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To the Graduate Council:

I am submitting herewith a thesis written by Jerry Lange Hixson entitled "No-Till Planting of Soybeans in Barley Stubble with Chemical Weed Control." 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 Plant and Soil Science.

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NO-TILL PLANTING OF SOYBEANS IN BARLEY STUBBLE WITH CHEMICAL WEED CONTROL

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Jerry Lange Hixson

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ABSTRACT

A study was conducted to examine: (1) the possibility that soybeans (Glycine max (L) Merr.) could be grown successfully in barley stubble as part of a double cropping system, (2) the effects of different methods of stubble management, (3) the effectiveness of different herbicide combinations for weed control, and (4) the usefulness of using no-till double cropped soybeans in both short and long term rotations.

The soybeans were planted on July 5 in barley stubble with five types of stubble management; viz., (1) stubble cut high just below the grain head, (2) stubble cut normal leaving 4 to 5 inches of standing stubble and bailing the straw, (3) stubble cut plus clipping with a rotary mower, (4) stubble cut close leaving 2 to 3 inches of standing stubble, and (5) stubble cut normal followed by conventional tillage. No significant differences were found in the yield from various stubble management systems. The ease and speed of planting was much better in the normal cut and where the straw was bailed since there was no residue to interfere with the planter operation.

The percent weed control obtained with alachlor (2-chloro-2, 6-dimethyl N-Methoxymethyl) acetanalide, linuron (3-(3,4,-dichlorophenyl)-1-methoxy-1-methylurea, and

(dynoseb + naptalam) 2-sec-butyl-4,6-dinitrophenol + N-1-naphthylphthalamic acid was not significantly different.

The average yield of the soybeans for the herbicides treatments was 21.7 bushels per acre, while the average for the weed free check was 23.1 bushels per acre and no treatment check was 17.7 bushels per acre.

Several types of cropping systems can be utilized in a double cropping system and no-till planting of soybeans. In a limited acreage situation the barley-soybean rotation lends itself to a beef and/or swine operation. In a dairy operation where acreage is not critical, this type basic rotation is a means of raising additional feed and supplementing the income of the producer.

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CHAPTER I

INTRODUCTION

Soybeans have become the number one cash crop in Tennessee and are rapidly gaining popularity in East Tennessee. The number of beef cattle are also increasing which is putting some additional demand on grain production. With the development of Barsoy cultivar of barley, an early maturing high yielding barley, many producers are substituting barley for corn in feed rations. After harvesting the barley much of the growing season remains, and since soybeans are a short season crop adequate time remains for seed maturity. By using no-till planting, and herbicides for weed control, valuable time can be gained and production costs can be lowered. Some hazards, however, are associated with this system. The major difficulties are: (1) inadequate moisture to germinate the soybean seed and maintain growth, (2) proper equipment to deposit seed in the soil through the residue, (3) inconsistency of herbicides on weed control, and (4) weed regrowth late in growing season can cause harvesting difficulties. By being aware of these hazards and by using good management practices a producer can use the double cropping, no-till system for a profitable part of his farming program.

There are four main objectives of this study: (1) to determine if soybeans could be grown successfully in barley stubble as part of a double cropping system, (2) to test different methods of stubble management, (3) to examine different herbicide combinations for weed control, and (4) to explore the possibility of using no-till double-cropped soybeans in both short and long term cropping systems.

CHAPTER II

LITERATURE REVIEW

No-Till Planting of Soybeans in Barley Stubble

The practice of raising no-till corn in Tennessee has become an accepted practice in recent years especially in East Tennessee. This practice has enabled farmers to grow corn on slopes, that in the past, were too steep for cultivation. The practice of no-till soybeans is a relatively new concept since soybeans have only become an important crop in East Tennessee during the past four years. With the use of barley for feed and the development of Barsoy cultivar, the practice of double cropping and no-till soybeans is gaining popularity.

Burning of the straw has been a common practice in double cropping programs to facilitate planting. In 1969 Henard (15) found that plants showed loss of vigor in July and August on burned plots as compared to no loss of vigor on the unburned plots. This was probably due to the conservation of moisture from the ground cover by straw residue. Henard (15) also found the yield to be greater on the unburned plots and the conventional till had the highest yield.

Mullins (19) in work at the Milan Field Station in West Tennessee found that burning of the straw increased yields on two different soil types in 1967 and 1968. They concluded that for highest yields the straw should be burned or removed prior to planting.

Beale and Langsdale (6) found that burning the straw increased the stand of the soybeans but caused no significant increase in yield.

Two major factors to consider in a double cropping system are time of soybean planting and the soybean cultivar. Peters et al. (22) found that Kent soybeans matured early and was not greatly affected by delayed planting. Peters (21) also found that barley could be planted following harvesting of early planted Hill soybeans and should be planted by October 15. Delay in planting the barley will delay harvest which will, in turn, delay soybean planting.

Philips and Young (23) indicate that using no-till planting gains valuable time in the double cropping system along with conserving soil moisture. As much as one inch of moisture has been retained in the soil by no-till which is needed for quick germination and a faster seedling growth. A general rule of thumb among soybean growers is: for every two days delay in planting double-cropped soybeans, harvest will be delayed one day and yields will be one to two bushels less. This rule will vary slightly with different cultivars. Estimated cutoff dates for planting double-cropped soybeans are July 10 to 15 for the deep south; July 1 to 10 for the lower corn belt and June 15 to 30 for the middle to upper corn belt. Peters (21) also found in Tennessee there was as average reduction in soybean yields of 0.36 bushels per acre for each day planting was delayed after June 1.

The decision of whether to burn or leave the residue should be based on seed vigor and stand because there will not be enough time to replant in a double cropping system.

Swearingin (26) reports that soybean double cropping is gaining popularity in Indiana south of U.S. Highway 40 and that approximately 10 percent of the farmers in this area are double cropping with small grain and soybeans. This system provides a way of utilizing the later half of the growing season. In 1971 farmers in this area obtained an average of 60 to 90 bushels of barley and 25 to 30 bushels per acre of soybeans.

Soil temperature and moisture conditions are two important items to consider in the double cropping program. Scott and Aldrich (25) found that soils are often hot and dry at the time soybeans are planted into small grain stubble. They contend that soybeans should not be planted unless enough moisture is present to insure germination. It is important to get the seed germinated rapidly because under high temperatures the seed loses its vigor and vitality and will result in a poor stand.

The decision on the type of seed bed to prepare will be governed by the type of machinery available, the date, and labor available. Mullins et al. (19) used four types of seed bed preparations: (1) break, disc, and harrow, (2) strip till, (3) off set disc, and (4) no-till. He found there was no significant effect on soybean yield. Beale and Langsdale (6) in working with an oat-soybean rotation also found that tillage practice had no effect on yield. However, the properties of the lister-plant-tilled and disc harrow tilled were more favorable for soybean growth than those of the turn plow tilled soils. The more favorable growth was not reflected in the yields. Philips and Young (23) indicate in Kentucky that with a barley-soybean rotation the no-till soybeans yield higher than the conventional till.

Philips and Young (23) indicate that a combine equipped with a straw chopper gives the best disposition of straw for stubble planting. Straw spreaders will disperse the straw but may cause bunching which will interfere with the planter. A planter with a fluted coulter and a straw guide to press the residue down so the coulter will cut through to the soil surface is desirable.

McKibben (18) reports that a 20 inch row spacing with Wayne and Amsoy soybeans gave equal or larger yields than did row spacings of 30 inches with the same number of plants per foot. Yields of both spacings were increased by a higher plant population up to eleven per foot. He also reports that the 20 inch rows provided a more rapid canopy and better weed control. High rates of fertilizer were applied to the preceding wheat crop and this increased weed control by providing a heavy canopy which reduced sunlight to the weeds. The abundance of straw residue cut soil moisture loss to a minimum.

Scott and Aldrich (25) indicate that small grain plants do not use much water during the two weeks before harvest.

Philips and Young (23) show that in stubble planted soybeans depth is not as critical. In conventionally tilled soil 1 inch to 1-1/2 inches is the desired planting depth to get good soybean emergence. In the no-till method the soybeans seed can be planted to a depth of 3 to 3-1/2 inches and still get good emergence because of more favorable moisture conditions. The straw tends to prevent crusting of the soil and retains the moisture which speeds germination.

In the final analysis the economics will determine the success or failure of the no-till system. Camper et al. (10) found that cost of the second crop in a double cropping system will vary considerably from farm to farm depending on the total farm operation. All of the fixed costs for the first crop need not be included in the costs for the second crop. Only variable costs and added returns affect the net return of the second crop. Reduced returns from the second crop need to be considered as a variable cost, thus, estimates of the second crop may vary widely. In comparing soybeans with corn and sorgum there was no consistent results, but either program is hazardous. The system is more profitable, however, if the second crop is planted by June 30.

Bayer and Brasher (5) indicate that net returns from soybeans in 1967 and 1968 in Tennessee were $24.41 per acre. This is for an average yield of 39.1 bushels per acre. Swearingin (26) found that the breakeven point in yield of soybeans was 8 bushels per acre in a small grain soybean double cropping system. The variable costs of production were charged to the small grain crop and only the soybean seed planting, harvesting, and herbicide cost were charged to the soybean crop.

Some effort has been made to plant soybeans in an established sod. Brown (8) was unable to control enough fescue sod with the type herbicides used in soybean production enough to permit vigorous soybean growth.

Herbicides

The chemical names of the herbicides used in this study are given in Table 1.

Alachlor. Alachlor is a general use herbicide for the control of most annual grasses and certain broad leaf weeds.

Table 1. Herbicides used in no-till plots and rates applied

Name			Rate Applied Active Ingredient
Common	Commercial	Chemical	
			lb/A
Alachlor	Lasso	2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide	4.0
Linuron	Lorox	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea	6.0
Paraquat	Paraquat	1,1'-dimethyl-4,4'-bipyridinium ion	1.0
Dinoseb + Naptalam	Dynap	2-sec-butyl-4,6-dinitrophenol N-1-naphthylphthalamic acid	1.5 + 3.0

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It can be applied by either preemergence soil surface treatment or preplant incorporation. Alachlor is absorbed mainly by the germinating plant shoots and secondarily by the roots. The material will translocate in the plant with a higher concentration accumulating in vegetative parts than in the reproductive parts. The action of alachlor is speculative, but is believed to inhibit protein synthesis in susceptible plants. Alachlor is almost completely metabolized in the plant within 10 days. Alachlor is adsorbed by the collodial particles in the soil and will persist for 6 to 10 weeks. Degredation of the material is 40 percent by microbial activity and 60 percent by chemical (16).

Evans et al. (13) reports that corn and soybeans are highly tolerant to alachlor. He also states that alachlor is nonvolatile and can be used over a wide range of soil types and soil moisture conditions. The relatively short residual life of alachlor can be utilized in other herbicidal mixtures to overcome residual problems.

<u>Linuron</u>. Linuron selectively controls germinating and newly established broad leaf weeds and grasses in crops such as soybeans, cotton, corn, and certain vegetable crops. Linuron can be sprayed on soils as a preemergence or post emergence treatment. With a suitable surfactant as a directed spray in certain crops it controls weeds up to 5 inches high (16)

Weed et al. (27) reports that when linuron is used as a postemergence spray it kills the existing weeds and provides a residual herbicide barrier to the development of weed seedlings that emerge after application. Linuron has a good degredation pattern from the soil which permits seeding a winter crop or succeeding spring crop without hazard of injury from residual carryover of the herbicide.

Bryant and Andrews (9) found, however, that some carryover residual did exist at the 1X rate, but showed no damage to oats the following year.

Dubey and Freeman (12) report that adsorption increases as the clay content and/or organic matter content of soil increases; clays of high exchange capacity adsorb more linuron than those of low exchange capacity. Movement by leaching is least in soils high in clay and greatest in sand. Dubey et al. (12) also report that microbes are the primary factor in the disappearance of linuron from the soils.

Evans et al. (13) found that losses by photodecomposition or volatility are insignificant unless linuron is exposed on the soil surface for several days or weeks under hot dry conditions. Under field conditions, when linuron is applied at selective rates, phytotoxic concentrations disappear within four months after application. An accumulation from annual applications to the same soil is not a problem (16).

<u>Naptalam</u>. Liquid naptalam is a selective preemergence herbicide for the control of a wide range of annual broad leaf weeds and grasses in soybeans and a wide variety of other crops. The naptalam appears to block the indole acetic acid and as the naptalam breaks down into alpha naphthylamine and phtalic acid the IAA renews its function. Weed control usually lasts 3 to 8 weeks, depending on soil and weather conditions. Moisture is required after application to activate the weed control properties. Heavy rain immediately after application will cause leaching which could result in poor weed control and possible crop injury. Naptalam is nonvolatile, photostable, and subject to slow microbial breakdown (16).

Ogle (20) reports a positive correlation with base exchange capacity and organic matter content of the soil.

<u>Dinoseb</u>. This chemical controls most seedling weeds and grasses in crops. Dinoseb leaches readily and some evidence has been found of partial adsorption in certain organic and clay soils (16).

Barrows and Fitzgerald (4) used dinoseb to kill Ladino clover sod for planting soybeans and corn.

Barrows (3) works indicate that soil temperature is not critical, but adequate moisture must be present to disperse the toxicant in the soil surface.

Henard (15) reports yields of 41.7 bushels per acre of soybeans planted in burned and unburned plots by using dinoseb and naptalam plus paraquat.

Paraquat. Paraquat shows moderate susceptibility to ultraviolet degredation. Where a large surface area exists as on the surface of a plant and in intense sunlight, 25 to 50 percent breakdown was noted in 3 weeks through photochemical decomposition. Paraquat is used for weed control during establishment of grass seed crops; for a general contact herbicide for noncrop uses; as a herbicide for orchard weed control; as a preemergence herbicide and as a direct postemergence herbicide. Paraquat is also used as a crop desicant and defoliant on cotton and potatoes (16).

Bovey and Davis (7) found that a temperature of 5-6°C delayed leaf necrosis at least 48 hours after treatment as compared with high temperature. After 96 hours as much necrosis was obtained as at the tempreature of 24-28°C.

Paraquat is rapidly and completely deactivated by the soil. The results from reaction between the double positively charged paraquat action and clay minerals present in soils to form complexes with the negatively charged sites on the clay minerals. Most soils have sufficient capacity in the top inch of soil alone to bind many hundred times the normal field rates of application of paraquat in this form (16).

CHAPTER III

MATERIALS AND METHODS

This experiment was established in Mascot, Tennessee, on the farm of American Smelting and Refining Company. The soils in the plots were Dewey and Decatur silt loam which had been planted to Barsoy barley in 1970 and soybeans in 1969. The field was fertilized with a broadcast application of 300 pounds per acre of 10-20-20 before the barley was planted and was top dressed in February 1971 with 100 pounds per acre of ammonium nitrate.

The plots were established on June 10, prior to barley harvest on June 29, 1971. Barley harvest was about two weeks late because of a late spring in 1971.

The barley yielded 50 bushels per acre, which is relatively low for Barsoy. A hail storm one week before harvest plus shattering at harvest time caused an approximate loss of 10 bushels per acre.

A John Deere self-propelled combine was used to harvest the barley. This machine did a good job of picking up lodged grain and in cleaning the grain.

The experiment was arranged in a split block design with three replications (Table 2). There were two sets of main blocks, one set encompassed five methods of the stubble

Table 2. Split block design of stubble management + herbicide treatment

	Normal Cut & Bailing Straw	High Cut	Rotary Mowing	Conventional Till	Close Cut
Alachlor + Paraquat					
Dinoseb + Naptalam + Paraquat					
Linuron + Paraquat					
Weed Free					
No Treatment					

management, i.e.: (1) stubble cut at a normal height of about 5 inches above the soil surface, (2) stubble cut at about 8 inches above the soil surface, (3) stubble cut at about 3 inches above the soil surface, (4) stubble cut with a rotary type farm mower, which cut the straw in small sections and distributed it evenly over the plot area, (5) the stubble cut about 5 inches, straw bailed, and a conventional type seed bed was prepared by discing four times. The second set of main blocks was arranged at right angles to the first set and the weed control treatments listed in Table 2 were assigned to these blocks. Each main block in each set was 40 feet wide and 200 feet long. Because the two sets of main blocks were arranged at right angles across each other a total of 25 subblocks each 40 feet wide by 40 feet long were delineated. These subplots represented the weed control by stubble treatment interactions and became the units from which all data was collected. Therefore, any one weed control treatment was in combination with five different stubble treatments and any one stubble treatment was in combination with five different weed control treatments with three replications.

Soybeans were planted on July 5 with a Ford sod planter. This planter has a single coulter opener, a winged type planting shoe and a packer wheel that firms the soil around the seed.

The planting conditions were ideal with good soil moisture so that the cutting coulter operated very effectively. The soybean cultivar planted was Hill, a short season variety, as it was near the end of the planting season. The seed was inoculated and treated with Molybendium in the planter box.

The herbicide was applied on July 6 in 40 foot wide strips that went across the five different seed bed main plots. The herbicides were applied with a sprayer borrowed from the Geigy Chemical Company. It was self-contained with power unit, pump and three separate tanks. The sprayer was calibrated to operate at 3 MPH using the tachometer on the tractor, and equipped with 8006 tips. The spray volume was 30 gallons of water to the acre. The herbicides and rates used in this experiment are listed in Table 1, page 9.

The sprayer boom was only 19 feet long. Consequently two trips across the field did not cover the 40 feet without overlapping with a third trip. This procedure worked fine because the plots were 40 feet wide and a narrow untreated strip was left between each of the herbicide plots. This strip was used to compare treatment with no treatment.

Included with the herbicide plots was one that had no treatment, as a check, and one that was hand weeded. The weed-free plots were hand hoed periodically; no other plots received any type of mechanical weed control.

The soybeans were harvested on December 1, 1971, with a John Deere 4400 combine. This machine did an excellent job of picking up the lodged soybeans. Field loss was insignificant as visual observation showed no soybeans left on the ground. The yields from each plot were obtained by catching the soybeans from the auger as they came into the bin and weighing them.

CHAPTER IV

RESULTS AND DISCUSSION

Stubble Management Systems

The soil moisture conditions were favorable for seed germination and plant growth at planting. The rainfall for July, August, and September was normal for the period (Table 8, Appendix).

Soybean plant vigor (visual observation) was good throughout the growing period, with soybeans in all plots growing approximately at the same rate.

High cut. The high stubble cut was accomplished by harvesting just the barley head and leaving 8 to 10 inches of stubble standing. There was only a small amount of residue remaining on the soil surface which facilitated easier planting. The tractor tires pressed the stubble down in the soybean rows so there was no shading of the soybean plants. The stubble between the rows was undisturbed and shaded the weeds, thus retarding some weed growth. This retardation of the weed growth allowed the soybeans to compete with the weeds for sunlight in the initial growth stages of plant growth resulting in rapid growth of the soybeans.

Normal cut and bailing straw. The normal cut left 4 to 5 inches of stubble standing and the straw was bailed. The absence of the straw residue permitted rapid soybean planting and good seed coverage.

The rhizome johnsongrass was the dominant weed as the seedling growth was controlled by the herbicides. The average yield of the five plots in the normal cut plus bailing the straw was 18.9 bushels (Table 3). The standing stubble was partially decayed by harvest time and did not interfere with the harvest operation.

Table 3. Yield of soybeans in the stubble management systems

Management System	Average Yield
	bu/acre
High Cut	22.0[a]
Close Cut	17.9
Conventional Till	22.6
Rotary Mow	22.7
Normal and Bailing Straw	18.9

[a]Yields were not significantly different at the 5 percent level.

Close cut. The barley stubble in the close area was 3 to 4 inches high with the cut straw residue distributed over the soil surface. The straw on the soil surface caused some difficulty in planting by gathering in front of the planter shoe. This made it necessary to stop and remove the straw, causing a delay in planting. The close cutting of the rhizome johnsongrass appeared, by visual observation, to retard regrowth. The retardation allowed the soybeans to grow above the johnsongrass early in the season. The johnsongrass grew above the soybeans by late in September. The johnsongrass did not appear to affect growth of the soybeans or cause any harvesting difficulties. The close cutting of the small grain could be useful in areas where johnsongrass persists. It might, however, be necessary to remove the residue on the soil surface to eliminate planting difficulties. The average soybean yield in the close-cut area was 19.5 bushels per acre (Table 3).

Rotary mowing. The rotary mowing of the barley straw left 2 to 3 inches of standing stubble remaining in the field. The action of the rotary mower caused the residue to windrow through the plots which caused planting difficulties. The close cutting of the barley straw, and other standing vegetation, had a retarding effect on the regrowth of the johnsongrass. This delayed regrowth of the rhizome johnsongrass allowed the soybeans to grow above it until the soybeans attained their normal height. The soybean yield in the rotary mowing plot was 22.7 bushels per acre (Table 3).

Conventional till. The conventional till area was prepared by discing five times to simulate discing and plowing. The straw residue was incorporated into the top 4 inches of the soil surface and there was no vegetation or weeds standing. The sod planter was used in the conventional till plot and the seed was planted too deep for emergence of all the seed planted. The excessive depth of planting caused a reduced stand in some areas. The soybean yield in the conventional till plots was 22.6 bushels per acre (Table 3).

Herbicides

The weed populations were low at the time of planting. The johnsongrass (Sorgum helepense L.) was the predominant weed at planting and at harvest. Volunteer barley was found growing by the middle of July and initially appeared to be a potential problem. However, by the middle of August the barley had ceased growing and did not present any difficulty in harvest. There was some wild mustard (Brassica kaber L.), Carolina geranium (Geranium carolinianum L.), red stern filaree (Erodium cicutarion L.), and foxtail (Setoria sp L.) growing in the plots during the season. They did not, however, cause any difficulty with harvest.

The johnsongrass was the only weed that was present during planting and persisted until harvest. The johnsongrass caused harvesting difficulties only in the no-treatment plots.

<u>Alachlor</u>. The alachlor was used at the rate of 4 pounds per acre with 1 pound paraquat plus nonionic surfactant (Table 1, page 9).

The percent weed control from the alachlor averaged 50.6 (Table 4). The yield of soybeans in the alachlor treated plots was 22.5 bushels per acre (Table 5). The highest degree of weed control was on the rotary mown area due to the close cutting of the vegetation and exposed soil surface (Table 1). Johnsongrass was the dominant weed in all of the plots. The alachlor controlled the seedling growth but had no effect on the rhizome growth.

Table 4. Weed control obtained by herbicide treatments

Treatment	Percent Weed Control
Alachlor + Paraquat	51
Linuron + Paraquat	57
Dinoseb + Naptalam + Paraquat	72
Weed Free	100
No Treatment	0

Table 5. Yields of soybeans on herbicide treated plots

Treatments	Yields
	Bu/Acre
Alachlor + Paraquat	22.6 b
Linuron + Paraquat	20.3 ab
Dinoseb + Naptalam + Paraquat	20.6 ab
Weed Free	23.1 b
No Treatment	17.7 a

[a]Values followed by the same letter are not significantly different at the 5 percent level according to Duncan's Multiple Range Test.

<u>Linuron</u>. The linuron was applied at the rate of 6 pounds per acre plus paraquat and a surfactant (Table 1, page 9). The weed control in the linuron treatment was 57 percent (Table 4). The average yield in the linuron treatments was 20.3 bushels per acre (Table 5).

The linuron controlled the johnsongrass seedlings through the growing season. There was no visual control of rhizome johnsongrass in the linuron plots. The hihgest degree of control from the linuron was in the conventional till areas where there was no residue on the soil surface to absorb the herbicide (Table 6).

Table 6. Effect of herbicide treatment and stubble management on weed control

Herbicide Treatment	PERCENT WEED CONTROL				
	Stubble Management				
	High	Low	Normal	Rotary Mowing	Conventional Seed Bed
	%	%	%	%	%
Alachlor + Paraquat	60	50	50	53	60
Dinoseb + Naptalam + Paraquat	60	77	77	77	70
Linuron + Paraquat	60	53	47	53	73
Weed Free	100	100	100	100	100
Weedy	0	0	0	0	0

Dinoseb + naptalam. The dinoseb + naptalam was applied at the rate of 4.5 pounds per acre plus paraquat and surfactant (Table 1, page 9).

The weed control in the dinoseb + naptalam treated plots was 72 percent (Table 4, page 23). The soybean yield in the dinoseb + naptalam treated plots was 20.6 bushels per acre (Table 6). The dinoseb + naptalam weed control was the highest of the three herbicides. This was probably due to the rapid movement of the naptalam in the soil as there was a rain immediately after the application of the herbicides. Germination damage also occurred to the soybean seed in all of the dinoseb + naptalam treated plots. The conventional till plots had the highest degree of germination damage. This apparently was because of the absence of residue on the soil surface to intercept the herbicide. The lowest degree of germination damage was in the high cut and rotary mown plots. This was because of the high amount of residue present to intercept the dinoseb + naptalam.

Weed free. The weed-free plots were hand weeded to simulate cultivation. The weed control was 100 percent with a yield of 23.1 bushels per acre (Table 5, page 24). No herbicides were used in these plots; all weeding was done by hand.

<u>No treatment</u>. These plots were used as checks to evaluate the effect of the herbicide. The average soybean yield was 17.7 bushels per acre (Table 5, page 24). The dominant weed in the no-treatment plots was johnsongrass, both rhizome and seedling. The highest yield of soybeans in these plots was in the conventional till and rotary cut (Table 7). This was due to the close cutting and discing of the residue on the soil surface which retarded any early weed growth.

<u>Paraquat</u>. The paraquat was applied at the rate of 1 pound per acre plus surfactant in combination with other herbicides (Table 1, page 9).

The paraquat provided an initial kill on all the green vegetation present in all the plots treated. The coverage on the high cut area was not as good as the other stubble management plots because the spray boom was not high enough to allow an overlapping coverage from the spray nozzels. The lack of complete coverage left some green vegetation standing and the regrowth of johnsongrass was more rapid than in the plot where there was complete herbicide coverage.

Table 7. Effect of herbicide treatment + stubble management on soybean yield

Herbicide Treatment	Stubble Management Treatment				
	High Cut	Low Cut	Normal Cut & Bailing Straw	Rotary Mowing	Conventional Seed Bed
	Bu/A	Bu/A	Bu/A	Bu/A	Bu/A
Alachlor + Paraquat	24.3[a]	22.3[a]	19.0[a]	26.5[a]	20.6[a]
Dinoseb + Naptalam + Paraquat	21.4	20.1	19.5	20.0	21.7
Linuron + Paraquat	23.3	15.3	16.1	21.3	25.2
Weed Free	23.2	20.4	21.3	25.8	24.6
No Treatment	18.0	11.6	18.6	20.0	20.6

[a]Yields were not significantly different at the 5 percent level.

CHAPTER V

ALTERNATIVE CROPPING SYSTEMS USING NO-TILL PLANTING OF SOYBEANS

The no-till double cropping system can be integrated into a variety of cropping systems. These systems can be long and short range rotations depending on the enterprise. Some limiting factors should be considered in the double cropping program, however, and they are: (1) proper equipment to do the work efficiently and quickly, (2) rapid harvest of the first crop to get the second crop planted as early as possible, and (3) the equipment required in a double cropping system is expensive and reasonable volume of crops must be maintained to make the system economical. Special attention must be given to the fertilization of the crops used in the system. Soybeans do not always respond to direct fertilization; therefore the fertility levels of the soil must be maintained to supply the nutrient requirements of both crops. The double cropping requires close management in both planting and harvesting the crops, especially if hired labor is used.

This study and others have shown that the type stubble management or seed bed has very little effect on soybean yield (Table 7). The decision on the type stubble management to use should be based on (1) the price of straw, (2) if the weed population is high enough to justify a close rotary mowing, and (3) if the type of no-till planter used is equipped to plant through a heavy residue cover on the soil surface. Close observation of the planting is necessary to insure a proper planting depth of 1 to 1-1/4 inches and proper spacing of 9 to 12 seed per foot. Close attention should be given to the application of the herbicides. If the stubble is cut high or the soil surface is covered with residue, the maximum amount of water recommended for the herbicide chosen should be used. This will permit adequate coverage of both the soil surface and the existing weeds. The height of the spray boom is very important, especially if there is any johnsongrass present. The sprayer boom must by high enough to allow complete coverage of the tallest vegetation when paraquat is used in the herbicide combination.

The return to land, labor, capital and management for the cropping systems reported in this discussion is taken from the Farm Planning Manual by Ray and Walch (25).

Cropping Systems in No-Till Planting

System One. The first year a barley crop can be planted to Barsoy cultivar of barley. The barley can be harvested June 15 or 20 and the soybeans planted by June 30. The soybeans can be harvested by November 15 which will be enough time to plant wheat followed by soybeans the second year. This type system will return $63.00 per acre to land, labor and capital. This small grain soybean rotation can be continued for extended periods of time depending on the producer's needs. If the producer had a beef and/or swine operation the small grain could be used in the feed ration with the soybeans as a cash crop. If the price of soybeans increased and corn and small grain decreased, the producer might choose to raise only soybeans and buy the corn needed. Since early planted soybeans yield higher than late planted soybeans they could possibly return more income than a double cropping system.

System Two. Fall or winter planted oats can be cut for hay and removed by May 15. This will leave ample time to plant soybeans and use a full season cultivar of soybean that will yield higher than late planted soybeans. If the soybeans are harvested by November 5 the oats can be planted in the fall for hay in the spring. This system will return $57.58 for the soybeans plus the value for the hay which will vary from year to year.

This system could be used by either a beef or dairy operation depending on the availability of land. This system is also suited for rolling land because it has vegetative cover and the soil most of the year to reduce soil loss by erosion.

<u>System Three</u>. Barley can be planted in the fall following corn that has been harvested for silage, or harvested early and dryed for grain. The barley can then be harvested and no-till planted with soybeans in June. Following the soybean harvest wheat can be planted, or the field winter fallowed and corn planted in the spring. The net return to land, labor and capital would be $62.07 for the barley and soybeans. This type rotational program would be beneficial in helping to control weeds, especially johnsongrass, by a combination of herbicides and cultivation. This system could be adapted to a dairy operation where acreage is critical, but enough acreage and quality of land was available for short term systems.

<u>System Four</u>. Barley can be harvested for small grain silage and no-till or minimum till planted with soybeans. Following soybean harvest, wheat can be planted for silage and again planted with soybeans. The net return per acre to land, labor and capital in this rotation would be $57.58 for the soybeans, plus the value for the small grain silage. This type system would have some limitations because of the facilities to harvest, store, and feed small grain silage. The system would be more applicable to short term rotations where corn would also be used.

Since the demand for both soybeans and small grain remains strong, a system using soybeans as a cash crop can be a profitable enterprise. Time losses and close management are the two factors that will determine the success or failure of the systems.

Adequate rainfall especially at time of planting is one of the major limiting factors in the double cropping no-till system. If the first crop, of small grain, is late being harvested this will delay soybean planting to a time when the soil moisture may be inadequate and rainfall more uncertain than earlier in the season. If soybeans are well established they will produce average yields under moisture stress.

If johnsongrass is a serious problem, no-till cropping would be questionable. The seedling johnsongrass can be controlled with herbicides in a no-till system, but rhizome johnsongrass control with a no-till system is not satisfactory for continual cropping. A desicant can be used to kill the top growth, but the johnsongrass will grow back causing serious competition with the soybeans.

As the cost of production inputs increases, production volume and efficiency must increase if a profitable return is to be obtained. A double cropping no-till system may be economically found and can be a part of a crop production system. This system can contribute to the net profit of the farming program if it is managed efficiently.

CHAPTER VI

SUMMARY AND CONCLUSION

Soybeans were grown in a double cropping system following barley. The soybeans were planted in the barley stubble using five types of stubble management. There were three different herbicides used for weed control, a weed free, and no-treatment plot.

The rainfall was adequate to maintain good plant growth and the plant vigor was good throughout the growing season. There was no significant difference in the yield between the stubble management plots. The plots that had the greatest amount of loose residue on the soil surface were the most difficult to plant. There was no significant difference in yield or percent weed control between the three herbicides. The dinoseb + naptalam did, however, cause some germination damage to the soybeans. This was probably due to the rainfall immediately following the herbicide application. The average soybean yield for all treatments was 20.1 bushels per acre. This is in addition to a 50 bushel per acre barley crop preceding the soybeans.

There are several rotation systems that can be used with a small grain no-till system. These systems can be applied to a variety of farm enterprises if proper equipment is available for no-till planting. There are some hazards associated with the no-till double cropping system, however. Dry weather, especially at time of planting soybeans, and weeds are two of the major impediments in obtaining high yields and profitable yields of the soybeans in a double cropping no-till system.

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REFERENCES

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CRANE'S CREST

APPENDIX

Table 8. Rainfall data for Knoxville area, 1971

Day of Month	July	August	September
	inches	inches	inches
1	.06	.11	--
2	.01	.25	--
3	.09	.23	--
4	--	.10	--
5	--	.01	--
6	.01	.28	--
7			.23
8			.15
9			
10			
11		.10	
12	.14	.30	.04
13			.07
14	.04		
15	.03		
16			
17		.27	.17
18			.72
19	.40		.03
20	.77		.09
21			.78
22			.01
23		.07	
24	.11		.03
25	.07		
26	.93		.85
27	.11	.02	
28			
29	.02		
30	.45		
31	.57		
Total Rainfall	6.60	1.77	3.17

VITA

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