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WEED CONTROL STRATEGIES FOR TILL-

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Geoffrey Allen List

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Major professor

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By

Geoffrey Allen List

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ABSTRACT

WEED CONTROL STRATEGIES FOR TILL-PLANTED FIELD CROPS ON RIDGES

By

Geoffrey Allen List

The contribution of herbicides and cultivation were examined as components of a total weed control strategy in corn (Zea mays L.) and soybeans (Glycine max (L.) Merr.) till-planted on ridges. Sequential applications with preemergence herbicide applications preceded by an early preplant application or followed by a layby application provided the most consistent season-long control of annual weeds. Under conditions of inadequate rainfall, early preplant applications in till-planted soybeans provided equal or greater weed control and crop tolerance than preemergence application of the same herbicides. Banded applications of herbicides, followed by one cultivation, provided control of common ragweed (Ambrosia artemisiifolia L.) in soybeans and common lambsquarters (Chenopodium album L.) in both crops and was not significantly different from broadcast treatments at any level of cultivation. No significant differences in yield were observed in either crop due to differences in herbicide programs or cultivation.

To Teresa

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REVIEW OF THE LITERATURE

INTRODUCTION

Early systems of row crop production on ridges were based on the bed-farming practices used for the production of cotton, tobacco and other high-value crops that indicated several advantages of the elevated ridge, such as drainage of ridge and low total power requirement per acre for production (6). Ridges were formed with either rolling disk bedders or lister-type ridging attachments that utilized a two-way moldboard plow to build ridges either in the growing crop or after fall harvest. Generally, adequate ridges were constructed with this equipment. However, the two-bottom lister was found to be unsatisfactory since it placed crop residue in a vertical plane through the middle of the ridge where the planter runner was to operate. The residue interfered with the operation of the planter and poor stands resulted when seeds were planted in this crop residue (6). Today, with advancements in planting and cultivating equipment, ridging is much more successful. Ridges planted no-till with seeds placed into a slot created by a coulter and planter unit with disk openers is termed ridge planting (46). Usually this term refers to planting only one seed row per ridge as is the case for till-planting on ridges. Till-planting involves the tilling of a strip of soil, usually in the

old crop row, to prepare a seedbed for row crops while leaving a protective cover of crop residue on, and mixed, in the surface layer between the crop rows (46). Till-planting may be done on a flat or ridged soil surface. Seedbed preparation and planting are completed in the same operation. Normally, till-planting on ridges occurs on ridges prepared in the growing crop or after harvest in the fall (26, 29, 43, 46, 65, 67, 72, 73, 86). If formed at cultivation time, all residues of the growing crop will remain on the soil surface.

In 1985, the ridge till-plant system increased in acreage by 45% in the United States, and more than 75% of that increase occurred within the Cornbelt and Northern Plains Regions[1]. There is clearly much interest in this and other conservation tillage systems and although research has dealt with the refinement of the ridge till-plant system, little research has been applied to weed control. The purposes of studies conducted in the ridge till-plant system were to: a) evaluate timing of herbicide application and multiple applications for weed control and crop tolerance; b) examine the contribution of herbicide application and cultivation as components of a total weed control strategy; and c) examine the effect of various weed control strategies on crop yield.

[1]According to a survey based on data provided by the Soil Conservation Service in conjunction with the Cooperative Extension Service, Agricultural Stabilization and Conservation Service, Soil and Water Conservation Districts and Agribusiness. (Executive summary obtainable from the Conservation Tillage Information Center, 2010 Inwood Drive, Fort Wayne, IN 46815).

Soil Suitability

Research in Michigan (67), Ohio (78, 79), and Indiana (26) has demonstrated that soil characteristics have a definite influence on crop response to tillage systems and has made suggestions for tillage selection based on certain soil and environmental conditions. Research has shown that one of the primary considerations before implementation of the ridge till-plant system of row crop production is soil suitability. Soil texture (26, 28, 65, 67, 79), natural soil drainage (26, 29, 67, 79), and surface slope (12, 26, 67) have been determined to be important factors in the intensive management of crop residue (6, 11, 14, 15, 25, 42, 43, 51, 60, 86, 88), and bed configuration (1, 9, 70, 86) has been cited as an aid in the reduction of erosion and maintenance of a warm seedbed.

Medium-textured, well-drained soils have been identified as well suited to ridge till-planting (26, 28, 65, 67). When ridges are formed after harvesting in the fall rather than in the growing crop, the beneficial effect of an over-wintering surface residue to prevent erosion and ridge breakdown may be lost. Galloway et. al. (26) suggest that till-planting consistently had the best stands of corn on sandy loam and loam soils, but often had poor stands on the poorly drained, fine-textured soils. They and others (26, 28, 29, 65, 73) suggested that if ridge height is maintained until planting, the ridge till-plant system may prove advantageous on these poorly drained, fine-textured soils due to earlier drying and warming of the seedbed.

In studies on a poorly drained soil, Triplett and VanDoren (79) observed that no-tillage continuous corn yields were significantly less than continuous corn grown on soil prepared by moldboard plowing in the fall. However, for tile-drained soil, improving drainage further by planting on ridges or simply rotating corn with other crops brought the no-till corn yields up to the same level as moldboard plowing. The study also showed that planting ridges partially substituted for tile drainage.

The surface slope should be no greater than 3 or 4% for the ridge till-plant system unless it is contoured (12, 67). If inadequate residue remains after planting or when planting is not done across the slope, the erosion control effectiveness drops greatly (49, 84). Research in Indiana on very poorly drained soils with less than 2% slope suggests planting with the slope to prevent ponding in the furrows (29).

It has been reported that crop residues left in the furrow decreases runoff and soil loss as well as the effect of slope gradient (51, 84). According to Moldenhauer (49), some soils require tillage for most effective erosion reduction. Ridge till-planting allows for this requirement and effectively reduces soil losses by allowing runoff to move down the ridges and through the residue accumulated in the furrow. Research in Delaware has included ridging in the fall followed by planting a cover crop of a mixture of annual ryegrass and hairy vetch to stabilize the ridge and suppress weed growth (73). Winter wheat or rye have been useful as cover crops especially following soybeans (72).

While some researchers have emphasized the benefits of a warmer seedbed due to the ridging configuration, others point to the improved soil water conservation in the ridge (1, 3, 25, 81). Adams (1) attributes the better stands and crop emergence to more available moisture on the ridge. Amemiya (3) adds that in years of deficient soil moisture, crop responses attributable to tillage can be expected. Fisher and Lane (25) found that a loose spongy ridge could in itself absorb and hold nearly 0.75 inch of rainfall.

If compaction was a problem prior to ridging, the system may not have any immediate benefits. Kapusta and Wolff (36) conducted experiments on a poorly drained silt loam soil comparing weed control on ridge-planted versus flat-planted corn. While corn emerged equally well on ridges as on the flat, growth was slower on the ridges due to compaction and was reflected in reduced yields, although weed control was excellent. Stevens et. al. (73) found less compaction by planting no-till corn over the old soybean row. Corn planted over the row yielded an average of 15.5 bushels more per acre than planting between old rows. Ridging over old soybean rows, however, did not result in a significant increase in yield. Reasons cited for failure of ridges to increase yields were lack of proper ridge height, use of well-drained soils, and failure to make firm ridges well in advance of planting. Preliminary results in Indiana (47) indicated that ridge till-planting improved soil structure and resulted in less compaction in comparison to conventional tillage on a variety of soils.

Tillage Requirements

Development of a system of producing corn on ridges is reported as early as 1938 in Missouri (35). Inadequacy of equipment to build and maintain ridges led to the abandonment of ridge farming there and again in Indiana in the late 1940's (29). Lack of satisfactory yield and weed control were also cited as reasons for its early failure.

Buchele et. al. (6) listed benefits of reduced soil loss and controlled water flow on land where other systems failed. With the advent of good preemergence herbicides and refined equipment in the 1960's, the concept of row crop production on ridges gained acceptance in areas of the Western Corn Belt (29).

Today, the ridge till-plant system has evolved to include generally no more than three tillage operations in one year (29, 43, 65, 67, 86). Typically the till-plant method involves preparation of a seedbed for row crops by scalping the area in the old crop row and leaving a protective cover of crop residue on, and mixed, in the furrow between the crop rows. A wide sweep or row-cleaning disks ahead of the planting unit facilitates scalping of 2-3 inches of the ridges (26, 44, 67), and residues are moved to the furrows. Cultivation during the growing season may be necessary to control weeds and condition residues in the furrows for more rapid decomposition (67). Burnside and Wicks (8) found that cultivation was necessary on soils with high silt content due to crusting. Soil crusting tends to be less of a problem on ridges due to the residues in the furrow and lack of standing water on ridges (67). A ridge-building cultivation in the growing crop or after harvest is a requirement of this system to maintain a ridge for next year's crop (26, 29, 43, 65, 67, 72, 73, 86).

If the previous year's crop was corn, planting into the old corn stubble may be a problem. Variations of dealing with excessive stubble on the ridge include chopping the stalks (25, 43, 47, 55, 68) or lightly disking the ridge crest prior to planting (11, 25, 43, 55, 68). Wittmuss et. al. (86) reported more even distribution of residues and less clogging of machinery in fields where corn stalks were cut.

Regehr (65) mentions two other variations of ridge preparation before planting. One variation is rotary strip-tillage where the tops of old ridges are roto-tilled to destroy weeds and prepare the seedbed. The other variation is to chisel plow the corn stalks and build ridges in the fall. Wittmuss et. al. (86) suggests that preplant tillage be kept to a minimum to conserve soil moisture.

Although preplant cultivation is another trip over the field with associated labor and fuel costs, it may be a better option than preplant disking. Disking breaks down the ridge, possibly to a point where planted seed may no longer be planted in a warmer, dryer environment for optimal germination and emergence (11). Fisher and Lane (25) reported soil crusting in disked rows after heavy rainfall, while till-planted rows did not crust.

Four to 6 inches (13, 26), 6-8 inches (44, 73), 7-9 inches (67), and 8-10 inches (5) are the suggested heights for ridges built with ridge-building cultivators. Where residues are light and soils are not fine-textured, a rolling cultivator may be adequate to build the ridge (26, 29, 65). Nebraska research suggests that ridges be formed and kept as high as possible (43). Ridge till-planting is suited to row crops planted in row spacings of 30 inches or more (55, 65, 67). Research in Nebraska has shown that under dryland conditions, 30 inch rows have led to greater weed control in the till-plant system compared to wider row spacings because soil and residues completely cover the furrows where established weeds may be present (55).

Herbicide Use

In the ridge till-planting system, soil incorporated herbicides do not appear to be an option (11, 29, 55, 68). However, other methods of seedbed preparation on the ridge, such as rotary tillage (11) and preplant disking (55), may allow sufficient incorporation of herbicides and effective weed control when a slot-planter is used.

Moomaw (11) listed application of preplant herbicides, preplant cultivation, or a light disking of ridges ahead of planting as options when heavy weed populations occur at planting. Disturbance of the soil before planting, however, may incorporate weed and volunteer crop seed and lead to additional weed management expense (25, 43, 65). Robison and Wittmuss (68) found that the weed yields in the till-plant system were significantly reduced by disking in two out of the three years tested, but crop yields were only significantly better in one out of the three years. Disking prevented early weed competition. However, the preemergence herbicide treatments gave excellent weed control without disking despite residue cover of 73% (68).

Since shallow tillage for weed control is an option before and after planting in the ridge till-plant system, reliance on herbicides may not be as great as it is for other minimum tillage systems (12, 54, 55, 65, 67). If insufficient residues exist in the furrow to help suppress weeds or delayed planting allows weeds to attain good size before the till-plant operation, tank mixes of herbicides with a burndown component is an option (11, 29, 55, 63, 65). If planting is attempted through tall weed growth, problems may arise along the cutting edge of the planter sweep where some broadleaf weeds may not be uprooted (11).

Advantages and Disadvantages

Wicks and Somerhalder (82) found fewer weed seeds in the row after seedbed preparation with till-planting as compared to a conventional system. Volunteer corn also was effectively removed from the row to furrow where it was later controlled by cultivation (82, 86, 89). Others (7, 33, 81) have reported lower weed populations, particularly annual grasses, in the ridge till-plant system compared to other conventional and conservation tillage practices.

Perennial weeds can become a problem in the till-plant system due to lack of deep tillage (29, 55). This theme is addressed throughout the literature on tillage technologies (2, 30, 64, 80, 83), and others (29, 80) suggest that reduced tillage systems should not be used where perennial weed problems already exist.

While greater herbicide management may be required for certain weed problems (12, 55) and timing of tillage operations are critical for effective weed control, the ridge till-plant system requires less labor than conventional and other reduced tillage systems (6, 11, 13, 16, 67, 86). Other than no-tillage, the ridge till-plant system uses less fuel (13, 43, 55, 67, 87). According to Wittmuss et. al. (86), in a tillage comparison between conventional and ridge till-planting, tillage costs were reduced 63%. In cost summaries, inputs for the till-plant system were below all tillage systems compared except no-till systems where input cost was comparable (16, 87). Jose (11) found that the ridge till-plant system was the least cost system due to less equipment expense and lower herbicide expense. Although the no-till system was found to be energy efficient, higher chemical costs tended to outweigh those cost savings. Wittmuss et. al. (87) found that output/input ratios for till-planting in corn and sorghum were among the highest obtained in comparison to other systems of crop production.

Early studies by Buchele et. al. (6) indicated that farming on ridges produced yields equal to those obtained under conventional tillage. In Nebraska, Wittmuss et. al. (86) obtained an average yield of two bushels per acre of corn greater with the till-plant system than conventionally tilled plots compared over fifteen locations. Olson and Schoeberl (60) conducted yield trials in four tillage systems including till-planting and conventional systems and found no significant difference in corn yield in any year or in 4-year averages. In long-term tillage experiments in Indiana, till-planting gave higher yields on well-drained soils and lower yields on poorly drained soils as compared to conventional moldboard plow tillage (28, 29). Mannering and Griffith (47) found no differences in four-year averages of yield of continuous corn planted into plots that were either moldboard plowed or till-planted on ridges. Research in Nebraska (43) indicated no significant difference in maximum yields in long-term studies comparing conventional tillage and till-planting. Mock and Erbach (48) reported reduced growth and productivity of early planted corn grown on till-planted and slot-planted ridges as compared to corn grown on moldboard plowed ground. They attributed reduced stands to nonuniformity of planter seeding depth and lower soil temperatures. However, in one of the two years of their study, till-planted ridges attained a higher yield and comparable soil temperature compared to a moldboard plow system, though neither figure was significantly different.

Observed benefits of the ridge till-plant system also include prevention of soil compaction in the row due to restricted traffic in the furrows (11, 43, 67, 73), a drier and warmer seedbed (6, 9, 11, 12, 13, 65, 67, 70, 86), more rapid emergence on the ridge (44, 81), and reduced runoff and soil loss due to the ridging tillage (4, 6, 12, 13, 14, 15, 32, 34, 42, 43, 49, 50, 60, 84, 88). However, in studies of 4 tillage systems, Olson and Schoeberl (60) indicated that the average soil temperature at seed depth by mid-June did not differ greatly from year to year or from tillage system to tillage system and that final yield was not consistently related to early soil temperature or to early growth of corn seedlings.

Lack of sufficient residue to maintain erosion control on ridges following soybean or navy bean harvest has been cited as a potential problem (67). Adaptation of the system to non-row crops for economic production may also be a shortcoming of the ridge till-plant system. Drilling wheat or soybeans into a ridge configuration is physically impossible. Cultivation is not possible in narrow row soybeans (61). Even if ridge-building cultivation occurred after harvest in the fall, it would eliminate the advantage of increased surface residues to control erosion that narrow row soybeans might otherwise create. Cover crops may be seeded broadcast when erosion is a problem (67, 73).

Methods of Weed Control

Due to the scalping of the ridge at planting and the option of cultivation during the growing season, banding of herbicide on the cleanly tilled ridge and reliance on cultivation to control weeds between the rows appears to be the most economical use of herbicides in this system. When weeds are not present at planting, a banded application of preemergence herbicides with subsequent cultivation as necessary is sufficient (11, 29, 54, 55, 65). In this system, banding of herbicides over the row may be more necessary with soybeans or milo than corn (43).

Moomaw and Robison (57, 58, 59) found in three separate experiments on soybeans, corn and sorghum grown on flat-tilled land, that banded applications of preemergence herbicides required one supplementary cultivation to control weeds and maintain crop yield as effectively as broadcast treatments. They also found that broadcast treatments without mechanical tillage yielded as well as the handweeded check in two out of three years for soybeans and both years of a two year study for sorghum. Broadcast treated corn without cultivation produced significantly less grain than the handweeded check both years of a two year experiment. They suggested that insufficient rainfall reduced herbicide performance and contributed to significant yield reduction in those years when herbicide treatments were not followed by cultivation.

Research in Indiana (29) indicates that broadcast application of preemergence herbicides on ridges should be applied at rates 10-20% higher than conventional tillage rates due to cloddiness and residues in the furrows. Due to this undisturbed portion of the field, the ridge till-plant system draws many of the weed control strategies from the no-till system of crop production. Increased rates for banded applications of herbicides is not necessary since the rows are clean tilled by the till-planter. Robison and Wittmuss (68) evaluated ten different preemergence herbicide treatments and one postemergence treatment for three years on till-planted ridges that were disked or nondisked prior to planting. The broadcast treatments were all effective in controlling weeds, but increased control was obtained on disked ground where a 35% average reduction in surface residue decreased interception of herbicides. A shallow preplant disking may be a substitute for herbicides in controlling emerged weeds (55).

Moomaw and Martin (54) investigated weed control in till-planted and slot-planted corn on ridges and found that till-planting was less dependent on herbicides due to increased surface tillage. Maximum corn yield was achieved in the till-plant system with banded applications of preemergence herbicides followed by one cultivation.

Cultivation for purposes other than weed control or forming the ridge may waste energy and cause loss of soil moisture (43). It is generally agreed that the number of cultivations required in the till-plant system is dependent on level of weed infestation and herbicide effectiveness. Moomaw (52) and Moomaw and Martin (54) found that mechanical cultivation alone gave weed control not significantly different than any of the cultivation treatments including herbicides in till-planted corn. Regehr (65) suggests that two cultivations are usually needed if herbicides are banded on the ridge. Peters et. al. (62) found that two cultivations gave significantly greater soybean yield and increased weed control than one cultivation where weeds were not sufficiently controlled by herbicides. Burnside and Wicks (8) found that the combination of cultivation and herbicides gave more dependable weed control in sorghum than either method used alone. But with effective treatments of atrazine, there was no significant difference in sorghum yield between plots cultivated 0, 1, 2, or 3 times. Gebhardt (27) found that in a conventionally tilled field, a combination of cultivation and preemergence herbicide treatments was necessary for improved weed control and soybean yield. Moomaw and Martin (54) found that slot planted corn on ridges benefited from two cultivations rather than one in terms of crop yield and weed control. Studies have shown that tillage has little influence on crop yield in the absence of weeds (31, 77). Swanson and Jacobson (76) found that if sufficient moisture and plant nutrients were supplied to corn, cultivation may not be needed to eliminate all weeds. Corn yields did not suffer from lack of cultivation, and soil structure deteriorated least with one cultivation compared to three.

In Nebraska, the approach used to control weeds on till-planted ridges has been to apply standard soil-applied, preemergence herbicides at planting and to deal with emerging weeds as they occur. If weeds, such as winter annuals, germinate prior to the planting operation, they are controlled with selective or nonselective postemergence herbicides or light tillage (11, 54, 55). Moomaw and Martin (54) found that if slot-planting was substituted for till-planting on the ridge, a preplant application of 2,4-D was essential for emerging broadleaf weed control and maintaining comparable corn yield between weed control methods used in the two planting systems.

In no-tillage and reduced tillage systems, early preplant applications of residual herbicides have been tested as an approach to controlling weeds prior to planting and as an aid to early season control (10, 17, 18, 19, 20, 21, 22, 23, 24, 36, 37, 38, 39, 40, 41, 45, 65, 66, 69, 74, 75). In Iowa, Fawcett et. al. (17) found over ten locations that early preplant treatments of residual herbicides in no-till corn gave comparable weed control to planting-time treatments consisting of residual and nonselective postemergence herbicides despite the heavy rainfall encountered. In subsequent years testing of residual early preplant applications at different locations in no-till corn, results showed that early preplant treatments generally provided equal or greater weed control than preemergence treatments (19, 20, 22, 24). Early preplant treatments generally provided 90% giant foxtail control (19, 20, 22) except several treatments where cyanazine was used alone (20).

The primary objective of applying early preplant treatments is to prevent weed germination during planting and early crop growth. Risk of herbicide failure due to dry weather after application is reduced, since the probability of receiving rainfall after herbicide application and prior to weed germination is increased. However, Lueschen and Hoverstad (45) reported failure of sequential applications, including an early preplant application, to provide adequate control on ridge till-planted corn due to lack of adequate rainfall. When frequent and heavy rainfall occurred before early preplant applications and near planting, studies conducted by Fawcett et. al. (18) indicated that early preplant applications on no-till soybeans did not provide weed control superior to preemergence treatments.

Fawcett et. al. (17, 18, 19) suggested that early preplant applications of residual herbicides usually eliminate the need for a nonselective postemergence herbicide in any planting-time application. Stougaard et. al. (75) found that fall and early preplant applications, including only residual herbicides, eliminated the need for nonselective herbicides at planting. However, Staniforth and Lovely (71) found that applications of alachlor, chloramben, and metribuzin, prior to weed emergence and alone and in various combinations, seldom eliminated the need for a nonselective burndown herbicide.

Although season-long weed control with early preplant applications of residual herbicides has been reported in the ridge till-plant (36), reduced tillage (40), and no-tillage systems (17, 40, 75), insufficient season-long control with early preplant treatments has also been reported (18, 19, 21, 39, 41, 45, 74, 75). Krausz and Kapusta (41) found that split applications involving an early preplant application gave the most complete control of broadleaf weeds in no-till soybeans. Fawcett et. al. (17, 18, 19, 20, 22) found over years and locations in Iowa that split applications involving both early preplant application and preemergence application improve consistency of weed control in no-tillage corn and soybeans by compensating for soil disturbance caused by the planter and providing longer herbicide persistence. This has special implications for ridge till-planting where wide sweeps or row-cleaning discs will remove considerably more herbicide treated soil from the row than no-till planting.

Cantwell and McGlamery (10) found essentially no differences in weed control between early preplant and sequential applications in no-till corn, except that cyanazine controlled velvetleaf more effectively with split applications than with early preplant applications alone. Fawcett et. al. (24) found that split application of cyanazine in no-till was more effective in controlling fall panicum in no-till corn than a single early preplant application. Krausz and Kapusta (40) reported poor fall panicum control with early preplant applications of triazine herbicides. Roskamp (69) and Fawcett et. al. (20) reported reduced giant foxtail control in no-tillage systems with cyanazine applied early preplant.

Another approach to controlling weeds at midseason in the no-tillage system has been to apply postemergence herbicides or to cultivate (19, 21, 23, 66). Fawcett et. al. (21) found in a no-till soybean study that due to heavy rainfall during the early growing season, treatments including supplemental postemergence applications, generally gave better weed control than treatments relying on early preplant or preemergence applications alone. Many of the soil applied treatments provided satisfactory late season weed control following a row cultivation.

In the ridge till-plant system, when cultivation to rebuild the ridge is done in the growing crop, applications of residual herbicides at this time may extend weed control to the end of the season. Moomaw and Martin (53) and Moomaw et. al. (56) found that layby applications were effective in controlling late germinating weeds in irrigated corn and extended weed control through the end of the growing season. Weeds that did emerge in layby herbicide treated areas remained small and annual grass seed production was effectively reduced.

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CHAPTER 2

HERBICIDES FOR RIDGE TILL-PLANTED FIELD CROPS

ABSTRACT

Field studies were conducted in corn (Zea mays L.) and soybeans (Glycine max (L.) Merr.) grown under the ridge till-plant system to evaluate weed control and crop tolerance for various herbicide programs and application timings. Only one cultivation followed planting to reform ridges. Preemergence herbicide applications, preceded by an early preplant application or followed by a layby application, provided the most consistent control of annual weeds and caused little or no crop injury.

Prior to cultivation, which occurred approximately 7 weeks after planting, control of common lambsquarter (Chenopodium album L.) and common ragweed (Ambrosia artemisiifolia L.) in corn was visually evaluated at 90% or greater for all early preplant treatments and provided satisfactory control of these weed species throughout the season. All preemergence treatments in corn also provided satisfactory season-long control of common lambsquarters and common ragweed.

In soybeans, in 1984, early preplant applications of alachlor (2-chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl) acetamide) at 3.36 kg/ha or oryzalin (4-(dipropylamino)-3,5-dinitrobenzenesulfonamide) at 1.68 kg/ha in combination with metribuzin (4-amino-6-(1,1-dimethylethyl)-3-

(methylthio)-1,2,4-triazin-5(4H)-one) at 0.56 kg/ha provided greater than 93% control of common lambsquarters and common ragweed prior to cultivation. Weed control for all early preplant treatments decreased by the late-season evaluation. Preemergence applications of alachlor at 3.36 kg/ha in combination with metribuzin at 0.56 kg/ha or linuron (N'-(3,4-dichlorophenyl)-N-methoxy-N-methylurea) at 0.84 kg/ha provided 90% or greater control of both weed species throughout the season. However, in 1985, early preplant applications in soybeans provided equal or greater weed control and crop tolerance than preemergence applications of the same herbicides, and generally provided season-long control of the weeds evaluated. Rainfall data indicated that much less rainfall occurred in 1985 at planting and was not adequate for activation of the residual herbicide component of the preemergence treatments.

INTRODUCTION

With the availability of a wider variety of herbicides for corn and soybeans, conservation tillage systems have become feasible alternatives to conventional tillage systems. The ridge till-plant system is unique in that it requires a scalping of an established ridge crest at planting and at least one cultivation to rebuild the ridge for the subsequent year's crop, while maintaining surface residues for erosion control. The farmer must develop weed control strategies around these requirements in the growing crop.

Much of the research involving till-planting on ridges has centered around erosion control and refinement of the tillage system to maintain observed benefits and ultimately, to attain yields comparable with other tillage systems. Only recently have refinements in weed control research been applied to the ridge till-plant method of row crop production.

Ideally, as in no-till, the soil and surface residues are left undisturbed much of the time under the ridge till-plant system, particularly between crops. If weeds are anticipated before planting, one approach has been to apply residual herbicides often several weeks before planting, to prevent weeds from germinating. If coordinated with rainfall and properly applied, early preplant treatments have been shown to be an excellent means of controlling weeds in no-tillage and ridge till-plant systems. Kapusta and Wolff (7) reported excellent annual weed control in ridge tilled corn and soybeans with early preplant applications. Lueschen and Hoverstad (8) found no advantage to applying early preplant herbicide treatments in ridge till-planted corn when weed densities were high and insufficient rainfall occurred following early preplant applications. Fawcett et. al. (2, 3, 4) suggested that early preplant applications of residual herbicides in no-till reduces the risk of herbicide failure due to dry weather.

In Nebraska, early germinating weeds on ridges are controlled with selective or non-selective herbicides or light tillage before or at planting (1, 10, 11). Staniforth and Lovely (13) found that early preplant applications of alachlor, chloramben, or metribuzin, alone or in combination, seldom eliminated the need for a burndown herbicide in no-till soybeans. However, Stougaard et. al. (15) found that fall or early preplant applications of cyanazine or cyanazine plus oryzalin prevented weeds from becoming established before planting and caused no injury to no-till soybeans.

Fawcett et. al. (2, 4, 5) found that split applications involving both early preplant application and preemergence application improved the consistency of weed control in no-till. The preemergence application was made to compensate for soil disturbance at planting and extend residual weed control. There was considerably more soil disturbance in till-planting on the ridge than no-till planting where seed was planted into a slot. This does not necessarily translate into increased use of herbicide at planting. Wicks and Somerhalder (16) found that the till-planter left only 30% as many weed seeds in the corn row as when the seedbed was prepared by plowing, disking, and harrowing. Due to the removal of residues from the row, the soil interception of herbicides in the row at planting should be comparable to conventional tillage systems. However, research in Indiana (6) suggested that broadcast application of preemergence herbicide rates on ridges should be increased by 10 to 20% compared with rates used in conventional tillage due to the cloddiness and residue in the furrow.

Whenever cultivation is done, new weed seed has the opportunity to germinate. Stobbe (14) reported that the majority of weeds imported to North America from Europe require cultivation in order to germinate. Since ridge-building cultivation moves soil into the row and inverts herbicide-treated soil, a supplemental layby application of herbicides may be useful in maintaining season-long weed control and reducing weed seed production. Moomaw and Martin (9) and Moomaw et. al. (12) found layby applications to be effective in controlling late germinating weeds in irrigated corn and in extending weed control to full season. Weeds that did emerge after layby applications remained small and annual grass seed production was reduced with various treatments.

The purpose of the following studies in corn and soybeans was to: a) examine strategies for weed control with herbicides in the ridge till-plant system and b) evaluate timing of application and multiple applications for weed control and crop safety.

MATERIALS AND METHODS

General Experimental Procedures

The experiments were conducted on established ridges built the previous year at North Star in Gratiot County, Michigan. All studies were conducted on a Parkhill soil series. In both corn (Zea mays L.) and soybean (Glycine max (L.) Merr.) studies, the plots were 3.0 m wide (4 rows) by 15.2 m long. The crops were planted in 76 cm rows. Soil applied herbicides were applied with a tractor mounted compressed air sprayer. Early preplant, preemergence and sequential applications of these treatments were applied in 215 L/ha water carrier at 206 kPa and included crop oil concentrate (COC)[1] (2.34 L/ha) or paraquat (0.56 kg/ha) + X-77[2] (0.25% v/v) in the initial application to facilitate burndown of existing weeds. Postemergence applications were made with a CO_2 backpack sprayer at 343 kPa. Postemergence broadcast treatments were applied in 234 L/ha, and post-directed treatments, including layby applications, were applied in 187 L/ha water carrier using drop nozzles.

[1]Herbimax - Registered trademark of Union Carbide Corp., manufactured for: Loveland Industries, Inc., Loveland, Colorado 80537 (83% light paraffinic distillate, odorless aliphatic petroleum solvent, 17% mono- and diesters of omega hydroxpoly oxyethylene).

[2]X-77 - Registered trademark of Chevron Chemical Company, San Francisco, CA 94120 (functioning agents: alkylarylpolyethylene, glycols, free fatty acids, and isopropanol).

Herbicide treatments were evaluated visually for weed control and crop tolerance based on the untreated check. Each study was arranged in a randomized complete block design with 4 replications. Analyses of variance were computed on all data. Differences among treatments were tested with Duncan's multiple range test at the 5% level of significance.

1984. Herbicide combinations were applied to corn and soybeans on soybean residue and corn residue, respectively. Herbicide treatments were aimed at providing broad spectrum weed control of annual weed species that occurred in the ridge till-plant system while maintaining crop tolerance.

Both crops were till-planted on ridges with a 12-row Hiniker Econ-O-Till[3] planter. Corn varieties used were 'Pioneer 3744 and 3747' and the soybean variety was 'Corsoy 79'. The predominant annual weeds in both studies were common lambsquarters (Chenopodium album L.) and common ragweed (Ambrosia artemisiifolia L.). Dandelion (Taraxacum officinale Weber in Wiggers) was present throughout the corn experiment and was the only perennial evaluated. Annual grass species were not evaluated due to lack of uniform and sufficient population.

The corn was planted on May 8. The soil texture was a clay loam with pH 6.6 and 3.4% organic matter. Early preplant applications were applied 6 days prior to planting and preemergence applications were applied 8 days after planting. Other than injection of anhydrous ammonia on June 9, the ridges were not disturbed after planting until June 30 when the field was cultivated to rebuild ridges. Postemergence applications were made 7 days before ridge building on June 21 and

[3]Manufactured by Hiniker Company, P.O. Box 3407, Mankato, Minnesota 56001.

layby herbicide applications were made 5 days after ridge building on July 5. All postemergence treatments except atrazine + COC, which was broadcast over the crop, were postemergence directed to the base of the corn stalk.

Soybeans were till-planted on May 18. The soil texture was a clay loam with pH 6.8 and 4.8% organic matter. The early preplant treatments in soybeans were applied 16 days before planting and preemergence applications were made 7 days after planting. The plots were cultivated once to build ridges on July 3. Postemergence applications were made before ridge building on June 21 and following cultivation on July 5. These applications were postemergence directed except for treatments involving acifluorfen and bentazon which were broadcast.

1985. Herbicides were applied either early preplant or preemergence to soybeans planted into soybean residue with a 4-row Buffalo All-Flex[4] till planter on May 8. The variety planted was 'Corsoy 79'. The soil was a clay loam texture with pH 7.3 and 2.7% organic matter.

The predominant annual weed in the study was common lambsquarters (*Chenopodium album* L.). Dandelion (*Taraxacum officinale* Weber in Wiggers) was the predominant perennial present throughout the study. Late in the season, giant foxtail (*Setaria faberi* Herrm.) and green foxtail [*Setaria viridis* (L.) Beauv.] developed as the primary annual grasses in the study.

Early preplant treatments were applied 9 days before planting on April 29, while preemergence treatments were applied 1 day after planting on May 9. The ridges were cultivated once on July 24.

[4]Manufactured by Fleischer Mfg., Box 848, Columbus, NE 68601.

RESULTS AND DISCUSSION

1984. Visual evaluation of weed control in ridge till-planted corn and soybeans indicates that the use of herbicides in this system is needed to achieve satisfactory control of weeds. The importance of timing of soil applied herbicide application was less evident in corn than in soybeans. This may have been due in part to the different time interval between early preplant applications and planting of the crop. In the soybean study, this time interval was 16 days, and with corn only 6 days passed after early preplant treatments before the corn was planted. In addition, much less rainfall occurred between early preplant and preemergence applications (May 2-May 16) in corn as compared to the rainfall occurring in the corresponding period (May 2-May 25) in soybeans (Appendix 1).

Rainfall data in Appendix 1 shows that early preplant herbicide treatments (applied May 2) in the corn study did not receive substantial rainfall until just prior to preemergence applications made on May 16. This would suggest that early preplant residual herbicides in corn were not activated adequately until close to the preemergence timing. Mid-season visual evaluations of common lambsquarters and common ragweed control, with either early preplant or preemergence applications of atrazine in combination with alachlor or metolachlor, were not significantly different (Table 1). Rates used for residual herbicides in the early preplant treatments were 20 to 30%

Table 1: Mid-season evaluations of common lambsquarters and common ragweed control with early preplant or preemergence herbicide treatments in ridge till-planted corn, 1984.[1,2]

Treatment[3]	Rate EPP	Rate PRE	common[4] lambsquarters	common[4] ragweed
	----------kg/ha---------		------------%---------	
alachlor +	3.36 + 2.24		100 a	100 a
atrazine		2.80 + 1.68	99 a	100 a
metolachlor +	2.80 + 2.24		100 a	93 a
atrazine		2.24 + 1.68	100 a	100 a

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 6/30/84.

[3]Each treatment includes paraquat (0.56 kg/ha) + X-77 (1/4% v/v).

[4]Evaluations were made on 8/13/84.

higher than the preemergence treatments to provide extended control due to earlier application and removal of a portion of the herbicide residue from the crop row by the till-planter. Control of these two weed species was comparable between early preplant and preemergence applications in corn and adequate season-long control of the two species was obtained for all herbicide treatments tested with either application timing.

The flowable formulation of cyanazine was used with a crop oil concentrate and was compared with the atrazine + paraquat + X-77 combination for burndown of existing weeds and for residual weed control from the early preplant timing. Whether in combination with alachlor, metolachlor, or alone, the atrazine + paraquat + X-77 tankmix provided equal or greater control of common ragweed than cyanazine + COC with these same combinations at the mid-season evaluation (Table 2). Cyanazine (4.48 kg/ha) + COC (2.34 L/ha) alone, at the highest rate tested, and atrazine + paraquat + X-77 tankmixes alone and in combination with alachlor or metolachlor gave essentially complete control of common lambsquarters by the mid-season evaluation (Table 2). All of these early preplant treatments provided satisfactory control of the two annual broadleaf weeds (Table 2).

Preemergence applications were compared to sequential applications of an early preplant application followed by a preemergence application. The sequential applications generally provided excellent season-long control of common lambsquarters and common ragweed (Table 3). However, when cyanazine was applied at 1.68 kg/ha at the early preplant timing as part of a split triazine herbicide application, results showed inconsistent control of common lambsquarters by the

Table 2: Mid-season evaluations of common lambsquarters and common ragweed control with early preplant herbicide treatments in ridge till-planted corn, 1984.[1,2]

Treatment[3]	Rate	common[4] lambsquarters	common[4] ragweed
	----kg/ha----	--------------%-------------	
cyanazine	4.48	100 a	93 a
alachlor + cyanazine	3.36 + 2.80	91 ab	86 a
metolachlor + cyanazine	2.80 + 2.80	86 b	95 a
atrazine	2.24	98 ab	96 a
alachlor + atrazine	3.36 + 2.24	100 a	100 a
metolachlor + atrazine	2.80 + 2.24	100 a	93 a

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 6/30/84.

[3]Crop oil concentrate (2.34 L/ha) is included in all cyanazine treatments and paraquat (0.56 kg/ha) + X-77 (1/4% v/v) is included in the atrazine treatments.

[4]Evaluations were made on 8/13/84.

Table 3: Late-season evaluations of common lambsquarters and common ragweed control with preemergence herbicide treatments with and without early preplant herbicide treatments in ridge till-planted corn, 1984.[1,2]

Treatment[3]	Rate EPP	Rate PRE	common[4] lambsquarters	common[4] ragweed
			%	
alachlor + atrazine		2.80 + 1.68	100 a	100 a
alachlor + atrazine + cyanazine		2.80 + 0.84 + 1.68	99 a	100 a
(cyanazine) + alachlor + atrazine	1.68	2.80 + 1.68	95 a	100 a
(cyanazine) + alachlor + atrazine	2.80	2.80 + 1.12	96 a	100 a
(atrazine) + alachlor + atrazine	1.12	2.80 + 1.12	95 a	95 a
(atrazine) + alachlor + cyanazine	1.12	2.80 + 1.68	97 a	100 a
(cyanazine) + alachlor + cyanazine	1.68	2.80 + 1.68	69 b	98 a
metolachlor + atrazine		2.24 + 1.68	97 a	100 a
metolachlor + atrazine + cyanazine		2.24 + 0.84 + 1.68	91 ab	100 ab
(atrazine) + metolachlor + atrazine	1.12	2.24 + 1.12	91 ab	100 ab
(cyanazine) + metolachlor + atrazine	1.68	2.24 + 1.68	75 ab	93 ab

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 6/30/84.

[3]Each treatment includes paraquat (0.56 kg/ha) + X-77 (1/4% v/v) in initial treatment, except EPP treatment of cyanazine at 2.80 kg/ha, which includes COC (2.34 L/ha).

[4]Evaluations were made on 10/6/84.

late-season evaluation (Table 3). This may have resulted due to the lack of soil persistence of cyanazine at this rate. Higher rates of cyanazine tested (2.80 or 4.48 kg/ha) at the early preplant timing, provided satisfactory control of common lambsquarters throughout the season (Tables 2 and 3).

Visual evaluations indicated sequential applications of an early preplant application followed by a preemergence application appeared to provide the greatest control of dandelion prior to the ridge-building cultivation (Table 4). However, due to variability within the study, there were no statistical differences among sequential treatments and early preplant and preemergence treatments at P=0.05 according to Duncan's multiple range test. Dandelion control in this study appeared to be influenced by the total amount of triazine herbicide applied and whether or not it was applied sequentially (Table 4).

Sequential treatments of a preemergence application followed by a layby application of residual herbicides resulted in complete control of common lambsquarters and common ragweed throughout the growing season (Table 5). Data suggest that the addition of paraquat + X-77 at the preemergence timing, as well as the high rate of layby application of triazine herbicide may not be required to achieve complete control of these weeds for the populations present in this study. The addition of alachlor and metolachlor to layby applications did not improve control of these weed species (Table 5). Although control of winter annuals was not evaluated, these species were noticably absent where layby applications were made. Benefits of the layby applications were not otherwise observed in terms of annual weed control in this study.

Table 4: Evaluations of dandelion control with early preplant, preemergence, and sequential herbicide treatments in ridge till-planted corn, 1984.[1,2]

Treatment[3]	Rate EPP	Rate PRE	6/12/84	6/28/84
	---------kg/ha----------		--------%---------	
(cyanazine)	4.48		73 a	75 a
(atrazine)	2.24		63 a	54 a
(alachlor + atrazine)	3.36 + 2.24		59 a	75 a
(alachlor + cyanazine)	3.36 + 2.80		65 a	48 a
(metolachlor + atrazine)	2.80 + 2.24		73 a	25 b
(metolachlor + cyanazine)	2.80 + 2.80		58 a	25 b
(cyanazine) + alachlor + atrazine	1.68	2.80 + 1.68	100 a	100 a
(cyanazine) + alachlor + atrazine	2.80	2.80 + 1.12	100 a	100 a
(atrazine) + alachlor + atrazine	1.12	2.80 + 1.12	93 a	68 a
(cyanazine) + alachlor + cyanazine	1.68	2.80 + 1.68	100 a	100 a
(atrazine) + alachlor + cyanazine	1.12	2.80 + 1.68	100 a	100 a
(cyanazine) + metolachlor + atrazine	1.68	2.24 + 1.68	98 a	100 a
(atrazine) + metolachlor + atrazine	1.12	2.24 + 1.12	90 a	40 a
alachlor + atrazine		2.80 + 1.68	73 a	33 b
alachlor + atrazine + cyanazine		2.80 + 0.84 + 1.68	93 a	73 a
metolachlor + atrazine		2.24 + 1.68	83 a	50 a
metolachlor + atrazine + cyanazine		2.24 + 0.84 + 1.68	95 a	75 a

[1]Means, average of four replications, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 6/30/84.

[3]Each treatment includes paraquat (0.56 kg/ha) + X-77 (1/4% v/v) in initial treatment, except where cyanazine is applied at 2.80 kg/ha or greater, which includes COC (2.34 L/ha).

Table 5: Early, mid-, and late-season evaluations of common lambsquarters and common ragweed control with preemergence herbicide treatments followed by layby applications in ridge till-planted corn, 1984.[1,2]

Treatment[3]	Rate PRE	Rate LAYBY	Common[4] Lambsquarters	Common[4] Ragweed
	----kg/ha----		----%----	
alachlor + atrazine + cyanazine** + (atrazine)	2.80 + 0.84 + 1.68	1.12	100 a	100 a
alachlor + atrazine + (atrazine)	2.80 + 1.68	2.24	100 a	100 a
alachlor + atrazine + cyanazine + (atrazine)	2.80 + 0.84 + 1.68	2.24	100 a	100 a
metolachlor + atrazine + (atrazine)	2.24 + 1.68	2.24	100 a	100 a
metolachlor + atrazine + cyanazine + (atrazine)	2.24 + 0.84 + 1.68	2.24	100 a	100 a
alachlor + atrazine + (cyanazine)	2.80 + 1.68	2.24	100 a	100 a
alachlor + atrazine + cyanazine + (cyanazine)	2.80 + 0.84 + 1.68	2.24	100 a	100 a
metolachlor + atrazine + (cyanazine)	2.24 + 1.68	2.24	100 a	100 a
metolachlor + atrazine + cyanazine + (cyanazine)	2.24 + 0.84 + 1.68	2.24	100 a	100 a
alachlor + atrazine + cyanazine + (alachlor + atrazine)	2.24 + 0.84 + 1.68	1.12 + 1.12	100 a	100 a
metolachlor + atrazine + cyanazine + (metolachlor + atrazine)	2.24 + 0.84 + 1.68	1.12 + 1.12	100 a	100 a
alachlor + atrazine + cyanazine + (alachlor + cyanazine)	2.24 + 0.84 + 1.68	1.12 + 2.24	100 a	100 a
metolachlor + atrazine + cyanazine + (metolachlor + cyanazine)	2.24 + 0.84 + 1.68	1.12 + 2.24	100 a	100 a
metolachlor + atrazine + (cyanazine + atrazine)	2.24 + 1.12	1.12 + 0.56	100 a	100 a
metolachlor + atrazine + (cyanazine + atrazine)	2.80 + 1.12	1.12 + 0.56	100 a	100 a
alachlor + atrazine + (cyanazine + atrazine)	2.24 + 1.12	1.12 + 0.56	100 a	100 a

[1]Means, average of four evaluations, within on column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 6/30/84.

[3]Each treatment includes paraquat (0.56 kg/ha) + X-77 (1/4% v/v) in initial treatment, except treatment denoted with **.

[4]Evaluations were made on 6/28/84, 8/13/84, and 10/6/84.

Postemergence treatments used were generally ineffective in controlling common lambsquarters (Table 6). Common lambsquarters had 6 to 10 leaves (5 to 20 cm in height) at postemergence timing. Lack of adequate coverage of these weeds with the methods used, in addition to the advanced stage of growth, may have caused the poor control of this species. Ametryn + X-77 provided excellent control of common lambsquarters initially and at the mid-season evaluation and provided significantly greater control than the other postemergence treatments tested (Table 6). Due in part to the ridge-building cultivation on June 30, mid-season evaluations of all of these treatments indicated improved control of common lambsquarters (Table 6). However, by the end of the season, lack of adequate residual control was evidenced by late germination of common lambsquarters. Evaluations in early October for all postemergence treatments were 65% or less for this weed species.

At the time of postemergence application, common ragweed had an average of 6 leaves (7 to 10 cm in height). Initially, ametryn + X-77 showed the greatest potential for postemergence control of common ragweed as evidenced by the evaluation made one week after postemergence timing (Table 6). While ametryn + X-77 demonstrated considerable contact activity with 95% control of common ragweed, the other treatments provided less than 68% control of this species 1 week after treatment (Table 6). Control of common ragweed with postemergence treatments was 94% or greater by the mid-season evaluation with cyanazine, 2,4-D amine, and ametryn + X-77 at the rates given in Table 6. Again, the ridge-building cultivation may have contributed to control of this weed species.

Table 6: Early- and mid-season evaluations of common lambsquarters and common ragweed control with postemergence herbicide treatments in ridge till-planted corn, 1984.[1,2,3]

Treatment[4]	Rate	Common Lambsquarters 6/28/84	Common Lambsquarters 8/13/84	Common Ragweed 6/28/84	Common Ragweed 8/13/84
	------kg/ha------	-----------------%-----------------			
atrazine + COC	2.24 + 1 1/2% v/v	33 d	81 b	40 d	81 b
ametryn + X-77	1.79 + 3/4% v/v	88 a	94 a	95 a	98 a
2,4-D amine	0.56	69 b	71 bc	67 b	95 a
cyanazine	2.80	48 c	68 c	53 c	94 a

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Postemergence treatments were applied on 6/21/84.

[3]Plots received a ridge-building cultivation on 6/30/84.

[4]Applications were post-directed except atrazine + COC (post-broadcast).

Although these postemergence treatments would be expected to perform the same in any tillage system, given the same environmental conditions and growth stages of crop and weeds, the advantage of selective control with the postemergence directed treatments was increased due to the greater height differential obtained by producing the crop on the ridge. Crop injury was evaluated one week after postemergence applications on June 28. At the June 28 rating, only the postemergence treatments showed visible injury symptoms (10 to 23% injury), with ametryn + X-77 being the only treatment to show significantly greater injury than the soil applied treatments.

In soybeans, in 1984, early preplant or preemergence herbicide treatments provided satisfactory control of common ragweed prior to building ridges and through the mid-season evaluation (Tables 7 and 8). However, control of common lambsquarters prior to cultivation on July 3 varied among early preplant and preemergence treatments. Early preplant applications of metolachlor with metribuzin at 0.56 kg/ha or linuron at 1.12 kg/ha provided less than 80% control of common lambsquarters prior to ridging, while metribuzin at 0.56 kg/ha with alachlor or oryzalin, or metribuzin at 0.84 kg/ha with metolachlor, provided 96% or greater control of common lambsquarters prior to the ridge-building cultivation (Table 7). All preemergence treatments provided essentially complete control of this weed species except treatments not including linuron or metribuzin as part of the treatment (Table 8). Over 5 cm of rainfall occurred 2 days prior to preemergence treatments and another 5 cm fell within a week after application of these treatments (Appendix 1). Treatments involving chloramben as the broadleaf component failed to control common lambsquarters prior to the

Table 7: Mid-season evaluations of common lambsquarters and common ragweed control with early preplant treatments in ridge till-planted soybeans, 1984.[1,2]

Treatment[3]	Rate	Common Lambsquarters		Common Ragweed	
		7/3/84	7/26/84	7/3/84	7/26/84
	--kg/ha--	%			
alachlor + metribuzin	3.36 + 0.56	96 a	92 ab	93 ab	93 ab
alachlor + linuron	3.36 + 1.12	85 a	92 ab	97 a	95 a
metolachlor + metribuzin	2.80 + 0.56	78 a	91 ab	80 b	88 a
metolachlor + linuron	2.80 + 1.12	69 a	77 b	81 b	92 a
metolachlor + metribuzin	2.80 + 0.84	100 a	98 a	95 a	98 a
oryzalin + metribuzin	1.68 + 0.56	100 a	96 ab	98 a	91 a

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 7/3/84 after evaluations on the same date above were made.

[3]Each treatment includes COC (2.34 L/ha).

Table 8: Mid-season evaluations of common lambsquarters and common ragweed control with preemergence herbicide treatments in ridge till-planted soybeans, 1984.[1,2]

Treatment[3]	Rate	Common Lambsquarters		Common Ragweed	
		7/3/84	7/26/84	7/3/84	7/26/84
	------kg/ha---------	----------%			-----------
alachlor + chloramben	2.80 + 3.36	46 b	94 a	96 a	95 a
metolachlor + chloramben	2.24 + 3.36	46 b	93 a	96 a	100 a
alachlor + chloramben + metribuzin	2.80 + 2.24 + 0.42	99 a	99 a	100 a	98 a
alachlor + chloramben + linuron	2.80 + 2.24 + 0.84	99 a	96 a	100 a	99 a
metolachlor + chloramben + metribuzin	2.24 + 2.24 + 0.42	100 a	97 a	97 a	100 a
metolachlor + chloramben + linuron	2.24 + 2.24 + 0.84	99 a	99 a	99 a	100 a
alachlor + metribuzin	2.80 + 0.42	99 a	98 a	99 a	99 a
alachlor + linuron	2.80 + 0.84	100 a	98 a	100 a	99 a
metolachlor + metribuzin	2.24 + 0.42	100 a	96 a	98 a	99 a
metolachlor + linuron	2.24 + 0.42	100 a	96 a	99 a	100 a

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 7/3/84 after evaluations on the same date above were made.

[3]Each treatment includes paraquat (0.56 kg/ha) + X-77 (1/4% v/v) applied preemergence.

ridge-building cultivation on July 3 (Table 8). Environmental conditions were such that a soluble herbicide such as chloramben was moved below the weed seed germination zone and could not exert its toxic effects on the common lambsquarters present.

The ridge-building cultivation considerably improved control of common lambsquarters where previously the early preplant or preemergence treatments did not provide adequate control (Tables 7 and 8). Twenty-three days after the cultivation, the early preplant treatment of metolachlor + linuron + COC provided only 77% control of common lambsquarters while all other early preplant and preemergence treatments provided 91% or greater control of this species. At the same evaluation, early preplant and preemergence treatments provided satisfactory control of common ragweed (Tables 7 and 8).

By the late-season evaluation, only an early preplant treatment of oryzalin + metribuzin + COC (1.68 kg/ha + 0.56 kg/ha + 2.34 L/ha), and preemergence treatments of alachlor + paraquat + X-77 (2.80 kg/ha + 0.56 kg/ha + 1/4% v/v) with metribuzin (0.42 kg/ha) or linuron (0.84 kg/ha) provided 90% or greater control of common lambsquarters (Table 9). Visual evaluations indicated that preemergence treatments provided greater control of common ragweed than the early preplant treatments at the late-season evaluation. However, due to variability within the study, there were no statistical difference between the two treatment timings (Table 9). When preemergence applications of chloramben with alachlor or metolachlor followed early preplant applications of linuron or cyanazine, the treatments resulted in 90% or greater control of both weeds throughout the season (Table 10). Sequential applications of a preemergence application and a layby application

Table 9: Late-season evaluations of common lambsquarters and common ragweed control with early preplant and preemergence herbicide treatments in ridge till-planted soybeans, 1984.[1,2]

Treatment[3]	Rate EPP	Rate PRE	Common Lambsquarters[4]	Common Ragweed[4]
	---------kg/ha--------		---------------%----------	
alachlor + metribuzin	3.36 + 0.56		84 ab	84 a
alachlor + linuron	3.36 + 1.12		70 ab	71 a
metolachlor + metribuzin	2.80 + 0.56		74 ab	65 a
metolachlor + linuron	2.80 + 1.12		53 b	61 a
metolachlor + metribuzin	2.80 + 0.84		81 ab	83 a
oryzalin + metribuzin	1.68 + 0.56		98 a	80 a
alachlor + chloramben		2.80 + 3.36	68 ab	93 a
metolachlor + chloramben		2.24 + 3.36	65 ab	90 a
alachlor + chloramben + metribuzin		2.80 + 2.24 + 0.42	75 ab	90 a
alachlor + chloramben + linuron		2.80 + 2.24 + 0.84	75 ab	86 a
metolachlor + chloramben + metribuzin		2.24 + 2.24 + 0.42	87 ab	94 a
metolachlor + chloramben + linuron		2.24 + 2.24 + 0.84	74 ab	96 a
alachlor + metribuzin		2.80 + 0.42	93 ab	100 a
alachlor + linuron		2.80 + 0.84	90 ab	94 a
metolachlor + metribuzin		2.24 + 0.42	65 ab	99 a
metolachlor + linuron		2.24 + 0.42	85 ab	97 a

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 7/3/84.

[3]EPP treatments include COC (2.34 L/ha) and PRE treatments include paraquat (0.56 kg/ha) + X-77 (1/4% v/v).

[4]Evaluations were made on 10/11/84.

Table 10: Mid- and late-season evaluations of common lambsquarters and common ragweed control with sequential herbicide applications of an early preplant application followed by a preemergence application in ridge till-planted soybeans, 1984.[1,2]

Treatment[3]	Rate EPP	Rate PRE	Common Lambsquarters 7/3/84	Common Lambsquarters 10/11/84	Common Ragweed 7/3/84	Common Ragweed 10/11/84
	----------%-------		------------------%------------------			
(metribuzin) + chloramben + alachlor	0.56	2.24 + 2.80	100 a	75 a	100 a	75 a
(linuron) + chloramben + alachlor	1.12	2.24 + 2.80	100 a	93 a	100 a	99 a
(metribuzin) + chloramben + metolachlor	0.56	2.24 + 2.24	100 a	85 a	100 a	92 a
(linuron) + chloramben + metolachlor	1.12	2.24 + 2.24	100 a	95 a	99 a	90 a
(cyanazine) + chloramben + metolachlor	2.24	2.24 + 2.24	99 a	93 a	99 a	90 a

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 7/3/84 after evaluations on the same date above were made.

[3]Each treatment includes COC (2.34 L/ha) with EPP treatment.

provided essentially complete control of both weed species throughout the season (Table 11). Under environmental conditions that produced excessive rainfall during the last half of May and under the imposition of cultivation, a single early preplant or preemergence application were often not enough to provide season-long control of both common lambsquarters and common ragweed (Table 9). Multiple applications gave more consistent control of these species throughout the season (Tables 10 and 11).

There were no significant crop injury symptoms from early preplant applications of metribuzin, linuron, or cyanazine alone or in combinations used in the soybean study. Only the sequential application of linuron and alachlor resulted in crop injury significantly greater than the untreated check (Table 12). The two combined applications of linuron at 0.84 kg/ha were excessive for this soil type. Layby applications of atrazine were applied in an attempt to control weeds in the furrow without directing the herbicide near the ridge and the soybeans which are very susceptible to atrazine. Atrazine at 1.12 kg/ha applied in this manner following preemergence treatments of chloramben + alachlor (2.24 + 2.80 kg/ha) with metribuzin (0.42 kg/ha) or linuron (0.84 kg/ha) resulted in 10% and 11% soybean injury eighteen days after layby applications. Later observations noted excessive phytotoxicity on the soybeans treated with atrazine but no visible injury from other layby applications.

Applications were made on soybeans at the 2 to 4 trifoliate leaf stage when the plants were 10 to 15 cm in height on ridges that were 18 to 20 cm high. Common lambsquarters was at the 6-leaf stage (5 to 10 cm in height) and common ragweed was at the 6- to 8-leaf stage (10 to

Table 11: Mid- and late-season evaluations of common lambsquarters and common ragweed control with sequential herbicide applications of a preemergence application followed by a layby application in ridge till-planted soybeans, 1984.[1,2]

Treatment[3]	Rate		Common Lambsquarters		Common Ragweed	
	PRE	LAYBY	7/3/84	10/11/84	7/3/84	10/11/84
	kg/ha		%			
alachlor + metribuzin + (alachlor + metribuzin)	2.24 + 0.42	1.12 + 0.28	100 a	100 a	100 a	100 a
alachlor + linuron + (alachlor + linuron)	2.24 + 0.84	1.12 + 0.84	100 a	96 a	100 a	100 a
metolachlor + metribuzin + (metolachlor + metribuzin)	2.24 + 0.42	1.12 + 0.28	100 a	99 a	100 a	99 a
oryzalin + metribuzin + (alachlor + metribuzin)	1.12 + 0.42	1.12 + 0.28	100 a	99 a	99 a	95 a

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 7/3/84 after evaluations on the same date above were made.

[3]Each treatment includes paraquat (0.56 kg/ha) + X-77 (1/4% v/v) applied PRE.

Table 12: Ridge till-planted soybean injury evaluations, 1984.[1,2]

Treatment[3]	Rate PRE	Rate LAYBY	Soybean[4] Injury
	----------------kg/ha----------------		---%---
chloramben + metribuzin + alachlor + (atrazine)	2.24 + 0.42 + 2.80	1.12	10 ab
chloramben + linuron + alachlor + (atrazine)	2.24 + 0.84 + 2.80	1.12	11 ab
metribuzin + alachlor + (metribuzin + alachlor)	0.42 + 2.24	0.28 + 1.12	15 ab
linuron + alachlor + (linuron + alachlor)	0.84 + 2.24	0.84 + 1.12	21 a
metribuzin + metolachlor + (metribuzin + metolachlor)	0.42 + 2.24	0.28 + 1.12	9 ab
metribuzin + oryzalin + (metribuzin + alachlor)	0.42 + 1.12	0.28 + 1.12	6 ab
untreated	-	-	0 b

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 7/3/84.

[3]All treatments except untreated include paraquat (0.56 kg/ha) + X-77 (1/4% v/v) in initial treatment.

[4]Evaluations were made on 7/26/84 (21 days after layby treatments were applied).

13 cm in height). Twelve days after application, all postemergence treatments showed significant soybean injury compared to the untreated check (Table 13). Atrazine at 1.68 kg/ha was post-directed following a preemergence application of metolachlor at 2.24 kg/ha. While this treatment provided the most consistent control of common lambsquarters throughout the season, it resulted in 59% soybean injury three weeks after application which was significantly greater than any postemergence treatment evaluated at this time (Table 13).

A post-directed treatment of 2,4-D amine resulted in a 20% soybean vigor reduction three weeks after application (Table 13). Subsequent observations showed excessive injury to soybeans following this treatment.

None of the postemergence treatments provided satisfactory control of both common lambsquarters and common ragweed prior to the ridge-building cultivation (Table 13). Due to the advanced stage of growth of common lambsquarters at the time of postemergence application, treatments including acifluorfen and bentazon were not effective. Control of common ragweed with these herbicides was initially very effective, but as with common lambsquarters, the weeds continued to germinate later in the growing season and lack of a residual herbicide component resulted in poor late-season control.

In 1984, no injury resulted from early preplant applications including metribuzin (0.56 kg/ha or 0.84 kg/ha), linuron (1.12 kg/ha), cyanazine (2.24 kg/ha), and oryzalin + metribuzin (1.68 kg/ha + 0.56 kg/ha). Preemergence applications including linuron (0.84 kg/ha) and metribuzin (0.42 kg/ha) with and without oryzalin (1.12 kg/ha) also resulted in essentially no visible injury.

Table 13: Early and mid-season evaluations of common lambsquarters, common ragweed control, and soybean injury with postemergence treatment in ridge till-planted soybeans, 1984.[1,2]

Treatment[3]	Rate		Common Lambsquarters		Common Ragweed		Soybean Injury	
	PRE	POST	7/3/84	7/26/84	7/3/84	7/26/84	7/3/84	7/26/84
	------kg/ha-------		---------------------%					----------------------
metolachlor + (acifluorfen + bentazon)	2.24	0.56 + 0.84	50 b	64 b	92 a	98 a	66 b	5 bc
(acifluorfen + bentazon + fluazifop)		0.56 + 0.84 + 0.28	61 ab	89 a	91 ab	83 b	71 ab	14 bc
metolachlor + (atrazine)*	2.24	1.68	89 a	90 a	66 c	93 ab	75 a	59 a
metolachlor + (2,4-D amine)*	2.24	0.56	87 a	99 a	78 b	98 a	31 c	20 bc
untreated	-	-	0 c	0 c	0 d	0 c	0 d	0 c

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 7/3/84 after evaluations on the same date above were made.

[3]Postemergence treatments, except 2,4-D amine, include COC (2.34 L/ha) and were applied on 6/21/84.

*Indicate treatments that were post-directed.

1985. An experiment was initiated on established ridges to examine soybean tolerance and weed control when herbicides were applied early preplant compared to the same herbicides applied preemergence. Paraquat + X-77 (0.56 kg/ha + 1/4% v/v) was applied to all plots to facilitate burndown of existing vegetation. All other herbicides used in the experiment were tested to determine the soil residual effect of each respective herbicide on soybean phytotoxicity. Early preplant treatments were applied at generally higher rates than those used for the preemergence counterpart to account for the removal of soil on the ridge from the till-planting operation and loss of available activity from natural transformation processes occurring in and on the soil.

In 1985, under much drier growing conditions than the previous year, significant soybean injury was observed 19 days after planting with treatments of metribuzin (0.56 kg/ha) applied early preplant, and preemergence treatments of metribuzin (0.42 kg/ha) or cyanazine (1.12 kg/ha) (Table 14). Symptoms were slight chlorosis and loss of vigor as compared to the untreated plots. Oxyfluorfen applied early preplant at 1.12 kg/ha and preemergence at 0.56 kg/ha exhibited severe stunting and chlorosis at the same evaluation and resulted in the greatest soybean vigor reduction. All other treatments including linuron, oryzalin, pendimethalin, an ester formulation of 2,4-D, and early preplant applications of the highest rates of cyanazine or metribuzin, did not result in significantly greater soybean injury than the untreated check at this early evaluation. By mid-season, after the ridge-building cultivation, no treatment resulted in soybean injury significantly greater than the untreated check (Table 14).

Table 14: Mid- and late-season evaluations of common lambsquarters and dandelion control and early- and mid-season soybean injury evaluations with early preplant or preemergence herbicide treatments in ridge till-planted soybeans, 1985.[1,2]

Treatment[3]	Rate		common lambsquarters		dandelion		soybean injury	
	EPP	PRE	7/17/85	10/3/85	7/17/85	10/3/85	7/17/85	10/3/85
	---kg/ha----		---%					---
metribuzin	0.84		100 a	92 a	98 a	95 a	6 d	0 a
metribuzin	0.56		98 a	83 a	99 a	86 ab	21 c	3 a
metribuzin		0.42	74 abc	75 ab	3 c	23 ef	20 c	8 a
linuron	1.68		87 ab	68 ab	98 a	95 a	3 d	4 a
linuron		0.84	83 abc	69 ab	23 bc	43 cde	1 d	9 a
cyanazine	2.24		98 a	88 a	96 a	95 a	6 d	0 a
cyanazine		1.12	36 cde	55 ab	25 bc	30 def	30 c	5 a
oxyfluorfen	1.12		76 abcd	70 ab	25 bc	30 def	48 b	5 a
oxyfluorfen		0.56	29 de	28 bc	3 c	54 cd	70 a	14 a
oryzalin	1.68		75 abcd	76 ab	0 c	20 ef	3 d	14 a
oryzalin		1.68	44 bcde	51 ab	0 c	38 cde	6 d	15 a
pendimethalin	2.24		91 ab	71 ab	0 c	33 cde	0 d	6 a
pendimethalin		1.12	55 abcd	51 ab	0 c	28 def	4 d	9 a
2,4-D ester	0.56		61 abcd	70 ab	99 a	88 ab	5 d	4 a
2,4-D ester		0.56	68 abcd	49 ab	38 b	25 def	7 d	10 a
untreated	-	-	0 e	0 c	0 c	0 f	0 d	0 a

[1]Means, average of four evaluations, within one column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

[2]Plots received a ridge-building cultivation on 7/24/85.

[3]Each treatment, except untreated, includes paraquat (0.56 kg/ha) + X-77 (1/4% v/v) applied preemergence.

These data suggest that the early preplant applications tested, although not ensuring tolerable soybean injury, may be less injurious to soybeans due to the removal of excessive herbicide residues by the till-planter. Oxyfluorfen, although applied at twice the rate early preplant compared to the preemergence rate, resulted in significantly less injury four weeks after planting. This was the case for both cyanazine and metribuzin as well (Table 14).

Early preplant applications provided equal or greater weed control than preemergence treatments (Table 14). An early preplant application of metribuzin at 0.56 kg/ha, cyanazine at 2.24 kg/ha, or pendimethalin at 2.24 kg/ha gave 91% or greater control of common lambsquarters 10 weeks after planting. By comparison, preemergence applications of metribuzin at 0.42 kg/ha, cyanazine at 1.12 kg/ha, or pendimethalin at 1.12 kg/ha gave 74% or less control of this species 10 weeks after planting. This may have been due to the lower rate of herbicide application and the lack of adequate rainfall before and after the preemergence treatments. At the late-season evaluation only early preplant applications of metribuzin at 0.84 kg/ha or 0.56 kg/ha and cyanazine at 2.24 kg/ha provided better than 80% control of this weed. This suggests that there is an advantage to early preplant applications when adequate rainfall for proper activation of residual soil applied preemergence herbicides does not occur. Only applications of linuron and the ester formulation of 2,4-D did not follow this trend (Table 14). Since 2,4-D ester has limited persistence in the soil and generally only controls weeds that have emerged at the time of treatment, timing did not result in greater benefit under the conditions of delayed weed emergence.

Comparison of the two application timings for dandelion control was even more dramatic. Early preplant applications of metribuzin, linuron, cyanazine, and 2,4-D ester provided significantly greater control of this perennial weed throughout the season (Table 14). Although preemergence applications of metribuzin at 0.42 kg/ha and oxyfluorfen at 0.56 kg/ha exhibited some control of dandelion at early emergence of this weed approximately four weeks after planting on June 6, control was never adequate throughout the season (Table 14). The data suggest that under conditions of insufficient rainfall, early preplant application of residual herbicides may be necessary to control dandelion in soybeans.

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CHAPTER 3

CROP YIELD AND WEED CONTROL AS INFLUENCED BY HERBICIDE APPLICATION AND CULTIVATION

ABSTRACT

Broadcast applications of the herbicides tested provided greater than 91% control of common ragweed (Ambrosia artemisiifolia L.) and common lambsquarters (Chenopodium album L.) in both corn and soybeans grown on ridges with and without cultivation. Banded applications of the same residual herbicides without cultivation resulted in 70% or less control of the two weed species. However, when one cultivation followed a banded application, control of common ragweed in soybeans and common lambsquarters in both crops was not significantly different from broadcast treatments at any level of cultivation. Two cultivations alone without herbicide application provided 90% control of common ragweed in till-planted soybeans. No significant differences in yield were observed in either crop due to differences in herbicide programs or cultivation.

INTRODUCTION

Conservation tillage systems are gradually gaining acceptance in agriculture as a means of effectively controlling erosion and water loss through management of surface residues. A key feature of these systems is a reduction in tillage. Although benefits of reduced tillage such as erosion control and reduced energy expenditure may be obtained, there have been reports of reduced weed control in these systems. Griffith et. al. (18) found that crop germination and weed control tended to be more of a problem with no-plow systems across five soil types in Indiana compared to conventional tillage systems. These problems were accentuated on poorly drained, fine-textured soils as compared to well-drained, coarse-textured soils.

The ridge till-plant system is well suited for medium-textured, well-drained soils (16, 18, 38, 39). Galloway et. al. (16) and others (18, 19, 38, 43) suggested that ridge till-planting may be successful on poorly drained, fine-textured soils if ridges are pronounced and kept free of residues to ensure better drainage and thus, a warmer and dryer seedbed. Under proper management, till-planting on ridges offers a higher degree of erosion control while providing a residue-free seedbed and allows for timely cultivations to control weeds. Several studies have shown that a ridged configuration is beneficial for crop growth and erosion control (1, 8, 41, 50). Some have attributed better stands and crop emergence to more available moisture in the ridge (1, 3, 15, 46).

In the ridge till-plant system, the seed is planted in the ridge and into the old crop row where soil is warmer and better drained than in the furrow. Along with crop residue on the ridge, weed seed is moved with the soil from the crest of the ridge into the furrows. Wicks and Somerhalder (47) found that the till-planter left only 30% as many weed seeds in the corn row as compared to seedbeds prepared by plowing, disking, and harrowing. Others (6, 23, 46) have reported lower weed populations, particularly annual grasses, in the ridge till-plant system compared to conventional and other conservation tillage practices.

Greater reliance on herbicides and better management skills may be required in the ridge till-plant system (10, 32). Special emphasis on controlling perennial weeds with herbicides may be necessary since these species are less likely to be controlled by shallow tillage (2, 20, 37, 45, 48). Annual weeds can be controlled effectively in this system while saving labor (11, 14, 19, 39), energy (11, 19, 39, 51), soil moisture (1, 3, 15, 46) and soil (4, 5, 10, 11, 12, 13, 22, 24, 25, 26, 27, 28, 29, 36, 49, 51) when compared to conventional tillage systems.

Moomaw and Martin (31) investigated weed control in till-planted and slot-planted corn on ridges and found that till-planting was less dependent on herbicides due to increased surface tillage. Maximum corn yield was achieved in the till-plant system with banded applications of preemergence herbicides followed by one cultivation. Although broadcast treatments controlled weeds effectively in the till-plant system, the design of the test did not show weed control effects without cultivation. Corn that was slot-planted on ridges, a system featuring no-tillage on the ridge, benefited from two cultivations rather than one in terms of crop yield and weed control.

It is generally agreed that the number of cultivations required in the till-plant system is dependent on the degree of weed infestation and herbicide efficacy. Studies (30, 31) have demonstrated that mechanical cultivation alone gave weed control not significantly different than any of the treatments including both herbicides and cultivation in till-planted corn. Lane and Gaddis (26) suggested that a banding of herbicides is more necessary in soybeans or milo than in corn in this system. Under the dryland conditions in Nebraska, they also suggested that broadcast applications are not necessary since cultivation will control weeds between the crop rows. Regehr (38) suggested that two cultivations are usually needed if herbicides are banded on the ridge. Burnside and Wicks (7) found that a combination of cultivation and herbicides gave more dependable weed control in sorghum than either method used alone. Gebhardt (17) substantiated these results in soybeans.

In Nebraska and other states implementing the ridge till-plant system, the approach used to control weeds has been to apply preemergence herbicides and control emerging weeds as they occur with light tillage or postemergence herbicides (9, 31, 32). Several studies have shown that tillage has little influence on crop yield in the absence of weeds (21, 44). Where good tilth and soil structure exist, cultivation was adequately substituted by herbicides for weed control. At least two tillage operations, including till-planting and a ridge-building cultivation, are required if the ridge till-plant system is to be maintained (16, 19, 26, 38, 39, 42, 43, 50). Today, the ridge till-plant system has evolved to include generally no more than three tillage operations in one growing season (19, 26, 38, 39, 50). Research in ridge till-planting has included evaluation of preplant disking (40), roto-tilling ridges at planting (38), and chisel plowing corn stalks prior to a fall ridge-building (38). These tillage operations were done as variations of preparing a suitable seedbed free from residues. However, it was noted that these variations, although useful in many situations, will incorporate weed and volunteer seed in the crop row and possibly require additional weed control measures (15, 26, 38).

The objectives of this study were to: a) compare weed control in the ridge till-plant system with a zero, one, or two cultivation variable; b) compare preemergence herbicides and application method across three cultivation levels; and c) examine the effect of cultivation and herbicide application on crop yield in the ridge till-plant system.

MATERIALS AND METHODS

Corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr.) experiments were conducted on established ridges built the previous year at North Star in Gratiot County, Michigan where the previous crop was corn. The experiments were designed as a three factor factorial with one split. The factors were 5 herbicide treatments, broadcast or banded application, and 0, 1, or 2 cultivations. Main plots were number of cultivations. Subplots consisted of five preemergence treatments that were either banded in 25 cm bands or broadcast.

Both crops were till-planted on ridges with a 4-row Buffalo All-Flex[1] till-planter in 76 cm rows on May 8. The corn variety used was 'Pioneer 3744' and the soybean variety was 'Corsoy 79'. Each plot was three meters wide by 15 meters long and included four rows of the crop. Plots were trimmed to 13.7 meters length for uniformity in harvesting. The center two rows were then harvested on October 30 and yields were computed based on corn at 15.5% moisture and soybeans at 13% moisture.

The herbicide treatments for both studies are listed in Tables 1 and 2. All broadcast herbicide treatments included paraquat (0.28 kg/ha) + X-77 (1/4% v/v) and were applied with a tractor mounted compressed air sprayer in 215 L/ha water carrier at 206 kPa. Banded treatments were applied with a tractor mounted compressed air sprayer

[1]Manufactured by Fleischer Mfg., Box 848, Columbus, NE 68601.

Table 1: Preemergence herbicide treatments for ridge till-planted corn.

Herbicide Treatment	Rate (kg/ha)
alachlor + atrazine	2.80 + 1.68
alachlor + atrazine + cyanazine	2.80 + 0.84 + 1.68
metolachlor + atrazine	2.24 + 1.68
metolachlor + atrazine + cyanazine	2.24 + 0.84 + 1.68

Table 2: Preemergence herbicide treatments for ridge till-planted soybeans.

Herbicide Treatment	Rate (kg/ha)
alachlor + metribuzin	2.80 + 0.42
alachlor + linuron	2.80 + 0.84
alachlor + chloramben + metribuzin	2.80 + 2.02 + 0.42
alachlor + chloramben + linuron	2.80 + 2.02 + 0.84

in 299 L/ha water carrier at 206 kPa and drop nozzles were used to achieve the 25 cm band on the tilled ridges. Soybean treatments were applied the same day as planting and corn treatments were applied one day after planting.

Common lambsquarters (*Chenopodium album* L.) and common ragweed (*Ambrosia artemisiifolia* L.) were the predominant annual broadleaf weeds in both studies. Populations of both weeds were light to moderate but uniform throughout the studies. The soil in the corn study was a clay loam texture with pH 7.0 and 2.7% organic matter and in the soybean study, was a clay loam texture with pH 7.3 and 2.6% organic matter.

A 4-row Buffalo All-Flex[2] cultivator was used for all cultivations. Plots in both crops receiving two cultivations were first cultivated on June 21 with disk hillers set to throw soil and residues between the crop rows. Plots cultivated once and those receiving a second cultivation in corn were cultivated on July 1 and in soybeans on July 24 with disk hillers set to move soil and residues into the row to reform ridges. Ridges were approximately 18 to 22 cm in height after this cultivation. By comparison, main plots that received no cultivation were approximately 10 to 13 cm in height by mid-season. Corn was 15 to 36 cm in height (V-5 to V-8)[3] at the first cultivation timing. At this same timing, soybeans were 7 to 13 cm in height (V-2)[4]. At the second cultivation, corn was 36 to 71 cm in

[2]Manufactured by Fleischer Mft., Box 848, Columbus, NE 68601.

[3]How a corn plant develops. Special Report No. 48, Iowa State University, Ames, Iowa.

[4]How a soybean plant develops. Special Report No. 53, Iowa State University, Ames, Iowa.

height at the V-7 to V-9 stage of growth, and soybeans were 36 to 66 cm in height at the V-6 to V-10 stage of growth.

Analyses of variance were computed on all data. The difference between treatment means was tested with LSD values at the 5% level of significance.

RESULTS AND DISCUSSION

No significant treatment effects or interactions existed in either corn or soybeans due to differences in herbicide programs. Mid-season visual evaluations of annual weed control were therefore combined based on method of application and the number of subsequent cultivations received after herbicides were applied.

Broadcast applications of the herbicides tested provided greater than 91% control of common ragweed or common lambsquarters in corn and soybeans regardless of the level of cultivation (Figures 1, 2, 3, 4). Banded applications of the same residual herbicides, followed by no cultivation, resulted in 70% or less control of the two weed species. However, when one cultivation followed a banded application, control of common ragweed in soybeans and common lambsquarters in both crops was not significantly different from broadcast treatments at any level of cultivation (Figures 1, 2, 3, 4). These results support the findings of Moomaw and Martin (31) in the ridge till-plant system and Moomaw and Robison (33, 34, 35) on flat-tilled soil and suggest that banded herbicide applications with cultivations are a legitimate option in this system.

In the soybean study, two cultivations alone provided 90% control of common ragweed (Figure 3). However, even with two cultivations, herbicide application improved weed control. Evaluation of common

Figure 1. Common ragweed control in ridge till-planted corn as influenced by method of herbicide application and cultivation, 7/30/85.

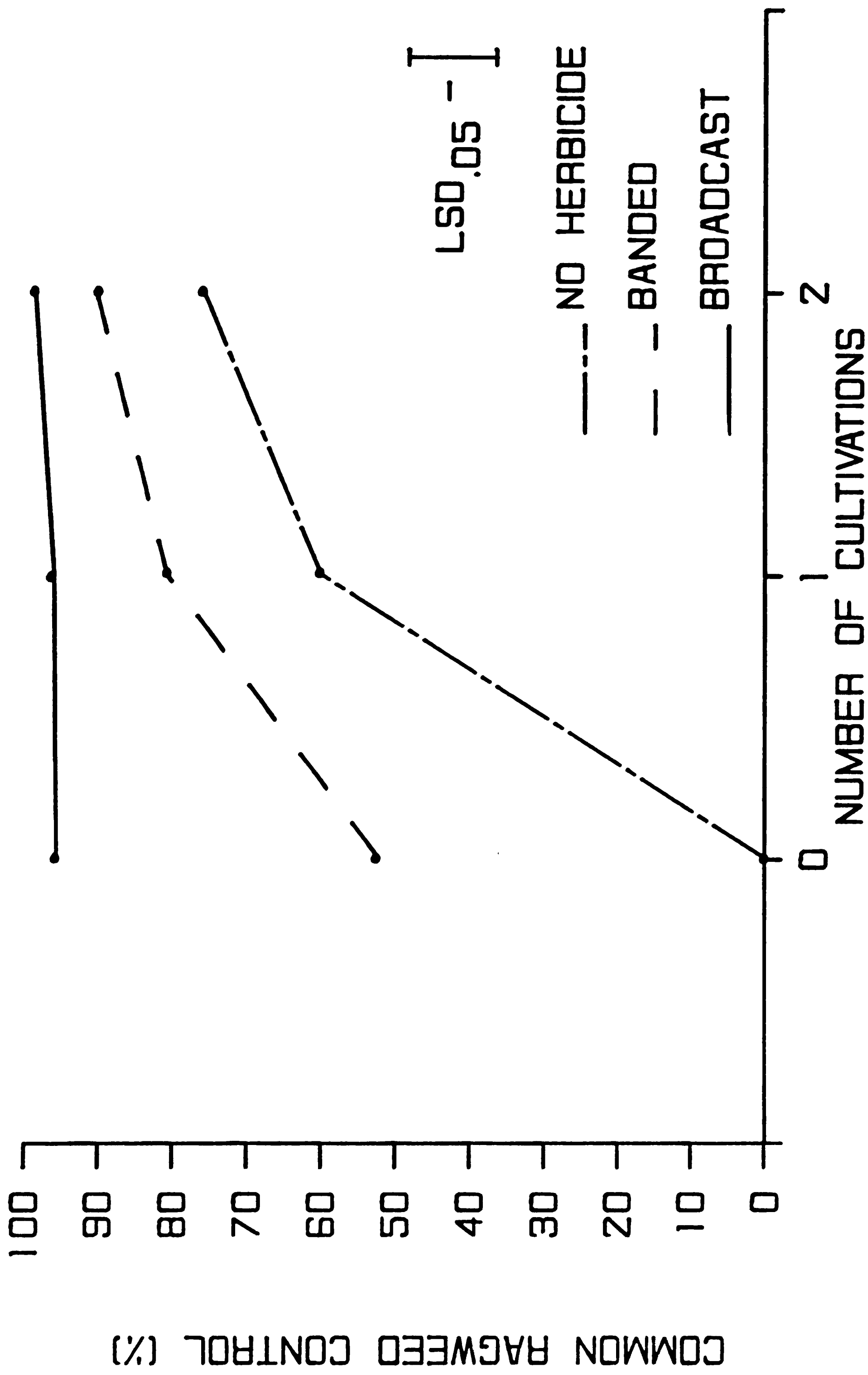

COMMON RAGWEED CONTROL (%)
0
10
20
30
40
50
60
70
80
90
100
NUMBER OF CULTIVATIONS
0
1
2
LSD.05
NO HERBICIDE
BANDED
BROADCAST

Figure 2. Common lambsquarters control in ridge till-planted corn as influenced by method of herbicide application and cultivation, 7/30/85.

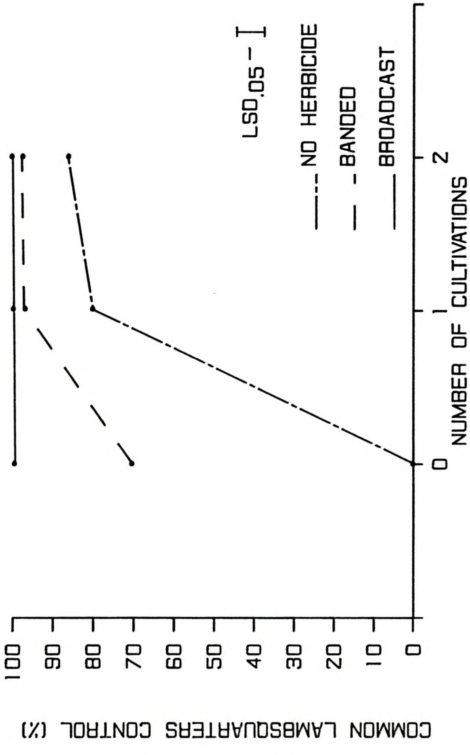

COMMON LAMBSQUARTERS CONTROL (%)
100
90
80
70
60
50
40
30
20
10
0
NUMBER OF CULTIVATIONS
0
1
2
LSD.05
NO HERBICIDE
BANDED
BROADCAST

Figure 3. Common ragweed control in ridge till-planted soybeans as influenced by method of herbicide application and cultivation, 8/8/85.

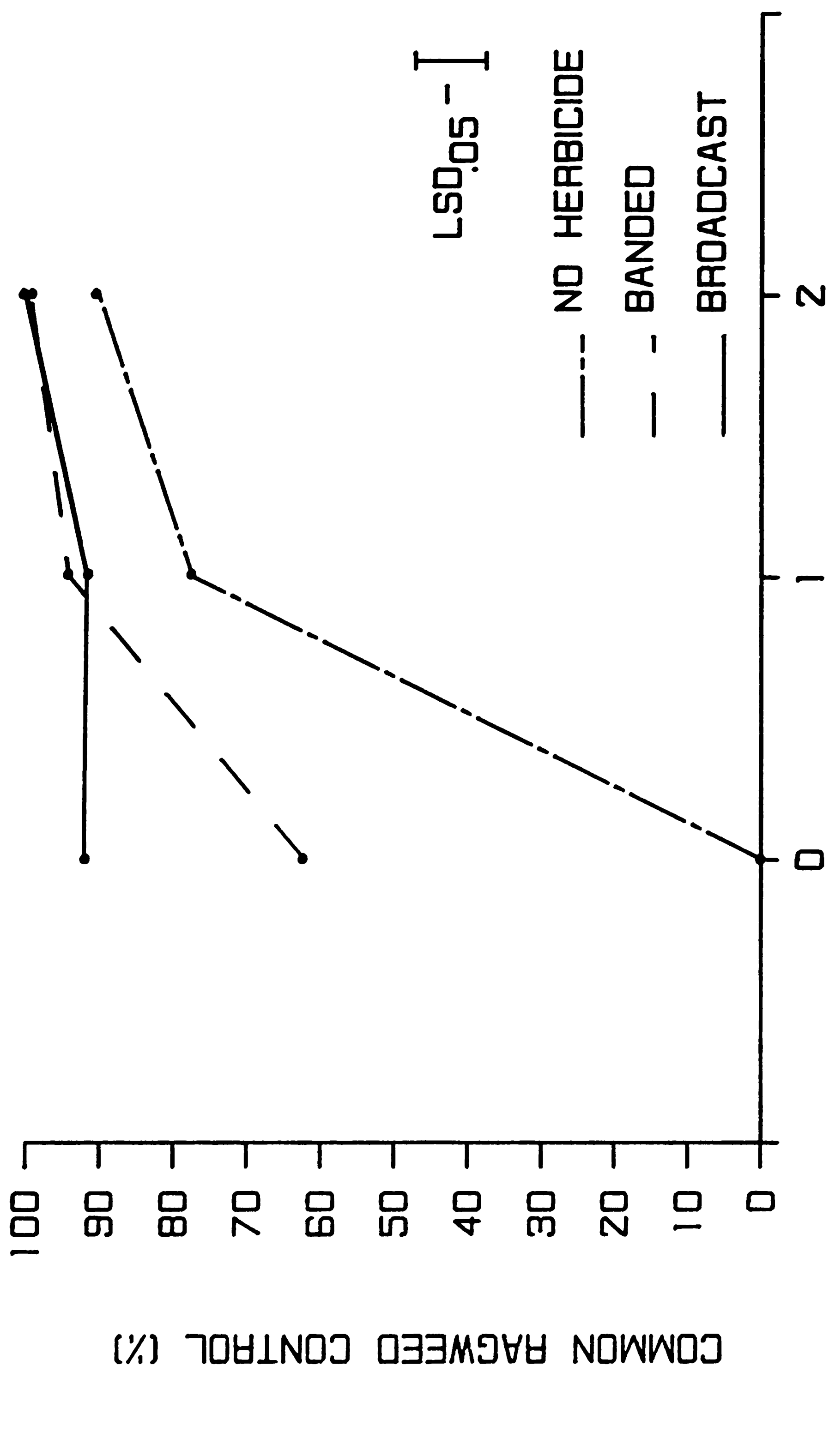
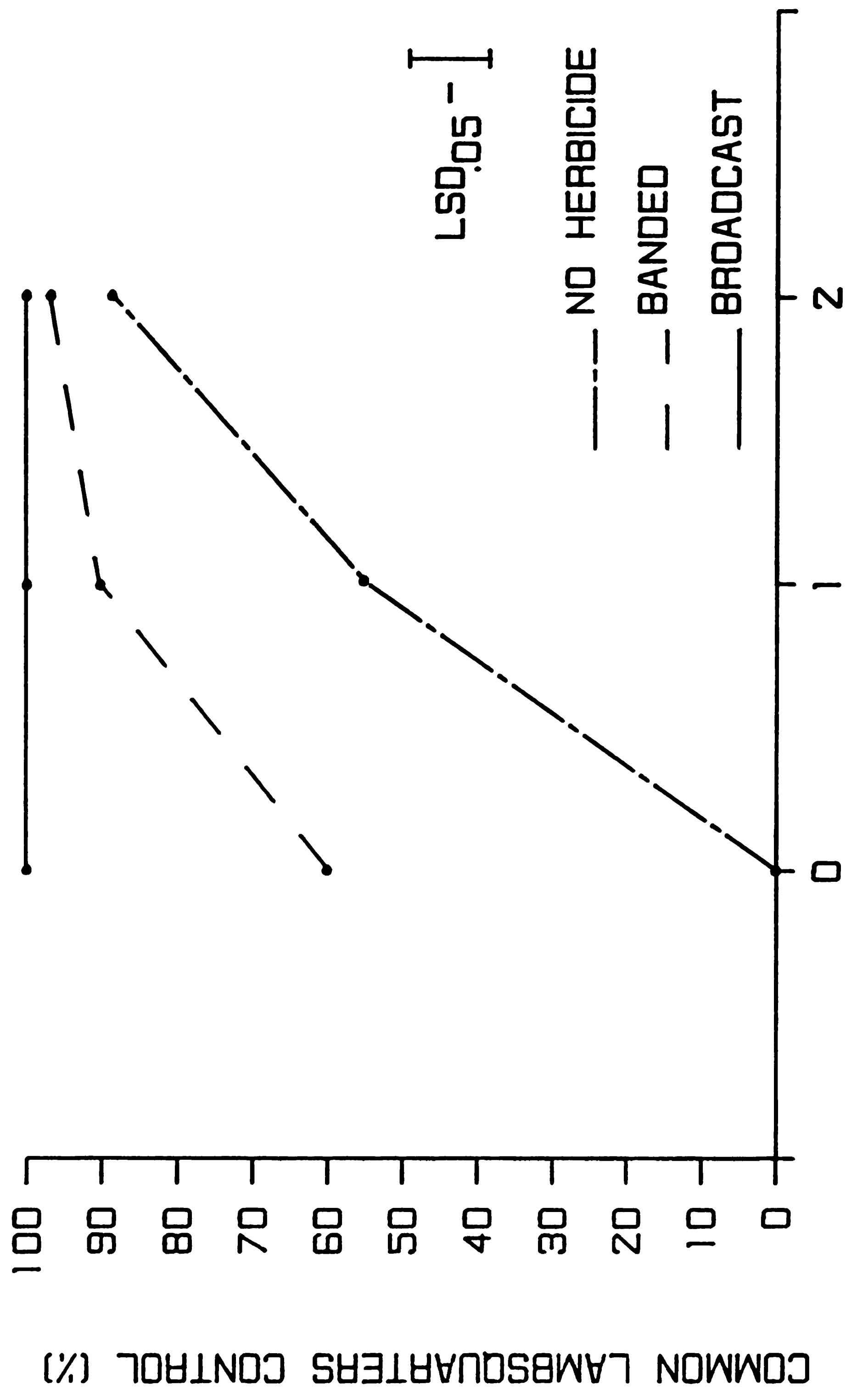

COMMON RAGWEED CONTROL (%)
0
10
20
30
40
50
60
70
80
90
100
NUMBER OF CULTIVATIONS
0
1
2
LSD.05
NO HERBICIDE
BANDED
BROADCAST

Figure 4. Common lambsquarters control in ridge till-planted soybeans as influenced by method of herbicide application and cultivation, 8/8/85.


COMMON LAMBSQUARTERS CONTROL (%)
0
10
20
30
40
50
60
70
80
90
100
NUMBER OF CULTIVATIONS
0
1
2
LSD.05 -
NO HERBICIDE
BANDED
BROADCAST

lambsquarters control at mid-season also showed limited necessity of herbicide application as control approached 89% when no herbicide was applied and two cultivations followed (Figure 4). However, broadcast herbicide application improved control of this weed as well.

In the corn study, although cultivation alone provided 80% or greater control of common lambsquarters, control of the two annual weeds was less than where cultivation was preceded by either a banded or broadcast herbicide application (Figures 1, 2). In addition, a broadcast herbicide application provided significantly greater control of both species than two cultivations alone.

Two cultivations generally improved control of both weed species as compared to one cultivation in both crops. However, considering the populations of the annual weeds present in the studies and the adequacy of the weed control attained, the second cultivation following herbicide treatment by either application method did not contribute greatly to the total weed control obtained.

No significant differences in yield were observed in either crop (Table 3). This may have been due to the generally low populations of weeds present in the studies and the lack of their ability to compete sufficiently with the crops. Weed establishment was delayed in comparison to the crop establishment due in part to the lack of adequate rainfall at planting and the effective seedbed preparation generated by the till-planter.

Table 3: Ridge till-planted corn and soybean yields as influenced by method of herbicide application and cultivation, 1985.

Method of Application[1]		Corn	Soybean
		--------(kg/ha x 10)--------	
Banded	0 cultivation	698	258
	1 cultivation	714	274
	2 cultivations	737	269
Broadcast	0 cultivation	748	265
	1 cultivation	765	274
	2 cultivations	733	265
No Herbicide	0 cultivation	657	263
	1 cultivation	702	287
	2 cultivations	704	272
	LSD .05 =	286	73

[1]Combined all herbicide treatments.

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CHAPTER 4

SUMMARY AND CONCLUSIONS

In the studies conducted for weed control in corn and soybeans grown on ridges with the till-plant system, soil applied herbicides were shown to be a necessary component of a total weed control strategy. Early preplant applications of residual herbicides may be beneficial in this system when rainfall is inadequate at planting to position and activate herbicides, especially in soybeans if planting is delayed allowing early establishment of weeds. High rates of herbicides applied early preplant, which may cause crop injury when applied preemergence, have been shown to be tolerated by the crop when the herbicide residue is partially removed by the till-planter. Therefore, early preplant treatments represent an option for maintaining crop safety and controlling early germinating annual weeds, established winter annuals, and possibly perennial weeds between seasons when crops are produced in the ridge till-plant system.

Sequential applications of an early preplant application followed by a preemergence application, or a preemergence application followed by layby herbicide application, at the timing of the final cultivation in the field provided the most consistent and complete season-long control in both crops. Early preplant applications of metribuzin, linuron, or cyanazine were more effective in controlling dandelion than the same treatments applied preemergence.

Herbicide treatments applied in these studies were aimed at providing season-long annual weed control and were developed around the tillage requirements of the till-plant system. Although not addressed in this paper, perennial weeds can become a problem in the ridge till-plant system due to lack of sufficient deep tillage to control these species (Appendix 2). Reliance on the action of the till-planter to displace residues and weed seeds from the row and cultivation as a means of controlling existing weeds, is seen as an advantage in this system and has been documented. However, weed control programs were examined as an alternative to cultivation to determine the necessity of broadcast applications of herbicides to control weeds in the furrow. In studies conducted in 1985, a broadcast application of residual herbicides with a burndown component gave greater weed control than banded applications. However, with the addition of one or two cultivations, banded applications gave comparable annual weed control. This suggests that when weed populations are low, as they were in these studies, reliance on herbicides is reduced. In a separate study where timing of herbicide application was examined for weed control, postemergence herbicide treatments tested as the primary means of weed control generally gave unsatisfactory control compared with treatments including a soil application of herbicides. This may have been due to poor coverage of weeds with these postemergence herbicides or more rapid metabolism and detoxication of the herbicide by the larger weeds.

It was an objective of studies conducted to determine the extent of cultivation and herbicide application needed to maximize yield in the ridge till-plant system. Although the contribution of cultivation as a component in the weed control strategy on ridges was found to be important in reducing weed establishment, especially when herbicides were row banded, no significant differences in yield were observed due to differences in herbicide programs, method of application or degree of cultivation. This was due to early crop establishment and lack of competition from light to moderate weed infestations that developed more slowly than the crop.

Appendix 1. Rainfall for April through August for the North Star site for 1984 and 1985, Gratiot County, Michigan.

	April		May		June		July		August	
Day	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
	cm									
1	-	0.58	-	-	-	-	-	-	-	0.36
2	-	-	0.03	-	-	-	-	-	-	-
3	-	0.36	0.03	-	0.30	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	0.33	1.50	0.05	0.13	1.14	-	-	0.53	-	1.68
6	0.56	1.60	-	0.03	0.71	-	1.04	-	-	1.07
7	-	0.05	-	-	-	-	-	-	0.03	0.33
8	-	-	-	-	-	0.10	-	0.10	-	-
9	-	-	0.05	-	-	1.32	-	-	1.09	-
10	-	-	-	-	0.33	-	0.03	0.05	1.22	-
11	-	0.10	0.03	-	-	0.05	6.05	-	-	0.05
12	-	0.05	-	-	-	0.64	0.10	-	-	-
13	0.64	-	0.81	-	0.08	0.05	-	-	-	0.56
14	0.18	-	1.65	-	0.03	-	-	0.03	-	0.08
15	0.48	0.41	-	-	-	-	-	0.08	-	0.36
16	0.56	-	-	1.07	-	3.05	-	-	-	0.13
17	0.89	-	-	0.08	1.80	0.46	-	-	-	-
18	0.43	0.81	0.13	-	2.84	-	0.03	-	-	2.18
19	-	0.58	0.08	-	-	-	-	-	0.28	0.46
20	-	0.89	-	-	-	-	-	0.86	-	-
21	-	-	-	0.36	-	-	-	-	-	-
22	-	-	0.13	-	-	-	-	-	-	-
23	2.03	-	5.84	-	-	0.94	-	-	-	-
24	0.15	-	-	-	-	-	0.18	-	-	3.51
25	-	0.64	0.99	-	-	-	-	-	-	3.30
26	0.15	-	0.81	-	-	-	-	5.26	-	-
27	-	-	-	2.16	0.46	-	0.25	-	-	-
28	-	-	0.10	0.84	-	-	-	-	0.38	-
29	-	-	3.07	-	-	-	-	-	0.13	0.28
30	0.20	-	0.10	-	-	-	-	-	1.50	0.03
31	-	-	0.03	0.25	-	-	-	0.13	-	0.05
TOTAL	6.60	7.57	13.90	4.92	7.69	6.61	7.68	7.04	4.63	14.43

Appendix 2. Pre-harvest herbicide treatments for Canada thistle control in ridge till-planted soybeans at the North Star site, Gratiot County, Michigan, 1984.

Treatment[1]	Rate	10/23/84	6/6/85
	------kg/ha-----	---------%--------	
glyphosate	1.68	20d	99a
glyphosate	2.52	20d	98a
bentazon + COC	1.12 + 2.34 L/ha	63a	17cd
atrazine + COC	2.24 + 2.34 L/ha	37bc	20cd
dicamba	1.12	33bcd	52bc
dicamba	2.24	43b	95ab
2,4-D ester	1.12	23cd	40cd
2,4-D ester	2.24	20d	42cd
mixture of free 2,4-D acid + 2,4-D butoxyethyl ester[2]	2.24	27cd	40cd
mixture of free 2,4-D acid + propylenediamine salt of 2,4-D[3]	2.24	30bcd	13cd
dicamba + 2,4-D ester	0.56 + 0.56	23cd	53bc
Untreated	--	0e	0d

[1]Applied on 10/11/84 to mature soybeans and Canada thistle at 80% bud stage.

[2]Active ingredients in commercial formulation Weedone 638.

[3]Active ingredients in commercial formulation of Dacamine 4D.

Reliance on selective and nonselective herbicides are seen as an option for controlling perennials that are not controlled by cultivation in the ridge till-plant system. Canada thistle (*Cirsium arvense* (L.) Scop.) was one such species detected as a problem perennial in soybeans grown on ridges. A study was initiated with herbicide treatments that were applied to mature soybeans immediately prior to harvest while Canada thistle was in the bud stage of reproduction. The visual evaluations of control of this weed are listed.