INFLUENCE OF PREPLANT TILLAGE SYSTEMS FOR CONTINUOUS CORN PRODUCTION ON THE POTENTIAL WEED POPULATION

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ABSTRACT

Da Silva, Joao Baptista. M.S., Purdue University, May 1976. Influence of Preplant Tillage Systems for Corn Production on the Potential Weed Population. Major Professor: J. L. Williams, Jr.

Field and greenhouse experiments were carried out in two locations and three different soils to study the influence of preplant tillage systems for continuous corn production on the potential weed population of untreated and herbicide treated plots and on the weed seed distribution throughout the soil depth.

At the Feldun-Purdue Agricultural Center, Bedford, Indiana, on a Bedford Silt Loam, 3 replications of conventional tillage-spring plowed, chisel plant, coulter plant, coulter plant plowed once, till plant and till plant plowed once were maintained under continuous corn production during the period of 1968-1973 and left fallow in 1974 to evaluate the weed population in plots treated during the same period with atrazine 3.0 kg/ha, atrazine 2.0 + alachlor 1.5 kg/ha and untreated. At the Pinney-Purdue Agricultural Center, Wanatah, Indiana on both Tracy Sandy Loam and Runnymede Loam, 4 replications of conventional tillage-spring plowed, chisel plant and coulter plant were kept under continuous corn production during the period of 1969-1974 and left fallow in 1975 to evaluate the weed population in plots treated during the 6 year period with atrazine 3.0 kg/ha, atrazine 2.0 + alachlor 1.5 kg/ha, simazine 2.0 + alachlor 1.5 kg/ha and untreated.

Besides recording weeds in the field six soil samples were taken from each untreated plot in all the tillage systems and locations for a seed-depth study in the greenhouse.

The influence of tillage systems on the weed population of untreated plots was primarily on broadleaves. Conventional tillage-spring plowed presented a lower population of broadleaves and total weeds than the reduced tillage systems. Grasses were less affected by the tillage systems but a trend existed for a decrease of fall panicum (Panicum dichotomiflorum Michz.) with less tillage. Variations in the predominance of weed species were observed for soils and tillage systems and in coulter plant a negative correlation between giant ragweed (Ambrosia trifida L.) and common lambsquarters (Chenopodium album L.) was noticed.

A significant tendency to decrease broadleaves and increase fall panicum was observed in herbicide treated plots, especially atrazine 3.0 kg/ha. This buildup of fall panicum varied with soils and tillage systems. Herbicide combinations were less affected by the tillage systems than atrazine alone but they showed a trend to allow the build-up of fall panicum in reduced tillage systems.

Data obtained from the greenhouse study indicated that conventional tillage-spring plowed caused a mixing of weed seeds throughout the soil depth. Chisel plant presented the same trend shown by conventional tillage-spring plowed but with less viable weed seeds in the 12.7-19.05 cm increment of depth and more in the 6.35-12.7 cm layer. Coulter plant showed an accumulation of weed seeds in the top layer of the soil but coulter plant plowed once in the 6-year period presented an even distribution of weed seeds throughout the soil depth similar to the conventional tillage-spring plowed.

INTRODUCTION

World War II research produced chemicals that has had a tremendous impact on the American farm. The need for food, fiber and oil for the American people and the Allies, coupled with the reduced labor force created by workers serving in the armed forces, caused a reversion in the tillage trend. According to Phillips (1974), 2,4-D replaced cultivation for broadleaf weed control in fields of Henderson County, Kentucky. The first substitution was made in that County by a group of farmers who were caught with an extremely wet season that prevented normal cultivation. This victory over weeds without cultivation was short lived since grasses replaced broadleaves when the natural competition was removed. Only some years later when new broader spectrum herbicides came onto the market, was it possible to give further consideration to the reduced-tillage systems.

The 1950's were the formative years in terms of developing limited tillage concepts by many farmers and researchers. The possibility of gaining the advantages of reduced erosion and savings in labor, fuel, soil moisture and equipment, all of them associated with the reduced-tillage systems, brought researchers, farmers and industry together, working toward the same goal. Several factors influenced the growth of those reduced-tillage systems across the

United States of America, especially the systems called no-tillage. Among other important factors, labeling of paraquat and triazines, introduction of commercial planters adapted to no-tillage conditions, reduction in farm labor supply and excessively wet springtime conditions in the southeastern United States, were factors which allowed for increased acceptance of the new tillage systems throughout the country.

Acceptance of the reduced-tillage systems has been astonishing and can be reflected in the figures from selected states. The estimated acreage of no-tillage in these states was compiled by Phillips (1974) from research and extension personnel for 1969 and 1971. Table 1 shows that increase of no-tillage acreage for the period of two years in some states was greater than 10-fold. According to Bagley (1973), in 1972 the acreage farmed by a variety of minimum tillage methods totaled 2,289,000 acres and the total minimum tillage practiced since 1968 exceeds 10 million acres.

Research has been a great factor in the development of the new tillage systems. Many scientists have dedicated a lot of effort to solve the arising problems of the new technique. Major contributions have been in the areas of tillage influence on soil properties, soil fertilization for the new tillage systems, studies on soil-water, evapotranspiration and soil temperature, tillage as a conservation tool for soil moisture, tillage as a conservation measure to control soil erosion, development of new tillage systems and implements for crop production, insect and disease control, economical aspects, etc. Also, contributions from weed researchers have been extensive in the

Table 1. No-tillage estimated acreages in selected states.

States	1969	1971	% of increase in 2 years
Arkansas	5,000	28,000	460
Illinois	6,000	40,000	566
Indiana	2,000	25,000	1,150
Iowa	3,000	12,000	300
Kansas	100	4,000	3,900
Kentucky	110,000	323,000	194
Missouri	2,500	30,000	1,100
Nebraska	900	3,000	233
North Carolina	30,000	90,000	200
Ohio	8,000	100,000	1,150
Tennessee	35,000	80,000	129
Virginia	20,000	180,000	800

areas of weed control for different crops and establishment of new crop systems such as double-cropping, sod-planting, pasture renovation, etc.

Although many weed scientists have reported good weed control in areas with reduced tillage conditions, there has been some concern about the influence of those tillage systems on the weed potential, mainly in circumstances such as continuous corn (Zea mays L.). Also, there has been some concern about the effect of possible interactions between tillage systems and herbicides on the potential weed population. This study is a contribution to this area of the tillage research. Field and greenhouse experiments were carried out to study the influence of tillage systems on the potential weed population after 7 years of continuous corn and the effect of the tillage systems on the weed seed distribution throughout the soil depth. The influence of the interactions between tillage systems and some herbicide combinations in corn, on the potential weed population, was studied in the field experiment.

CHAPTER I

Review of the Literature

For purposes of clarity, the literature review is divided into two sections. The first section deals with field research on effect of preplant tillage on the potential weed population. The second section is related to a greenhouse study on the preplant tillage effects on weed seed distribution throughout the soil layer.

Preplant Tillage Influence on the Potential Weed Population

Most reports on the influence of preplant tillage systems for corn production on the potential weed population have been concerned with herbicide treated plots, thus interactions between tillage systems and herbicides. The influence of tillage systems on the potential weed population of plots without herbicides is not well documented in the literature. Reported effects on the weed population in areas under reduced and no-tillage systems for corn production have been increase of perennial weeds and shift from annual broadleaf weeds to some annual grasses.

Rieck and Herron (1974) in Kentucky, pointed out that perennial weeds have become a problem and producers have avoided the practice of no-till systems in the infected areas. Johnsongrass (<u>Sorghum halepense</u> (L.) Pers.), bindweed (<u>Convolvulus arvensis</u> L.), milkweed

(Asclepias syriaca L.), horsenettle (Solanum carolinense L.), nutsedge (Cyperus sp.), trumpetcreeper (Campsis radicans (L.) Seem) were listed by Rieck and Herron as the most troublesome species in no-till areas for corn production. Perennial weeds are a more acute problem in corn plantings made into old sods where the weeds are already well established (Peters, 1972). Ross (1970), reporting from the midwest, listed dandelions (Taraxacum officinale Weber), brambles (Rubus spp.), sassafras (Sassafras albidum (Nutt.) Nees) and ironweed (Vernonia altissima Nutt.) as perennial weeds which tended to become prevalent in corn plantings after sod.

Other researchers have reported the same type of problem in areas under reduced and no-tillage systems for corn production. Williams, Jr. et al. (1970a) found in Indiana that counts of Canada thistle (Cirsium arvense (L.) Scop), nightshade (Solanum nigrum L.), horsenettle and milkweed were higher in plots of continuous no-till corn when compared to chisel and conventionally tilled plots. Fowler (1972) in Arkansas, Triplett, Jr., and Little (1972) in Ohio and Peters (1972) in Connecticut, are some of the authors who have reported perennial weeds in areas for corn production as a result of decreasing preplant tillage operations.

Perennial weedy grasses and sedges have also been mentioned as problems related to tillage systems. Worsham (1970) cited bermudagrass (Cynodon dactylon (L.) Pers.), dallisgrass (Paspalum dilatatum Poir.), johnsongrass and nutsedge as perennial weed problems that remained unsolved in the Southwest. Furthermore, Worsham reported bermudagrass infesting considerable portions of the Piedmont area of

North Carolina. Causes of the problem were said to be suppression of fescue (Festuca arundinacia Schred.) and resistance of bermudagrass to herbicides. As corn growers tried no-tillage systems, bermudagrass became a serious problem.

Shift from annual broadleaf weeds to herbicide resistant annual grasses has been another problem related to reduced and no-tillage systems for production of corn and other crops especially in areas under the system of continuous corn where there is not a crop rotation and the same chemicals are used for many crop seasons. The problem varies with the area and conditions where it occurs.

At Hays, Kansas, yields of sorghum (Sorghum bicolor (L.) Moench) were markedly increased by chemical fallow, compared to regular sweep tillage (W. M. Phillips, 1964). However, after a few years the weed population shifted from broadleaf species that were susceptible to atrazine to field sandbur (Cenchrus incertus M. A. Curtis) which was resistant. As a consequence, yields were reduced unless some tillage was used at critical times to control field sandbur (W. M. Phillips, 1969).

In Indiana, Williams, Jr. et al. (1970b) found that the number of grasses per square foot (0.0929 m^2) germinating on non-plow systems was much greater than the numbers on wheel track and conventional spring plow systems. Griffith et al. (1970) observed that the type of tillage system influenced both the kind and number of weeds. They reported a shift to fall panicum (Panicum dichotomiflorum Michx.), a late starting grass, as a consequence of the resistance of this weed to herbicides used in corn. Previously, in

1969, Ross et al. had noticed a shift from broadleaf weeds to fall panicum and crabgrass (Digitaria sanguinalis (L.) Scop.).

Identical shifts have been observed in other areas as reported by Wicks (1972) in Nebraska, Rieck and Herron (1974) in Kentucky, Lewis (1973) in North Carolina and Triplett, Jr. and Little (1972) in Ohio.

Fall panicum is the most common of many closely related Panicum species which are often collectively considered late season grasses in many corn fields. Once considered only a nuisance in harvesting during wet periods, it now has become a serious problem in Indiana corn fields (Williams, Jr. et al., 1974a). This problem has become so serious that some weed researchers have started working on specific trials to obtain fall panicum control. Bauman et al. (1973), working on a Tracy Sandy Loam in Northern Indiana, compared the effect of both cultivation and chemical control in conventional and no-till corn plots on the fall panicum control. They found that fall panicum can germinate in the field as early as foxtails (Setaria spp.) and that fall panicum is not as resistant to tillage as other weeds. Cultivation increased fall panicum control by 36% on no-till plots and by 25% on conventional plots. Cultivation by itself gave 83% fall panicum control.

Other researchers in the Midwest have shown some concern about the wide-spread of fall panicum. McKibben (1972) studied fall panicum control with herbicides in Illinois, working on a Belknap Silt Loam at Dixon Springs. He reported good control of fall panicum in alachlor treated plots in the early spring and a longer control in simazine plots. Atrazine gave only temporary control of fall panicum. A different approach on fall panicum control is given by Moschler et al. (1974). Working on a Frederick Silt Loam in Virginia, they found that fall panicum could be controlled with the help of limestone incorporation, either 2000 kg/ha once in 4 years or 500 kg/ha every year.

Weed problems in reduced or no-tillage systems for corn production such as increase in perennial weeds and shift from annual broadleaf weeds to annual grasses have been attributed most to the poor performance of herbicides in those systems. Alachlor is a good example of this. Peters (1972) reported alachlor gave consistent control of annual grasses in conventional corn but frequently appearing weaker in no-tillage corn. That same observation was made in Indiana by Williams, Jr. et al. (1972) on a Tracy Sandy Loam. Alachlor in combination with simazine, cyanazine or atrazine gave good control of annual grasses in conventional plots but gave less control in no-tilled and chisel plowed plots, especially in the no-till plots.

Williams, Jr., et al. (1971) explained the lack of weed control on no-plow systems mentioning the following factors:

1) Soil is compact, it is not fluffed up as it is with normal plowing each spring.

2) Water penetration is slowed down and consequently so is herbicidal movement into the soil.

3) The trash can intercept herbicides to slow the rate with which they reach the soil where the weed seedlings are germinating.

4) The tight soil which still has the trash on the surface serves as an excellent medium for the germination of small seeded grasses.

5) Finally, some weeds are present at planting time in plots under no-plow systems and contact herbicides are required to improve control. This accounts for an increase in the cost.

Mechanical operations such as preplant plowing and cultivation have been used for a long time as a means of weed control. Bauman et al. (1971) working with conventional corn, cited the moldboard plow as a very effective way of controlling weeds, especially perennial weeds. An example of the beneficial effect of mechanical practices on weed control is provided by johnsongrass, a perennial grass which is difficult to control by herbicides without the help of cultivation. Roeth (1970), in Indiana, recommended mechanical practices such as tillage, cultivation, mowing, etc. to prevent seed production and improve johnsongrass control.

Crop establishment and weed control are the major considerations for no-tillage crop production under all circumstances (Triplett, Jr., 1968). Whether weed control should be obtained with chemicals only or in combination with mechanical practices is still a question to be answered. Williams et al. (1975) affirmed that an increase in fall panicum and perennial weeds can be readily reversed by conventional tillage (moldboard plow). A better understanding of the influence of tillage systems on the potential weed population is needed to help farmers to decide whether they should use reduced and no-tillage systems for corn production or plow the soil for seedbed preparation.

Preplant Tillage Influence on Weed Seed Distribution Throughout the Soil Layer

Weeds survive in agricultural soils because they produce tremendous numbers of seeds that have varying degrees of dormancy (Wiese and Staniforth, 1973). This was shown by Brenchly and Warington (1930) who found at Rothamstad, England 113 million weed seeds per acre in continuous wheat (Triticum aestivum L.) and barley (Hordeum vulgare L.) plots. Robinson (1949) reported that over 70 million weed seeds per acre were found on farms in Minnesota. Stevens (1932) studied the number and weight of seeds produced by weeds in North Dakota and found that 9 species produced over 100,000 seeds per plant. Witchweed (Striga lutea Lour.) is a good example of this high capability of seed production per individual plant. Witchweed plants growing on corn produce over a half million seeds per plant (Shaw et al., 1962).

Seed viability is another mechanism which accounts for the survival of weeds in agricultural soils. Darlington (1941) reported about the 60 year results of Dr. Beal's seeds viability experiment. Seeds of many common weeds were buried in the soil in East Lansing, Michigan, in the fall of 1879 by Dr. Beal. Seeds were dug up at 5 or 10 year intervals and germination tests were carried out. Seeds of curly dock (Rumex crispus L.) were still viable after 60 years, seeds of redroot pigweed (Amaranthus retroflexus L.) after 40 years and seeds of yellow foxtail (Setaria lutescens (Weigel) Hubb.) after 30 years.

According to Wiese and Staniforth (1973) weed seeds apparently possess an additional complex of special germination mechanisms, related perhaps to soil tillage. Soil disturbance may trigger the mechanisms through changes in soil moisture, temperature, oxygen supply, exposure to light, change in depth of burial and alternate wetting and drying at the sites of soil seed coat contact. The role of soil disturbance in weed seed germination is not well documented beyond the obvious effects of tillage on soil moisture, temperature and aeration and the observed germination of weed seeds following tillage. Depth of seed burial and soil revolving by plowing are also important in the germination of weed seeds. Warren (1971) listed the advantages of no-tillage systems and among others he mentioned that without soil disturbance only the seeds near the surface germinate.

The influence of tillage systems on the weed seed distribution throughout the soil layer is not well documented in the literature. A great contribution to this area of research was given by Wicks and Somerhalder (1971) who studied the effect of seedbed preparation for corn on distribution of weed seeds, comparing the Nebraska till-planting system with the conventional system. They sampled the soil at 0 cm, 25.4 cm and 50.8 cm horizontally from the row and the samples were taken at increments of depth from 0 to 7.6 cm, 7.6 to 15.2 cm, 15.2 to 22.9 cm and 22.9 to 30.5 cm, prior and after seedbed preparation. They reported the following results:

1) Prior to seedbed preparation there were significantly more weed seeds in the 0 to 7.6 cm depth and significantly less weed seeds in the 7.6 to 15.2 cm layer on the Nebraska till-plant than on the conventional plant system;

2) After seedbed preparation, under the conventional plant system weed seeds were equally distributed throughout the soil depth. Under the Nebraska till-plant system fewer weed seeds were buried deeper than 15.2 cm and more remained in the top layer than under the conventional-plant system;

3) Weed seeds in the 0 to 30.5 cm depth were distributed evenly in samples taken at 0, 25.4 and 50.8 cm from the row in conventional-plant system, before and after seedbed preparation. However, under the Nebraska till-plant system, weed seed counts in the row area were reduced by the passage of the till-planter sweep.

CHAPTER II

Influence of Tillage System on the Potential Weed Population

Introduction

A cooperative research project involving six departments in the School of Agriculture and 15 staff members was started at Purdue University in 1967 to study several tillage systems in relation to conventional tillage. This project was started in 1967 at the Feldun-Purdue Agricultural Center, Bedford, Indiana, and in the following year at the Pinney-Purdue Agricultural Center, Wanatah, Indiana. Specific objectives of the project were:

1) To study the corn production of no-plow systems, limited tillage systems which use the moldboard plow, and conventional systems on a range of soil types.

2) To compare effects of different tillage and planting systems on the physical properties of a range of soil types.

3) To determine effectiveness of the different tillage and planting systems on erosion control.

4) To evaluate for the no-plow systems studied, various methods of fertilization, soil insect control, weed control and residue management.

5) To determine the power requirements and fuel consumption for the various tillage-planters studied.

6) To determine the effect of the various tillage-planting systems on optimal farm organization, income and resource use.

To accomplish the specific objective of weed control for continuous corn production, herbicide treated and untreated plots were superimposed on each tillage strip and were kept in both locations as Standard treatments for the period of 6 years, the duration of the project.

This study is an extension of the objectives of the aforementioned project. Tillage strips and plots previously set up for the project, were left fallow in the seventh year in both locations for the purpose of studying the influence of both tillage-planting systems and previous chemical treatments on the potential weed population. Credit is given to all Purdue University staff members who started the project and allowed the completion of this study.

Materials and Methods

Locations and Soil Types. The tillage-planting strips and herbicide plots were established at two Purdue University Agricultural Centers: the Feldun-Purdue Agricultural Center located in Bedford, Lawrence County, in southern Indiana and the Pinney-Purdue Agricultural Center located in Wanatah, on the Porter-Laporte County line, northern Indiana.

Three soil types, ranging from well-drained sandy loam to slowly-drained silt loam, were studied. A description of the soils follows.

Bedford Silt Loam, a typic fragiudult, fine silty family, on the Feldun-Purdue location, occupies a gently sloping ridge top. Most of the Bedford soil is on slopes of one to three percent. A rather constant fragipan layer occurs at a depth of 50 to 60 cm, delays downward percolation and causes slow subsoil drainage in the preplant season. This soil has a 20 to 30 cm top layer of brown silt on silt loam with weak fine granular structure. It grades to a strong brown or yellowish brown heavy silt loam or silty clay loam subsoil which has weak medium sub-angular blocky structure and fine faint mottling of yellowish red in the lower part. It then grades to a gray silty compact cemented fragipan. This layer is splotched and mottled and has gray silt streaks and crack fills which roots can penetrate, but the layer itself effectively bars normal root penetration. The fragipan layer grades below 75 to 85 cm to a yellowish red silty clay loam subsoil which becomes more reddish below 100 cm and has light clay texture and strong medium sub-angular blocky structure. The reddish material is a residue from limestone while the upper 50 to 75 cm of the soil is in an overburden of silty loess. Chemical and mechanical analysis of samples from the upper layer indicated an organic matter content of 1.71%, pH 6.4, medium content of both P and K and 83.75% of silt, 10.02% of sand and 6.22% of clay.

Tracy Sandy Loam, a typic hapludalf, coarse loamy family, located on the Pinney-Purdue Agricultural Center, is a well-drained, nearly level soil with a broad convex surface. It has 20 to 25 cm of dark grayish brown weak medium granular sandy loam which rests on brown or strong brown sandy clay loam of weak medium sub-angular blocky structure. This loamy layer is porous and permeable and usually grades after 5 cm to a brown stratified sandy loam which changes to loamy sand below 75 to 90 cm. This underlying material is variable from place to place, but it is thought to have layers of pure sand and gravel 7.5 to 15 cm thick to a depth of at least 182 cm. Here the sand particles contain a high proportion of shale fragments which contribute to finer materials, normally acid. Chemical and mechanical analysis of samples from the top layer indicated an organic matter content of 1.41%, pH 6.1, high content of both P and K and 38.93% of silt, 59.36% of sand and 2.64% of clay.

Runnymede Loam, a typic ariaquoll, fine loamy over sandy skeletal family, also located on the Pinney-Purdue Agricultural Center, is a level poorly-drained soil with water table normally between 30 cm in winter and spring and 120 cm in summer. It has 25 to 35 cm of nearly black glanular loam over dark grayish brown sandy clay loam which has a weak medium prismatic and moderate medium blocky form. This grades at about 45 to 55 cm to grayish brown sandy clay loam which is mottled with yellowish brown and continues to about 75 or 90 cm. Below this is light gray loamy sand or sand containing many coarse sand size shale fragments. The permanent water table seldom drops below 105 to 120 cm and is seasonally near the surface. Chemical and mechanical analysis of samples from the upper layer indicated an organic matter content of 2.99%, pH 6.3, a slightly high content of both P and K and 44.79% of silt, 47.48% of sand and 7.73% of clay.

<u>Tillage-planting Systems</u>. The tillage-planting systems for continuous corn production included in this study were established

by Purdue University staff members who participated in a cooperative research project (Griffith et al., 1970). At the Feldun-Purdue Agricultural Center strips of conventional tillage-spring plowed, chisel plant, coulter plant, coulter plant plowed once, till plant and till plant plowed were established in 1968 on the Bedford Silt Loam. These tillage strips were kept under the system of continuous corn for the period of 1968 to 1973 and left fallow in 1974 for the purpose of studying the potential weed population on the strips.

At the Pinney-Purdue Agricultural Center strips of conventional tillage-spring plowed, chisel plant and coulter plant were established in 1969 on both Tracy Sandy Loam and Runnymede Loam. The tillage strips established on these soils were kept under the system of continuous corn for the period of 1969 to 1974 and left fallow in 1975 for the purpose of this study.

Tillage systems used in this study are described by Griffith et al. (1970). Strips of coulter plant plowed once and till plant plowed once are the same as coulter plant and till plant respectively except that these strips were plowed once in the fourth year after establishment. The original purpose of this plowing operation was to incorporate P and K broadcast.

Experimental Design and Herbicides. Tillage strips were put in randomized complete blocks with 3 replications at Bedford, Indiana and 4 replications at Wanatah, Indiana. At Bedford, Indiana, each replication contained one strip of conventional tillage-spring plow, chisel plant, coulter plant, coulter plant plowed once, till plant and till plant plowed once, giving a total of 6 tillage strips. At

Wanatah, Indiana, on both soils, each replication contained one strip of conventional tillage-spring plow, chisel plant and coulter plant for a total of 3 tillage strips. Tillage strips were 3.05 m wide in both locations and 27.4 m long at Bedford, Indiana, and 36.6 m long on both soils at Wanatah, Indiana.

Herbicide treatments were randomized on the tillage strips, each tillage strip containing all herbicide treatments. Herbicide plots in all tillage strips were 3.05 m wide and 9.14 m long, in both locations. At Bedford, Indiana, one control and two herbicide treatments were studied. At Wanatah, Indiana, on both soils, one control and three herbicide treatments were studied.

Herbicides used in this study were atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine), simazine (2-chloro-4, 6-bis(ethylamino)-s-triazine) and alachlor (2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide). A complete list of herbicide treatments, locations, and period of application for continuous corn production, are shown in Table 2.

Field Procedures. Weeds were recorded in the field on all three soils with a counting square measuring 30.5 cm x 152.4 cm, divided in five equal sections of 929 cm^2. The counting square was placed at the same location in all plots, each time weeds were recorded. This location was 3.05 m from the front of the plot and between the middle two rows of corn, 22.9 cm from the row. The corn stubble remained in all cases so that the location of the rows of the previous corn crop could be determined. To keep the same position of the counting square for subsequent weed recordings, the

Table 2. Herbicide treatments, locations and period of application for continuous corn production.

Location		Time of Application*	Rate kg/ha	1969	1970	1971	1972	1973	1974	1975
				Period of Application						
Bedford	untreated	-	-	x	x	x	x	x	**	
Silt Loam	atrazine	PRE	3	x	x	x	x	x	**	
Feldun-PAC	atrazine + alachlor	PPS	2 + 1.5	x	x	x	x	x	**	
Tracy Sandy	untreated	-	-	x	x	x	x	x	x	**
Loam and Runnymede Loam	atrazine	PRE	3	x	x	x	x	x	x	**
Pinney-PAC	atrazine + alachlor	PRE	2 + 1.5	x	x	x	x	x	x	**
	simazine + alachlor	PRE	2 + 1.5	-	x	x	x	x	x	**

* PRE and PPS stand for Preemergence and Preplant Surface, respectively.

** Plots were left fallow for observations.

location of two corners of the counting square was marked with 30.5 cm plot stakes. Figures 1 and 2 show weeds being recorded in the field and details of the counting square, respectively.

Weed counts were taken from both end sections and from the middle section of the five-sectioned-counting square, for a total area of 2787 cm^2 per plot. The other two sections were used for soil sampling. All the weeds found inside the three sections were identified and recorded by species. To allow all the weeds to germinate in the field and obtain the full weed potential of the plots, sampling areas and then the experimental area were sprayed with paraquat immediately after each recording. Sampling areas were sprayed with a CO_2 pressurized back-pack sprayer equipped with a 1108 Teejet nozzle, delivering 272 ml/m^2 of the herbicidal solution. The entire experimental area was then sprayed with a tractor-mounted sprayer equipped with 8003 Teejet nozzles, delivering 280 l/ha of herbicidal solution. The rates of application were 1.357 mg/m^2 on the sampling areas and 2.723 kg/ha broadcast over the entire experimental area. Paraquat was in both cases applied in aqueous solution with a non ionic surfactant (X-77) added at 0.5% per volume. Figure 3 shows application of paraquat on sampling areas.

At Bedford, Indiana, on the Bedford Silt Loam, weeds were recorded in 1974, on May 16, August 1 and October 2. At Wanatah, Indiana, weeds were recorded in 1975 on May 28 and August 6 for the Tracy Sandy Loam and on May 29 and August 5 for the Runnymede Loam.

Figure 1. Recording weeds in the field, Bedford, Indiana, 1974.

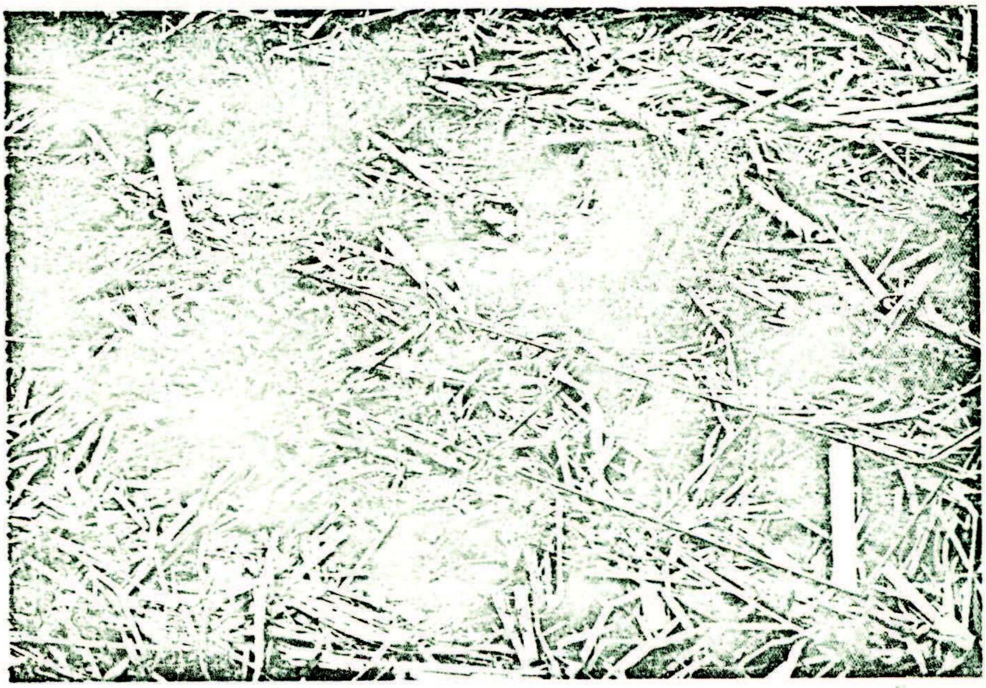

Figure 2. Detail of the counting square used for recording weeds and soil sampling.

Figure 3. Paraquat was sprayed on sampling areas after weeds were recorded.

Results and Discussion

Bedford Silt Loam. At the Feldun-Purdue Agricultural Center, Bedford, Indiana, the predominant weeds recorded inside the counting square were fall panicum, large crabgrass (*Digitaria sanguinalis* (L.) Scop), downy brome (*Bromus tectorum* L.), common lambsquarters (*Chenopodium album* L.) pennsylvania smartweed (*Polygonum pensylvanicum* L.) wild buckwheat (*Polygonum convolvulus* L.), redroot pigweed, horsenettle, common ragweed (*Ambrosia artemisiifolia* L.), giant ragweed (*Ambrosia trifida* L.), prickly sida (*Sida spinosa* L.), purslane speedwell (*Veronica peregrina* L.) and catchweed bedstraw (*Galium aparine* L.).

Data obtained from the three accumulated weed recordings on the tillage strips of the Bedford Silt Loam are shown in Tables 3 through 7. Figures 4 through 9 show the appearance of untreated plots on the tillage systems included in this study. Pictures were taken on May 21, 1974 when weeds were recorded for the first time.

The influence of tillage systems on the weed population of plots without herbicides is shown in Table 3. As indicated by the data, the influence of tillage systems on the weed population of these plots was primarily on the population of broadleaves, especially pennsylvania smartweed, the most predominant weed of this group in the experiment. The lowest population of broadleaves was observed in conventional tillage-spring plowed. No other tillage system showed a reduction in the population of broadleaves; however, the distribution of broadleaf species varied with the tillage systems. As shown by Figures 4 through 9, chisel plant had a high population of

Table 3. Influence of tillage system on the potential weed population of untreated plots treated on a Bedford Silt Loam, Bedford, Indiana, fallow 1974.

Tillage Systems Past Years	Fall Panicum (#/m^2)	Smartweed (#/m^2)	Total Grasses (#/m^2)	Total Broadleaves (#/m^2)	Total Weeds (#/m^2)
Conventional (Spring)	99*a	7 c	136 a	78 b	214 b
Chisel Plant (Fall)	91 a	309 a	91 a	518 a	609 ab
Coulter (No-till)	19 a	134 bc	481 a	408 ab	889 a
Coulter plowed once	55 a	50 c	59 a	426 ab	485 ab
Till Plant	147 a	221 ab	148 a	349 ab	497 ab
Till Plant plowed once	91 a	285 ab	92 a	490 a	582 ab

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 4. Influence of tillage system on the potential weed population of plots treated with atrazine (preemergence) on a Bedford Silt Loam, Bedford, Indiana, fallow 1974.

Tillage Systems Past Years	Fall Panicum (#/m^2)	Smartweed (#/m^2)	Total Grasses (#/m^2)	Total Broadleaves (#/m^2)	Total Weeds (#/m^2)
Conventional (Spring)	98* b	5 a	118 b	148 b	263 a
Chisel Plant (Fall)	255 ab	51 a	271 ab	554 a	825 a
Coulter (No-till)	298 ab	5 a	298 ab	128 b	428 a
Coulter plowed once	300 ab	2 a	301 ab	395 ab	696 a
Till Plant	566 a	6 a	572 a	75 b	647 a
Till Plant plowed once	413 ab	4 a	415 ab	165 b	580 a

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 5. Influence of tillage system on the potential weed population of plots treated with atrazine + alachlor (preplant surface), on a Bedford Silt Loam, Bedford, Indiana, fallow 1974.

Tillage Systems Past Years	Fall Panicum ($\#/m^2$)	Smartweed ($\#/m^2$)	Total Grasses ($\#/m^2$)	Total Broadleaves ($\#/m^2$)	Total Weeds ($\#/m^2$)
Conventional (Spring)	123*a	10 a	127 a	133 a	260 a
Chisel Plant (Fall)	274 a	18 a	281 a	275 a	556 a
Coulter (No-till)	463 a	8 a	463 a	260 a	723 a
Coulter plowed once	443 a	36 a	443 a	209 a	652 a
Till Plant	434 a	24 a	437 a	294 a	731 a
Till Plant plowed once	231 a	37 a	238 a	164 a	402 a

* Values followed by the same letter in a column are not significantly different at the 5% level of Duncan Multiple Range.

Table 6. Influence of the interaction tillage systems x chemicals on the potential population of fall panicum on a Bedford Silt Loam, Bedford, Indiana, fallow 1974.

Tillage Systems Past Years	Untreated	Atrazine (PRE)	Atrazine + Alachlor (PPS)
	(#/m^2)	(#/m^2)	(#/m^2)
Conventional (Spring)	99*a	98 a	123 a
Chisel Plant (Fall)	91 b	255 ab	274 a
Coulter (No-till)	19 b	298 ab	463 a
Coulter plowed once	55 b	300 ab	443 a
Till Plant	147 b	566 a	434 a
Till Plant plowed once	91 b	413 a	231 ab

* Values followed by the same letter in a row are not significantly different at the 5% level of Duncan Multiple Range.

Table 7. Influence of the interaction tillage systems x chemicals on the potential population of smartweed on a Bedford Silt Loam, Bedford, Indiana, fallow 1974.

Tillage Systems Past Years	Untreated	Atrazine (PRE)	Atrazine + Alachlor (PPS)
	(#/m^2)	(#/m^2)	(#/m^2)
Conventional (Spring)	7*a	5 a	10 a
Chisel Plant (Fall)	308 a	51 ab	18 b
Coulter (No-till)	134 a	5 b	8 b
Coulter plowed once	50 a	2 a	36 a
Till Plant	221 a	10 b	24 b
Till Plant plowed once	285 a	4 b	37 b

* Values followed by the same letter in a row are not significantly different at the 10% level of the Student-Newman-Keuls' Test.

Figure 4. Conventional tillage plot with no herbicides on 5/21/74, Bedford, Indiana.

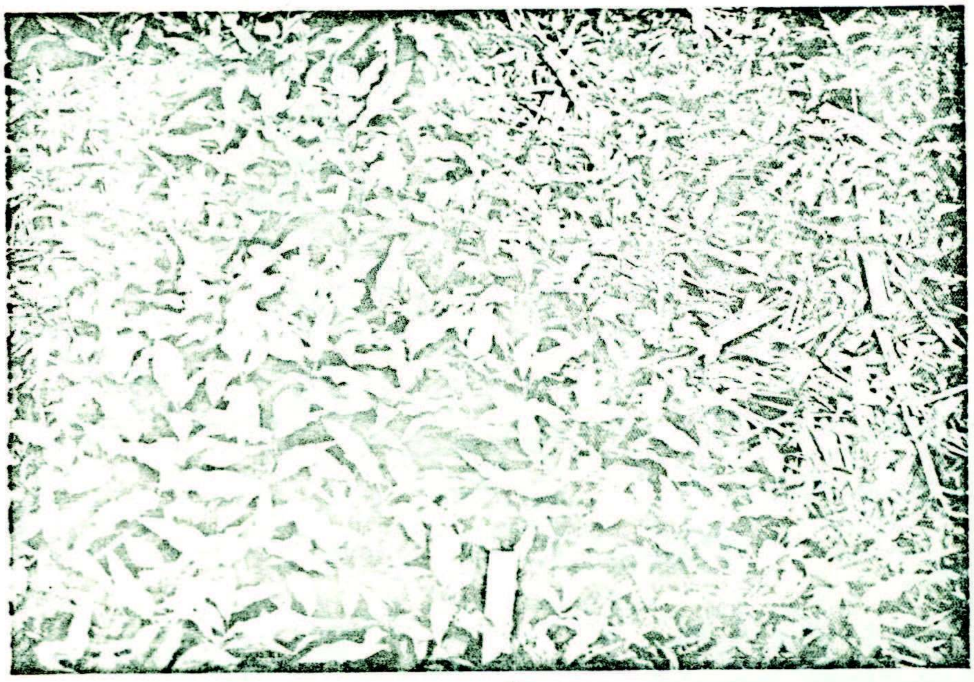

Figure 5. Chisel plow tillage with no herbicides on 5/21/74, Bedford, Indiana.

Figure 6. No-till plot with no herbicides on 5/21/74, Bedford, Indiana.

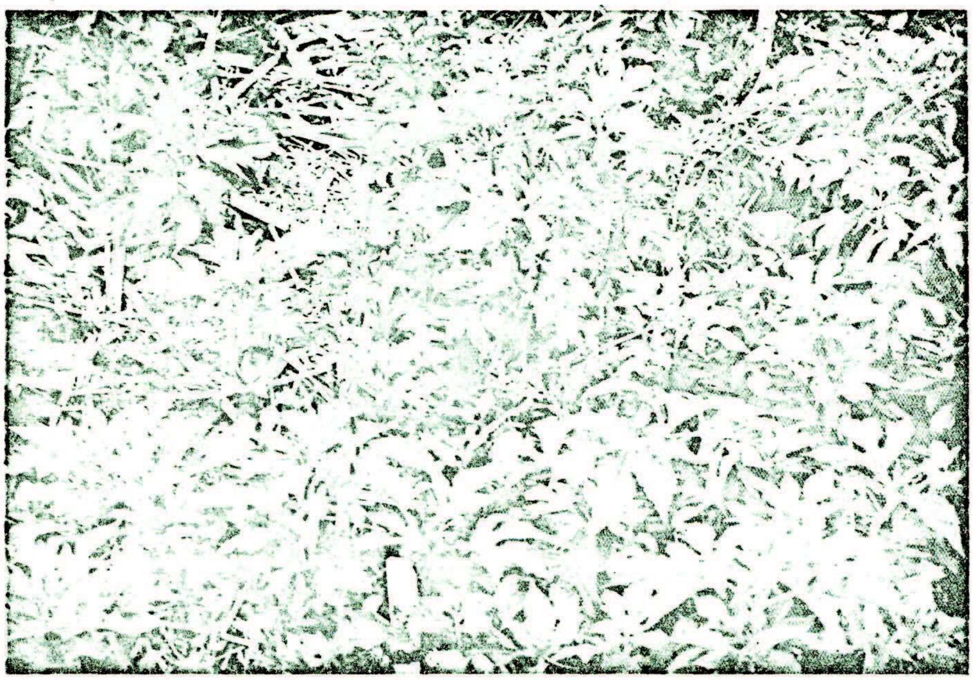

Figure 7. No-till plowed once in 1971 with no herbicides on 5/21/74, Bedford, Indiana.

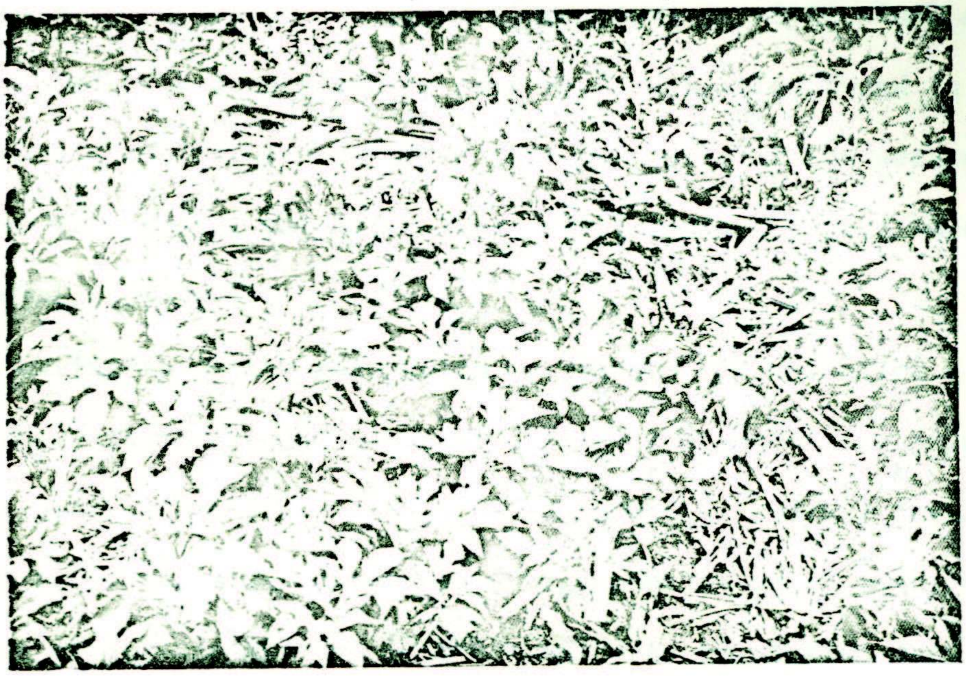

Figure 8. Till plant with no herbicides on 5/21/74, Bedford, Indiana.

Figure 9. Till plant plowed once in 1971 with no herbicides on 5/21/74, Bedford, Indiana.

pennsylvania smartweed and the other systems of reduced tillage had a weed population comprised primarily of giant ragweed. Till plant and till plant plowed once presented the same weed population found in coulter plant and coulter plant plowed once but early in the season when pictures were taken, the till plant and till plant plowed once appeared somewhat cleaner.

A high variation in the population of grasses did not allow a conclusive analysis of the influence of tillage systems on the population of this group of weeds. Coulter plant showed a tendency for less fall panicum but these plots contained a high population of downy brome. The influence of tillage systems on the total weed population was similar to that found for broadleaves alone.

The influence of tillage systems on the weed population of plots treated with atrazine and atrazine + alachlor is shown in Tables 4 and 5. As indicated by the figures in the tables, fall panicum constituted more than 90% of all grasses in herbicide treated plots and the analyses for both fall panicum and total grasses are identical. All the reduced tillage systems, especially till plant, showed a higher population of fall panicum than conventional tillage system in atrazine treated plots. However, the difference was not significant in atrazine + alachlor treated plots.

Chisel plant presented a higher population of broadleaves than the other tillage systems in atrazine treated plots but this difference was not significant in atrazine + alachlor treated plots. The potential population of pennsylvania smartweed was low for all the tillage systems and no significant difference was observed in the population of total weeds.

Tables 6 and 7 show the influence of the interaction between tillage systems and chemicals on the population of fall panicum and pennsylvania smartweed, respectively. Except conventional tillage-spring plowed, all the tillage systems presented a higher potential of fall panicum when treated with herbicides. However, the potential population of pennsylvania smartweed was reduced in the herbicide treated plots on all tillage systems except conventional tillage-spring plowed and coulter plant plowed once, where the potential population of this broadleaf weed was low in all three types of plots. This suggests that plowing the coulter plant once in 1971 was enough to reduce the potential of pennsylvania smartweed to that found in conventional tillage-spring plowed.

Tables 6 and 7 also suggest that there was a shift of weeds from broadleaves to grasses, especially fall panicum in herbicide treated reduced tillage systems. This observation is consistent with the data obtained by Williams, Jr. et al. (1970b), Griffith et al. (1970), Ross et al. (1969), Wicks (1972) and others.

Tracy Sandy Loam. The predominant weeds recorded inside the counting square in plots on the Tracy Sandy Loam, at the Pinney-Purdue Agricultural Center, Wanatah, Indiana, were fall panicum, large crabgrass, downy brome, Kentucky bluegrass (Poa pratensis L.), giant foxtail (Setaria faberi Herrm.), green foxtail (Setaria viridis (L.) Beauv.), common ragweed, horseweed (Conyza canadensis (L.) Cronq.), prickly lettuce (Lactuca serriola L.), common dandelion (Taraxacum officinale Weber), pennsylvania smartweed, wild buckwheat, common lambsquarters, redroot pigweed, carpetweed (Mollugo verticillata L.)

shepherdspurse (Capsella bursa-pastoris (L.) Medic.), velvetleaf (Abutilon theophrasti Medic.) and purslane speedwell. Fall panicum and common ragweed were the most prevalent weeds in the plots.

Data obtained from the two accumulated weed recordings on the tillage strips of the Tracy Sandy Loam are shown in Tables 8 through 12. Table 8 shows the influence of conventional tillage-spring plowed, chisel plant and coulter plant on weed population of untreated plots, Tables 9, 10 and 11 show the influence of the tillage systems on potential weed population of herbicide treated plots and Table 12 shows the influence of interaction between tillage systems and chemicals on the population of fall panicum and common ragweed.

As indicated by the data in Table 8, the effect of tillage systems on weed population of untreated plots on the Tracy Sandy Loam was primarily on broadleaf weeds, especially on common ragweed which represented more than 70% of all broadleaf weeds. Analyses for both common ragweed and total broadleaves showed that the population was the lowest in conventional tillage-spring plowed and the highest in coulter plant. Untreated plots of chisel plant presented intermediate populations in both analyses. This influence on the population of broadleaf weeds did not cause a significant difference in the population of total weeds.

Fall panicum accounted for more than 80% of all grasses in all untreated plots and analyses for both fall panicum and total grasses were identical. Although a consistent trend existed for a decreased population of fall panicum with less tillage no significant differences

Table 8. Influence of tillage system on the potential weed population of untreated plots on a Tracy Sandy Loam, Wanatah, Indiana, fallow 1975.

Tillage Systems Past Years	Fall Panicum ($\#/m^2$)	Common Ragweed ($\#/m^2$)	Total Grasses ($\#/m^2$)	Total Broadleaves ($\#/m^2$)	Total Weeds ($\#/m^2$)
Conventional (Spring)	666*a	339 c	833 a	419 c	1252 a
Chisel Plant (Fall)	420 a	589 b	501 a	765 b	1266 a
Coulter (No-till)	151 a	944 a	165 a	1389 a	1554 a

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 9. Influence of tillage system on the potential weed population of plots treated to atrazine (preemergence) on a Tracy Sandy Loam, Wanatah, Indiana, fallow 1975.

Tillage Systems Past Years	Fall Panicum (#/m^2)	Common Ragweed (#/m^2)	Total Grasses (#/m^2)	Total Broadleaves (#/m^2)	Total Weeds (#/m^2)
Conventional (Spring)	1932*a	21 a	2008 a	200 a	2208 a
Chisel Plant (Fall)	1260 ab	7 a	1281 a	150 a	1431 ab
Coulter (No-till)	982 b	8 a	1014 a	38 a	1052 b

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 10. Influence of tillage system on the potential weed population of plots treated with atrazine + alachlor (preemergence) on a Tracy Sandy Loam, Wanatah, Indiana, fallow 1975.

Tillage Systems Past Years	Fall Panicum ($\#/m^2$)	Common Ragweed ($\#/m^2$)	Total Grasses ($\#/m^2$)	Total Broadleaves ($\#/m^2$)	Total Weeds ($\#/m^2$)
Conventional (Spring)	767*a	13 a	1315 a	52 a	1367 a
Chisel Plant (Fall)	1241 a	12 a	1406 a	99 a	1863 a
Coulter (No-till)	1165 a	43 a	1214 a	102 a	1316 a

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 11. Influence of tillage system on the potential weed population of plots treated with simazine and alachlor (preemergence) on a Tracy Sandy Loam, Wanatah, Indiana, fallow 1975.

Tillage Systems Past Years	Fall Panicum (#/m^2)	Common Ragweed (#/m^2)	Total Grasses (#/m^2)	Total Broadleaves (#/m^2)	Total Weeds (#/m^2)
Conventional (Spring)	922*a	4 b	1014 a	133 a	1146 a
Chisel Plant (Fall)	1089 a	0 b	1190 a	106 a	1296 a
Coulter (No-till)	956 a	170 a	1009 a	282 a	1291 a

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 12. Influence of the interaction tillage system x chemicals on the potential population of fall panicum and common ragweed on a Tracy Sandy Loam, Wanatah, Indiana, fallow 1975.

Chemicals	Conventional (Spring)		Chisel Plant (Fall)		Coulter (No-till)	
	Fall Panicum (#/m^2)	Common Ragweed (#/m^2)	Fall Panicum (#/m^2)	Common Ragweed (#/m^2)	Fall Panicum (#/m^2)	Common Ragweed (#/m^2)
atrazine at 3 kg/ha (PRE)	1932*a	21 b	1260 a	7 b	982 a	8 b
atrazine + alachlor at 2 + 1.5 kg/ha (PRE)	767 b	13 b	1241 a	12 b	1165 a	43 b
simazine + alachlor at 2 + 1.5 kg/ha (PRE)	922 b	4 b	1089 ab	0 b	956 a	170 b
untreated	666 b	339 a	420 b	589 a	151 b	944 a

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

among the three tillage systems were observed.

The influence of tillage systems on the weed population of plots treated with atrazine, atrazine + alachlor and simazine + alachlor is shown in Tables 9 through 11, respectively. The population of both common ragweed and total broadleaves in herbicide treated plots, as indicated by the data in the tables, was low and not significantly different among the three tillage systems, except in simazine + alachlor treated plots. In simazine + alachlor treated plots the population of common ragweed was significantly higher in coulter plant than in the other tillage systems. This suggests a negative interaction between coulter plant and the herbicide simazine in the control of common ragweed.

As indicated in the tables, the three tillage systems did not show a significant influence on the potential population of both fall panicum and total grasses in herbicide treated plots except in plots treated with atrazine alone. The potential population of fall panicum was significantly higher in atrazine treated plots of conventional tillage-spring plowed than in the plots of coulter plant. Chisel plant presented an intermediate population but not significantly different from the other tillage systems.

In atrazine treated plots, fall panicum accounted for 97% of the total grass population and 89% of the total weed population recorded. The difference between the tillage systems in the population of fall panicum was reflected in the total weed potential.

The influence of the interaction between tillage systems and chemical treatments on the population of fall panicum and common ragweed on the Tracy Sandy Loam is shown in Table 12. The population of common ragweed was significantly reduced by the herbicide treatment in all three tillage systems, as compared to the untreated plots. However the effect of herbicide treatments on the population of fall panicum was different in the three tillage systems. Atrazine + alachlor and simazine + alachlor treated plots presented a population of fall panicum which was not significantly different from that potential found in untreated plots of conventional tillage spring plowed but atrazine treated plots had a higher population than the untreated plots. In chisel plant and coulter plant, the herbicide treatments caused increase in the population of fall panicum. This build up of fall panicum was significant except for simazine + alachlor treated plots in chisel plant.

Data obtained from the Tracy Sandy Loam and shown in Table 12 suggest that herbicide treatments were not greatly influenced by the tillage systems in their effect on a susceptible weed such as common ragweed. However, the effect of the herbicide treatments on a less susceptible weed such as fall panicum was influenced by the tillage systems. Data also suggest that atrazine alone caused a build up of fall panicum in all three tillage systems. This observation on the performance of the chemical treatments on fall panicum control is consistent with the data obtained by McKibben (1972), Peters (1972) and Williams, Jr. et al. (1972).

Runnymede Loam. The most predominant weeds recorded in plots on the Runnymede Loam of Pinney-Purdue Agricultural Center, Wanatah, Indiana, were fall panicum, large crabgrass, giant foxtail, green foxtail, common lambsquarters, giant ragweed, common ragweed, Canada thistle, horseweed, prickly lettuce, common dandelion, common cocklebur (Xanthium pensylvanicum Wallr.), pennsylvania smartweed, prostrate rustweed (Polygonium aviculare L.), jimsonweed (Datura stramonium L.) redroot pigweed and carpetweed. Fall panicum, common lambsquarters and giant ragweed were the most prevalent species and they were chosen for separated analyses.

Data on the influence of conventional tillage-spring plowed, chisel plant and coulter plant on weed population obtained from two accumulated weed readings on the Runnymede Loam of Pinney-Purdue Agricultural Center are shown in Tables 13 through 17. Data obtained from untreated plots are shown in Table 13, data from three different types of herbicide treated plots are shown in Tables 14, 15 and 16 and Table 17 shows the effect of the interaction between tillage systems and chemical treatments on the population of fall panicum and common lambsquarters. As indicated by the data in Table 13, the influence of the three tillage systems on the weed population of untreated plots was statistically significant for common lambsquarters, giant ragweed and total weeds. The populations of fall panicum, total grasses and total broadleaf weeds were not significantly affected by the tillage systems. The population of common lambsquarters was the highest in conventional tillage-spring plowed and the lowest in coulter plant. The population in chisel plant was intermediate and significantly different from both conventional and coulter systems.

The population of giant ragweed was higher in coulter plant than in both conventional tillage-spring plowed and chisel plant. This tall,

Table 13. Influence of tillage system on the potential weed population of untreated plots on a Runnymede Loam, Wanatah, Indiana, fallow 1975.

Tillage Systems Past Years	Fall Panicum (#/m²)	Lambs-quarters (#/m²)	Giant Ragweed (#/m²)	Total Grasses (#/m²)	Total Broadleaves (#/m²)	Total Weeds (#/m²)
Conventional (Spring)	273*a	659 a	3 b	317 a	1209 a	1526 ab
Chisel Plant (Fall)	223 a	413 b	187 b	418 a	1214 a	1587 a
Coulter (No-till)	45 a	3 c	468 a	61 a	973 a	1034 b

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 14. Influence of tillage system on the potential weed population of plots treated with atrazine (preemergence) on a Runnymede Loam, Wanatah, Indiana, fallow 1975.

Tillage Systems Past Years	Fall Panicum ($\#/m^2$)	Lambs-quarters ($\#/m^2$)	Giant Ragweed ($\#/m^2$)	Total Grasses ($\#/m^2$)	Total Broadleaves ($\#/m^2$)	Total Weeds ($\#/m^2$)
Conventional (Spring)	799*a	3 a	2 a	822 a	50 a	872 a
Chisel Plant (Fall)	484 ab	30 a	15 a	492 ab	171 a	663 a
Coulter (No-till)	183 b	11 a	42 a	200 b	434 a	634 a

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 15. Influence of tillage system on the potential weed population of plots treated with atrazine + alachlor (preemergence) on a Runnymede Loam, Wanatah, Indiana, fallow 1975.

Tillage Systems Past Years	Fall Panicum (#/m^2)	Lambs-quarters (#/m^2)	Giant Ragweed (#/m^2)	Total Grasses (#/m^2)	Total Broadleaves (#/m^2)	Total Weeds (#/m^2)
Conventional (Spring)	330*a	51 a	6 a	451 a	183 a	634 a
Chisel Plant (Fall)	488 a	13 a	4 a	757 a	153 a	910 a
Coulter (No-till)	509 a	22 a	74 a	631 a	318 a	949 a

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 16. Influence of tillage system on potential weed population of plots treated with simazine + alachlor (preemergence) on a Runnymede Loam, Wanatah, Indiana, fallow 1975.

Tillage Systems Past Years	Fall Panicum (#/m^2)	Lambs-quarters (#/m^2)	Giant Ragweed (#/m^2)	Total Grasses (#/m^2)	Total Broadleaves (#/m^2)	Total Weeds (#/m^2)
Conventional (Spring)	130*a	12 a	1 a	178 a	74 a	252 b
Chisel Plant (Fall)	199 a	12 a	132 a	265 a	220 a	485 ab
Coulter (No-till)	270 a	6 a	6 a	352 a	442 a	794 a

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

Table 17. Influence of the interaction tillage system x chemicals on the potential population of fall panicum and lambsquarters on a Runnymede Loam, Wanatah, Indiana, fallow 1975.

Chemicals	Conventional (Spring)		Chisel Plant (Fall)		Coulter (No-till)	
	Fall Panicum (#/m^2)	Lambs-quarters (#/m^2)	Fall Panicum (#/m^2)	Lambs-quarters (#/m^2)	Fall Panicum (#/m^2)	Lambs-quarters (#/m^2)
atrazine at 3 kg/ha (PRE)	799*a	3 b	484 a	30 b	183 b	11 a
atrazine + alachlor at 2 + 1.5 kg/ha (PRE)	330 bc	51 b	488 a	13 b	509 a	22 a
simazine + alachlor at 2 + 1.5 kg/ha (PRE)	130 c	12 b	199 a	12 b	270 ab	6 a
untreated	273 bc	659 a	223 a	413 a	45 b	3 a

* Values followed by the same letter in a column are not significantly different at the 5% level of the Duncan Multiple Range.

competitive weed seems to have played a role in the populations of other weeds. Data suggest that giant ragweed reaches its maximum potential in coulter plant and that this weed exerted a negative effect on the population of common lambsquarters and apparently on the potential of fall panicum. This negative correlation between giant ragweed and other less competitive weeds was reflected in the analysis of total weed population. In terms of numbers, the total weed population was lower in coulter plant, where the population of giant ragweed was high.

The influence of the three tillage systems on the weed population of plots treated with atrazine, atrazine + alachlor and simazine + alachlor is shown in Tables 14, 15 and 16, respectively.

Atrazine treated plots had a significantly higher population of both fall panicum and total grasses in conventional tillage-spring plowed than in coulter plant. The populations of these weeds in conventional tillage and coulter plant were not significantly different from the potential found in chisel plant.

The influence of the three tillage systems on the weed populations of plots treated with atrazine + alachlor was not significant.

In simazine + alachlor treated plots the influence of the three tillage systems was significant on the population of total weeds but not on the population of any weed or group of weeds. Plots treated with simazine + alachlor presented a population of total weeds which was higher in coulter plant than in conventional tillage-spring plowed but not significantly different from the potential found in chisel plant.

Data from the herbicide treated plots on the Runnymede Loam suggest that the influence of the three tillage systems on the weed population was exerted to a greater extent in atrazine treated plots than in the plots treated with simazine + alachlor and atrazine + alachlor. This observation does not seem to be very consistent with the data from the same type of plots on the Tracy Sandy Loam where the two herbicide combinations were more influenced by the tillage systems.

Table 17 shows the influence of the interaction between tillage systems and herbicide treatments on the population of fall panicum and common lambsquarters, two representative weeds of the plots on the Runnymede Loam. The population of common lambsquarters was significantly reduced by the herbicide treatments in conventional tillage-spring plowed and chisel plant. As it has been shown in Table 13, due to the presence of a high population of giant ragweed, untreated plots in coulter plant had a low population of common lambsquarters and this accounted for no significant difference between the herbicide treatments and untreated.

Fall panicum population was significantly higher in atrazine plots in conventional tillage-spring plowed and in plots treated with atrazine + alachlor on coulter plant than the untreated. In all the other cases, the population of fall panicum was not significantly different from the population of this weed in untreated plots.

Data from the Runnymede Loam of Pinney-Purdue Agricultural Center, Wanatah, Indiana, suggest a shift of less competitive to more competitive broadleaf weeds such as giant ragweed in untreated plots in coulter plant and a shift from broadleaf weeds to more tolerant grasses such as fall panicum in herbicide treated plots. The relative importance of fall panicum was increased in herbicide treated plots. Fall panicum accounted for only 13% of the total weeds in untreated plots but represented 39% in simazine + alachlor treated plots, 53% in atrazine + alachlor treated plots and 67.6% of the total weed population of plots treated with atrazine alone. This suggests that to a variable extent, depending on the tillage system, herbicide treatments for corn production such as atrazine, atrazine + alachlor and simazine + alachlor, may cause a shift from susceptible broadleaf weeds to fall panicum.

CHAPTER III

Influence of Tillage System on the Distribution of Weed Seeds Throughout the Upper Soil Layer

Introduction

This study was carried out to complement the field study on the influence of preplant tillage systems for continuous corn production on the potential weed population. Soil samples from the same untreated plots for the field study were used in the greenhouse seed germination experiment. A description of the locations, soil types and tillage systems, used for both studies, is found in Chapter II. The procedures used in soil sampling and in the greenhouse for the purposes of this study, are detailed in this chapter.

Materials and Methods

Soil Sampling. Soil samples were taken from the untreated plots with a standard 2.3 cm internal diameter soil probe. As described in Chapter II, the counting square was placed at the same location in all plots, 3.05 m from the front of the plot and between the middle two rows of the past corn crop, 22.9 cm from the row. Weed counts were taken from the two end sections and from the middle section of the five sectioned counting square and the two remaining sections were used for soil sampling. From each section 3 soil samples were taken for a total of 6 per plot. Figures 10 and 11 show details on soil sampling on the Runnymede Loam of Pinney-Purdue Agricultural Center, Wanatah, Indiana.

Soil samples were taken from a total depth of 19.05 cm and divided into increments of 0 to 6.35 cm, 6.35 to 12.7 cm and 12.7 to 19.05 cm. The total sample on each plot for each increment of depth was kept in a separate plastic bag and the three increment samples from the same plot were put together in a paper bag. Soil samples were then transported to the greenhouse in West Lafayette, Indiana, where they were processed. Figures 12 and 13 show details on the separation of the increments of depth and transport of samples in the marked paper bags.

At the Feldun-Purdue Agricultural Center soil samples were taken on May 16, 1975 and at the Pinney-Purdue Agricultural Center samples were taken on May 28, 1975 on the Tracy Sandy Loam and on June 9, 1975 on the Runnymede Loam.

Greenhouse Procedures. Air dried samples from the same field plot and from the same increment of depth were hand crushed one day after sampling to break up the clods and mixed uniformly. From the total volume of each combined soil sample three 50 cm^3 sub-samples of soil were taken for the germination test in plastic cups.

The plastic cups were set up on a greenhouse bench covered with a double plastic sheet to hold a 4 cm layer of water. Each plastic cup received 250 cm^3 of sand and then a sub-sample of hand-crushed soil aggregate. The sub-samples were placed on top of the sand and spread to form a uniform 1 cm layer of soil aggregate over the sand.

Figure 10. Soil sampling of a Runnymede Loam, Wanatah, Indiana, 1975.

Figure 11. Detail of soil sampling, Wanatah, Indiana, 1975.

Figure 12. Soil samples were divided into 3 increments of 6.35 cm, Wanatah, Indiana, 1975.

Figure 13. Soil samples were transported in individual bags to the greenhouse.

The plastic cups were previously perforated on the sides, at the base, to allow water to enter. Water was provided during all the time of the experiment by subirrigation.

Figures 14 and 15 show details in the greenhouse for subirrigation and germination of common ragweed and common lambsquarters from samples taken from the Tracy Sandy Loam. As indicated by the figures, light and temperature conditions in the greenhouse were not controlled but conditions were considered satisfactory for seed germination.

As the weed seeds germinated weed counts by species were taken from the 3 plastic cups representing each increment of depth and accumulated. Weeds germinated from the soil samples taken from the Bedford Silt Loam were recorded on July 1, 1974, August 12, 1974 and on September 12, 1974. Weeds germinated from the soil samples taken from the Tracy Sandy Loam were recorded on July 14, 1975, August 4, 1975 and on September 29, 1975. Weeds germinated from the soil samples taken from the Runnymede Loam were also recorded in 1975 on July 17, August 4 and September 29. No more weed seeds germinated after these final recording dates.

Results and Discussion

Bedford Silt Loam. The most prevalent weed species germinated from the soil samples taken from the untreated plots of six different tillage systems on the Bedford Silt Loam of the Feldun-Purdue Agricultural Center, Bedford, Indiana, were fall panicum, large crabgrass, green foxtail, carpetweed, common lambsquarters, pennsylvania smartweed, common ragweed, giant ragweed, rough fleabane (*Erigeron strigosus* Muhl.), redroot pigweed, sulphur cinquefoil (*Potentilla recta* L.) and

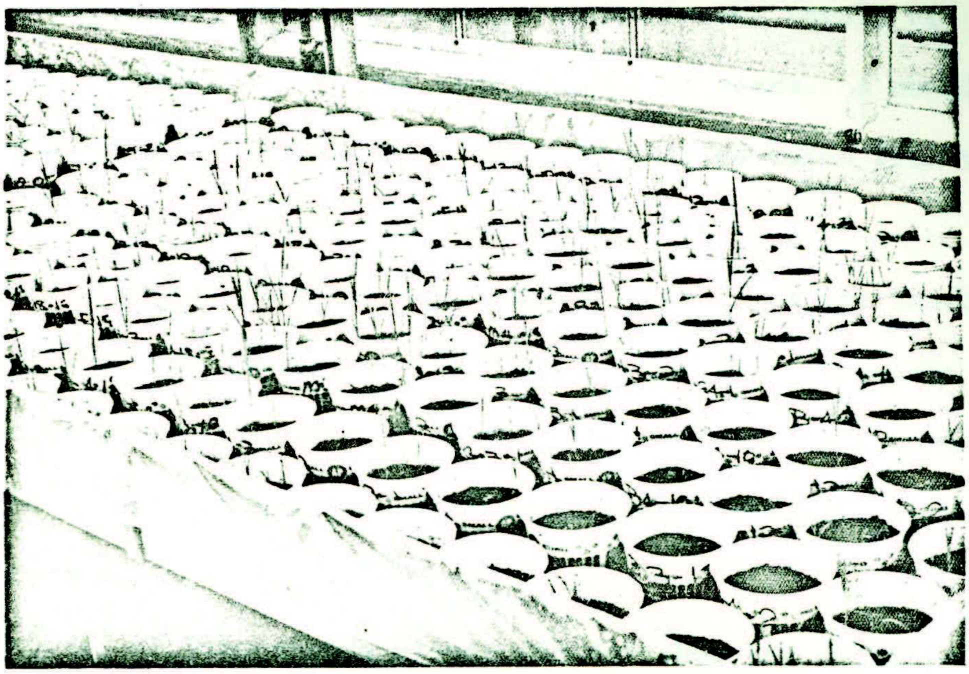

Figure 14. Set up for sub-irrigation on a greenhouse bench.

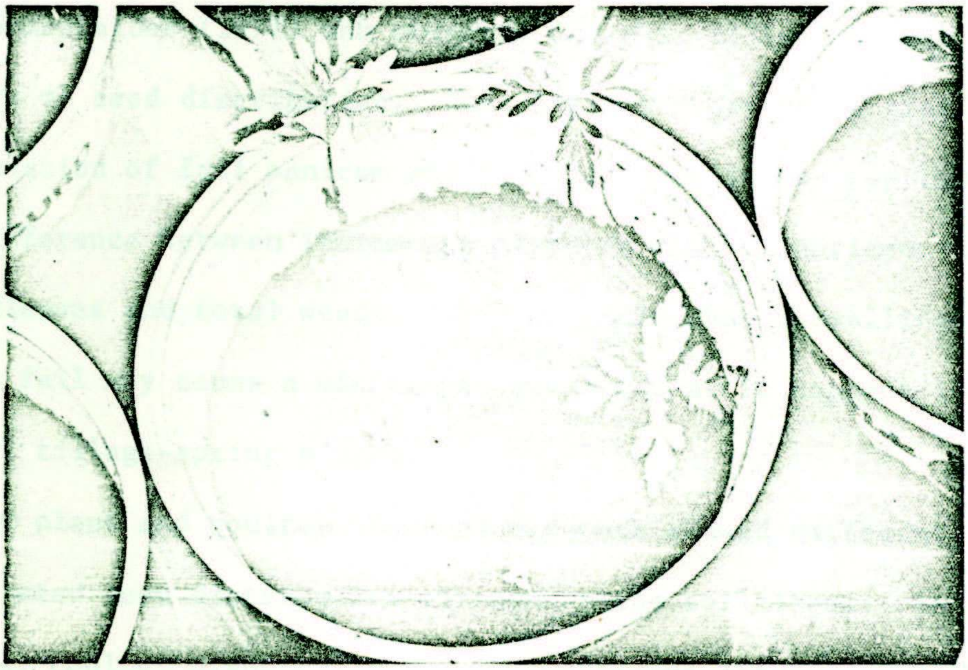

Figure 15. Germination of common ragweed and lambsquarters in the greenhouse.

smallflower buttercup (Ranunculus abortivus L.). Some other less frequent weed species were also recorded and added to the totals of grasses and broadleaves and to the total number of weeds. A complete list of weed species germinated from the soil samples taken from the three different soils is found in Appendix A.

Weed data obtained from the soil samples taken from the Bedford Silt Loam are shown in Table 18. Figures in this table represent the total number of weeds germinated from the three plastic cups containing the three 50 cm^3 sub-samples of each increment of depth, average of 3 replications.

Conventional tillage-spring plowed did not show any significant difference between increments of depth suggesting that plowing with the moldboard plow every spring causes a mixing of weed seeds throughout the soil layer. This is consistent with the data obtained by Wicks and Somerhalder (1971) who observed for this tillage system the same pattern of seed distribution. Chisel plant presented a significant accumulation of fall panicum and total grasses in the top layer but this difference between increments of depth was not noticed for total broadleaves and total weeds. This suggests that chiselling the soil in the fall may cause a mixing of weed seeds as it happens in conventional tillage-spring plowed.

Coulter plant and coulter plant plowed once showed different patterns of weed seed distribution throughout the soil layer. In all the analyses, coulter plant presented a significant accumulation of viable weed seeds in the top layer of the soil. Coulter plant plowed once showed a significant accumulation of fall panicum and total

Table 18. Influence of tillage systems on the distribution of viable weed seeds throughout the soil layer of untreated plots on a Bedford Silt Loam, Bedford, Indiana, 1974.

Tillage System (Layer)	Fall Panicum (#/3 cups)	Total Grasses (#/3 cups)	Total Broadleaves (#/3 cups)	Total Weeds (#/3 cups)
Conventional (Spring)				
Top	0.3*a	1.3 a	9.6 a	11.0 a
Middle	0.3 a	0.3 a	9.0 a	9.3 a
Bottom	2.0 a	2.3 a	19.3 a	21.6 a
Chisel Plant (Fall)				
Top	4.6 a	7.0 a	15.3 a	22.3 a
Middle	1.6 b	2.0 b	23.3 a	25.3 a
Bottom	0.3 b	0.6 b	18.6 a	19.3 a
Coulter (No-till)				
Top	3.3 a	4.6 a	23.3 a	28.0 a
Middle	0.3 b	1.0 b	8.6 b	9.6 b
Bottom	0.6 b	1.3 b	6.6 b	8.0 b
Coulter plowed once				
Top	0.0 b	0.0 b	12.0 a	12.0 a
Middle	0.3 b	0.6 ab	15.3 a	16.0 a
Bottom	2.6 a	3.0 a	12.6 a	15.6 a
Till Plant				
Top	0.6 a	1.3 a	12.6 a	14.0 a
Middle	0.3 a	0.3 a	14.6 a	15.0 a
Bottom	0.0 a	0.3 a	12.0 a	12.3 a
Till Plant plowed once				
Top	3.3 a	4.0 a	11.0 b	15.0 a
Middle	0.0 b	0.0 b	23.0 a	23.0 a
Bottom	0.0 b	0.0 b	21.3 ab	21.3 a

* Values followed by the same letter in a column, within a tillage system, are not significantly different at the 5% level of the Duncan Multiple Range.

grasses at the bottom and a uniform distribution of broadleaves and total weeds throughout the three increments of depth. The total number of viable weed seeds germinated from the three soil layers in both coulter plant and coulter plant plowed once was very close for both systems, suggesting that plowing once in 1971 did not reduce the number of viable weed seeds in coulter plant plowed once but the plowing operation moved down weed seeds from the top layer to the two deeper layers.

Till plant did not show any significant difference between increments of depth. This is not consistent with the results obtained by Wicks and Somerhalder (1971) who found more viable weed seeds in top layer. Till plant soil samples presented in all the increments of depth a low concentration of fall panicum and other grass seeds and a high concentration of carpetweed seeds. This fact did not allow a conclusive analysis of the influence of till plant on the weed seed distribution throughout the soil depth. Till plant plowed once showed viable seeds of fall panicum and other grasses only in the top layer but viable seeds of broadleaves were accumulated at the 6.35-19.05 cm layer of the soil. However this difference was not significant for total weeds.

Tracy Sandy Loam. The most prevalent weed species germinated from the soil samples taken from the untreated plots of conventional tillage-spring plowed, chisel plant and coulter plant on the Tracy Sandy Loam of the Pinney-Purdue Agricultural Center, Wanatah, Indiana, were fall panicum, purpletop (*Tridens flavus* (L.) Hitch.), common ragweed, common lambsquarters, carpetweed, redroot pigweed, shepherds-purse and pennsylvania smartweed. Appendix A shows a complete list of weeds germinated from samples of this soil. Less frequent weed species were recorded and added to the totals of grasses and broadleaves for analysis.

Weed data obtained from the soil samples taken from the Tracy Sandy Loam are shown in Table 19. Figures in this table represent the accumulated total number of weeds germinated from the three plastic cups containing the three 50 cm^3 sub-samples for each increment of depth, average of 4 replications.

Conventional tillage-spring plowed presented an accumulation of viable seeds of fall panicum and other grasses at the bottom layer of the soil and a uniform distribution of broadleaves and total weeds throughout the soil layer. Chisel plant presented a uniform pattern of weed seed distribution throughout the soil layers with no significant differences. The accumulation of viable seeds of fall panicum and other grasses in the top layer observed in samples from the Bedford Silt Loam was not noticed in samples from the Tracy Sandy Loam.

As previously observed in samples from the Bedford Silt Loam, coulter plant presented an accumulation of viable weed seeds in the 0-6.35 cm increment of soil depth. Also, the number of weed seeds in the top layer was higher than in conventional tillage-spring plowed and chisel plant.

Runnymede Loam. The most prevalent weed species germinated from the soil samples taken from the untreated plots of conventional tillage-spring plowed, chisel plant and coulter plant on the Runnymede Loam of the Pinney-Purdue Agricultural Center, Wanatah, Indiana, were

Table 19. Influence of tillage system on the distribution of viable weed seeds throughout the soil layer of untreated plots on a Tracy Sandy Loam, Wanatah, Indiana, 1975.

Tillage System (Layer)	Fall Panicum (#/3 cups)	Total Grasses (#/3 cups)	Total Broadleaves (#/3 cups)	Total Weeds (#/3 cups)
Conventional (Spring)				
Top	1.0* b	1.0 b	6.0 a	7.0 a
Middle	1.0 b	1.0 b	4.2 a	5.2 a
Bottom	5.7 a	5.7 a	5.7 a	11.5 a
Chisel Plant (Fall)				
Top	0.7 a	1.2 a	4.0 a	5.2 a
Middle	2.2 a	2.2 a	5.7 a	8.0 a
Bottom	0.0 a	0.5 a	7.2 a	7.7 a
Coulter (No-till)				
Top	9.5 a	10.2 a	13.5 a	23.7 a
Middle	1.7 b	2.0 b	6.5 b	8.5 b
Bottom	1.2 b	2.0 b	8.5 b	10.5 b

* Values followed by the same letter in a column, within a tillage system, are not significantly different at the 5% level of the Duncan Multiple Range.

fall panicum, purpletop, common ragweed, giant ragweed, rough fleabane, common lambsquarters, carpetweed, pennsylvania smartweed, redroot pigweed and sulphur cinquefoil. Other less frequent weed species were recorded and added to the analyses for total grasses and total broadleaves.

Table 20 shows the weed data obtained from the soil samples taken from the Runnymede weed counts in Table 20, as shown in Tables 18 and 19, represent the total number of viable weed seeds from each increment of depth, average of four replications.

Conventional tillage-spring plowed did not show any significant difference between the three increments of soil depth. Chisel plant showed an accumulation of fall panicum seeds in the 0-12.7 cm soil layer but this difference between increments of soil depth was not significant for the analyses of total grasses, total broadleaves and total weeds. A comparative analysis between conventional tillage-spring plowed and chisel plant suggests that in both systems there is mixing of weed seeds throughout the soil layer but chisel plant shows less viable weed seeds at the bottom layer and more in the middle. Although this trend was not significant it is present in all three locations.

Coulter plant showed the same pattern of weed seed distribution throughout the soil depth previously observed in samples from both Bedford Silt Loam and Tracy Sandy Loam but the accumulation of seeds of fall panicum and other grasses in the top layer of the soil was not observed.

Table 20. Influence of tillage system on the distribution of viable weed seeds throughout the soil layer of untreated plots on a Runnymede Loam, Wanatah, Indiana, 1975.

Tillage System (Layer)	Fall Panicum	Total Grasses	Total Broadleaves	Total Weeds
	(#/3 cups)	(#/3 cups)	(#/3 cups)	(#/3 cups)
Conventional (Spring)				
Top	1.2*a	1.7 a	6.7 a	8.5 a
Middle	1.2 a	1.5 a	3.2 a	4.7 a
Bottom	0.0 a	0.2 a	6.0 a	6.2 a
Chisel Plow (Fall)				
Top	2.5 a	3.0 a	3.7 a	6.7 a
Middle	1.7 ab	2.5 a	7.5 a	10.0 a
Bottom	0.0 b	1.7 a	1.2 a	3.0 a
Coulter (No-till)				
Top	1.5 a	1.7 a	9.5 a	11.2 a
Middle	0.5 a	1.2 a	1.0 b	2.2 b
Bottom	0.2 a	0.5 a	2.5 b	3.0 b

* Values followed by the same letter in a column, within a tillage system, are not significantly different at the 10% level of the Student-Newman-Keuls' Test.

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APPENDICES

Appendix A: Alphabetical list of weeds and places where they were recorded.

	Field Study			Greenhouse Study		
	Bedford Silt Loam	Tracy Sandy Loam	Runny-mede Loam	Bedford Silt Loam	Tracy Sandy Loam	Runny-mede Loam
Abutilon theophrasti		x	x			
Acalypha virginica L.				x		x
Amaranthus retroflexus L.	x	x	x	x	x	x
Ambrosia artemisiifolia L.	x	x	x	x	x	x
Ambrosia trifida L.	x		x	x	x	
Asclepias syriaca L.			x			
Bromus tectorum L.	x	x				
Capsella bursa-pastoris (L.) Medic.		x			x	
Chenopodium album L.	x	x	x	x	x	x
Cirsium arvense (L.) Scop.			x			x
Collinsia parviflora Dougl.				x		
Conyza canadensis (L.) Cronq.		x	x			
Cynodon dactylon (L.) Pers.				x		

Appendix A: Continued.

	Field Study			Greenhouse Study		
	Bedford Silt Loam	Tracy Sandy Loam	Runny-mede Loam	Bedford Silt Loam	Tracy Sandy Loam	Runny-mede Loam
*Cyperus esculentus L.				x		
Datura stramonium L.			x			
Digitaria sanguinalis (L.) Scop.	x	x	x	x	x	x
Erigeron strigosus Muhl.				x	x	x
*Equisetum arvense L.					x	x
Galium aparine L.	x					
Lactuca serriola L.		x	x			
Lobelia sp.				x	x	
Mollugo verticillata L.		x	x	x	x	x
Oxalis stricta L.				x		x
Panicum dichotomiflorum Michx.	x	x	x	x	x	x
Physalis heterophylla Nees				x	x	x

* Numbers for these were not included in the data.

Appendix A: Continued.

	Field Study			Greenhouse Study		
	Bedford Silt Loam	Tracy Sandy Loam	Runny-mede Loam	Bedford Silt Loam	Tracy Sandy Loam	Runny-mede Loam
Plantago major L.				x		
Poa pratensis L.		x				
Polygonum aviculare L.			x			
Polygonum convolvulus L.	x	x				
Polygonum pensylvanicum L.	x	x	x	x	x	x
Portulaca oleracea L.				x		
Potentilla recta L.			x	x		x
Ranunculus abortivus L.				x	x	x
Setaria faberi Herrm.		x	x			
Setaria viridus (L.) Beauv.		x	x	x		
Sida spinosa L.	x			x		
Solanum carolinense L.	x			x		
Solanum nigrum L.				x		

Appendix A: Continued.

	Field Study			Greenhouse Study		
	Bedford Silt Loam	Tracy Sandy Loam	Runny-mede Loam	Bedford Silt Loam	Tracy Sandy Loam	Runny-mede Loam
Stellaria media (L.) Cyrillo					x	x
Taraxacum officinale Weber		x	x			
Tridens flavus (L.) Hitchc.				x	x	x
Veronica peregrina L.	x	x		x	x	
Xanthium pensylvanicum Wallr.			x			

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