No other section of our country has the climate *so* well suited to continuous production as here in the Southeast.

PLANNING AHEAD

Most of the remainder of what I have to say will be geared to how I beleive a farmer should plan to grow a crop next year using some form of minimum tillage or minimum tillage multicropping. This, I will try to do in an orderly sequence, or in the order I think things should be done beginning now and following through with the crop.

First I believe we should be very honest with ourselves in pursuing the following question. Am I prepared and do I get things done exactly when they should be done the majority of the time? If the answer to this question is yes one will succeed with minimum tillage. If the answer is no one will not succeed. Timeliness (doing the right thing at the right time) is probably the biggest single factor in farming. The timely farmer will succeed, the untimely farmer will eventually fail. Almost every failure I have ever experienced farming can be traced directly to simply not being ready to do the job when it should have been done. I believe timeliness becomes much more important in minimum tillage and multicropping than in conventional farming. One of the reasons I say this is because we must obtain our weed and grass control from some means other than mechanical cultivation if the system we are using involves litter left on the soil surface. Another reason we must be more timely in a minimum tillage system is we must plant when soil moisture conditions are nearly optimum because we will not have the seedbed we prepare with conventional tillage. Most of the failure experienced with minimum tillage will be due to poor weed and grass control and inadequate crop stand.

If a person decides to try minimum tillage in 1981 he should decide now, in the following order, what crop he will plant, which field he will plant, approximately how many acres he will plant and how he will handle equipment needs. Before making these decisions I believe a person should get acquainted with people who have knowledge and experience in this type of cropping. This could very well be the best advice you could accept. We need answers to questions concerning soil fertility, weed control, water management insect management, equipment needs, choices of crops, planting dates, and many others that will arise. These questions meed to be answered as to how they apply to minimum tillage in each individual situation. Many times the answers would be different in minimum tillage and/or multicropping than they would in conventional practices. An example of this would be in the area of weed identification and recommended control practices for minimum tillage situations. We farmers a lot of the time are not accurate enough in weed identification and we need the assistance of an expert. I would suggest that you get to know a weed specialist through your county extension office and ask him to come look at your situation a full season before you intend to plant your minimum tillage crop.

In deciding which crop to plant, I would suggest corn. In my opinion, corn is by far the easiest crop to deal with in minimum tillage conditions. Some of the reasons that I say this are: (1) We can plant corn early enough to get a jump on grasses and weeds, (2) we have a broader selection of herbicides to use in corn in minimum tillage conditions than we do in other crops at this time, (3) the quick, errect growth nature of corn gives us the ability to come underneath the plant canopy with post-direct applications of contact herbicides to solve any weed problems which might escape preemergence or postemergence herbicides (post-direct cultivation can be used in most crops but seems to be easier in corn), (4) it seems to be the opinion of people who have worked with minimum tillage for several years that corn is very well adapted to minimum tillage conditions without sacrificing yield. I would suggest that a farmer not choose soybeans as the crop for his first experience with some form of minimum tillage. Even if a farmer has had successful experience with minimum tillage corn he should approach minimum tillage beans with much caution. The reasons why I maintain these opinions are: (1) It is more difficult to obtain proper seed placement in minimum tillage conditions. Those who plant soybeans know the seed must be placed shallow and in adequate moisture. This is more difficult to obtain in minimum tillage conditions than in a well prepared conventional seedbed. If we do not achieve proper seed placement we will not get the quick and proper stand we must have to aid in grass and weed control. (2) The time of year we plant beans in the southeast is also the optimum season for most of our weeds and grasses. This, together with the fact that we are very limited in our choices of herbicides to be successfully used in minimum tillage soybeans, gives us reason to be cautious. I believe the grasses are our problem in minimum tillage beans and not the broadleaf weeds. At the present time I think the timely manager has available to him, the herbicides to successfully deal with most broadleaf weed problems. But I do not think, at the present time, we have the chemicals nor the know how to deal with these grasses an acceptable percentage of the time in most conditions.

...

After the decision of which crop to plant is made. the decision of where it is to be planted must be made. One thing to consider in making this decision is, will irrigation be used? If possible plan to irrigate. In our operations we use the center pivot systems for more than just to add supplemental water in dry conditions. We will use them to apply herbicides in the future. We presently apply fertilizer through them. Many times in minimum tillage conditions we are planting into existing live plant growth of some kind. This live growth is constantly pulling moisture from the soil causing dry planting conditions at a time when we would like to be planting. With irrigation, we have the advantage of planting when we would like to. Planting into existing plant growth and trash is different from planting into a clean, well prepared seedbed. As a person begins to use minimum tillage equipment and deal with different kinds of situations it is comforting to know we can irrigate to compensate for mistakes. If it is not possible to irrigate I would be more careful in my consideration of where to plant. I would seek the advice of people who have had several years experience in this type of cropping. I believe after a fanner gains experience in minimum tillage or no-tillage farming he has a Setter possibility of success without irrigation than the conventional because of having trash (or mulch) on the soil surface. But this advantage will. develop as a person gains experience because farming successfully under minimum tillage conditions without irrigation takes much planning and the timely application of those plans.

The second thing I would consider in the choice of a field or fields, is soil type. Some soil types lend themselves very well to minimum tillage planting operations and some do not. Heavy, dense, hard clay type soils can be a problem to plant in with the equipment available on the market at this time. If possible, I would choose a loamy, easily worked soil. If a farmer has some of both soil types or a random mixture it probably would be good for him to plant some of both. This would prevent him from making the mistake of thinking he could or could not plant in a particular soil type Without actually doing so.

The third thing I would do is make a very careful weed study of the fields I was consideriig. I think this should be done a full season previous to the actual planting of the crop. If possible get someone trained in weed identification and herbicide use to help you do this. I do not think it will be a problem for farmers to get someone who is trained in this area to help them if they start a year before actually planting the crop. Many times the farmer is not able to identify the weeds in his field and make proper selections of herbicides to be used. This is especially true under minimum tillage conditions. Much of the time we have herbicides available that will fit a particular weed in a particular field under conventional farming practices 'but under minimum tillage conditions will not perform successfully at all. Since weed control is one of the two main obstacles to be overcome in minimum tillage farming, I would again like to stress the importance of securing the help of someone who has experience in this area.

After the crop to be planted and the field or fields to be planted has been chosen, then I would test the soil and water. Every farmer, I am sure, is familiar with how to properly take samples for soil tests. But the thing that is different under minimum or no-tillage conditions is that we probably are not moving the soil vertically. The layer of soil on the surface remains on the surface. This can cause the surface soil to be quite different (fertility wise) than the soil deeper than one inch, Because of this, and because we subsoil, I like to sample the soil at three depths. We sample at one inch, two to twelve, and thirteen to eighteen inches all out of the same hole. The one inch sample will mainly tell you if you have a pH problem on the soil surface which will affect herbicide activity. The sample deeper than twelve inches will show you if you have fertility differences between the normal root zone and the subsoil. Another thing that I think is a good thing to do is to divide the samples and send them to at least two labs and preferably three different soil testing labs. This makes a comparison possible which can be valuable. I am learning more all the time as to how minor element imbalances can completely cause all other proper practices to be ineffectual. By having the different soil analysis we have a better chance of detecting these problems. The more intensively we farm the more scientific we must be to keep fcom causing ourselves problems. Also, we should have the water we plan to use (as irrigation cr in tha spray tank) checked. pH and calcium levels in water are things that can cause big problems. These may sound like small unimportant things until we have a crop that so far as we know, we have done evcrything right. For some unknown reason the crop may not do like it should and then we find out we have some small problem that all of a sudden has become big because we did not check the things we could have and made proper corrections.

As we make the decisions as to how many acres we are going to plant, again I would suggest beginning with a small number of acres and increase the acreage as our experience and confidence increases. This possibly can be done by borrowing equipment, having the work done by someone who has the equipment, or by more than one farmer sharing in the cost of the needed equipment. The. main thing is to remember you must be capable of doing the right thing at the right time.

This brings us to the final. thing I listed in which a farmer needs to make decisions on, a full season in advance of actually planting his first minimum tillage crop. When I use the term minimum tillage I am refering to some method of planting into existing crops or crop residue without previous soil preparatlon. I know that there are other ways of reducing tillage such as plant, disc and plant, chisel and plant, and others but I do not consider these true minimun tillage systems in the sense we are dealing with.. To practice minimum tillage it takes equipment especially adapted to the situations. The choice and the securing of minimum tillage equipment is the final thing I have listed that a farmer needs to do in advance of planting his crop. There is limited availability of economical equipment on the market that will do an adequate job in all condltions a high pcrcentage of the time. A farmer should probably look at all the different p1anters he can find out about and evaluate the job they actually do by looking at the crops planted with them and the field conditions under which they were planted. One of the most important things to look at js the soil type in which the planter was used. Was the soil a very easily worked soil such as sand or was it a more difficult soil to deal with such as clay. In the deep sands any of the planters will do a pretty good job unless there is a lot of litter on the soil surface. Under heavy mulch or litter conditions some of the planters do not have enough clearance to avoid dragging on the planter. This is especially true of the subsoil planters. In heavier type soils I have not seen a planter that I feel will consistantly do an acceptable job. Some will do a good job if moisture conditions are just right, but if it is a little too wet or dry you began to see a poor stand.

If the planter to be used is of the subsoil type look at the length of the subsoilers. It takes adequate clearance between the soil surface and anything on the planter that might catch trash and cause a build up of trash which will prevent smooth operations,

Look at the ability of the planter to prepare an adequate seed bed. I think that many of the manufacturers who are attempting to build and sell minimum tillage planters have the wrong attitude about seedbed preparation. We must have a smooth, well prepared seedbed even though it may not be but two to four inches wide. We cannot get by with just a slit in the ground to drop a seed in. This may work in some conditions but consistantly it will not. Also the seedbed must be firm enough behind the snbsoiler to prevent caving in. Another thing to look at are the planter parts used to prepare the seedbed. Many use spiders or other attachments that will wrap up or cake up some way with crop mulch or other things on the soil surface. As you look at the planting job by different planters take note of whether irrigation was used to compensate for a poor planting jbb. Many times in situations where a poor seedbed was formed causing improper seed placement or coverage, the problem can be overcome with an application of water.

I stated before that I believe the two things that cause failure with minimum tillage cropping, most of the time, are poor weed control and improper stand. Both of these are directly related to the job done with the planter. If the seed is well placed in an adequately prepared seedbed we obtain the stand we need and also we obtain the proper, even growth which gives us our most effective weed control. In my opinion the manufacturers of minimum tillage equipment must become conscious of the need for a narrow yet well prepared seedbed. In your search for the proper equipment for your situation look for the planter that disturbs the soil surface the least but leaves a narrow well prepared seedbed under the soil conditions on your farm.

I think to be successful with minimum tillage a farmer needs three basic pieces of equipment. These are a planter, a broadcast sprayer, and a directed sprayer. We have discussed the planter. The sprayer should be capable of delivering from 20 to 50 gallons of material per acre under adequate pressure and maintain proper agitation. The directed sprayer must be capable of placing the sprayed material properly in relation to the crop. When the crop grows as it should and the weeds are suppressed adequately this is a simple job, we just spray broadcast directed under the plant canopy. In some situations we may need to use shields. Therefore, the directed spraying unit probably should have the option of adding these shields. In my opinion every minimum tillage farmer should own or have a directed sprayer available to operate the direct sprayer properly. This can be the difference in success or failure. I believe the first step toward success in 1981 is for you to make these decisions now and not six months from now.

Lets imagine that you have decided what crop and variety to plant, you have decided where it will be planted, how many acres you will plant, and have made all necessary decisions concerning equipment. A true minimum tillage cropping situation begins with the crop grown previous to the actual crop to be grown. This, in my opinion, is one of the tremendous advantages of the system. Every crop carries over into and influences the following crop. An example of what I mean is in the area of fertility. We can afford to adequately fertilize the first crop because we know the following crop will benefit from it. In some planned rotations the following crop will not need any additional plant food other than the residual from the previous. An example of this could be soybeans following corn in the same year. I know this program can be followed under conventional tillage practices but not nearly as effeciently as with minimum tillage. You probably will want to begin your program with a winter crop of small grain. This small grain crop may be used in many different ways depending on the system you have chosen. Some of the options you have when growing this small crop are to use it for grain, silage, or just a mulch for the following crop. The idea of growing a heavy mulch may become important where irrigation is not used. As you make plans for your cover crop, have someone who trained in fertility help you work out a season-long fertility program using your soil test results. One of the things you might consider is the application of calcium after the cover crop is planted to insure proper pH on the soil surface if, of course, soil test results show a need. There are choices of cover crops depending on your program.

After the cover crop has been planted and utilized as you planned, it becomes planting time. All decisions concerning variety, population, fertility, insect control plans, and herbicide use have been made months before. One of the things you should be cautious about is how to handle the existing live plant growth at planting. One of the things I think we are in need of, that we have not had, is an economical product we can use that will completely kill everything growing at planting time. Most of the time it is desirable to have everything completely killed at the time of planting to give the crop a head start. So far we have not had a product I felt we could afford that would do this job. Paraquat has not done the job for-me. Early in the year we have not been able to kill small grains with paraquat without making two to three applications. Later at soybean planting time we have not been able to satisfactorially kill existing grasses. The thing I would caution you about is to not plant your crop and wait until just before it emerges to use paraquat and expect to consistantly get an adequate kill of existing plant growth.

You might want to spray paraquat several days previous to crop emergence and then again just before emergence. There has been some work done wjth low rates of Roundup that looks good, but the tests are limited at this time. A product like Roundup is what we need but we can not afford it at the manufacturers present recommendations and prices.

After we have planted, we should monitor for insects and weeds just as in conventional tillage methods. Mnay times the minimum tillage planted field will look very rough to the traditional eye. This look will disappear as the crop covers the soil surface and becomes tall enough to go under the plant canopy and clear up any undesirable weeds which exist with direct spraying. From this point on the management will be much like that which we traditionally use. Some things we might plan to do that we have not done before is soil test in the middle of the crop growing season and have plant tissue analyses run. As we begin to more intensively use the soil through multicropping we must be more aware of soil fertility.

REMINDER AND POSSIBILITIES

Remember, probably the most important advice in what you have read is to contact people who can advise you and help you make decisions as we learn a different method of producing food, fiber and fuel. Soon we will be seeing professional consultants in this area.

I do not think that there has ever been anything come on the scene in agriculture that offers the production possibilities and problem solving abilities that minimum tillage and multicropping does. As an example to think on, consider this - A farmer in Levy County Florida (or any other county in the Southeast), has problems with wind and water erosion, high cost of fuel and equipement, high cost and unavailibility of labor. His best solution is to produce more per acre and and farm fewer acres. He plants a crop of small grain (with or without legumes) to graze. He grazes that crop 60-90 days then plants irrigated corn. He harvests the corn crop as silage or high moisture grain. He then plants a second crop of corn for silage (using tropical corn varieties), or plants grain sorghum or soybeans. He harvests this third crop and plants small grain to graze again. He has done this with almost zero erosion from wind or water and a minimum of input for what he has produced. This is just one possible program. There are many other combinations such as this one which are being successfully applied by a few farmers.

CONCLUSION

I believe farming has a bright future, but we need to produce more per farmed acre to minimize cost to the farmer and also provide our people with high quality food at the lowest possible price. Our people must eat and I for one want to see us eat as inexpensively as possible. Do not say it can not be done, the first step toward accomplishment is to believe it can be done, There will always be farmers, that is not the question. The question is, who will be the farmers? I believe the majority of those who continue to farm will be applying some form of the type program we have been discussing.

Remember as I stated at the beginning of this article, "these are my views and feelings". Some of them may have changed or may not apply to you but I thank you for taking your time to read them.

I would like to make public written record of appreciation for service to agriculture to John Bladwin (Levy County Agent), Dr. David Teem, and Dr. Raymond Gallaher.

To you the reader, consider this - what greater use of a life can there be than *to* work with the soil of the earth and see it produce.

POSTEMERGENCE DIRECTED SPRAY EQUIPMENT AND CALIBRATTON

DAVID B. TEEM

Introduction

Sandy soils with low organic matter content combined with intense pressure from difficult to control weeds are major problems found by producers in Florida and much of the southern United States. These soils often eliminate the use of certain herbicides or the herbicides must be used at low rates. In addition, frequent rains which move rapidly through these soils often leach the herbicides. Intense weed pressure, low herbicides rates, and leaching are a few of the factors which result in poor weed control or at best, short-term weed control. Effective weed control for the first four to six weeks if often sufficient for many crops to produce good yields but producing a good yield is beneficial only if the crop can be harvested. Weeds which emerge four to six weeks after the crop and are not controlled can result in tremendous harvesting problems. In conventionally planted crops many of these weeds can be controlled by cultivation; however, adverse weather conditions which delay cultivation may result in weeds in the row becoming too large to kill with cultivation. In no-till plantings, cultivation is not an option for controlling these late emerging weeds. Many weeds can be effectively controlled by spraying over the top of the crop; however, in certain situations there are no herbicides which can be sprayed over the crop without serious crop injury. In these situations, a postemergence directed spray is the best answer for control of these weeds in either conventional or no-till plantings.

Time of Application

The objective of a directed spray is to spray the weeds with minimum contact of the herbicide on the crop leaves. Directed sprays will be effective only if there is a height differential between the crop and weed. For most of the herbicides to be safely used, the crop should be at least 12 inches tall and the weeds less than 4 inches tall (Figure 1). If the crop is smaller or the weed larger than this, increased crop injury will generally result. If the crop is taller than 12 inches and the weeds are less than 4 inches then a greater height differential exists and less crop injury will result. In this situation, it is generally advisable to delay the application and allow as many weeds as possible to emerge before the largest weed reaches 4 inches.

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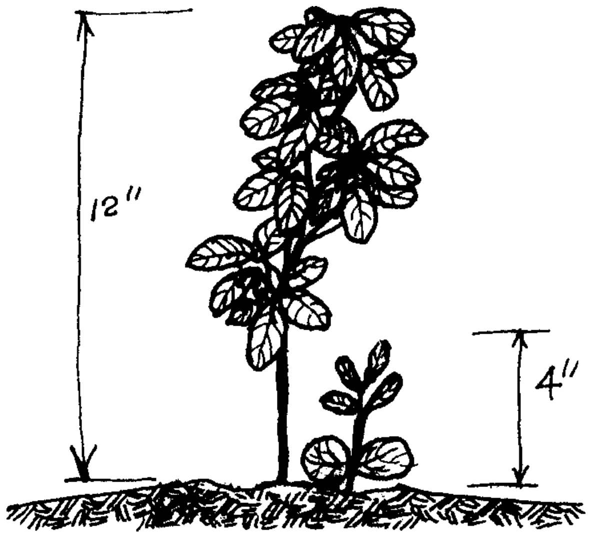

Figure 1. Minimum crop height and maximum weed height for effective control without crop injury when applying post-directed sprays.

Equipment Needed

Several types of directed spray applicators are commercially available. The equipment is not complicated and many producers have constructed their own applicators.

The basic requirement of the equipment is to allow setting the height and orientation of the spray nozzle in a constant position in relation to the soil and crop. This can be accomplished by mounting the nozzles on equipment such as slides, guage wheels, or cultivators (Figure 2). Once the nozzles have been adjusted to spray the lower 4 inches of the crop, they will remain in that position even in rough fields. Nozzle height and orientation must be set for the crop and weed situation in each field to be sprayed. Boom sprayers with drop nozzles are not well suited for this type application since the height of the nozzle is not constant in rough fields. Each time the boom bounces, the nozzle sprays higher than 4 inches on the crop and injury results. Applicators are also available with shields which protect the c.rop from the spray. This type equipment may be useful in certain situations, but will generally result in uncontrolled weeds in the row.

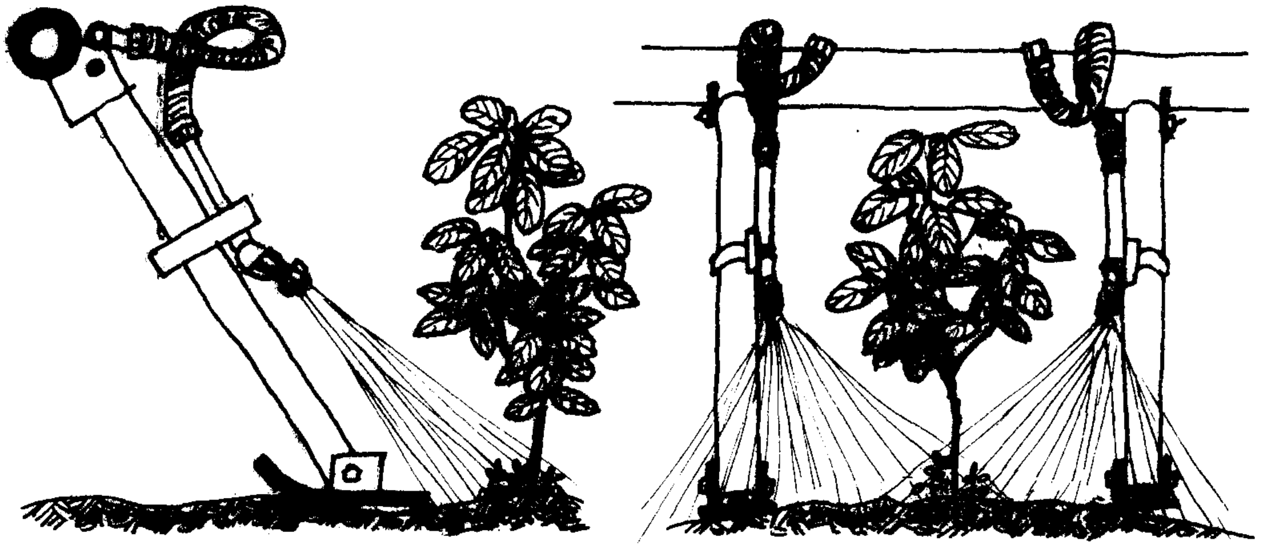

Figure 2. Side and rear view of 2-nozzle per row arrangement mounted on slides.

Nozzles, Pressure, and Spray Volume

Most of the herbicides used for directed sprays require good spray coverage of the weed for effective control. Proper choice of nozzles, pressure, and gallonage can be critical for effective control with minimum crop injury.

Nozzles

Flat fan nozzles are well suited for directed sprays. These nozzles can be operated at low pressure and the spray pattern overlapped in the drill (Figure 2). The overlap should be about 6 inches for uniform distribution. A typical flat fan nozzle tip is a Tee Jet 8004. This type tip is available for different gallonage or different spray angles. For example, if higher gallonage is desired an 8005 or 8006 may be used. If lower gallonage is desired, an 8003 or 8002 may be used. If a wider spray angle is needed, 95 and 110 degree spray angles are available. For example a 9504 will apply the same gallonage as an 8004 but with a wider angle (95° versus 80°). This can be helpful since the wider spray angle allows spraying the same area with the nozzle at a lower height.

Floodjet (TK series) nozzles provide wide spray angles at low pressure; however, in dense weed situations the large droplets produced may not provide sufficient coverage.

Off-center (OC series) tips are also available. This type sprays only from one side of the tip and no coverage will be achieved in the middles unless multiple nozzles per row are used. If cultivation is to be used for the middles then two off-center tips per row can be effectively used.

Cone (D and TX series) tips are not well suited for directed sprays. These tips are designed for high pressure and produce fine spray particles. These fine particles will drift onto the crop leaves and result in injury. In addition the cone shape of the pattern is not well suited for spraying low on the crop.

Pressure

The lowest possible pressure which will provide sufficient spray coverage of the weeds should be used. Pressures in the range of 15 to 25 psi are desirable. If sufficient coverage is not achieved at these pressures, choose a tip with a larger orifice. This will increase gallonage without increasing pressure. High pressure creates small particles which drift and should be avoided.

Spray Volume

The gallons per acre needed will vary depending on the density and size of the weeds. In most situations 20 to 30 gallons per acre is adequate.

Speed

Directed sprays can be applied at any speed which can safely be used to operate the equipment without crop injury. Choose the speed which can be safely used for the size of the crop and select nozzle tips which will deliver the desired gallonage at that speed.

Sprayer Calibration

Proper calibration is critical since herbicide rates which are too high may result in crop injury and will increase costs. Rates which are too low may result in poor weed control. Any method of calibration which is accurate can be used for directed sprays. One of the easiest to use methods which is accurate is outlined in the following steps:

Step 1. Measure the swath width sprayed by one nozzle in inches (Figure 3). This width will vary with nozzle height and orientation therefore measurements should be made after these adjustments are made in the field to be sprayed.

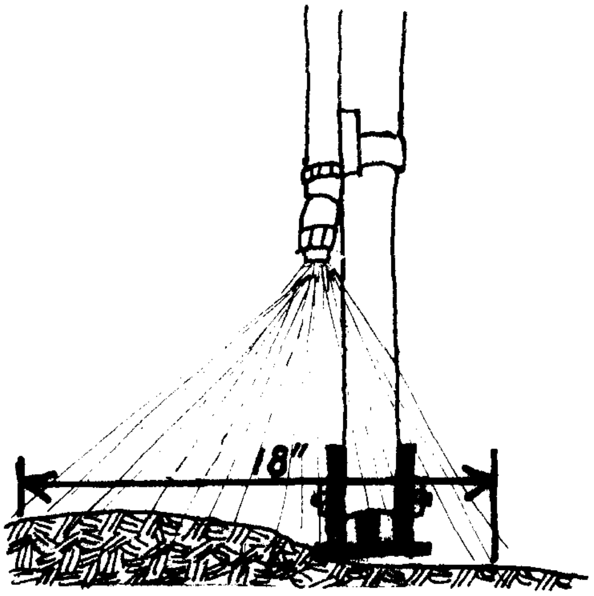

Figure 3. Measure the swath width sprayed by one nozzle to determine the course length required to equal 1/128 acre.

Step 2. Determine the course length required for the measured swath width to equal 1/128th acre.

Swath width of one nozzle (inches)	Course length to equal acre (feet)
10	408
12	340
14	292
16	255
18	226
20	204

Step 3. Measure and mark this course length in the field.

Step 4. Choose the gear and RPM to be used, drive the measured course and record the time required to travel that distance. The tractor should be moving prior to crossing the start of the course and the time begun when the tractor crosses the marker.

Step 5. Start the sprayer and adjust the regulator to the desired pressure.

Step 6. Check the uniformity of the nozzles. This is a critical step in the calibration of any sprayer with any calibration method. Catch the flow from a nozzle in a baby bottle or graduated cylinder for 10 seconds and record the amount. Repeat this procedure for 10 seconds at each nozzle. Compare the amount caught from each nozzle for uniformity. If the flow from a nozzle is 15% higher or lower than the other nozzles, replace it.

Step 7. Catch the flow in ounces from one nozzle for the length of time required to drive the measured course (from step 4). The ounces caught in this length of time is equal to the gallons per acre being applied by the sprayer. If 4 nozzles per row (2 nozzles per slide) are used and the front and rear nozzles on one slide are spraying the same swath, then collect the flow from both nozzles.

Step 8. Determine the acres sprayed per tank.

$$\frac{\text{Gallons per tank}}{\text{Gallons per acre}} = \text{acres per tank}$$

Step 9. Determine the amount of herbicide needed per tank. Acres per tank X herbicide rate per acre = herbicide per tank.

Example:

Step 1. Swath width measured - 18 inches.
Step 2. Course length from chart = 226 ft.
Step 3. Measure and mark 226 foot course.
Step 4. Time to drive 226 ft. in 5th gear at 1400 rpm = 34 seconds.
Step 5. Sprayer adjusted to 20 psi.
Step 6. Nozzles checked and uniform.
Step 7. Catch flow from one nozzle for 34 seconds. Amount collected = 20 ounces. Sprayer is applying 20 gallons per acre.
Step a. Sprayer tank capacity is 200 gallons.

$$\frac{\text{200 gal per tank}}{\text{20 gal per acre}} = \text{10 acres sprayed per tank}$$

Step 9. Recommended herbicide rate = 1 quart per acre. Ten, acres per tank X 1 quart per acre = 10 quarts per tank.

Summary

A directed spray applicator is similar to an insurance policy. Purchase it and hope you never need to use it. Unfortunately herbicides applied preplant or preemergence seldom provide full season control and directed sprays are needed. Directed spray equipment is available and is not difficult to use. Herbicides are available and are effective. The major need is to have a sufficient height differential between the crop and the weed.

SOIL AND WATER CONSERVATION THROUGH DOUBLE CROPPING

F. D. TOMPKINS, C. H. SHELTON, AND C. R. GRAVES

INTRODUCTION

Excessive soil loss from row-cropped land due to water erosion continues to be a prominent problem in West Tennessee. Proven erosion control practices are often rejected by farmers on the basis of implementation and maintenance costs and incompatibility with machinery operation and existing field arrangement. The wind-deposited soils typifying the area are highly susceptible to erosion when vegetative cover is not present. Farmers have historically favored clean cultivation to insure establishment of adequate plant stands and assure effective weed control. Demand for soybeans has resulted in increased use of marginal land having steep slopes for row crop production using conventional tillage practices. As a result, soil loss frequently exceeds tolerable limits; and water quality in receiving streams is impaired by sediment and accompanying pollutants.

One of the most effective methods of controlling water erosion is to maintain either growing vegetation or plant residue on the soil surface. Vegetation tends to absorb the energy of falling raindrops, reduce the velocity of surface runoff, and increase infiltration capacity through improved soil structure. No-tillage cultural practices provide a scheme for engaging in row crop production while simultaneously maintaining a protective cover of vegetative material on the soil surface. Improvements in planting equipment and advances in herbicide and applicator technology are expected to allow more producers to realize the documented advantages of no-tillage cropping without excessive risk of poor stands and inadequate weed control. Currently about 100,000 acres of soybeans are no-till seeded annually in Tennessee; most of these plantings are in wheat stubble as part of a double crop program.

SOIL AND WATER CONSERVATION STUDIES

Research involving double cropping of soybeans and wheat was initiated at the Milan Experiment Station in West Tennessee in 1963. Several area farmers were already employing the practice on a regular basis. To evaluate the conservation implications of several cropping and management practices, two watersheds were instrumented to monitor rainfall and runoff. Field 8 contained 9.3 acres with an average slope of two percent. Predominant soils were Calloway and Henry silt loams. Field 9 initially consisted of 36 acres with about two percent average slope. In September 1975, the field was graded to an average slope of about 1.2 percent and diversions were installed, reducing the watershed area to 28 acres. Collins and Loring silt loams were the predominant soil types.

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Seasonal distribution of rainfall and runoff rates and volumes on Field 8 is shown in Figure 1. For the 12-year period of record, the maximum rainfall intensity and peak rate of runoff occurred during the period containing the months of April through June. These events thus occurred when soil under conventional cultivation was most vulnerable to soil loss as particles loosened during seedbed preparation were readily available for transport in runoff water. The volume of runoff, in percentage of annual average, was also greatest during this three-month period. While about half of the annual rainfall occurred during the first six months of the year, 61.4 percent of the total runoff occurred in these months. Average annual surface runoff from the watershed over the period of record was 32 percent of the rainfall volume.

Table 1 shows rainfall, runoff, and sediment yield from Fields 8 and 9 €or selected storms. Crops were soybeans, either produced with conventional cultivation or no-till planted in wheat stubble in a double crop program. The selected storms occurred at times when greatest soil loss differences between the two systems would be expected. Sediment yield, as used here, refers to suspended sediment measured at the outlets of grassed waterways which carried surface runoff from the two fields. Some of the soil eroded by raindrops and surface runoff would have been redeposited at points lower in the fields and would not have reached the monitoring station during a given storm. Consequently, actual soil erosion on the field would have been greater than that indicated by sediment yield.

Field 8 was conventionally tilled in 1974 and double cropped in 1975, To illustrate the advantage of vegetative cover, compare the storms occurring June 10, 1974 and April 30, 1975. Note that, for similar antecedent conditions, highest sediment yields usually correspond to highest rates and volumes of rainfall and runoff. The rainfall intensity of the 1975 storm was almost three times that of the 1974 event, and total rainfall volume was over five times as great. Yet the 1974 storm, occurring when the field was cleanly cultivated, produced three times as much sediment as the 1975 storm. Total rainfall between the storm of April 30, 1975 and that of December 15, 1975 was 30.1 inches. However, there was only 1.0 inch of runoff and sediment yields were quite low. This was attributed primarily to the presence of vegetation and stubble residue associated with the double cropping system.

Field 8 was disked on May 5, 1976 to prepare a conventional seedbed. The first storm thereafter occurred on May 13. The 2.82-inch storm (1.20 inches per hour maximum intensity) resulted in a sediment yield averaging 181 pounds per acre. A 2.53-inch rain fell on the cleanly cultivated field on June 2, 1976; and resulting runoff was 1.58 inches. Not only was sediment yield high at 141 pounds per acre, but infiltration was less than *38* percent.

The advantage of no-till practices for erosion control is vividly illustrated by the three storm events shown for Field 9 for 1976. Total rainfall and runoff during the March 5 storm were not very great (1.25 and 0.32 inches, respectively). However, the high rainfall intensity (4.68 inches per hour), coupled with the sparse vegetative cover provided by the wheat at that time, resulthd in a sediment yield of 137 pounds per acre. On April 24, when the rainfall rate and quantity were less and the wheat growth was considerably greater, the sediment yield was only 7 pounds per acre. When the storm of

July 14 occurred, the wheat had been harvested and soybeans had been planted in the stubble. Due to the excellent ground cover on undisturbed soil, the runoff of 0.02 inches was only one percent of the rainfall and sediment yield was only 3 pounds per acre.

Field 9 contained a mixture of conventionally tilled and no-till soybeans in 1977 and 1978. Table 1 shows that more soil was lost in 1978 when a higher percentage of the area was conventionally tilled. Observation of runoff water entering the grassed waterway during the spring and summer months indicated that virtually all of the soil erosion which occurred was on the conventionally tilled areas.

PERFORMANCE OF DOUBLE CROP SOYBEANS

A total of 310 acres of double crop soybeans were grown in production fields at Milan between 1971 and 1979 as indicated in Table 2. Production practices changed from year to year as improved varieties, herbicides, and field machines were developed and became available. The most promising practices indicated by replicated experiments conducted simultaneously were applied in the production fields. Mean per-acre yield was 32 bushels over the nine-year period. Yields of single crop soybeans in similar production fields averaged 36 bushels per acre. Thus, yields of no-till double crop soybeans averaged 11 percent below yields of single crop beans grown with conventional tillage.

Several researchers have noted that row spacing in stubble planted soybeans was more important than in conventional plantings. Thus, five soybean varieties were evaluated from 1974 through 1976 in rows spaced 40 and 20 inches apart planted no-till in wheat stubble. Table 3 shows that a positive yield response to the closer row spacing was obtained each year. The average response of the five varieties to the closer row spacing was about 5 bushels per acre yield increase. There was no significant variety/row spacing interaction in any year.

Performance of four soybean varieties was evaluated from 1977 through 1979 in rows spaced 10 and 20 inches apart. Plantings were no-tillage immediately following wheat harvest. Soybeans in the 10-inch rows yielded an average of three bushels per acre more than plantings in 20-inch rows as shown in Table 4. However, the yield response was significant in only one year, 1977. The overall low yields observed in 1977 were attributed to severe drought conditions. The higher production field yields in 1977, shown in Table 2, resulted from plantings made after the severe drought conditions had ended. As in the previous row spacing study, there was no variety/row spacing interaction in any of the three years.

Plantings in narrow rows may help reduce soil erosion as well as increase yield. The plant canopy will tend to absorb most of the raindrop impact energy, and the additional plant material will physically restrain the soil

Date of planting studies have indicated that planting after June 1 results in reduced soybean yields. As indicated in Table 1, production fields planted in stubble were never seeded before mid-June. Consideration is being given to seeding soybeans in green wheat to overcome the penalty of late seeding inherent with stubble planting systems. Performance of soybeans grown in five cropping systems, including seeding in green wheat, was compared at Milan from 1977 to 1979. The cultural practices are described and average annual yields are given in Table 5. Recall that drought conditions existed at the time of planting in 1977 and continued for several days. Seeding in green wheat did not result in increased yields over stubble planting. Soil moisture content at planting was observed to be critical for beans seeded aerially if adequate stands were to be established. Only fields relatively free of weeds lend themselves to seeding in the growing wheat.

SUMMARY

No-till planting in stubble is an effective practice for reducing soil loss by water erosion. For a 12-year period of record, maximum rainfall intensity apd peak rate of runoff occurred during the months of April through June. These months include the period of concentrated seedbed preparation and planting under a conventional tillage system; and losses of unprotected, freshly tilled soil may be large.

Yields of double crop soybeans stubble planted in wheat averaged 11 percent below those of single crop soybeans in conventional seedbeds. Average yields of double crop beans were increased by five bushels per acre when row spacing was reduced from *40* to 20 inches. Seeding in green wheat did not produce a yield advantage over planting in stubble following wheat harvest.

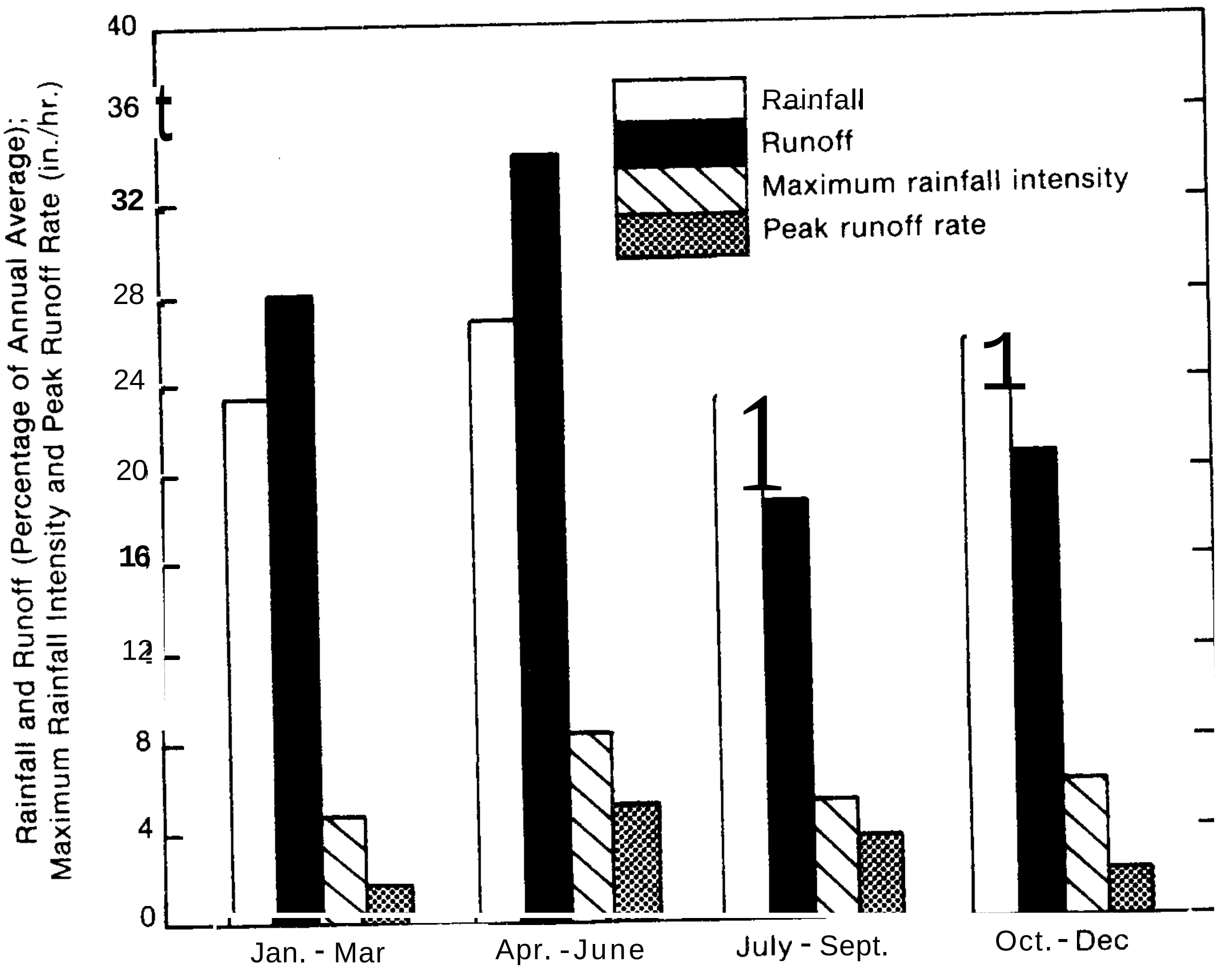

Figure 1. Seasonal distribution of rainfall and runoff on Field 8 at Milan, Tennessee, 1966-1977.

Table 1. Rainfall, runoff, and sediment yield during selected events and associated with conventional tillage (CT) and no-till (NT) soybean production on two fields at Milan Experiment Station

Field	Date	Tillage	Crop	Rainfall Max. Rate (in./hr)	Rainfall Total (in.)	Runoff Peak Rate (in./hr)	Runoff Total (in.)	Sediment Yield (lb/ac)
	5/15/74		Soybeans,	1.44	0.60	0.29	0.31	6
8	6/10/74	CT	No Winter	0.72	0.27	0.12	0.23	10
	7/4/74		Cover	3.57	0.97	0.25	0.31	33
	3/22/75		Double	2.64	0.83	0.45	0.67	10
8	4/30/75	NT	Crop, Soy-	2.00	1.43	0.34	0.69	3
	12/15/75		beans and	0.80	1.48	0.05	0.07	0.4
			Wheat					
	3/5/76		Double	4.68	1.25	0.32	0.32	137
9	4/24/76	NT	Crop, Soy-	2.40	0.90	0.12	0.11	7
	7/14/76		beans and	1.60	1.60	0.02	0.02	3
			Wheat					
	7/11/77	90% NT	Soybeans	4.27	0.70	0.12	0.13	2
9	8/14/77		and Wheat	0.90	0.80	0.02	0.07	2
	9/24/77	10% CT	Soybeans	2.07	1.73	0.06	0.27	10
	1/9/78	90% CT	Soybeans	2.28	4.14	0.47	1.74	71
9	5/8/78			2.28	1.15	0.29	0.50	86
	6/21/78	10% NT	Soybeans and wheat	4.30	0.80	0.41	0.30	101

Table 2. Performance of soybeans planted no-till in wheat stubble at Milan Experiment Station from 1971 to 1979

Year	Planting Date	No. of Acres	Mean Yield, Bu/A
1971	6/15-18	11	36
1972	6/14-17	28	24
1973	6/19	5	41
1974	6/20	28	28
1975	6/18-23	47	30
1976	6/14-22	82	27
1977	7/5	32	24
1978	6/26	18	34
1979	6/14-16	59	42

Table 3. Mean yields of five soybean varieties planted no-till with row spacings of 20 and 40 inches in wheat stubble at Milan Experiment Station

Row Spacing, inches	Mean Yield, Bushels per Acre			
	1974	1975	1976	Avg.
40	35	18	17	23
20	38	26	21	28

Table 4. Mean yields of four soybean varieties planted no-till with row spacings of 10 and 20 inches in wheat stubble at Milan Experiment Station

Row Spacing, inches	Mean Yield, Bushels per Acre			
	1977	1978	1979	
20	8	29	31	23
10	14	30	34	26

Table 5. Performance of soybeans grown in five cropping systems at Milan Experiment Station from 1977 to 1979

Cultural Practice	Mean Yield (Bu/A)			
	1977	1978	1979	Avg.
1. Single crop, conventional seedbed	56	39	44	46
2. No-till in wheat stubble	7	34	44	28
3. Conventional seedbed after wheat harvest	4	37	41	27
4. Drilled in green wheat before heading	6	28	46	26
5. Simulated aerial seeding in green wheat	0	14	36	17

SOIL FERTILITY AND ITS RELATIONSHIP TO CROP PRODUCTION COST IN NO-TILLAGE SYSTEMS

J.T. Touchton

The rapidly increasing cost of crop production is forcing an interest in practices that reduce or eliminate specific cost variables normally associated with crop production. Some practices which have been shown to be beneficial in reducing production cost are reduced tillage, double cropping, and crop rotations. Reduced tillage operations decrease operating costs such as fuel and labor, however, added cost of special herbicides may offset this advantage if an effective weed control management system is not utilized. Double cropping systems help decrease fixed costs by spreading cost associated with taxes, land rent, and equipment over exceptionally long growing seasons rather than over a few months during the spring and summer. Double cropping winter legumes with summer annuals such as corn and sorghum may substantially reduce the amount of nitrogen (N) required for summer crop production. Crop rotations are effective in eliminating special weed problems and can be a big advantage in fertilizer utilization, especially if leguminous/non-leguminous systems are used.

Other methods used to cut production cost include reductions in fertilizer usage, plant populations, and herbicide usage. Excessive reduction in any of these and similar essential items may reduce crop yield below an economical level and actually increase rather than decrease production cost.

The purpose of this paper is to report results from some of the fertility/tillage research studies conducted in central and north Georgia during the past three years and relate these management practices to production costs. The reader should be aware that the prices quoted may vary among seasons and locations. Cost figures were valid at the time and location at which the research was conducted, but may not be valid for other locations or future purchases. Most of the studies cited in this paper have not been completed and rates of fertilizer or herbicides used should not be interpreted as a recommendation.

Value of maintaining optimum phosphorus levels for double-cropped, no-tillage wheat and soybeans

Wheat and no-tillage soybeans have been double-cropped on a Ceci1 soil with various P levels for the past two years. Treatments were a one time application of P_2O_5 applied in the fall of 1977. Applied P, cost of P, soil P levels, soybean and wheat yields are listed in Table 1. There is no doubt that the \$15/acre cost of applying 130 lbs/acre of P_2O_5 in the fa1l of 1977 was a sound economical investment. This application increased net returns over the two year period by approximately \$95/acre for wheat and \$90/acre for soybean. There was, however, a more economical return than illustrated by yield alone, especially with no-tillage soybean production. In both

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years, soybeans grown on the low P soil failed to develop a closed canopy which resulted in extreme but unnecessary weed pressure. To effectively control weeds in the low P plots, soybeans had to be post directed twice in both years with contact herbicides which added $12/acre/year to the production cost of the lower yielding soybeans.

Table 1. Applied P_2O_5, cost of applied P, soil P levels, and yield of double cropped no-tillage soybean and wheat.

Applied P_2O_5	cost/ acre	Soil P level		Yields			
				Wheat		Soybean	
		1978	1979	1978	1979	1978	1979
lbs/acre	$	-lbs/acre-		---------bu/acre----------			
0	0	10	9	32	20	34	36
130	15	20	19	46	35	40	43
260	30	56	32	40	39	45	45
520	60	96	100	35	38	46	46
780	90	200	168	29	38	46	47

Applying large applications of P every three of four years instead of recommended annual rates will reduce total application cost but may be detrimental to wheat yields. Early season wheat growth and winter survival increased as applied P increased in both years, but in 1978 wheat grain yield decreased when applied P_2O_5 rates were greater than 260 lbs/acre (Table 1). The 1977/1978 growing season was favorable for glume blotch infections; the infection along with lodging was related to excessive P, applications (Table 2). In order to avoid possible problems associated with excessive P, fertilizer application rates should always be based on soil test recommendations.

Table 2. Lodging and glume blotch infection of wheat in 1978 as affected by applied P_2O_5.

Applied P_2O_5	Lodging		Glume blotch infection
	6 April	4 June	
lbs/acre	%		
0	0	0	29
130	30	35	47
260	40	64	70
520	53	77	73
780	65	95	84

Data in Table 2 was collected by B.M. Cunfer, Dept. of Plant Pathology, Georgia Station, Experiment, GA.

Time and method of P fertilization for double-cropped wheat and soybeans

Phosphorus mobility in soils is restricted and losses through leaching are generally not encountered. The restricted mobility and non-leaching characteristics of the phosphate ions will permit advanced applications of P fertilizers. In double-cropping systems, once a year applicatons instead of fertilization for each crop can cut production cost. However, as previously pointed out, over-fertilization with P can decrease wheat yield and, in addition, P fertilizers can be converted to a form that is not readily available for plant uptake which may be a disadvantage to applying P several months in advance of planting, especially on low P soils. In continuous no-tillage systems, P fertilizers may accumulate at or near the soil surface and could possibly result in P deficient subsurface soils.

A major study was established in the Georgia Piedmont on a Cecil sandy loam soil in the fall of 1977 to investigate the effects of time and methods of P application on wheat and soybean yields. Treatments consisted of times of application (fall only, spring only, and fall plus spring); methods of application (incorporated and unincorporated); and P_2O_5 rates (0, 65, 130, and 260 lbs/acre/year). Method of application is also a form of tillage and no-tillage, since phosphorus was incorporated by turning and disking immediately after application.

In 1978, there was a response to applied P (Table 3) but no differences in methods of application. Maximum yield was obtained with the 65 lb/acre/year P_2O_5 application which cost approximately $7.50/acre. This $7.50/acre/year investment resulted in an increased gross return of $3l/acre for wheat and $90/acre for soybeans. With adequate P_2O_5 applications (65 lbs/acre/year), preemergence residual herbicides applied prior to planting soybeans were effective in supressing weed growth. Postemergence herbicide applications in the unincorporated, no-tillage plots and cultivation in the incorporated, conventional tillage plots were not required. The no-tillage system at the optimum P level resulted in an approximate $10/acre savings in total production cost over the conventional tillage system; however, in the conventional ti1lage system, a more economical preemergence herbicide program could probably have been utilized which would have helped equalize the production cost between the tillage systems. The biggest advantage for no-tillage would have been in time saved during land preparation. When soybeans were grown at the low fertility level (no applied P_2O_5), cost of the postemergence herbicides required for effective weed control was much greater than cultivation cost for the conventional tillage system.

In 1979, wheat yield for the conventional tillage, incorporated P treatments averaged 10 bu/acre higher than yield from the no-tillage system. The yield difference could not be equalized with the cheaper no-tillage production system. Lower wheat yield with the no-tillage system was a result of a poorer stand than with the conventional tillage system.

Soybean yield was lower in 1979 than 1978 but the response to applied P was similar in both years. The conventional tilled beans averaged 35 bu/acre and the no-tillage beans averaged 40 bu/acre. The soybean yield increase with no-tillage equalized the loss obtained with no-tillage wheat, but the most economfcal practice was with the conventional tilled wheat and no-tilled soybeans.

Table 3. Yield of wheat and soybeans in 1978 as affected by applied phosphorus

Applied P_2O_5	Yield Wheat	Yield Soybean
lbs/acre/year	bu/acre	
0	39[1/]	34
65	48	46
130	46	47
260	46	45

[1/]Yields are averaged over two methods of application and three times of application.

Nitrogen fertilizer for grain sorghum when no-tilled into crimson clover

When winter crops are planted for the sole purpose of providing a no-tillage mulch, a winter legume may be an economical choice for the winter cover crop. Legumes will generally provide an adequate mulch so that the advantages of no-tillage can be realized and in addition, they may also provide an adequate quantity of N for the summer crop. The cost of seeding these legumes cost $20 to $25/acre, which is approximately equal to the price of 100 pounds of N. In the Southern Piedmont of Georgia, crimson clover will mature in mid-to-late May which is an ideal time for planting grain sorghum. Allowing these legumes to mature each year will eliminate the cost of reseeding each fall, thereby providing an exceptionally low cost N source and no-till mulch.

A major study was established in the Southern Piedmont of Georgia in 1977 to evaluate crimson clover as a partial or complete source of N for grain sorghum production. The grain sorghum was no-tilled into self-seeded, mature crimson clover. Nitrogen was applied to the grain sorghum at rates of 0, 13, 27, 40, 80, and 120 lbs/acre. There was no response to applied N, therefore only 3 rates are shown in Table 4. The nitrogen plots were split into two application periods (at planting and 30 days after planting), but time of application did not influence yield. The N produced by the clover reduced production cost of grain sorghum approximately $20/acre/year. It is noteworthy that the 2-year average grain sorghum yield was 100 bu/A where the sole source of N was the legume. Since the clover reseeded itself each year, there was no cost for clover establishment except for the initial seeding.

Additional treatments included removing the clover tissue at maturity for hay and no-tilling sorghum into the clover stubble. This did not effect re-establishment of clover the following fall or influence grain sorghum yield relative to applied N. However, an additional consideration relates to replacing P and K removed in the clover which can be an added cost factor. Phosphorus and K removed in the clover tissue averaged 14 and 138 lbs/acre, respectively. Replacement cost would be approximately $8/acre for P and $21/acre for K. The value and need for the clover hay may easily overcome this additional cost.

Table 4. Yield of grain sorghum no-tilled into mature crimson clover as affected by applied nitrogen

Applied nitrogen	Year 1978	1979
lbs/acre	bu/acre	
0	94	106
40	90	112
120	96	110

Choice of double cropping systems may help decrease fertilizer cost

In many no-tillage systems, continuous grain crops are grown on the soil throughout the year. Stubble and unused materials from each crop remains on the soil surface as a no-tillage mulch for the following crop. Two compatable cropping systems are wheat double cropped with soybeans and wheat double cropped with grain sorghum. When wheat follows soybeans, N application to wheat can be reduced resulting in a substantial savings in N fertilizer cost. Yield from a N fertilizer wheat study following no-tillage grain sorghum and no-tillage soybeans are listed in Table 5. Nitrogen fertilizer required for maximum wheat yield was 60 lbs/acre when planted behind soybeans and 100 lbs/acre when planted behind grain sorghum. Considering possible weed, disease, insect, and nematode problems, a good management system would not include continuous double cropped wheat and soybeans for several years on the same soil. However, when wheat follows soybeans in the overall cropping system, the cost saving advantage with reduced N fertilizer should be utilized.

Table 5. Effect of fall and winter N applications on yield of wheat following soybeans or grain sorghum.

February applied N	Summer crop and N applied at planting (lbs/acre) Soybeans 0	Soybeans 20	Soybeans 40	Sorghum 0	Sorghum 20	Sorghum 40
lbs/acre	wheat yield, bu/acre					
0	31	40	41	4	12	24
20	47	45	58	14	28	29
40	48	46	52	21	39	39
60	50	54	55	34	45	51
80	51	48	51	50	52	55

Source and method of nitrogen fertilization for no-tillage corn

Many agricultural specialists have suggested that no-tillage corn requires more N than conventional tillage corn. These suggestions are partially erroneous. The amount of N required for a specific variety to produce top yields is the same regardless of production practice. If more N is lost from the soil or is immobilized in one system than another, then more N fertilizer may be required in the higher loss system to supply the plant with sufficient quantities of N to produce maximum yield.

Unfortunately, some of the cheaper N fertilizers are more susceptible to losses through ammonia volatilization than the more expensive ones. These losses are often accelerated with surface applications in no-tillage systems. An example of nitrogen sources that are susceptible to N losses through ammonia volatilization is urea and urea containing compounds such as 28, 30, and 32% N solutions. Climatic and soil conditions that determine the potential for ammonia volatilization are numerous and whether or not losses will occur in any particular system are difficult to predict.

Surface applications of N solutions in no-tillage systems, which is a common practice, can be risky. In some years N losses will be insignificant, but in others, losses may be severe due to factors such as inadequate moisture, high soil pH and/or high temperatures. In no-tillage systems it may be best to use ammonium nitrate which is not very susceptible to N losses through ammonia volatilization. However, if the price difference between ammonium nitrate (19% liquid or 34% solid) and the various urea-ammonium nitrate solutions is substantial, it may be more economical to use the solutions. Even under maximum loss conditions, from solutions seldom reach 25% of the amount applied. It may be more economical to apply a high rate of the N solution if the price of solid ammonium nitrate is 15% or greater than solution costs (based on cost per pound of actual N).

A comparison between solid ammonium nitrate and 32% N solutions in no-tillage corn production indicated there was no difference between the two sources in 1978 but a difference in favor of NH_4NO_3 in 1979 (Table 6.) Due to the many factors that may influence losses of urea-N from the soil, it is difficult to predict in advance when it would be safe to surface apply urea-N compounds to the surface of no-tilled soils.

Table 6. No-tilled corn yield as affected by nitrogen sources

Applied nitrogen	Year and nitrogen source 1978 Ammonium nitrate[1/]	Nitrogen solution[2/]	1979 Ammonium nitrate	Nitrogen solution
lbs/acre	grain yield, bu/acre			
80	137	133	132	110
160	144	149	155	147
240	165	161	172	157

[1/] 34% solid amnonium nitrate

[2/] 32% urea - ammonium nitrate solution

Starter fertilizer for early planted no-tillage grain sorghum

When soils are cool, sorghum is a slow growing plant. This slow growth will increase susceptibility to insect and disease damage, and in season when preemergence herbicide activity is poor, weeds may grow as fast as the sorghum plant. This equal weed growth may prevent satisfactory application of post directed herbicides.

In ratooning systems, the initial seeding must be planted in relatively cool soils during late winter or early spring so that the second crop will mature before a killing frost occurs in late fall. In 1977 and 1978, early no-till planted sorghum on some of the University of Georgia's experimental stations grew much slower than did early planted conventional-tilled sorghum. In 1979, a study was designed to investigate the possible use of starter fertilizers to increase growth rate of early planted no-tillage sorghum. Results of test conducted at Plains and Griffin, Georgia (Table 7) indicate that there may be an economical advantage in using these fertilizers. Growth rates during the first two months after planting were almost twice as great when starter fertilizer was applied than when it was not applied. In addition, plants receiving starter fertilizer matured 7 to 14 days earlier than those not receiving starter fertilizer. When averaged over N rates the use of starter fertilizer increased net returns $14/acre at Plains and $25/acre at Griffin.

Table 7. Yield of early planted sorghum as affected by N and starter fertilizers at Plains and Griffin, GA, 1979

Sidedress[2/] N	Location and starter fertilizer,[1/] lbs/acre			
	Plains		Griffin	
	0	80	0	80
lbs/acre	sorghum yield, bu/acre			
0	22	32	39	54
40	31	41	64	79
80	39	45	70	88
120	42	47	68	88

[1/] The sorghum was planted in an in-row subsoiler. The starter fertilizer (DAP or 18-46-0) was applied in the subsoil tract at planting.

[2/] Nitrogen was applied four weeks after planting

If soil test values are medium to high in P and/or K, the total amount of these fertilziers needed may be applied as a starter application; thereby, eliminating costly fertilzier application. However, high concentration of fertilizers should not be placed in contact with the seed or banded directly beneath the seed.

Conclusion

Methods to reduce production cost or at least slow down the rate of increase must be developed and utilized. Properly managed no-tillage and double cropping systems appear to be excellent methods for reducing cost. Fertilizer cost increased during the past year and will probably continue to increase. A reduction in fertilizer use is tempting but as pointed out in this paper, an over-reduction in fertilizer use can actually increase production cost. Cost associated with fertilizer use may be reduced through proper application method, source selection, and crop rotations. Regardless of production practice, tillage system, or crop rotation, the most economical method for determining fertilizer application rate is through soil testing. When irrigation systems are utilized, plant analysis should be used, along with a soil testing, to determine the most economical fertilizer rates.

REDUCING ENERGY INPUTS INTO NO-TILLAGE SYSTEMS

ALBERT C. TROUSE, JR. AND CARL A. REAVES

No-tillage farming is credited with conserving soil, water, on-farm fuel, time, and labor. In addition, it increases yield, improves planting and harvest timing, reduces some weather risks and soil damage, and permits fanning of land too steep to till under conventional systems (Phillips and Young, 1973). If conventional tillage is unnecessary, the elimination of fuel, labor, and material now used to produce, assemble, and deliver the big machinery for conventional tillage would increase savings. Successful no-tillage farming, however, relies heavily on chemicals for pest control, and there is some question as to the overall savings when energy required to produce these chemicals is considered. True savings are best evaluated by comparing the total fuel input against the output of marketable agricultural products.

Many of the advantages attributed to no-tillage farming do occur, hut only when soils are in exceptional physical condition. Such soils are common in virgin lands and in well drained pastures and hay fields that have been well husbanded over many years. These are soils without the pans and crusts typical in fields tilled and trafficked year after year with heavy machinery. After years of conventional tillage and traffic, the structure of topsoil degrades and easily compacts into dense bands. Root systems confined by traffic lanes above impenetrable plowpans have access only to moisture stored between these bands. Water unable to seep rapidly through compressed bands rushes down compacted tire lanes, transporting valuable topsoil and expensive chemicals from the field.

Crops can survive when roots are confined to such narrow "window boxes," but usually fail to produce satisfactorily. And when no-tillage farmed, crops often yield less than in conventionally plowed and harrowed fields. The simple, direct seeding employed in standard no-tillage reduces water and wind erosion, but crops grown in soils in less-than-good physical condition require larger rootbeds than those formed by the slight disturbance provided by standard no-tillage planters. Unless the farmer can make a profit using conservation systems, he cannot afford to save soil, water, and fuel.

NO-TILL-PLUS

An alternate system of no-tillage farming called "no-till-plus" has been developed to achieve many of the benefits of no-tillage farming on lands in poor physical condition. The system incorporates an additional operation: the "plus" referring to plus subsoiling in a location where seeds are to be planted. Subsoilers are attached to no-till planters to open a narrow channel through the plowpan to create a pathway into the subsoil for deep root development and rapid entry of water and oxygen.

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Since this system does not destroy existing cover or disturb soil between the planted rows, it can be accepted as "no-tillage" in spite of the drastic tillage performed in narrow strips. One might consider that this planter simply prepares a deeper seedbed than that formed by most standard no-tillage planters.

Several equipment manufacturers in the Southeast produce machines for no-till-plus farming. However, no-till-plus planters require additional tractor power to pull the 4-, 6-, or 8-row machines. It is necessary for tractors to supply from 30-35 hp per row to pull these planters in conditions existing in the Coastal Plains area. This forces many farmers in the Southeast to upgrade their tractor sizes to the 140 hp range to handle a 4-row operation. However, many benefits of no-tillage farming can be achieved when fields that are in less-than-ideal physical condition are farmed with no-till-plus equipment.

ROOTBED CONDITIONING

Soils already in ideal physical condition provide good rootbeds and require no more than enough conditioning to assure good seedbeds for a short period of time. Such fields are exactly in the condition for which the standard no-tillage implements were designed. Standard no-tillage farming, however, is wasteful of fuel when soil and water are not conserved and yields are not at least comparable to those obtained by conventional farming techniques.

When the A_p horizon is not badly degraded and excessive moisture is only a slight problem, a larger seedbed can be beneficial. This may allow sufficient drainage for rapid root development within the loosened soil as other roots slowly penetrate through mildly compressed pans. In many areas of the Coastal Plains, however, the degradation of the A_p horizon is so severe that inadequate rootbeds and excessive runoff are major problems. No-till-plus planters have evolved to provide the conditioning needed to achieve the benefits of no-tillage farming on such soils. Where the physical condition of the subsoil is satisfactory, a narrow, man-made extension from seedbed through the pan to the subsoil can provide an adequate rootbed. The passageway must completely penetrate the plowpan for rapid drainage of excessive moisture and to allow roots access to moisture stored in the subsoil. A good rootbed is essential for successful crop production and must be assured either by conditions already existing or by conditioning provided by machinery.

NO-TILL-PLUS PLANTERS

No-till-plus planters currently incorporate a tandem arrangement of multiple conditioning tools, followed by a planting device. Early models were essentially assemblages of commercially available tools to perform needed tasks. Stringing out these tools, especially in multiple-row units, created a load difficult to lift from the soil to a travel position. Some tractors could barely lift the cantilevered load, although they had the power to pull the planters. Planters were condensed through closer assembly, or through modification and elimination of some tools. The load is now centered closer to the tool bar, easing the stresses on beams and the hydraulic lift unit.

As with most no-tillage planters, the no-till-plus planter requires a coulter. Soils in various physical conditions require different coulter features to slice through various cover crops, sod or stubble, and chopped stalks, grain straws, or other vegetal matter on the surface. Coulters are essential to reduce the buildup of trash and roots on the subsoiler shank and to free debris from the path of the planter, but they also assist in the pulverization needed for a good seedbed. Problems caused by large clods, massive soils, and binding root systems must be reduced by proper coulter action. Size and type of coulter, as well as the action required to form a particular seedbed, depend upon implement design and many soil and weather factors. Coulters, as well as each of the subsequent tools, must work the soil sufficiently and be set deep enough to aid in seedbed preparation since there is only one opportunity to form the seedbed. The proper coulter setting is too important a step to neglect in no-tillage farming.

A subsoiler or deep chisel follows the coulter in all no-till-plus planters. It is needed to form an opening that penetrates the plowpan in a location where soil will remain loosened during the development of the crop. Subsoilers loosen sections of soil that are V-shaped down to 8-12 inches, and at deeper depths the subsoiler point creates a channel point-width wide, completing a cross section resembling a "Y." Usually, soil sheared from the profile by this tool is thrown forward, upward, and to the sides of the center of action. As the tool passes by, some lumps of soil fall back into the narrow groove at the tail of the "Y" and bridge the gap. This temporarily supports the remaining soil that is returned to the loosened zone, leaving a large void near its bottom.

To prevent downward sifting of soil, seeds, and seedlings into the void during later rains, enough soil must be returned to fill the channel or the loosened soil above the void must be stabilized. Although it must be firmed to support a seedbed, it should not be firmed so much as to adversely affect air, water, or root permeability. Accomplishing this firming action is where the design principles currently used in various no-till-plus planters differ, Some planters use rotary tillers, a pair of firming wheels, or an array of tools that apply either a constant band of pressure or spot pressure to the seedbed, After firming, some manufacturers add implements to return loosened soil (thrown too far during subsoiling) to the narrow band that is to be planted, but with a minimum of loose straw and root material that would foul the planting devices. Usually, additional secondary tillage is then performed to assure the well granulated seedbed required for satisfactory seed germination. The last tool is usually a planting device designed to work in conventionally prepared fields.

The actions performed by the implements between the coulter and planting device are not necessary in standard no-tillage. These actions require additional power inputs which increase the fuel expenditure and cost of no-till-plus farming. Farmers require income from practices implemented, thus expenditures for extra work are justified only when sufficient conservation and additional production are assured.

FORCE REDUCTION IN NO-TILL-PIUS PLANTING

There are techniques and designs that can reduce the fuel demanded For an acceptable no-ti1l-plus operation. However, certain applications depend upon soil and climatic conditions and are specific for the crops sown. It should be remembered that forces increase as work is performed, and where some work is useful and needed, some is wasteful or even harmful. Forces applied to soils by tools should accomplish only needed reactions.

a. Coulters

Proper coulter action is valuable to all no-tillage systems. Draft of 14 coulter types has been measured in the soil bins at the National Tillage Machinery Laboratory. When traveling at a speed of 4.5 mph, in firm soil without cover, draft was increased about 350% as depth was increased from 2 to 6 inches, and about 20% more weight was needed to maintain depth. When greater depth is not required, force is wasted. Under similar test conditions, increasing speed from 2.4 to 7.1 mph increased draft by only 7% when the coulters were set at a depth of 4 inches, but the coulters did little beneficial work with the additional force.

A series of tests conducted in a moist, sandy loam soil compared experimental coulters with standard smooth coulters. All coulters were 17 to 18 inches in diameter, 3/16-inch thick, worked at a 4-inch depth, and traveled at 4.5 mph. A 1-inch fluted coulter increased draft by about 60%, and about 50% more weight was required to maintain depth. A 2-inch fluted coulter increased draft 90% and required 80% more weight. Wide flutes increase soil disturbance and are sometimes necessary for adequate pulverization. Where increased width and pulverization are needed, more soil can be disturbed per unit of force by fluted coulters. The rippled coulter disturbed a band of soil about one-third as wide, yet required almost as much power as the 1-inch fluted coulter. Angling the flutes in coulters at about 45" increased their draft about 10%. Large diameter coulters were not tested, but they take up more space and should need more weight to force them into the soil. If space is not a factor, however, their use should improve the cutting of trash and reduce draft.

The dominant purpose of the coulter is to cut through trash, sod, and roots, but this could not be tested under controlled conditions. Table 1 shows the response obtained from 3 soils without cover using 7 types of coulters in the 17- to 18-inch diameter range. The force for a single smooth coulter, traveling at 4.5 mph (shown in Table l), would convert to about 2 hp, and a 4-row unit would then utilize about 8 hp to cut through soil without roots, sod, or stalks. Four 2-inch fluted coulters, working under the same conditions, would require 12 hp, so 4 additional horsepower would be needed for a 4-row unit just to widen a cut through the soil.

b. Subsoilers

The subsoiler on a no-till-plus planter produces a pathway for air, water, and roots through compacted Ap horizons. Since subsoiling requires most of the on-farm energy used by no-till-plus planters, it is in the subsoiling operation that proper use and design offer the greatest possibility for fuel reduction. Two major factors affecting draft during subsoiling--depth and speed--are under the farmer's control.

Research under uniform soil conditions at the Laboratory suggests an exponential increase in draft with increased depth. Table 2 shows the mean values for four chisel designs working in a Norfolk sandy loam soil and compares them with calculations squaring the depth value. When the depth is doubled, for example, the draft increases about fourfold--the table shows that doubling the depth produced a measured draft of 8.4 N which compared closely to the calculated 9.6 N value. In fields, however, moisture content and soil condition are rarely constant with depth. Evidence shows, nonetheless, that draft is increased substantially with each additional. increment of depth. In subsoils where roots can develop easily, barely piercing the plowpan is as effective as deep subsoiling in encouraging root proliferation. In material in which roots cannot develop, the volume of soil loosened by deep subsoiling is insufficient. If no benefit is to be derived, why extend subsoiling depth?

Increasing speed from 2.2 to 4.9 mph increased draft about 40% when subsoiling at a 14-inch depth in the Norfolk sandy loam bin (Table 3). Much of that energy was expended throwing soil further to the sides, necessitating additional energy to return it to the seedbed. Almost no increase in volume of soil disturbed could be verified for this expenditure of fuel, and the increase in pulverization was negligible.

Extrapolating forces obtained from a single subsoiler working 14 inches deep and converting them into horsepower requirements to subsoil 4 rows should convince anyone that speed costs money. Calculations with the sandy loam in Table 3 indicate that at 2.2 mph, 36 hp is required to accomplish subsoiling, and at 4.9 mph 112 hp is needed to accomplish the same task. Table 3 shows that it takes more force to subsoil at greater speeds, and since it takes more energy to develop the higher speed, horsepower requirements escalate rapidly. Farmers must decide if advantages from increased speed while planting are worth more fuel and increased wear and tear on equipment.

Design features of the better currently available commercial subsoilers can reduce draft by about 25% over the poorest designed units on the market. If low draft subsoilers are to be selected, certain features should be considered. The subsoiler shank has a minor effect on draft as long as its length is adequate for the needed depth and allows for clearance of loosened soil and trash beneath the tool bar. The thickness should give needed support under tractor driving conditions and withstand impact with rocks, tree roots, or other buried objects. Increasing shank thickness has little effect on draft when point width allows for adequate lateral clearance between the undisturbed soil and shank. Beveling the leading edge of a shank can reduce subsoiler draft by about 5% in lumpy soils, but the reduction is at the expense of decreased pulverization. With beveling, large draft reductions are possible when roots or trash tend to build around blunt shanks.

Where the leading edge of a shank has the proper slant--often more than 15" greater than vertical--and the point extends more than 10 inches in front, lumps and trash usually slide up the non-beveled shank and are easily cleared. This feature alone reduces draft about 30% below that of the old vertical shanked subsoilers. When soils adhere strongly to a shank, more slant and greater lateral clearances are needed. The practice of welding a hard facing; to reduce wear can extend the life of a shank but does so at the expense of draft. It may be less expensive to replace worn shanks than to buy fuel to pull the soil surrounding a shank through every mile of subsoiling. Under many conditions in the Coastal Plains, the subsoiler shanh on a no-till-plus planter can be 3/4 to 1 inch thick and about 4 inches deep. Less depth of section in the shank decreases strength, and increasing its depth increases material costs and adds weight to the unit, but with little effect on draft.

Width of the subsoiler channel where it pierces the plowpan appears to be of little consequence to either taprooted or nodal-rooted crops as long as the channel remains open. However, under some soil and climatic situations, wide channels may improve drainage, but forming channels wider than needed wastes fuel doing unnecessary work and increases the ease of serious recompaction. In many soil conditions, a channel created by a point 2 to 2.5 inches wide appears suitable. Narrow channels are prone to easy closure by lateral fcrces from interrow traffic. Wide channels lead to excessive settlement and are easily compacted during later interrow travel.

Studies involving width of subsoiler points are inconclusive due to the effects of other features in point design, shank geometry, and soil factors. Although inconclusive, point width per se appears to exert a small effect on draft, but loosening more soil than required wastes fuel. Draft is affected substantially by other design features involving the point. The top surface of points with an angle between 20" and 30" from horizontal gives the lowest draft value in many soils. Low draft is commonly produced when the bottom of the point makes a 5" to 10" angle with the floor of the subsoiled channel. With these dimensions designed into subsoiler points, soils are lifted adequately and shear with a minimum of force wasted on compression and adhesion along the top of the point, In addition, energy expended in confinement and compaction of soil behind and beneath the point is reduced.

The variety of firming devices on no-till-plus planters has not been evaluated under test conditions. Our limited observations indicate that some devices cause excessive soil puddling and recompaction, whereas othhrs produce low draft values by doing an inadequate job. Draft measurements of planting devices and their attachments have not been initiated.

TRACTION IMPROVEMENT

Improving tractive efficiency while pulling no-till-plus planters is equal in value to reducing their draft. Tractors are the source of power used while planting, and engine tuning and power transmission to wheels are important, but power is transferred from wheel rotation to forward drive through forces applied to soils. After loose soil is firmed during a first pass of a tractor, about 30% more pull can be developed traveling in the same pathway during the second trip, and often an additional 10% can be gained during the next trip. Pull in plowed fields can be increased more than 100% in firm, untilled soil with dry sod; thus, no-tillage is conducive to improved traction. Besides improving traction, driving on firm, untilled soil can increase the opportunity to plant, control pests, and harvest at the proper times. Traction becomes difficult to evaluate when cover crops are involved because results can vary with crop condition. In dense, recumbent, succulent cover, pull can be effectively reduced, while the same tractor might scarcely slip on sparce, dry, clipped, stable-stooled sod.

All wheels slip as they develop pull, but more traction can be developed with less slip on stable soil. Tire slippage not only increases wear, but consumes fuel doing work not converted into forward motion. Tire specialists feel that each percent of slip increases fuel consumption by about an equal percentage. Although maximum traction is not achieved, a pull at 12% slip wastes close to 12% fuel. By increasing weight on tires, slippage can be reduced and pull increased. In a plowed strip, for example, a 13.6 X 38 tire inflated to 22 psi produced 120%:more traction at 10% slip when carrying 3,630 lbs than when carrying 1,820 lbs. This is equivalent to developing about 40 hp more pull with a two-wheel-drive tractor. However, increasing load can increase sinkage in loose soils. Sinkage wastes power compacting soil in the ruts formed beneath tires. In addition, the wheel. must climb the small rise in front of the tire or expend energy flattening it. Here is where tire geometry becomes an important factor. Wide tires flatten a wide band of soil to their front, and duals flatten two mounds, both requiring additional power. Duals and wide tires are used to reduce sinkage and improve flotation. However, supporting a load on a greater area of soil reduces pressure which affects traction. Both lengthening the contact and increasing its width gain flotation, but lengthening decreases the energy lost in compacting a wide band of soil. Contact length can be increased with wheels of a larger diameter; tracks (steel or pneumatic); by reducing air pressure in tires; and by arranging wheels in a tandem design so rear wheels will drive on soil firmed by the front wheels. Radial tire construction is gaining prominence. On firm soil, radials can produce about 10% more traction than bias tires, but the advantage is reduced in loose soil.

Results are always variable when forces are applied to soil. The resistance a soil offers a tillage tool and the support given to a tire depend upon soil strength. And strengths of all soils can be monumentally altered by relatively small changes in moisture content.

CONCLUSION

Many fields in the Coastal Plains of Southeastern USA can be no-tillage farmed only if root access to the subsoil is assured. Although no-till-plus planters can provide this, they expend more energy than standard no-tillage planters. Major draft reductions and improved tractor traction can be implemented by the farmer--reductions due to equipment design are less dramatic. No-till-plus offers benefits of no-tillage farming to farmers whose fields are in less-than-ideal physical condition.

ACKNOWLEDGEMENT

The authors wish to acknowledge research data from I. F. Reed, M. L. Nichols, A. W. Cooper, J. H. Taylor, E. C. Burt, and A. C. Bailey.

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TABLE 1

EFFECT OF COULTER TYPES ON MEAN DRAFT*

Coulters	Draft Force (kN) Sandy Loan	Clay Loam	Silty Loam
1-in. fluted	1.01	1.20	0.98
2-in. fluted	1.08	1.27	1.04
Smooth	0.63	1.10	0.68
1-in. bubble	1.03	1.28	1.10
Concave	1.11	1.35	1.24
Ripple	1.01	—	1.08
45° angled flute	1.06	1.30	0.99

* Speed = 4.5 mph; Depth = 4 in.; Dia. = 17 & 18 in.

TABLE 2

EFFECT OF DEPTH ON MEAN DRAFT*

Depth	Actual Draft (N)	Calculated Draft (N)
X	2.4	$2.4 \times 1^2 = 2.4$
2x	8.4	$2.4 \times 2^2 = 9.6$
3x	18.1	$2.4 \times 3^2 = 21.6$
4x	34.0	$2.4 \times 4^2 = 38.4$
6X	73.8	$2.4 \times 6^2 = 86.4$
8X	157.8	$2.4 \times 8^2 = 153.6$

* Norfolk sandy loam using 1-in. wide chisel.

TABLE 3

EFFECT OF SPEED ON MEAN DRAFT AND HORSEPOWER*

Speed (M/s)	Speed (mph)	Norfolk sandy loam Draft (kN)	Norfolk sandy loam Horse-power	Decatur clay loam Draft (kN)	Decatur clay loam Horse-power
1.0	2.2	7.0	9	12.0	16
1.4	3.1	8.0	15	16.0	30
1.8	4.0	8.8	21	19.0	46
2.2	4.9	9.5	28	21.0	62

* At 14-in. depth.

EFFECT OF PLANT POPULATION ON YIELD, DISEASE, AND OTHER PARAMETERS OF SOYBEANS PLANTED NO-TILL AND CONVENTIONALLY

D. L. Wright, F. M. Shokes and W. B. Tappan[1]

No-till and reduced tillage farming are being widely accepted by growers with a minimal amount of information on management of crops grown under these conditions. Labor, fuel, equipment savings and timely plantings with multiple-cropping are major advantages of these systems. Little is known about the long-term effects of no-till farming on populations of insects, weeds, nematodes, and plant pathogenic fungi. Florida has high levels of certain pests and serious problems could result from continuous no-till planting. A **5-10% loss** of stand can occur with no-till planting due to insect problems, cooler soil, slower seed germination, improper seed placement in sods and bird damage. Slower seedling emergence and cooler soils as well as a build-up of inoculum in soil residues, could also contribute to a higher incidence of seedling disease.

Planting a winter cover crop of a small grain followed by soybeans is becoming popular, but research is needed to determine whether such a crop is sufficient to prevent the build-up of pest populations.

Current Research

With consideration of the above factors, research on soybean no-till systems was begun at the Agricultural Research and Education Center at Quincy, Florida, in 1977-78. In one study the 'Centennial' soybean was grown under the following cultural systems: 1) soybeans after rye-ryegrass winter cover no-till planted into stubble; 2) soybeans no-till planted into soybean stubble; 3) soybeans after rye-ryegrass winter cover, conventional plow-plant; 4) soybeans planted into soybean stubble, conventional plow-plant. Three nematicides, Temik 15G (18 lbs/A), Soilbrom 90EC (1.5 gal/A) and sodium azide 2C (50 lbs/A), were tested using these cultural systems. The foliar fungicide, Benlate was also compared to an unsgrayed check using these cultural practices.

In a second study seven different soybean plant populations were compared under no-till and conventional plow-plant cultural regimes. Populations of 8, 6, 4, 3, 2, 1, and 0.5 plants per foot of row were used. Seedling disease, foliar disease, yields and morphological parameters (plant height and stem diameter) were measured.

Kesults and Discussion of 1979 Data

Soybeans under the four cultural systems showed no significant differences in yields due to the cultural systems or the nematicides. Only the spiral nematode was present in sufficient numbers to be of importance. Table 1 shows that there was a two-fold increase in numbers of this nematode in no-till plots. Spiral nematode is not known to be a major problem in soybeans.

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The fungicide, Benlate, decreased overall foliar disease but had no effect on yield in this study as is often the case with the Centennial variety of soybeans.

Soybean yields at different plant populations in 36 inch rows are shown in Table 2. Yields were similar for both no-till and conventional plantings from 3-8 plants per foot of row. As plant numbers decreased below three plants per foot of row, yields were sharply reduced and weed populations increased with both methods of planting. Stem diameters increased with a decrease in plant height resulting in a low bushy growth as compared to plants in higher populations. Plants were taller under no-till conditions than with conventional planting (Table 3). This might be attributed to increased moisture under the stubble mulch. The hundred seed weight increased as population decreased (Table 4). Seed weights were consistently higher for soybeans in the conventional plow-plant system but differences were not statistically significant.

The incidence of seedling diseases, as evidenced by root rot and stem lesions was 12% greater on seedlings from no-till plots than on seedlings from conventional plow-plant plots. Plant population had only a nominal effect pn overall foliar disease ratings (Table 5), but pod and stem blight increased as population increased. Anthracnose ratings were significantly different in relation to tillage practices and were higher in the lower populations and lower in the no-till plots.

Further research is needed on no-till systems in relation to effects on yields and disease. Optimal management systems need to be developed to permit maximum yields and minimize losses when available land for rotations is limited, More data is needed to determine if the short rotation with a winter crop of small grains is sufficient to permit continuous no-tillage planting of soybeans. Insufficient data is available at this time to project any long-term effects of such plantings on diseases or other pests in no-till systems in North Florida.

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Table 1. Effect of Nematicides on Spiral Nematode Numbers and Yield of Soybeans (Quincy 1979).

Treatment	Nematode Counts/100 cc Soil		Yield
	Conventional	No-Ti11	Bu/A
Soilbrom	309	734	32.7
Temik	350	905	33.1
Sodium azide	578	857	37.3
Check	612	1171	34.5

'Yields were not significantly different across cultural practices or in relation to treatments.

Table 2. Effect of Plant Population on Soybean Yields Under No-Till and Conventional Planting - 1979.*

Plants/row ,ft.	No-Till	Conventional
	bu/A	
8	58.2 a	57.2 a
6	59.2 a	56.5 a
4	55.5 a	55.3 a
3	54.5 a	50.8 a
2	40.6 b	43.3 b
1	27.5 c	30.5 c
0.5	16.6 d	24.7 d

* Means in a column followed by the same letter are not significantly different DMRT p = .05). There were no significant differences between cultural practices.

Table 3. Plant Height and Stem Diameter at Maturity - 1979 Soybean Plant Population Study.

Plants/row ft.	Plant Ht. (an) No-Ti11	Plant Ht. (an) Conventional	Stem Diameter (cn)*
8	113.8 a	99.0 ab	0.96 cd
6	110.9 ab	105.2 a	0.92 d
4	108.2 ab	102.2 ab	1.00 cd
3	107.7 ab	99.6 ab	1.04 c
2	102.3 b	95.3 bc	1.14 b
1	93.4 c	88.0 cd	1.45 a
0.5	87.7 c	82.4 d	1.38 a

1 Numbers in a column with the same letter are not significantly different (DMRT p = .0l). Each number represents a mean of at least 80 measurements.

2 Numbers in this column represent a mean of no-till and conventional plow-plant stem diameters for a given population. Tillage practices had no significant effect on stem diameters.

Table 4. Weight of 100 Soybean Seed in Relation in Plant Populations with No-Till and Conventional Management - 1979.*

Plants/row ft.	No-Till	Conventional
8	14.0 ab	14.7 c
6	13.6 b	14.7 c
4	14.2 ab	14.5 c
3	14.5 ab	15.0 bc
2	15.1 a	15.6 abc
1	15.2 a	16.1 ab
0.5	14.9 ab	16.6 a

*Means in a column followed by the same letter are not significantly different (DMRT p = .05). There was no statistically significant difference between cultural practices.

Table 5. 1979 Soybean Plant Population Study Disease Ratings.[1]

Plants/row ft.	Overall[2] Foliar Disease	Pod & Stem[2] Blight	Anthracnose[3] No-Till	Anthracnose[3] Conventional Plow-Plant
8	4.6 a	3.0 a	1.9 a	3.4 ab
6	5.0 a	2.6 a	3.2 ab	3.2 ab
4	5.2 a	2.6 a	1.9 a	2.8 a
3	4.7 a	2.4 ab	2.1 a	3.9 abc
2	4.6 a	1.0 b	2.5 a	4.5 bc
1	4.0 b	1.1 b	4.1 bc	3.9 abc
0.5	4.1 b	0.9 bc	4.7 c	5.4 c

[1] Numbers in a column with the same letter are not significantly different (DMRT p = .05). Each number represents a mean rating for four replications. All disease ratings were on a scale from 1-10 with one representing plants free from disease and 10 representing plants killed by disease.

[2] Numbers in these columns represent combined means of no-till and conventional plow-plant for a given population. Tillage practices had no significant effect on disease.

[3] Anthracnose ratings were significantly different in relation to tillage practices (DMRT p =