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To the Graduate Council:

I am submitting herewith a thesis written by Boyd E. Brown entitled "Growing Corn and Soybeans on Chemically Killed Sod." 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.

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GROWING CORN AND SOYBEANS ON CHEMICALLY KILLED SOD

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

Boyd E. Brown

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ABSTRACT

A study was made to (1) determine whether soybeans (Glycine max. (L) Merrill) could be grown successfully on chemically killed sod, (2) to evaluate a new experimental herbicide for use in growing corn (Zea mays L.) on sod, (3) to test different rates and combinations of recommended herbicides, and (4) to determine the effect of herbicide residues on the germination and growth of six fall-seeded crops following sod-planted corn.

It was found that weed control was fair to excellent in all treatments in both corn and soybeans.

In the soybean experiments, sod control was insufficient for good soybean growth in any of the treatments except the conventionally prepared seedbed at Knoxville. Yield data were not obtained in the soybean experiments.

Sod control in the corn experiments was good enough for high yields. At Springfield, the only location where yield data were taken, the best sod control and highest yields were obtained from the treatment using two pounds 2-chloro-4-ethylamino-6-isopropyl-amino-s-triazine (atrazine) plus one-quarter pound of 1, 1'-dimethyl-4,4'-bipyridinium salt (paraquat). The poorest sod control was in the treatment with two pounds of atrazine plus four pounds of cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid (AP20). This treatment also resulted in the lowest corn yields.

Rye (Secale cereale L.) at Springfield was the only fall-seeded crop that became established. There was no apparent herbicide injury to the rye as a result of herbicide residues.

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CHAPTER I

INTRODUCTION

Weed control is one of the most important phases of row crop production. Until recent times, cultivation has been the prevailing method of controlling weeds. Cultivation has always been associated with increased erosion due to more rapid water runoff, depletion of organic matter, increased surface evaporation, and impairment of soil structure (28).[*]

The use of selective herbicides to control weeds was an important step in eliminating the tillage hazards associated with row crop production. At first herbicides were used as a "chemical hoe" to control weeds in the row. Next the herbicides were broadcast over the entire soil surface to eliminate the necessity of cultivation.

A farther step in reducing tillage operations was the plow-plant method. With this method the field is plowed and the crop planted without disking or leveling the soil surface. Herbicides are used to control weeds. This is known as minimum tillage.

With corn, minimum tillage has been carried a step farther. Selected herbicides are applied directly to the sod surface, after which corn is planted with a special planter designed for use in untilled soil. This method of growing corn is known as zero tillage and has proved successful at some experiment stations (1,12,16).

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

The benefits derived from this method of corn production are obvious. Erosion and runoff are reduced, the organic matter is depleted less rapidly than with cultivation, soil surface evaporation is reduced, and the favorable soil structure developed under sod is maintained.

Another advantage is the elimination of tillage operations to prepare the soil for planting. The cost of herbicides required to kill the sod is less than the cost of plowing and disking the soil to prepare a conventional seedbed. Therefore the cost of planting corn is reduced.

Still another advantage is that during a wet spring, high soil moisture may delay preparing a conventional seedbed. With minimum tillage, however, corn can be planted when the soil is too wet to plow or disk.

When considering the millions of acres of land that are too steep for cultivation, the significance of the benefits received from planting crops in chemically killed sod can be seen. If the demand for food keeps increasing as is expected, much of this land could be used to produce badly needed crops if minimum tillage is used. One of the present benefits would be the reduction of erosion on much of the steep land now being cultivated.

If crops that can be grown on chemically killed sod could be expanded to include such plants as soybeans, it would be a step of major importance to agriculture. In many states such as Tennessee where much of the land is sloping, more of it could be used for profitable row crop production.

One of the limitations in using some herbicides has been the persistence of herbicidal residues in the soil after the crop has been harvested. Because of this persistence, crops such as oats (*Avena sativa* L.) and other small grains cannot be sown in the fall due to injury resulting from herbicides applied the preceding summer.

The purpose of this study was fourfold: (1) to determine whether soybeans could be grown successfully on chemically killed sod, (2) to evaluate a new experimental herbicide for use in growing corn on sod, (3) to test different rates and combinations of recommended herbicides, and (4) to determine the effect of herbicide residues on the germination and growth of six fall-seeded crops following sod-planted corn.

CHAPTER II

REVIEW OF LITERATURE

I. MINIMUM TILLAGE IN CORN PRODUCTION

Much work has been done in growing corn without cultivation on chemically killed sod. Moody *et al.* (33) stated that the new approach to growing corn affords excellent soil and water conservation in that the dead grass acts as a mulch to protect the soil, thereby reducing runoff and evaporation. The mulch also aids the infiltration of summer rains into the soil (29). Moscher (34) found 6 per cent more soil moisture under sod-planted corn than under conventionally tilled corn, especially during the first half of the growing season. In addition to these advantages, Shear *et al.* (41) suggest that sod-planting will help to maintain the favorable soil structure built up under grass, whereas tillage operations tend to destroy it.

Minimum tillage also reduces the number of times the tractor must be on the field. This reduces the amount of soil compaction. Phillips and Kirkham (36) found that soil compaction reduced the corn stand. Even when the stands from the compacted and uncompacted soils were equalized, it was found that the yields were reduced from 90 to 82 bushels per acre on the compacted soil.

Research data show that the reduced number of tillage operations does not affect yields in most cases. At the University of Illinois, tests were run for three consecutive years, 1962, 1963, and 1964, to compare the effect of different numbers of tillage operations on corn yields (22). Results of these tests showed that the number of diskings after plowing and before planting had little influence on corn yield, plant population, or soil moisture. Neither did cultivation alone, or in addition to preemergence herbicides, have a significant effect on these characteristics when compared to atrazine alone. The major exceptions were on light colored soils low in organic matter, such as Blount Silt Loam, where cultivation resulted in higher corn yields two years out of three when compared with soils high in organic matter.

In soils which tend to crust heavily, cultivation may be beneficial. Prihar (37) obtained corn grain yield increases of 1,790 kilograms per hectare which he associated with post-planting cultivation of weed-free corn on a soil susceptible to crusting. The infiltration of water was increased by 770 kilograms per hectare when the crusted soil was cultivated. Cultivation reduced short-term water evaporation from the soil surface 30 to 45 per cent and resulted in a two to six fold increase in root weights between corn rows to a depth of 23 centimeters.

Under most other soil conditions, a practically complete sod kill is the most important factor for success in growing corn on chemically killed sod. Shear (40) reported a 40 bushel per acre reduction in corn yields which he attributed to incomplete kill of the orchardgrass (<u>Dactylis glomerata</u> L.) sod.

Many herbicide mixtures have proved satisfactory for killing sod. Triplett (46) found several herbicide combinations to be satisfactory. Most of these contained atrazine or 2-chloro-4,6-bis (ethylamino)-s-triazine (simazine) for control of perennial grasses and annuals and 2,4-dichlorophenoxyacetic acid (2,4-D) or a similar herbicide for destruction of broadleaf perennials.

Treanor and Andrews (45) did some preliminary work with sod planting and found that four pounds of atrazine per acre gave good sod control as did two pounds of atrazine plus one-half to one pound of paraquat.

Andrews and Bryant (2) obtained good sod control using atrazine at the rate of three and four pounds active ingredient per acre plus a surfactant. They obtained excellent yields of sod-planted corn grown without cultivation.

Lewis (30) found that two pounds atrazine plus one-fourth pound of paraquat gave good control of perennial sod at Raleigh, North Carolina.

Work was done by Peters and Andrews (35) to determine the effect of sod height and time of herbicide application on soil moisture, soil temperature, and yields of corn grown 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 found that corn planted on sod that had been mowed and sprayed the same day gave excellent results as did sod that was sprayed and not mowed.

II. REDUCED TILLAGE IN SOYBEAN PRODUCTION

Soybean acreage in the United States has increased to an estimated 40,123,000 acres in 1967. Many thousand acres were on sloping upland where serious erosion hazards exist. Many farmers are practicing reduced tillage in order to reduce erosion. Some Illinois farmers use chisel plows or disks rather than moldboard plows to prepare the seedbed (5). Herbicides are used to reduce the number of cultivations necessary for weed control. Other farmers are using the plow-plant method of tillage for soybeans (27).

Beale and Langdale (3) found that the physical properties of the lister plant tilled and disk harrow tilled soils were more favorable for soybean growth than those of the turnplow tilled soils.

McAlister (31) tested a minimum tillage lister-planter that prepared the seedbed, distributed fertilizer, and planted the soybeans in one operation after small grain had been harvested in mid June. He suggested that soil moisture conservation, improved soil tilth, and lower production costs are factors that favor lister planting of soybeans without burning the straw or using conventional turnplow tillage.

III. EFFECT OF SURFACTANTS ON CONTACT KILL OF HERBICIDES

Surfactants have an important influence on the surface tension relationship which occurs between the herbicide and plant foliage.

Staniforth and Loomis (44) stated that the major influence of surfactants on herbicide activity was found in the range of concentrations above which the greatest changes in surface and interfacial tensions occur. Schwartz and Perry (39) found that in addition to these changes, surfactants also modify the characteristic drop in the electrical potential of a two-phase system such as occurs in the herbicide-plant relationship.

The use of surfactants to increase herbicide activity is a desirable practice. Behrens (4) states that surfactants are useful additives for formulated herbicides because they contribute to wetting, spreading, emulsification, and solubilization of the herbicide.

In addition to the action of surfactants at the point of contact between the plant surface and the herbicide, Freed and Montgomery (17) speculated that surfactants may help to maintain the herbicides in a fluid state when the aqueous carrier begins to evaporate, thus enabling more of the herbicide to penetrate the plant foliage.

Many experiments have been conducted which show that the use of surfactants increases herbicide action. Boyer and Drever (8) found that in general, 3-(3,4-dichlorophenyl)-1,1-dimethylurea (diuron) caused foliage burn most rapidly when used in conjunction with surfactants which thoroughly wetted the plants. Marginal and tip burn were apparent on some plants one day after spraying with the diuron-surfactant combination. Plants treated with the less phytotoxic surfactants began to show similar effects only after two or three days. 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.

Jansen _et_ _al_. (24) in a test of 63 surfactants found that the most common reaction obtained was a progressive enhancement of herbicide activity with logarithmic increases in surfactant concentration.

Freed and Montgomery (17) studied the effect of alkylarylpolyoxyethylene glycols on the foliar adsorption of 3-amino-1,2,4-triazole (amitrole) applied to beans. When amitrole alone was applied, only 12.2 per cent of the herbicide had been adsorbed after 24 hours; but with the addition of alkylarylpolyoxyethylene glycols, 51.0 per cent had been adsorbed after 24 hours. The surface tension dropped from 69.6 to 50.9 dynes/cm.

Mitchell and Linder (32) obtained increases in both the concentration and total amount of 2,4-D in the main axis of plants when pollyoxyethynene sorbitan monolaurate was added. As a result of this increased rate of adsorption and translocation due to pollyoxyethynene sorbitan monolaurate, the amount of herbicide which moved from the leaves to the roots was increased by 71 per cent.

The interaction of several paraquat-surfactant mixtures when applied to corn foliage were studied by Smith and Foy (43). When one gram of pollyexyethynene sorbitan monolaurate was added per liter of herbicide solution, a rate of only one-eight ounce per acre of paraquat was required to cause a 50 per cent reduction in weight of corn. When paraquat was sprayed without surfactant, a rate of approximately one and one-half to two ounces per acre was needed to cause the same reduction.

Hill et al. (21) studied the influence of several surfactants on the activity of diuron, 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea (linuron) and 5-bromo-3-sec-butyl-6-methyluracil (bromacil) as foliar sprays on weeds. In this test, alkylarylpolyoxyethylene glycols was superior to others with all three materials.

IV. CONTACT KILL CHARACTERISTICS AND PERSISTENCE OF SPECIFIC HERBICIDES

Atrazine

Atrazine is primarily a preemergence herbicide, but because it can be adsorbed through foliage, as well as roots, it also had post-emergence effects (28). The addition of a surfactant will increase the postemergence effect as shown by Ilnicki et al. (23) working with broadleaf weeds. Dexter et al. (13) used an early spraying of atrazine plus alkylarylpolyoxyethylene glycols to reduce the top growth yield of six grass species.

The use of atrazine as a postemergence herbicide increases the chance of injury to the crop following corn. Results of tests by Saghir and Choundhary (38) showed that toxicity to subsequent crops from a postemergence application of atrazine was much higher than from a preemergence application. The effects were more pronounced with winter crops than spring crops.

Past research by Wisk and Cole (47) indicated that when atrazine was used on a crop at rates no higher than three pounds active ingredient per acre, only slight injury occurred to oats sown afterwards. In oats planted in the fall of 1962 and 1964 slight injury occurred but there was no significant reduction in stand or vigor.

Bryant (10) reported, from bioassay data, that toxicity from an application of two pounds atrazine generally disappeared with 16 weeks at Knoxville and 24 weeks at Jackson. He also found that oats seeded in the field showed no significant injury at either location where atrazine at two pounds per acre had been applied to the preceding crop. At the rate of five pounds atrazine, however, some injury occurred.

Toxic and non-toxic levels of atrazine have been established for certain agronomic crops by the Pennsylvania Agricultural Experiment Station (9). Workers found that oats and soybean seedlings were killed when there was from nine-tenths of a pound to one pound per acre of atrazine present in the soil. Legume seedlings started to show damage when the atrazine level in the seedling zone reached eight-tenths pound per acre. The seedlings of all other common agronomic species except corn were damaged if the level of atrazine was over one pound.

Paraquat

Paraquat is an effective contact herbicide which rapidly kills green plant tissue (7). In short-time studies, it was determined that paraquat caused a stimulation in respiration and an inhibition in photosynthesis of duckweed (*Lemna minor* L.) (19).

The rapid disappearance of paraquat due to photodecomposition would indicate there should be no residue problem. Slade (42) applied paraquat dichloride to corn, tomato (*Lycopersicon esculentum*), and bean (*Phaseolus vulgaris* var. *humilis*) plants as droplets of aqueous solution. The plants were analyzed at intervals and the results showed that the degradation of paraquat was caused by photochemical decomposition on the leaf surface and not by metabolism. The degradation was not observed in the dark and occurred to a significant extent only in the daylight.

Herbicide residue from paraquat is so low that autumn and spring cereal crops may be drilled into the soil after spraying with paraquat without causing injury to the crops. Feater and McIlvenny (15) reported that yields from autumn and spring cereal crops direct-drilled into pasture or weedy stubble after spraying with paraquat were comparable with those obtained from normal cultivation.

Blood (6) found that perennial ryegrass and white clover had some resistance to low doses of paraquat.

AP20

AP20 is an experimental contact herbicide and no references are available as to its effectiveness as a herbicide.

Linuron

Linuron is a recent addition to the group of substituted urea herbicides. In addition to being used as a preemergence herbicide, it has postemergence contact toxicity to both broadleaf and grass weeds (28).

Herbicide residue would not be a problem when linuron is used to control sod. Dubey *et al.* (14) found that, in general, soils having higher organic matter resulted in less herbicidal activity, indicating that there is probably a faster rate of breakdown of these herbicides in such soils.

Wisk and Cole (50) reported no injury to fall-seeded oats after using linuron at the rate of one pound per acre for two consecutive years.

Bryant (10) reported no injury to oats in the field following linuron treatments except at Knoxville in 1965 where five times the recommended rate of one pound active ingredient was used.

2-ethylamino-4-isopropylamino-6-methylmercapto-s-triazine (ametryne)

Ametryne is a preemergence herbicide of the triazine group. Johnson (25) reported that ametryne at the rate of three and four pounds active ingredient per acre resulted in slight injury to soybeans while 80 per cent broadleaf weed control and 88 per cent annual grass weed control were obtained.

Freeman (18) found that one pound of atrazine plus one pound of ametryne applied preemergence resulted in 93 per cent control of grass and 100 per cent broadleaf weed control. No injury was apparent in the corn.

4, 6-dinitro-o-sec-butylphenol (DNBP)

DNBP is very toxic to growing plants and is used as a general contact herbicide (11). It lacks selectivity and is toxic to all plants when used at high rates. DNBP is a respiration stimulant and inhibits the action of growth substance.

Jones (26) found a decline in the activity of DNBP between five and twelve weeks after application. The only case where residue was a problem was at Knoxville where it had been applied at five times the recommended rate or 30 pounds acid equivalent per acre.

CHAPTER III

MATERIALS AND METHODS

Experiments were conducted at the Highland Rim Experiment Station near Springfield, Tennessee, and the Plant Science Farm near Knoxville, Tennessee, in the summer of 1967 to (1) determine whether soybeans could be grown successfully on chemically killed sod, (2) to evaluate a new experimental herbicide for use in growing corn on sod, (3) to test different rates and combinations of recommended herbicides, and (4) to determine the effect of herbicide residues on the germination and growth of six fall-seeded crops following sod-planted corn. The plots consisted of six rows 42 inches wide and 35 feet long arranged in a randomized complete block design. At Springfield eleven treatments were replicated five times and at Knoxville ten treatments were replicated four times.

The treatments used are shown in Tables I and II. The untreated checks in corn and soybeans were used to compare the growth of the chemically treated sod with that of the untreated sod. In corn, three pounds of atrazine plus dodecyl ether of polyethylene glycol were used as a standard to which the other chemical treatments could be compared. In past experiments this herbicide mixture has given good sod control and resulted in yields as high as those obtained in corn grown in a conventional seedbed (2). Three pounds of atrazine plus surfactant tri-ionic were used to compare the relative effectiveness of the ionic and

TABLE I

TREATMENTS USED IN THE CORN AND SOYBEANS ON SOD EXPERIMENTS CONDUCTED AT SPRINGFIELD, TENNESSEE, IN 1967

Treatment	Rate in lbs. ai + % Surfactant by volume
CORN	
Untreated Check	------
Atrazine + dodecyl ether of polyethylene glycol	3.0 + 0.3
Atrazine + surfactant tri-ionic	3.0 + 0.3
Atrazine + paraquat + alkyl-phenoxy polyethoxy	2.0 + 0.5 + 0.3
Atrazine + paraquat + alkyl-phenoxy polyethoxy	2.0 + 0.25 + 0.3
Atrazine + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid + dodecyl ether of polyethylene glycol	2.0 + 4.0 + 0.3
Atrazine + amatryne + dodecyl ether of polyethylene glycol	2.0 + 1.0 + 0.3
SOYBEANS	
Untreated Check	------
DNBP + dodecyl ether of polyethylene glycol	6.0 + 0.3
Linuron + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid + alkyl-phenoxy polyethoxy	0.5 + 4.0 + 0.3
Linuron + paraquat + alkyl-phenoxy polyethoxy	0.5 + 0.5 + 0.3

TABLE II

TREATMENTS USED IN THE CORN AND SOYBEANS ON SOD EXPERIMENTS CONDUCTED AT KNOXVILLE, TENNESSEE, IN 1967

Treatment	Rate in lbs. ai + % surfactant by volume
CORN	
Conventional seedbed + cultivation	-----
Untreated Check	-----
Atrazine + dodecyl ether of polyethylene glycol	3.0 + 0.3
Atrazine + paraquat + alkyl-phenoxy polyethoxy	2.0 + 0.5 + 0.3
Atrazine + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid + dodecyl ether of polyethylene glycol	2.0 + 4.0 + 0.3
Atrazine + amatryne + dodecyl ether of polyethylene glycol	2.0 + 1.0 + 0.3
SOYBEANS	
Conventional seedbed + cultivation	-----
Linuron + paraquat + alkyl-phenoxy polyethoxy	0.5 + 0.5 + 0.3
Linuron + paraquat + alkyl-phenoxy polyethoxy + power driven rotary cultivator	0.5 + 0.3
DNBP + alkyl-phenoxy polyethoxy + power driven rotary cultivator	6.0 + 0.3

non-ionic surfactants when used with high rates of atrazine. Two pounds of atrazine plus AP20 were used to determine if the experimental herbicide would be effective in controlling sod for corn production. The other treatments used in growing corn on sod were to determine if a cheaper mixture of herbicides could be found that would be as effective as the high rates of atrazine plus a surfactant.

Another reason for using treatments with reduced rates of atrazine plus other herbicides was that with high rates of atrazine, residues sometimes affect fall-seeded crops. The purpose was to find a herbicide mixture which would eliminate the residue problem.

The herbicides used to control the sod in the soybean treatments did not include atrazine which gives excellent sod control but would also kill the soybeans. The herbicides used in the soybean experiments were selected because it was thought that they would control the sod yet not injure the soybeans.

At Knoxville the experiment was located on a Sequoia silt loam and at Springfield on a Dickson silt loam. A vigorous, uniform stand of tall fescue (*Festuca arundinacae* Schreb.) sod was growing on each experimental site. The grass was mowed with a rotary mower to a height of about three inches at both locations. This height was selected because it best simulates spring grazing conditions.

For treatments requiring a conventional seedbed, the plots were plowed and disked. A power driven rotary cultivator was used to work up the sod in the rows where soybeans were to be planted. This treatment was not used on corn rows, however. Prior to planting, approximately 600 pounds per acre of 6-12-12 fertilizer for corn and 600 pounds per acre of 20-20-20 fertilizer for soybeans was surface broadcast on all plots. At Springfield, but not at Knoxville, the corn was sidedressed with nitrogen fertilizer at the rate of 150 pounds per acre.

On May 30 at Springfield, and on June 8 at Knoxville, inoculated Ogden soybeans and Tennessee 604 corn were planted. The varieties used were recommended by The University of Tennessee Agricultural Experiment Station. A sod planter was used (Figure 1). The unique operational features of this type of planter are that a colter plate makes a vertical cut in the sod; then a slanting disk cuts and lifts a strip of sod. This is followed by the planter foot which deposits the seed in a two inch deep trench made by the disk plates. A packer wheel follows the planter foot and packs the strip of sod back down in the trench. As a result there is minimum disturbance to the soil.

A broadcast boom sprayer mounted on a conventional tractor was used to apply the herbicides at both locations. The sprayer was calibrated to deliver 60 gallons of solution per acre. A measured amount of the herbicide plus a one-half per cent solution by volume of surfactant were mixed with an appropriate quantity of water to deliver the desired active ingredient when sprayed at the rate of 60 gallons per acre. The surfactant was added to increase the contact kill of the sod by the herbicides. All the herbicides were sprayed uniformly over the soil the day after planting at Knoxville and four days after planting at Springfield.

Figure 1. Sod planter used in the corn and soybeans grown on sod experiment at two locations in Tennessee in 1967.

On July 22 and November 2 at Springfield, and on August 19 and October 5 at Knoxville, sod injury, weed control, and crop vigor ratings were made. The ratings were made on a zero to ten scale with zero indicating no weed control or injury to the sod and ten indicating complete weed control and sod kill. For plant vigor, zero indicated maximum vigor while higher numbers indicated reduced vigor and ten indicated complete kill of the crop. All ratings were visual estimates. This system of rating is widely used in the field of weed science.

Twenty feet of the two center rows of each corn plot at Springfield was harvested by hand to determine yields. The corn was weighed in the field and samples taken for moisture determination. Corn yields were calculated on a 15.5 per cent moisture basis.

On October 5 at Knoxville, and on November 2 at Springfield, orchardgrass, fescue, annual ryegrass (*Lolium multiflorum* Lam.), rye, oats, and crimson clover (*Trifolium incarnayum* L.) (Table III) were sown on the corn plots. A rotary mower was used to cut the corn stalks on the plots and a disk harrow was used to work the soil surface. The seed were surface broadcast with a two foot wide push model broadcast seeder at rates recommended by The University of Tennessee Experiment Station (Table III). Each corn plot was seeded with a two foot strip of each species with the strips within each plot arranged in a randomized pattern.

TABLE III

CROPS AND RATES OF SEEDING USED IN OVERSEEDING TO TEST THE PERSISTENCE OF HERBICIDES USED IN GROWING CORN ON CHEMICALLY KILLED SOD AT TWO LOCATIONS IN TENNESSEE IN 1967

Crop and Variety	Rate/A
Orchardgrass: Common Tennessee Grown	10 lb.
Fescue: Kentucky 31	10 lb.
Annual Ryegrass: Italian	20 lb.
Rye: Balbo	1-1/2 bu.
Oats: Forkedeer	2 bu.
Crimson Clover: Common	20 lb.

CHAPTER IV

RESULTS AND DISCUSSION

I. GENERAL OBSERVATIONS

At planting time sod growth was vigorous and the fields relatively weed free at both locations.

Precipitation was adequate at both locations for good yields (Tables IV and V).

II. RESULTS FROM CORN EXPERIMENTS

Sod Control

Even though sod is considered a weed in row crops, sod control is discussed separately from weed control here because it is the key to successful crop growth in this type of corn production. Also, some herbicides may control the grasses and legumes in a sod crop but not other weeds such a pokeweed (*Phytolacca americana*) and foxtail (*Setaria viridis* L.). Ratings on the control of these weeds were therefore made separately.

Sod control was good during the first half of the growing season in all chemically treated corn plots but regrowth was occurring in some plots when the fall ratings were made (Table VI). Sod regrowth at Knoxville was more rapid than at Springfield. This rapid sod regrowth was probably due to lack of competition from the corn since the

TABLE IV

RAINFALL AT THE AGRICULTURAL EXPERIMENT STATION, KNOXVILLE, 1967

	Inches				
	May	June	July	Aug.	Sept.
1		.38	.03		
2	.03	.01	.20		
3	.27	.05	.70		
4		1.78		.04	.09
5	.09	.01		.03	
6			2.10		
7	1.50		1.07		
8			.78		
9	.31		.11	T	.48
10				.07	.03
11		.12	.81		
12	.04		.04		
13	.98		.06		
14	.19	.04	.07		
15	.99				
16	.74				
17					
18		.03		.03	
19				.01	
20	.03				
21	.37			.19	
22	.05	.34		.09	.71
23		.87	.18	.29	
24				.16	
25		.03	.11	.29	
26		.69	.51	.66	
27			.06	1.12	
28				.02	1.50
29		.31	3.26		.47
30	.43	.03	.05		
31	.01				
Total	10.41	4.69	10.14	3.00	3.28

TABLE V

RAINFALL AT THE AGRICULTURAL EXPERIMENT STATION, SPRINGFIELD, 1967

	Inches				
	May	June	July	Aug.	Sept.
1	1.09	.33	.01	.08	
2	.90	.01			
3	.02	.02	.73	.01	
4		.09		.09	.03
5					
6			2.23		
7	.98	.26			
8	.04				.04
9	T			.59	.33
10			.02	.28	.01
11	T		.25		T
12	.04		.03		
13	.98		.18		
14	.05				
15	2.68				
16	.05				
17				.01	
18				.08	
19				.43	
20	.10			.01	
21	.01				
22		1.00			.67
23		.02	.17		
24					
25		.19		.35	
26		.13	.21	.17	
27			.15	.35	
28			.84		1.04
29		1.08	1.17		.10
30	.43	.55			
31	.25				
Total	7.62	3.42	6.25	2.45	2.22

TABLE VI

AVERAGE RATINGS FOR SOD CONTROL IN PLOTS OF CORN GROWN ON SOD AT TWO LOCATIONS IN TENNESSEE IN 1967

Treatment	Knoxville		Springfield	
	Aug. 19	Oct. 5	July 22	Nov.2
Untreated check	0[a]	0	0	0
Conventional seedbed + cultivation	8.2	8.0	-	-
Atrazine + dodecyl ether of polyethylene glycol	6.0	4.7	7.8	6.0
Atrazine + surfactant tri-ionic	8.0	4.2	-	-
Atrazine + one-half pound paraquat	-	-	8.8	8.2
Atrazine + one-quarter pound paraquat	7.5	7.1	9.0	7.9
Atrazine + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid	3.5	2.5	7.2	2.2
Atrazine + amatryne	5.0	4.7	8.0	7.8

[a]Average of four observations.
0 = no control;
10 = complete control.

corn vigor was much lower at Knoxville. Sod growth was normal in the untreated check (Figure 2).

At Knoxville conventional seedbed preparation plus cultivation gave the best season-long sod control in corn (Table VI, page 26). The best chemical treatment was with two pounds atrazine plus one-quarter pound of paraquat. Even though the sod control for this treatment was not as good as for the conventional seedbed, it was sufficient for high yields. The poorest sod control was obtained with two pounds of atrazine plus four pounds of AP20. It was not sufficient for good corn yields.

Two pounds of atrazine plus one-quarter pound of paraquat also gave the best sod control in the corn plots at Springfield (Figure 3). Two pounds of atrazine plus four pounds of AP20 again gave the poorest sod control and resulted in the lowest yield among the chemical treatments (Figure 4). All other treatments resulted in sufficient sod control for high yields.

Weed Control

Weed control in corn was excellent for all treatments at both locations (Table VII). This was due to the low weed population in the well-established sod at planting time. Treatments which had high sod control ratings also had high weed control ratings because of the herbicidal action on any weeds that were present at planting time. In the treatments which had the lowest sod control ratings, weed control ratings were excellent. In addition to the low initial weed population

Figure 2. Corn growing on non-treated sod plots at Springfield in 1967.

Figure 3. Corn three weeks after being treated with two pounds of atrazine plus one-quarter pound paraquat at Springfield in 1967.

Figure 4. Corn three weeks after being treated with two pounds of atrazine plus four pounds of AP20 at Springfield in 1967.

TABLE VII

AVERAGE RATINGS FOR WEED CONTROL IN PLOTS OF CORN GROWN ON SOD AT TWO LOCATIONS IN TENNESSEE IN 1967

Treatment	Knoxville		Springfield	
	Aug. 19	Oct. 5	July 22	Nov. 2
Untreated check	9.2[a]	9.7	7.6	8.6
Conventional seedbed + cultivation	9.7	9.7	-	-
Atrazine + dodecyl ether of polyethylene glycol	10.0	9.5	8.8	6.4
Atrazine + surfactant tri-ionic	-	-	8.2	5.6
Atrazine + one-half pound paraquat	-	-	9.2	6.0
Atrazine + one-quarter pound paraquat	9.7	9.7	8.6	7.2
Atrazine + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid	9.7	9.0	8.1	7.0
Atrazine + amatryne	9.2	8.7	9.4	6.8

[a]0 = no control; 10 = complete control.

and herbicidal activity, weeds present in these treatments could not compete with the growing sod.

At the end of the growing season, the weeds present in the corn were pokeweed and ragweed (*Ambrosia artemisiifolia* L.) at both locations. Foxtail was also present at Springfield.

Crop Vigor

The corn at Knoxville was not as vigorous as at Springfield (Table VIII). Since growth was uniformly poor, including plots with a conventional seedbed, the reduced vigor was due to some factor other than sod planting or chemical injury. At the end of the growing season, there were definite nitrogen deficiency symptoms in the corn, and this would indicate that nitrogen deficiency was the reason for the reduced vigor. The corn at Knoxville was not sidedressed with nitrogen. Heavy rainfall from mid-season to harvest time caused heavy leaching of the nitrogen from the soil. For these reasons the nitrogen necessary for good plant growth was not available.

Plant vigor of corn at Springfield was excellent in all plots except the untreated check and the treatment with two pounds of atrazine plus four pounds of AP20. This treatment also had the lowest yield. Since the stand was as good as the other treatments which had excellent vigor and yields of over one hundred bushels per acre, there is an indication that the low crop vigor was probably due to fast, late season sod regrowth or possibly herbicidal injury. The late season sod regrowth rate was much higher in this treatment than in the other treatments. This indicates that competition from the uncontrolled sod

TABLE VIII

AVERAGE RATINGS FOR CROP VIGOR IN CORN GROWN ON SOD AT TWO LOCATIONS IN TENNESSEE IN 1967

Treatment	Knoxville		Springfield	
	Aug. 19	Oct. 5	July 22	Nov. 2
Untreated check	9.2[a]	9.0	8.0	8.6
Conventional seedbed + cultivation	3.3	3.5	-	-
Atrazine + dodecyl ether of polyethylene glycol	4.0	4.0	1.6	1.8
Atrazine + surfactant tri-ionic	-	-	1.8	2.2
Atrazine + one-half pound paraquat	-	-	1.4	2.0
Atrazine + one-quarter pound paraquat	3.0	3.3	1.0	1.8
Atrazine + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid	5.5	5.8	2.8	3.2
Atrazine + amatryne	5.3	5.8	2.4	2.6

[a]0 = maximum vigor; 10 = plants killed.

was the reason for reduced crop vigor instead of herbicide injury. Plant vigor was highest in the treatment with two pounds of atrazine plus one-quarter pound paraquat which also resulted in the highest yield. All other treatments had sufficient crop vigor for yields of over one hundred bushels per acre.

Corn Yield and Plant Population

Because of low plant vigor and a poor stand, corn yield data were not obtained at Knoxville. The stand in the conventionally prepared seedbed was also poor so it was probably due to factors other than planting corn on chemically killed sod. One possible factor is that there was little rainfall about two weeks after planting which may have resulted in insufficient moisture for good germination. Another possible factor is that the planter did not meter the seed satisfactorily. Another factor which must also be considered is that the site where the corn was planted in Knoxville was not as level as that in Springfield. When operating the planter on an unlevel soil surface, the side of the planter on the high side of a slope tended to place the seed deeper in the soil than on the lower side of the slope. If part of the seed were placed too keep, this plus the insufficient moisture may have been the cause of the poor stand.

The yield of all herbicide-treated corn plots at Springfield was significantly higher than that of the untreated check ($P < 0.10$) (Table IX). Two pounds of atrazine plus one-quarter pound of paraquat yielded 120 bushels per acre which was significantly higher than atrazine

TABLE IX

AVERAGE YIELDS AND PLANT POPULATIONS OF CORN GROWN ON SOD AT SPRINGFIELD, TENNESSEE, 1967

Treatment	Yield bu./A ($P < 0.10$)[a]	Population
Atrazine + one-quarter pound paraquat	120 a	10,600
Atrazine + amatryne	114 ab	10,500
Atrazine + surfactant tri-ionic	110 ab	10,600
Atrazine + one-half pound paraquat	105 ab	11,900
Atrazine + dodecyl ether of polyethylene glycol	93 b	8,800
Atrazine + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid	87 b	10,500
Untreated check	26 c	6,300

[a]Duncan's Multiple Range Test, critical values after Harter.

plus dodecyl ether of polyethylene glycol at 93 bushels per acre or atrazine plus AP20 at 87 bushels per acre. The lower yield of atrazine plus AP20 was probably related to the inadequate late season sod control (Table VI, page 26) and reduced crop vigor (Table VIII, page 33). The lower yield of atrazine plus dodecyl ether of polyethylene glycol was probably due to the low plant population caused by the planter clogging up in one plot since sod control and plant vigor were good. There was no significant difference among the other treatments all of which had good plant populations (Table IX) and resulted in yields of over one hundred bushels per acre. The low plant population and yield of 26 bushels per acre on the untreated check plot was due to the competition from the uncontrolled sod.

III. RESULTS FROM SOYBEAN EXPERIMENTS

Sod Control

Except for the conventional seedbed, sod control for the soybean treatments was not sufficient to permit good crop growth anytime during the growing season at either location (Table X). At the end of the growing season, a complete stand of fescue was present in all treatments except the conventional seedbed at Knoxville. The chemical treatments of one-half pound linuron plus four pounds of AP20 at Springfield (Figure 5) and one-half pound of linuron plus one-half pound of paraquat plus the power driven rotary cultivator gave slightly better sod control than the other chemical treatments early in the season.

TABLE X

AVERAGE RATINGS FOR SOD CONTROL IN PLOTS OF SOYBEANS GROWN ON SOD AT TWO LOCATIONS IN TENNESSEE IN 1967

Treatments	Knoxville		Springfield	
	Aug. 19	Oct. 5	July 22	Nov. 2
Untreated check	-	-	0[a]	0
Conventional seedbed + cultivation	7.5	7.0	-	-
DNBP	-	-	0.6	0
DNBP + power driven rotary cultivator	3.2	2.2	-	-
Linuron + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid	-	-	1.2	0
Linuron + paraquat	2.2	0	1.0	0
Linuron + paraquat + power driven rotary cultivator	3.5	2.7	-	-

[a]0 = no control; 10 = complete control.

Figure 5. Soybeans three weeks after being treated with one-half pound of linuron plus four pounds AP20 at Springfield in 1967.

Weed Control

Although the soybean treatments resulted in poor sod control, weed control was excellent at both locations (Table XI). As in the corn treatments, the weed population was low at planting time. This plus competition from the poorly controlled sod was probably the reason for the excellent weed control in soybeans. The complete stand of fescue in the soybeans at harvest time resulted in almost complete weed control at both locations.

Crop Vigor

Soybean plant vigor was not good at either location in any of the chemically treated plots (Table XII). The soybeans planted in the conventional seedbed at Knoxville had excellent crop vigor and this would indicate the incomplete sod control in the chemically treated plots was responsible for the low crop vigor.

At Springfield where only chemical treatments were used, the sod had grown vigorously enough to completely eliminate the soybean stand at the end of the growing season. The treatments in Knoxville which had included the power driven rotary cultivator plus herbicides resulted in crop vigor higher than the treatments with herbicides minus the power driven rotary cultivator (Table XII). The reason for the increased crop vigor was that the sod in the row where the soybeans were planted was destroyed by the power driven rotary cultivator thus allowing the soybeans to grow more vigorously than those in the treatments not including the power driven rotary cultivator. At the end of the growing season,

TABLE XI

AVERAGE RATINGS FOR WEED CONTROL IN PLOTS OF SOYBEANS GROWN ON SOD AT TWO LOCATIONS IN TENNESSEE IN 1967

Treatments	Knoxville		Springfield	
	Aug. 19	Oct. 5	July 22	Nov. 2
Untreated check	-	-	8.2[a]	9.0
Conventional seedbed + cultivation	7.7	6.7	-	-
DNBP	-	-	8.4	9.0
DNBP + power driven rotary cultivator	9.5	9.2	-	-
Linuron + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid	-	-	8.2	9.0
Linuron + paraquat	9.7	9.0	7.6	9.0
Linuron + paraquat + power driven rotary cultivator	9.6	8.7	-	-

[a]0 = no control; 10 = complete control.

TABLE XII

AVERAGE RATINGS FOR CROP VIGOR IN SOYBEANS GROWN ON SOD AT TWO LOCATIONS IN TENNESSEE IN 1967

Treatment	Knoxville		Springfield	
	Aug. 19	Oct. 5	July 22	Nov. 2
Untreated check	-	-	3.4[a]	-
Conventional seedbed + cultivation	0.5	1.3	-	-
DNBP	-	-	3.6	-
DNBP + power driven rotary cultivator	5.5	7.8	-	-
Linuron + cis-2,3,5,5,5-pentachloro-4-ketopentenoic acid	-	-	6.6	-
Linuron + paraquat	3.5	5.3	5.2	-
Linuron + paraquat + power driven rotary cultivator	5.0	7.8	-	-

[a]0 = maximum vigor; 10 = plants killed.

the sod had not eliminated the soybeans in the treatments using the power driven rotary cultivator as it had in the treatments using herbicides only.

From the above discussion it can be concluded that the low crop vigor in soybeans resulted from incomplete sod control rather than from herbicide injury.

Soybean Yield and Plant Population

The herbicides did not control the sod in soybeans (Table X, page 37), therefore plant vigor was low. The incomplete sod control also caused a low plant population, averaging about 50 per cent of the recommended population. Because of this, yield data on soybeans were not taken at either location.

IV. GERMINATION AND GROWTH OF FALL SEEDED CROPS

Of the orchardgrass, fescue, annual ryegrass, rye, oats, and crimson clover crops sown at both locations, only the rye at Springfield was established. The other crops germinated but did not become established. There was no difference in stand or plant vigor of rye between the untreated check and the chemically treated plots. This indicates that the herbicide residue in the chemically treated plots was not high enough to injure the rye.

Since the other five crops failed to become established in either the chemically treated plots or the untreated plots, this implies some factor other than injury due to herbicide residue was responsible for the failure. Rye has a later recommended planting date (November 1) than the other crops (September 15). All crops, except rye, were sown at dates later than those recommended by The University of Tennessee Agriculture Experiment Station and this was probably the reason for the failure of the other crops to become established.

CHAPTER V

SUMMARY AND CONCLUSION

A study to determine the effects of different herbicides on sod control, weed control, and crop vigor was conducted on the Plant Science Farm at Knoxville and the Highland Rim Experiment Station at Springfield, Tennessee, in 1967. Six fall seeded crops were sown to determine the persistence of the herbicides in the soil. Eleven treatments at Springfield were replicated five times and ten treatments at Knoxville were replicated four times.

Sod control, weed control, and crop vigor ratings were taken at both locations to determine the effectiveness of the herbicides used in the treatments. Corn yield data were taken at Springfield but not at Knoxville. The sod control was insufficient for good soybean growth in the chemically treated plots at both locations, therefore soybean yield data were not taken.

The best sod control in the chemically treated corn plots was obtained with two pounds of atrazine plus one-quarter pound of paraquat. At Springfield where corn yield data were taken, this treatment also resulted in the highest yield but was not significantly different from other treatments yielding over one hundred bushels per acre. The poorest sod control was in the treatment with two pounds of atrazine plus four pounds of AP20. This treatment also resulted in the lowest corn yields.

In the soybean experiments, sod control was insufficient for good soybean growth in any of the treatments except the conventionally prepared seedbed at Knoxville.

Weed control was fair to excellent in all treatments in both corn and soybeans.

Rye at Springfield was the only fall seeded crop that became established. There was no difference in crop vigor and plant stand among the untreated check and the chemically treated plots. There was no apparent herbicide injury to the rye as a result of herbicide residue.

From data obtained at Springfield, it could be concluded that the excellent corn yields, sod control, and weed control could be expected from using two pounds of atrazine plus one-quarter pound of paraquat. The data also indicate that a good crop of rye could be expected from seeding in the fall after the corn is harvested.

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