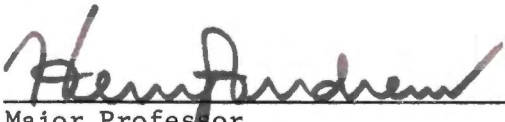


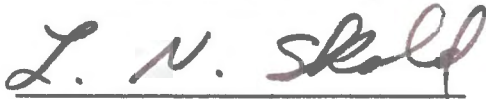
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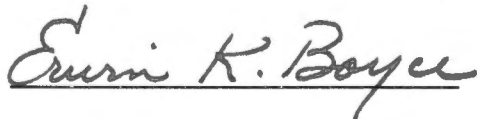
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I am submitting herewith a thesis written by John R. Roper, entitled "Stand Establishment and Growth of Corn on Chemically Killed Sod as Influenced by Type of Sod Planter and Speed of Operation." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

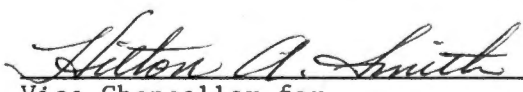

Major Professor

We have read this thesis
and recommend its acceptance:





Accepted for the Council:


Vice Chancellor for
Graduate Studies and Research

STAND ESTABLISHMENT AND GROWTH OF CORN ON CHEMICALLY KILLED SOD AS
INFLUENCED BY TYPE OF SOD PLANTER AND SPEED OF OPERATION

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
John R. Roper

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ABSTRACT

A study was made to determine the effectiveness of three types of sod planters at three different operating speeds when corn (Zea mays L.) was planted into four different sod treatments. Another study was conducted to compare the effectiveness of a fertilizer high in monocalcium phosphate with that of a less soluble fertilizer high in dicalcium and tricalcium phosphate when each was broadcast on top of the sod, and with the fertilizer high in monocalcium phosphate incorporated into the soil.

It was found that sod control was excellent and season long weed control was adequate for high yields in all herbicidal treatments.

In the planter experiment, corn yields were not significantly different due to planters, or planter speeds; however, the sod treatments outyielded the conventional seedbed treatment. There was considerable variation in plant population due to the planters and planter speeds used in the experiment. The Ferguson and Allis-Chalmers planters at 2 mph produced the highest plant population in sod. These differences were not reflected in differences of yield. Poor growing conditions during the month of August may have resulted in low yield per plant for plots with high plant populations.

In the phosphorus solubility test, there was no significant difference in corn yields between different formulations of phosphate applied to a soil low in available phosphorus. Broadcasting phosphorus gave as good a yield as phosphorus incorporated into the soil.

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CHAPTER I

INTRODUCTION

In recent years, several research workers (30, 35, 47)* have shown that corn can be grown successfully on chemically-killed sod. Excellent sod kill and season-long weed control have been obtained with currently available herbicides. Corn yields have been comparable to those where conventional seedbeds were prepared and production costs have been less.

Sod planting of corn appears to be of significance in Tennessee and other Eastern states where there is considerable rolling land not suitable for row crops. With the use of chemicals, millions of acres of marginal land can become productive corn sites.

However, there is concern at the present time about the performance of sod planters. The purpose of this study was to determine the effectiveness of three different types of commercially available sod planters at three different operating speeds.

Due to the increasing use of no-tillage equipment in corn production there is much concern in fertilizer placement. Therefore, a second experiment was designed to compare the responses of sod-planted corn in a phosphorus deficient soil to surface applications of complete fertilizers high in monocalcium phosphate, and in the less soluble dicalcium and tricalcium phosphate.

*Numbers in parentheses refer to similarly numbered items in the Literature Cited.

CHAPTER II

REVIEW OF LITERATURE

I. EFFECTS OF MINIMUM TILLAGE ON THE SOIL AND CORN YIELDS

In recent years, considerable research has been conducted on growing corn (Zea mays L.) without cultivation on chemically killed sod. Among the early workers were Barrows and Fitzgerald (2), who in 1952 reported success in growing corn in a ladino clover (Trifolium repens L.) sod killed with 2,4-dichloro-phenoxyacetic acid) (2,4-D).. They found that the dead mulch remained intact on the surface between the rows throughout the season. Soil just below the mulch was always in a friable condition even at times when soil receiving conventional preplant tillage was extremely compacted. Interest in no-tillage corn production has developed rapidly since the initiation of studies in Virginia in 1960 by Moody, Shear, and Jones (39). They reported better growth of corn throughout the season and higher stover yield in zero tillage sod than under conventional tillage practices. In the experiment 2-chloro-4, ethylamino-6, isopropylamino-s-triazine (atrazine) at the rate of 4 pounds active ingredient per acre was used to kill the sod. Available soil moisture in the 0- to 18-inch depth was at least 1 inch greater in the no-tillage plots than in the conventional tillage area early in the growing season. This indicates the effectiveness of the mulch in reducing runoff and evaporation.

However, corn must be planted at higher rates on sod to get stands comparable to those on a conventional seedbed. Triplett and

Van Doren (50) found that seedling emergence on a silt loam soil, at the Ohio Agriculture Experiment Station, was 65 per cent for no-tillage and 85 per cent with conventional methods. In the Ohio trials corn was planted with a grassland drill equipped with a coulter. On the average, there was no yield difference between the two tillage systems.

Minimum tillage reduces the amount of soil compaction as compared to conventional seedbed preparation. Phillips and Kirkham (33) worked with a Calo clay soil in Iowa, and found that soil compaction reduced the corn stand. When the stands from the compacted and uncompacted soils were adjusted to the same plant population it was found that the yields were reduced from 90 bushels per acre on the uncompacted soils to 82 bushels per acre on the compacted soils.

Research by Davidson and Barrows (13) in southwestern Michigan, using a quack-grass (Agropyron repens L.) sod on a sandy loam soil found a 12 per cent reduction in larger, water stable soil aggregates, where the soil had been plowed as compared with soil under the undisturbed sod. This improved soil aggregation, combined with the mulching effect of the dead sod resulted in a 70 per cent higher soil moisture content in the untilled soil. Continuous tillage destroyed this cover crop-induced improvement in soil structure.

Lewis and Martin (26) at Raleigh, North Carolina, compared four broadcast herbicide treatments to four band application treatments of the same herbicides and rates. The broadcast treatments significantly out-yielded band treatments by 37 to 68 per cent.

Jones et al. (18) found that yields from no-tillage corn production during a six-year period were comparable to and ranged from 18 to 39 per

cent above, yields from conventional turnplow tillage on Greendale, Lodi, and Groseclose silt loams in Virginia. Also, soil moisture measurements indicated that the dead sod mulch provided by the no-tillage procedure was highly effective in reducing evaporation and runoff from the soil surface. Average soil moisture in the top 15.2 cm of soil was higher under no-tillage than under conventional tillage, ranging from 0.81- to 0.15-cm per 15.2 cm of soil in various years.

Experiments in Virginia by Moody et al. (29) over a five year period revealed that corn, planted in dead sods with only enough soil disturbance to place and cover the seed, produced consistently good stands of vigorous plants. Also, corn yields were comparable, to, or higher than, those from conventional tillage. In these experiments, 4 pounds active ingredient per acre of atrazine was used to kill the sod prior to corn planting.

Research by Maschler et al. (27) in Virginia revealed that the sod planting method of corn production gave better yields of corn than conventional tillage on a clay loam, two silt loams, and a loamy sand in one or more instances. In no case was yield lower using this method.

Work has been completed by Peters and Andrews (32) to determine the effect of sod height and time of herbicide application on soil moisture, soil temperature, and yields of corn on chemically killed sod. They found that the cultivated treatments had a lower level of moisture during dry conditions at all locations. The sod treatments had a higher

maximum and minimum soil temperature at the beginning and ending portion of the growing period than did the treatments receiving cultivation. They also found that corn, planted on sod that had been mowed and sprayed the day of planting gave yields as high as did corn planted on sod that had been sprayed the day of planting but not mowed.

Shear (37) at Blacksburg, Virginia, compared barley (Hordeum vulgare L.), rye (Secale cereale L.), ryegrass (Lolium multiflorum L.), and wheat (Triticum aestivum L.) as a winter mulch crop for no-tillage corn production. He found that rye met the requirements for ease of establishment, winter hardiness, and the production of adequate mulch more than the other grasses. Rye was also most susceptible to 1, 1'-dimethyl-4, 4'-bipyridylium salts (paraquat), making this potentially the most useful herbicide yet developed for killing a grass winter mulch crop.

Research at the Virginia Agricultural Experiment Station (51) revealed that soil structures associated with dense sod crops were retained through the growing season, improving moisture and air movement in the root zone in no-tillage corn production. At Blacksburg in 1963, when 15.74 inches of rain fell from May to September, no-tillage corn outyielded corn produced by the conventional method 116.0 to 106.0 bushels per acre. The dead mulch provided by the sod improved water infiltration, reduced erosion, and provided insulation which reduced moisture loss and increased corn yields.

II. CHEMICALS USED IN NO-TILLAGE CORN PRODUCTION

Atrazine

Considerable work has been completed using chemicals for sod kill. According to Andrews and Bryant (1), atrazine at the rate of 3 and 4 pounds active ingredient per acre plus surfactant and a mixture of 2 pounds of active ingredient atrazine plus 1 pound of paraquat per acre were the most promising treatments used in three Tennessee locations. Yields of corn planted in sod killed with these treatments were equal to those from plots in which conventional seedbeds were prepared and weeds were controlled by either cultivation or a pre-emergence application of atrazine at the rate of 2 pounds active ingredient per acre.

Atrazine controlled most perennial and annual grasses on a Canfield silt loam soil at Wooster, Ohio. In research released by Triplett (48), corn was grown for three years following sod, using herbicides rather than tillage to destroy vegetation. Atrazine at 4 pounds active ingredient per acre or 2 pounds of atrazine plus 2 pounds of paraquat per acre destroyed grasses present in these experiments. However, atrazine or combinations of atrazine and paraquat did not control perennial broadleaf plants. If broadleaf plants were present in significant amounts, 2,4-D or 3-amino-1,2,4-triazole (amitrole) was necessary in the herbicide system. Also, according to Eddows and Harpur (14) atrazine was superior to 2-chloro-4, 6-bis (ethylamino)-s-triazine (simazine), a closely related material, probably because of its greater solubility in water, 70 ppm as compared to 5 ppm for simazine.

Research in Virginia (34) revealed that the high rates of atrazine, 4 pounds active ingredient per acre, needed to give consistent kill to sods such as orchardgrass (Dactylis glomerata L.) and fescue (Festuca elation L.) could create a residue hazard for the crop following corn. Of the various chemicals tested, the combination of atrazine 2 pounds active ingredient and paraquat 1 pound active ingredient per acre was the most effective. This combination greatly increased the rate of kill, permitted a reduction in the amount of atrazine needed, and did not create a residue problem.

Lewis (25) found that 2 pounds of atrazine plus 1/4 pound of paraquat gave good control of perennial sod at Raleigh, North Carolina.

In Nebraska (54) atrazine was used at 1, 2, and 4 pounds active ingredient per acre on sorghum to control weeds in a Sharpsburg silty clay loam soil. Residues from all rates affected oats (Avena sativa L.) and alfalfa (Medicago sativa L.) sown one year after atrazine had been applied.

According to Buchanan and Rogers (9) oats and soybeans (Glycine max (L.) Merrill) germinated and grew normally in field plots that had received 2 and 4 pounds of atrazine seven weeks prior to planting. However, this was under conditions of high rainfall and high temperature in Florida on an Arrendonda loamy fine sandy soil

With work completed at The University of Tennessee by Bryant (8), bioassays indicated that toxic residues from the recommended rate of 2 pounds active ingredient per acre of atrazine generally disappeared from the soil within 18 to 20 weeks after application.

Sheets (40) conducted an experiment at Beltsville, Maryland, and reported that under ideal climatic and edaphic conditions, the rate of disappearance of atrazine may equal or exceed 80 per cent per year. When atrazine was applied at 2 pounds per acre for several consecutive years on the same soil the maximum residue 12 months after application was found to be 1/2 pound per acre. The disappearance of herbicide toxicity from the soil is due to microbiological decomposition, adsorption, leaching, chemical decomposition, vaporization, and plant intake (19, 20, 42, 46).

Inactivation of atrazine appears to be affected by tillage. Frank (16) revealed that fall plowing immediately after corn harvest, as opposed to spring plowing, reduced injury to sugar beets the next season from atrazine residue.

The major uptake of triazines by plants is by adsorption through the roots. Klingman (22), proposed that triazines affect the Hill reaction in plants, an important step in photosynthesis. Further studies have shown that corn has enzymes which break down the atrazine molecule, deoxygenating the triazine herbicides. Montgomery and Freed (28) studied the degradation of simazine and atrazine by corn plants through the use of C-ring-labeled compounds. They concluded that the herbicides had been degraded by the corn since there was evolution of $C^{14}O_2$ by the plant.

Paraquat

Paraquat is an effective contact herbicide which kills green plant tissue rapidly (5). Cornshey (12) revealed that paraquat and related compounds are rapid-acting translocated desiccants which kill the aerial

parts of most plants, but have no residual action at all through the soil. It has been shown that paraquat is adsorbed to the soil rapidly and completely by ion exchange.

The herbicidal action of paraquat is dependant upon its reduction in plants to relatively stable, water soluble free radicals. Reduction to the free radical is freely reversible and it is believed that reoxidation by molecular oxygen of the free radicals formed results in the formation of peroxide radicals or accumulation of hydrogen peroxide which destroys plant cells (10).

According to Slade (44), photochemical degradation of paraquat can take place on the surface of plants; however, never was more than two-thirds of the chemical degraded by light in this test. Presumably the paraquat not broken down is absorbed into the plant soon after application and protected from the ultraviolet light.

Lewis and Martin (26) reported that paraquat did provide initial top kill at the time of application but no further weed control beyond that. Atrazine, used alone at the rate of 4 pounds active ingredient per acre did not provide the necessary initial top kill to an orchard-grass sod at Raleigh, North Carolina. Thus, the sod remained competitive to corn during its early growth and development.

According to Klingman and Spain (23) when herbicides are used alone in nitrogen solution, paraquat gave the quickest top kill, followed by cacodylic acid, then atrazine. Low rates of herbicides are made effective by combining them with nitrogen solution plus wetting agents, the latter increasing contact kill.

Surfactant

The use of surfactants to increase herbicide activity is desirable. Behrens (3) stated that surfactants are useful additives for formulated herbicides because they contribute to wetting, spreading, emulsification, and solubilization of the herbicide.

The interaction of several paraquat-surfactant mixtures, when applied to corn foliage, was studied by Smith and Foy (45). When 1 g of the adjuvant, polyoxyethynene sorbitan monolaurate was added per liter of herbicide solution, a rate of only 1/2 ounce per acre of paraquat was required to cause a 40 per cent reduction in weight of corn. When paraquat was sprayed without the surfactant, a rate of approximately 1-1/2 to 2 ounces per acre was needed to cause the same reduction.

Surfactants increase herbicidal action of most herbicides. Boyer and Drever (6) revealed that in general 3'-(3,4-dichlorophenyl)-1, 1-dimethylurea (diuron) caused foliage burn most rapidly when used in conjunction with surfactants which thoroughly wet the plants. Marginal and tip burns were apparent on some plants one day after spraying with a diuron-surfactant combination. The affected plants usually exhibited maximum symptoms within seven to ten days. In contrast, plants sprayed with a suspension of diuron in water alone or water with surfactant alone showed only slight leaf necrosis and growth retardation in the same period of time.

According to Crafts et al. (11) when aqueous sprays are used to kill weeds and/or grasses, a wetting agent may be used to aid in spreading the water over the waxy surface of the plant leaves. Both the

over-all effectiveness and the degree of selectivity of a herbicide may be largely determined by the amount of spray retained on the leaves of the plant.

III. EFFECT OF PHOSPHORUS SOLUBILITY ON CORN YIELD

There is much concern with the immobility of phosphorus and the effect this might have on the future of sod planting, due to the lack of movement into the soil from the surface. Research was conducted at The University of Tennessee (53) in 1959 concerning the vertical distribution of phosphorus in a Decatur silty clay loam soil. In this experiment phosphorus was broadcast over experimental plots containing alfalfa. Data revealed that phosphorus from annual applications moved downward only slightly in a three-year period. The highest soil test values for available phosphorus were found in the surface inch.

According to Kennen (21) when ordinary superphosphate is treated with ammonia, a portion of the monocalcium phosphate is converted into dicalcium and tricalcium phosphate. The amount of tricalcium phosphate produced increases rapidly with the amount of ammonia added above 2-1/2 per cent.

According to Weast (52) phosphorus formulations differ greatly in solubility. A formulation of tricalcium phosphate ($\text{Ca}_3(\text{PO}_4)_2 \cdot \text{H}_2\text{O}$) is only 20 ppm soluble in cold water whereas a monocalcium phosphate ($\text{CaH}_4(\text{PO}_4)_2 \cdot \text{H}_2\text{O}$) has a 1800 ppm solubility rate in cold water. Moreover, a dicalcium phosphate $\text{Ca}_2\text{H}_2(\text{PO}_4)_2 \cdot \text{H}_2\text{O}$ is intermediate between the above two compounds in solubility.

Gingrich (17) found that the higher the percentage of water soluble phosphorus in the phosphate fertilizer added to the soil, the greater the amount of top growth of fall seeded wheat. Also, there was higher phosphorus percentage in the tops and a greater total uptake of phosphorus. Fertilizer materials in which either 30, 54, or 100 per cent of the phosphorus was water soluble were mixed with the soil or applied in a zone below the seed. Confining the phosphorus to a zone rather than mixing it with the entire soil increased the yield of dry matter in wheat. Phosphorus application did increase greatly the percentage of phosphorus in the shoot of wheat and the total yield of phosphorus for those plants grown at a soil temperature of 50°F or above.

Bray (7) in 1954 stressed that the necessity for precision of placement would not be expected to be the same for nitrogen as for phosphorus and potassium because of their different chemical properties. Nitrogen is classified as a mobile nutrient, because in the nitrate form it moves readily in the soil with water. Contrariwise, phosphorus and potassium are classified as "immobile" nutrients because they do not move readily in the soil.

Triplett and Rask (49) also revealed that phosphorus and potassium were not as mobile as nitrogen, but maintenance applications of these can be applied with sod planters to the top of the soil on sites that are high in fertility. Some movement of phosphorus and potassium occurs and roots growing near the surface take up substantial amounts of these elements. Fertilization with broadcast application on sod has not been a problem on sites high in fertility.

Singh (43) found that fertilization with phosphate, whether broadcast on the surface of the no-tillage treatment or incorporated into the soil of a conventional treatment, increased corn grain yields in 1963. Phosphorus uptake, phosphorus content of corn leaves, and corn yields were nearly equal from surface applied and from incorporated phosphate treatments or were higher from surface applied phosphate treatments.

Knoll et al. (24) used monocalcium phosphate, a less soluble dicalcium phosphate and a mixture of these two sources, and showed that different phosphate sources did not affect dry weight or the phosphorus content of the corn tissue. However, uptake of the phosphorus and its concentration in the tops of corn increased with increasing soil temperature and increasing phosphorus content of the soil.

Drying of the soil tends to make phosphorus less available according to Olsen and Fried (31). They also revealed that phosphorus applied to soil as fertilizer is changed into forms similar in some respects to the native forms already present. A characteristic feature of soil phosphorus is low solubility in water or in soil solution.

Bennet et al. (4) offered evidence that the application of nitrogen to the soil increases the nitrogen compounds within the plants present thus resulting in a greater need for the absorption of phosphorus. However, this increase was due to physiological stimulation of the plant by applied nitrogen and not due to increased phosphorus solubility due to acid forming nitrogen fertilizers.

IV. DEVELOPMENT AND PERFORMANCES OF SOD PLANTERS

Little data have been released concerning sod planters and their performance. However, according to Triplett and Rask (49) satisfactory planters are those which assure seed-soil contact and cover seed to a depth of 1-1/2 inches. Disk openers for seed and fertilizer are more satisfactory than shoe openers for sites with very heavy mulch cover. Planters using coulters or strip rotary tillers to open the soil for the seed openers are commercially available.

According to Shear (38) sod planters vary in their effectiveness under different soil and mulch conditions. Depth regulators are essential to maintain uniform depth of planting under varying soil conditions.

CHAPTER III

MATERIALS AND METHODS

I. HIGHLAND RIM EXPERIMENT STATION

The first experiment to compare sod planters and planter speeds on two chemically killed sods and on a conventionally prepared seedbed was conducted at the Highland Rim Experiment Station near Springfield. The experimental plots were located on a relatively new, well-maintained tall fescue (Festuca arundinacea Schreb.) sod on Dickson silt loam soil. The sod was mowed and raked to simulate grazing prior to initiating the equipment.

Before planting, fertilizer was broadcast uniformly over the entire test area at the rate of 150-50-50 pounds per acre of N, P_2O_5 , and K_2O . The fertilizer was incorporated into the soil using a turning plow and disk only on the conventional seedbed. "Dixie" 29 corn, a white, full-season hybrid, was planted April 23 in 36 inch wide rows. A split-plot arrangement of treatments with four replications was used. Three different sod planters were used in the sub-treatments. Sub-sub-treatments were planter speeds of 2, 4, and 6 mph, on plots that were 30 feet by 12 feet running perpendicular to the main plots (Tables I, II). Prior to planting, each planter was calibrated to deliver 16,000 seeds per acre. The planter box gears were adjusted until the desired spacing was obtained. The plots were arranged so that for any given planter and planter speed, four plots were planted in one pass without stopping. In

each planting run one of the four plots was conventionally tilled.

One of the planters used was a two-row sod planter with a rolling coulter, built by the Ferguson Manufacturing Company of Suffolk, Virginia. Another was a four-row Allis-Chalmers, Model 600, with a fluted coulter. The third was a two-row Side-Winder rotary tiller, Model 90 with Oliver single-unit tool-bar planters and a PTO operated rotary cultivator which was adjusted to till a 2-inch wide strip.

There are several distinctive features of each planter used in this experiment. They vary in size, but perform the same function of getting the seed into the sod with minimum soil disturbance. The sod planter is a relatively new implement on the market, and owes its existence to the practice of using herbicides for weed control.

The Ferguson is a two-row sod planter equipped with a three-point hitch attachment (Figure 1). Planting depth is regulated by gauge wheels located at the front of the planter. Adjustments can be made to the front coulter by moving the shaft up and down inside a stationary sleeve, to obtain proper cutting depth. The front coulter slices the sod, and is followed by a single disc coulter set to cut the sod at an angle, to provide a lip of soil which is pressed back over the seed (Figure 2). A chain from the planter box is attached to, and moves with, the press wheel to regulate seed deposition.

The Allis-Chalmers sod planter is a trailer type planter, equipped with a hydraulic system designed to regulate planter depth (Figure 3). The distinctive fluted coulter has a rubber bushing to allow the coulter to float over solid obstacles when operating on a vertical plane (Figure 4).



Figure 1. A two-row sod planter with a rolling coulter built by the Ferguson Manufacturing Company of Suffolk, Virginia.



Figure 2. Close up of the Ferguson planter shows the rolling coulter, followed by a single disk coulter.



Figure 3. A four-row Allis-Chalmers Sod Planter Model 600, with a fluted coulter.



Figure 4. The fluted coulter is a unique feature of the Allis-Chalmer, Model 600 planter.

Located behind the fluted coulter is a boot with a small shovel opener to channel the seed to the soil.

The Side-Winder is a PTO operated cultivator, which has a two-row Oliver single-unit tool-bar planter attachment (Figure 5). The cultivator width had been reduced to provide a 2-inch-wide cultivated strip by removing the rotary tines. The Oliver planter was equipped with conventional runner openers, and deposited seed in the 2-inch-wide cultivated strip.

Herbicides were applied pre-emergence to the corn April 24, 1968, with a broadcast boom sprayer mounted on a conventional tractor. The following herbicides were applied to the main plots, that were 108 feet long and 30 feet wide: atrazine at 3 pounds active ingredient per acre plus 0.5 per cent alkylphenoxy polyethoxy (HDD surfactant), 2 pounds active ingredient per acre of atrazine plus 1/2 pound active ingredient per acre of paraquat plus 0.5 per cent HDD surfactant and 2 pounds active ingredient per acre atrazine on a conventional seedbed. No herbicide was applied to the untreated check.

Plant vigor, weed control, and sod-kill were rated visually using a zero to ten rating scale with zero indicating no weed control or injury to the sod and ten indicating complete weed control or sod kill. For plant vigor, zero indicated maximum vigor while higher numbers indicated reduced vigor and ten indicated complete kill of the crop. Lodging at maturity was calculated by dividing the plant population of a plot into the number of plants lodged and was expressed as a percentage.



Figure 5. A two-row Side-Winder, Model 90 with Oliver single-unit tool bar planter.

A 25-foot section of the two center rows of each plot was harvested by hand to determine yields. The ear corn was weighed in the field and samples taken for moisture determinations. Corn yields were reported in bushels per acre of shelled corn on a 15.5 per cent moisture basis.

II. TOBACCO EXPERIMENT STATION

The second experiment was conducted at the Tobacco Experiment Station near Greeneville. This experiment was carried out to compare the effectiveness of a fertilizer high in monocalcium phosphate with that of a fertilizer high in dicalcium and tricalcium phosphate when each was broadcast on top of the sod, and with the fertilizer high in monocalcium phosphate incorporated into the soil.

A randomized complete block design was used on a Cumberland silt loam soil, which was covered with an old orchardgrass sod. The plots consisted of six 36-inch wide rows, 25 feet long. Ten-foot wide alleyways were left between each range and each treatment was replicated four times.

Fertilizer was broadcast prior to planting at the rate of 150-120-120 pounds per acre of N, P_2O_5 , and K_2O and was applied individually to each treatment using different phosphate formulations (Table III). The fertilizer was incorporated into the conventional seedbed with a power-driven rotary cultivator. Treatments consisted of an unfertilized check, a sod treatment, and a conventional seedbed treatment receiving fertilizer containing monocalcium phosphate, and another

TABLE III
TREATMENTS USED IN THE CORN ON SOD EXPERIMENT CONDUCTED
AT GREENEVILLE, TENNESSEE, 1968

Type of Seedbed	Source of Fertilizer	Lbs/A
Sod	None	0
Conventional Seedbed	6-12-12(N-P ₂ O ₅ -K ₂ O)+NH ₄ NO ₃	800 + 50
Sod	6-12-12(N-P ₂ O ₅ -K ₂ O)+NH ₄ NO ₃	800 + 50
Sod	15-15-15 (N-P ₂ O ₅ -K ₂ O)	800

sod treatment receiving fertilizer containing a less soluble dicalcium and tricalcium phosphate.

"Dixie" 29 corn was planted June 8 using a sod planter with a rolling coulter. Herbicides were applied pre-emergence with a broadcast boom sprayer immediately after planting, Atrazine at the rate of 2 pounds active ingredient per acre plus 1/2 pound of paraquat and 0.5 per cent by volume of surfactant was applied in 47 gallons of water per acre to the sod area for sod-kill and weed control. The conventional seedbed received the same herbicide combination except that a surfactant was not used.

Soil samples were taken prior to fertilization to determine the fertility level. Samples were taken again July 25 at 2, 4, and 6 inch depths to determine if there were any significant differences in the movement of different phosphate compounds into the soil.

After planting, weed control and sod-kill ratings were made. Later, after the emergence of the corn, plant vigor ratings were made. During harvest the number of lodged plants was recorded.

A 20-foot section of the two center rows of each plot was harvested by hand for yield determinations. The corn was weighed in the field and samples taken for moisture determination. Corn grain yields were calculated on a 15.5 per cent moisture basis.

CHAPTER IV

RESULTS AND DISCUSSION

I. HIGHLAND RIM EXPERIMENT STATION

In the experiment conducted at the Highland Rim Experiment Station, near Springfield, the few weeds that were present in the fescue stand were killed and sod control was excellent in all treated plots, plowed and unplowed (Table IV). However, in the untreated check plot, the fescue continued to grow vigorously and eliminated the corn. The corn seedlings emerged but did not reach maturity.

Some panicum species invaded the sod plots near the end of the growing season. Season-long weed control was best where a seedbed had been prepared and treated with atrazine, but was adequate on both herbicide treatments of the sod-planted plots (Table IV).

Several problems were encountered with the different sod planters used during planting. The Ferguson planter was inflexible. In rough or uneven terrain, it was hard to keep the press wheels on the ground at all times. This resulted in skipped areas, due to the dual function of the press wheel to manipulate seed deposition, as well as to press the sod back in place. The small discharge tube, located behind the single disk coulter, clogged easily, resulting in uneven seed distribution. However, soil disturbance was reduced to a minimum (Figure 6).

With the Allis-Chalmers planter, entry of the fluted coulter to the proper depth in the sod was difficult to achieve. It was necessary to add 600 pounds of weight to the planter in order to obtain the

TABLE IV
AVERAGE SOD CONTROL AND WEED CONTROL RATINGS FOR CORN PLOTS ON SOD
AT SPRINGFIELD, TENNESSEE, 1968

Treatment	Rate lbs. ai/A	Sod Control		Weed Control	
		July 5 ^a	Oct. 3	July 5	Oct. 3
Untreated check	0	0	0	0	0
Conventional seedbed plus atrazine	2	10.0	9.2	10.0	8.2
Atrazine plus surfactant	3 + 1/2%	9.0	8.0	9.2	7.0
Atrazine plus paraquat plus surfactant	2 + 1/2 + 1/2%	8.3	8.0	9.2	7.2

^a0 = no control, 10 = complete control.



Figure 6. Sod in the foreground was planted with the Ferguson planter at the Highland Rim Experiment Station in 1968.

desired planting depth. If the fertilizer had been applied at the time of planting, the added weight of fertilizer in the fertilizer boxes would have partially solved this problem.

No mechanical problems were encountered with the Side-Winder planter during this experiment. However, much more horse-power was needed to operate this planter, because of the rotary cultivators which were set to prepare a 2-inch wide cultivated strip (Figure 7).

Plant populations were recorded in the sub-treatments, planters and planter speeds, for both the sod and conventional seedbed. Although the planters had been calibrated prior to planting to deliver 16,000 seeds per acre, there was considerable variation in the plant population obtained among planters and planter speeds, in both the sod and conventional seedbed. These differences were statistically significant at the 0.05 level of significance (Table V). Highest plant populations in sod were obtained from the Side-Winder and Allis-Chalmers planters, at a speed of 2 mph. Lowest plant populations occurred with the Ferguson planter at 4 and 6 mph, and the Allis-Chalmers at 6 mph.

Plant Lodging

There was significantly less stalk lodging in the sod treatment than in the conventional seedbed (Table VI). The higher incidence of lodging in the conventional seedbed may have been due to a higher plant population, or to seedbed preparation. There was little root lodging in any of the treatments.



Figure 7. Sod immediately after planting with the Side-Winder planter at the Highland Rim Experiment Station in 1968.

TABLE V

AVERAGE PLANT POPULATION OF CORN PLANTED WITH VARIOUS PLANTERS AND
AT THREE DIFFERENT SPEEDS IN SOD AND IN THE CONVENTIONAL
SEEDBED AT SPRINGFIELD, TENNESSEE, 1968

Planter	Speed mph	Plant Population			
		Sod		Conventional	Seedbed
Ferguson	2	11,800 ^a	b	11,800 ^a	d
Ferguson	4	8,700	de	10,300	e
Ferguson	6	8,700	de	10,500	e
Allis-Chalmers	2	14,300	a	18,500	a
Allis-Chalmers	4	10,000	cd	18,500	a
Allis-Chalmers	6	8,200	e	15,900	b
Side-Winder	2	14,500	a	16,000	b
Side-Winder	4	11,100	bc	14,900	bc
Side-Winder	6	10,500	bc	14,500	c

^aPopulations followed by the same letter are not significantly different from each other at the 0.05 level of probability.

TABLE VI

AVERAGE YIELD, CROP VIGOR RATING, AND PER CENT LODGING OF CORN UNDER
DIFFERENT SOD TREATMENTS AT SPRINGFIELD, TENNESSEE, 1968

Treatment	Yield bu/A P < 0.10	Crop Vigor		Lodging %
		July 5 ^a	Oct. 24	
Untreated	0	9	10	
Conventional seedbed plus atrazine	52 ^b	3.5	4	31 ^c
Atrazine plus paraquat plus surfactant	62	4.0	3.0	14
Atrazine plus surfactant	67	4.0	2.5	11

^a10 = dead, 0 = no injury.

^bSignificant difference in yields (untreated check not included in the analysis).

^cHighly significant different lodging per cent.

NOTE: Duncan's Multiple Range Test, Critical values after Harter.

Crop Vigor

Crop vigor was fair early in the season (Table VI). Due to adverse weather conditions, emergence was slow and the last seedlings to emerge were weak and chlorotic. These corn plants were never as vigorous throughout the growing season as those emerging earlier. Corn plants in the untreated check plots lacked vigor throughout the growing season, were stunted, and died before maturity due to competition.

Precipitation in the latter part of the growing season was not adequate for optimum grain yields (Table VII). During the month of August only .79 inch rain fell, which is well below the state average for this period.

Corn Yield

An analysis of variance was conducted to determine if there were any significant yield differences and interactions in the experiment (Table VIII).

There was a significant difference in corn yield for the herbicide treatments in this experiment. The conventional seedbed produced less corn grain than did the sod plots. Yields varied from 52 bushels per acre for the conventional seedbed to 67 bushels per acre for the sod-planted treatment receiving atrazine plus surfactant (Table VI). No grain was produced by the untreated check due to competition from the uncontrolled fescue sod.

There were no significant differences in grain yields among the sub-plots or the sub-sub-plots (Table IX). Yields for the sub-plots ranged from 56 bushels per acre from the plots treated with the Ferguson

TABLE VII
DAILY RAINFALL IN INCHES AT THE HIGHLAND RIM EXPERIMENT STATION,
SPRINGFIELD, 1968

Date	Month					
	April	May	June	July	Aug.	Sept.
1	.55					.02
2			.68	.05	.01	
3	.35		.28			
4	1.34	.72				.11
5	1.26					.62
6						.07
7					.03	
8	1.45					
9	.30	.35		.95		
10	.12					.10
11		.26			.42	
12		.25				
13		.02				
14		.88			.28	
15	.30	.02				
16		.61			.05	.12
17	.01		1.60	.05		.47
18	.08	.44				.42
19						.52
20	.01					
21		.02				
22						
23	.05	.04				
24						.59
25		.02				
26		1.07				
27	.32	1.04	.07	.53		
28	.08			1.35		
29	.12			.20		
30	.01	.23				
31				.15		
Total	6.23	6.09	4.22	3.28	.79	3.04

TABLE VIII

ANALYSIS OF VARIANCE TABLE FOR AVERAGE GRAIN YIELDS IN THE CORN ON
SOD EXPERIMENT CONDUCTED AT SPRINGFIELD, TENNESSEE, 1968

Source	D.F.	Sum of Squares	M.S.	F. Test
Replications	3	181.78	60.59	3.36 ^a
Herbicides	2	161.17	80.58	4.48 ^a
Error A	6	108.05	18.01	
Planters	2	28.93	14.47	1.46 NS
Speeds	2	12.00	6.00	.61 NS
Planters x Speeds	4	4.36	1.09	.01 NS
Error B	24	235.28	9.80	
Herbicides x Planters	4	13.27	3.32	1.14 NS
Herbicides x Speeds	4	18.01	4.50	1.55 NS
Herbicides x Planters x Speeds	8	48.26	6.03	2.07 ^a
Error C	58	137.90	2.87	
Total	107	948.99		

^aSignificant at the 0.10 level.

TABLE IX

AVERAGE YIELD OF CORN GROWN ON THE SUB-PLOTS AND SUB-SUB-PLOTS AT
SPRINGFIELD, TENNESSEE, 1968

	Yield bu/A (P<0.10)
<u>Planter</u>	
Ferguson	56 ^a
Allis-Chalmers	62
Side-Winder	63
<u>Speed of Operation</u>	
2 mph	63 ^a
4 mph	59
6 mph	59

^aNo significant difference in yield.

planter to 63 bushels per acre for the Side-Winder treatment. Yields for the sub-sub-plots varied from 59 bushels per acre for the plots treated with the 4 and 6 mph speed of operation to 63 bushels per acre for the plots treated with the 2 mph speed. Apparently, limited rainfall masked the yield differences that might have resulted from a wide range of plant populations. Yields were below expectation for all treatments.

II. TOBACCO EXPERIMENT STATION

At Greeneville, precipitation was adequate for higher corn yields (Table X). This experiment was conducted in an old orchardgrass sod and several species of weeds were present at the time of planting. The more prominent weeds present were johnsongrass (Sorghum halepense L.), dallisgrass (Paspalum dilatatum L.), foxtail (Setaris italic L.), bluegrass (Poa pratense L.), trumpet creeper (Campsis radicans L.), horse nettle (Solanum Carolinense L.), and passionflower (Passiflora incarnata L.).

Sod Control

The sod was not mowed or grazed prior to planting, and the dense orchardgrass was 2 feet high (Figure 8). However, sod control was good (Table XI). The above mentioned weeds, except bluegrass, were somewhat resistant to the atrazine-paraquat combination. These weeds had apparently been suppressed by the orchardgrass stand and grew vigorously after the orchardgrass was killed. One replication, infested with johnsongrass, was abandoned. It was not anticipated that the herbicides used would control this weed.

TABLE X

DAILY RAINFALL DATA IN INCHES AT THE TOBACCO EXPERIMENT STATION,
GREENEVILLE, TENNESSEE, 1968

Date	Month					
	April	May	June	July	Aug.	Sept.
1	.99				.73	.44
2			.14		.02	
3	.23		.46	1.48		
4		.16				
5	.33					
6						.17
7						
8	.24		.40			
9			.07	.06		
10	.33		.12	.04	.01	.90
11				.03	.67	
12		.07	.09			
13				.01		
14		.75				
15	.50	.20				
16		.10		.01		
17		.10	1.07			
18		.32	.43			.07
19				.91		.07
20				.09		
21		.04				
22						
23	.03			.12		
24			.18			
25		.33	.56		.02	
26		.83		.16	.17	.28
27	.07	.61	.28	.43		.11
28				.22		
29	.58					
30	.09	.41		.05		
31				.48		
Total	3.94	3.92	3.80	4.09	1.62	2.04



Figure 8. At the Tobacco Experiment Station, the sod was not mowed or grazed at planting in 1968.

TABLE XI

AVERAGE SOD KILL AND WEED CONTROL RATING FOR CORN GROWN ON
SOD AT GREENEVILLE, TENNESSEE, 1968

Herbicide	Rate lbs. ai/A	Sod Control		Weed Control	
		July 25 ^a	Oct. 24	July 25	Oct. 24
Conventional seedbed plus atrazine plus paraquat	2 + 1/2	8.0	8.0	7.5	7.5
Atrazine plus paraquat plus surfactant	2 + 1/2 + 1/2%	8.0	8.0	6.2	6.2

^aAverage of four replications, 0 = no control, 10 = complete control.

Several grass species in the Paniceae and Andropogoneae tribes are resistant to atrazine. Before starting an extensive sod planting program, careful observation should be made to determine the quantity and type of resistant species in an area. Several species have seed that are capable of lying dormant in the soil for several years, then germinating and becoming highly competitive with the corn crop.

Weed control was fair (Table XI). Several of the species present at planting were not killed, but were too few in number to be competitive with the corn. Weed control was adequate for high yields.

Soil Tests

Soil tests showed the area to be low in phosphorus. This permitted a comparison of the phosphate formulations added to the soil. Soil samples were taken again on July 25 at 2, 4, and 6 inches to determine whether there had been movement of surface-applied phosphorus into the soil (Table XII). In all of the fertilized sod plots, most of the phosphorus was found in the surface 2 inches, indicating the immobility of phosphorus regardless of formulation. In the conventional seedbed, the phosphorus was incorporated into the soil with a power-driven rotary cultivator. In this treatment the phosphorus was distributed fairly uniformly in the top 6 inches of soil. The phosphorus content of the check plot was the same as that in the soil samples taken prior to planting.

TABLE XII
AVERAGE POUNDS PER ACRE OF PHOSPHORUS AT DIFFERENT SOIL DEPTHS FROM SAMPLES
TAKEN JULY 25, 1968, AT GREENEVILLE, TENNESSEE

Type of Seedbed	Source of Fertilizer	Rate lbs/A	Depth in Inches	Lbs. Phosphorus/A
Sod	No fertilizer	0	2	4
			4	4
			6	4
Conventional seedbed	6-12-12(N-P ₂ O ₅ -K ₂ O)+NH ₄ NO ₃	800 + 50	2	24
			4	23
			6	18
Sod	6-12-12(N-P ₂ O ₅ -K ₂ O)+NH ₄ NO ₃	800 + 50	2	40
			4	6
			6	7
Sod	15-15-15(N-P ₂ O ₅ -K ₂ O)	800	2	47
			4	5
			6	4

Plant Lodging

There was no noticeable difference in stalk lodging between the sod planted corn and that planted in a conventional seedbed. No plot had more than 10 per cent stalk lodging, and root lodging did not occur.

Crop Vigor

Crop vigor was excellent in all plots except those receiving no fertilization. Treatments receiving a complete fertilizer at planting were vigorous throughout the growing season. The fertilized plots had an average rating of 0.4 which means they were growing vigorously, while the check plots received an average rating of 3 on the same scale (Table XIII). The no-fertilizer treatment lacked normal vigor throughout the growing season and produced significantly lower yields than the fertilized treatments (Table XIII).

Corn Yields

There was no significant difference in corn yields between the two phosphate formulations or between phosphate incorporated into the soil or applied broadcast to the top of the soil.

Another treatment receiving fertilizer lacking in phosphorus would be necessary to determine the effect of phosphorus on yields. However, this treatment was omitted from the experiment.

TABLE XIII
AVERAGE YIELD AND CROP VIGOR RATINGS FOR CORN GROWN ON SOD
AT GREENEVILLE, TENNESSEE, 1968

Treatment	Yield bu/A ($P < 0.10$) ^a	Crop Vigor July 5 ^b
Unfertilized Check	81	3.0
Monocalcium Phosphate	111	0.3
Dicalcium and Tricalcium Phosphate	106	0.3
Monocalcium Phosphate Incorporated	118	0.7

^aSignificantly different yields.

^bAverage of three replications: 10 = dead, 0 = maximum vigor.

CHAPTER V

SUMMARY AND CONCLUSIONS

At the Highland Rim Experiment Station near Springfield, in 1968, a study was conducted to determine the effects of herbicide treatments, sod planters, and planter speeds on corn plant population and yields. Corn grown on chemically killed sod was compared to that grown on a conventionally prepared seedbed for weed control, plant lodging, plant vigor, plant population, and yield. Another study was conducted at the Tobacco Experiment Station near Greeneville to determine if the solubility of different phosphate compounds in a complete fertilizer affected corn yields when the fertilizer was broadcast on top of the soil at planting time. Also, phosphorus was incorporated into the soil to check the importance of site of deposition upon corn yields.

At Springfield, the three herbicide treatments gave excellent sod kill and adequate weed control for high corn yields. However, limited rainfall during the latter part of the growing season resulted in reduced yields for all plots.

The sod plots yielded considerably more corn than the conventional seedbed plots. The yield increase could have been due to higher moisture in the untilled area. The mulching effect of the dead sod reduced evaporation and runoff thus reducing soil moisture loss. The sod plots contained a lower plant population than the conventional seedbed which is sometimes beneficial in dry years due to competition for moisture. There was considerably more stalk lodging in the conventionally prepared

seedbed, possibly because of the higher plant population; or the lodging could have been the result of seedbed preparation. Corn in the check plot failed to reach maturity due to competition from the fescue sod.

There was no significant difference in yields in relation to the type of sod planter used in the experiment.

In the sub-sub-plots there was no significant difference in corn yields. There was considerable variation in plant population between the different sod planters used and also between different operating speeds in the experiment. In this experiment the Side-Winder and Allis-Chalmers planters at 2 mph produced the highest plant populations in sod. These differences were not reflected in yield differences. Poor growing conditions during the month of August may have resulted in low yields per plant for plots with high plant populations.

In the experiment conducted at the Tobacco Experiment Station, an application of 2 pounds active ingredient of atrazine plus 1/2 pound active ingredient per acre of paraquat gave excellent sod control and adequate weed control.

There was no significant difference in corn yields between different soluble phosphorus formulations applied to the soil low in phosphorus. When phosphorus was incorporated into the soil at planting, yields were not significantly higher than when it was broadcast on top of the soil. There was a significant increase in corn yield due to application of fertilizer when compared to the unfertilized check,

Differences in the solubility of the two phosphate sources did not reflect significant differences in yield for this experiment.

Broadcasting phosphorus gave as good a yield as phosphorus incorporated into the soil.

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VITA

John R. Roper was born December 25, 1944, in Manchester, Tennessee. He attended the public schools of Coffee County, Tennessee. Later, he received the Bachelor of Science in Agriculture degree in June, 1967, from The University of Tennessee, Martin, and the Master of Science degree with a major in Agronomy in June, 1969, from The University of Tennessee.